Comparison of Measured & Calculated RF Fields Around Mobile Base Stations

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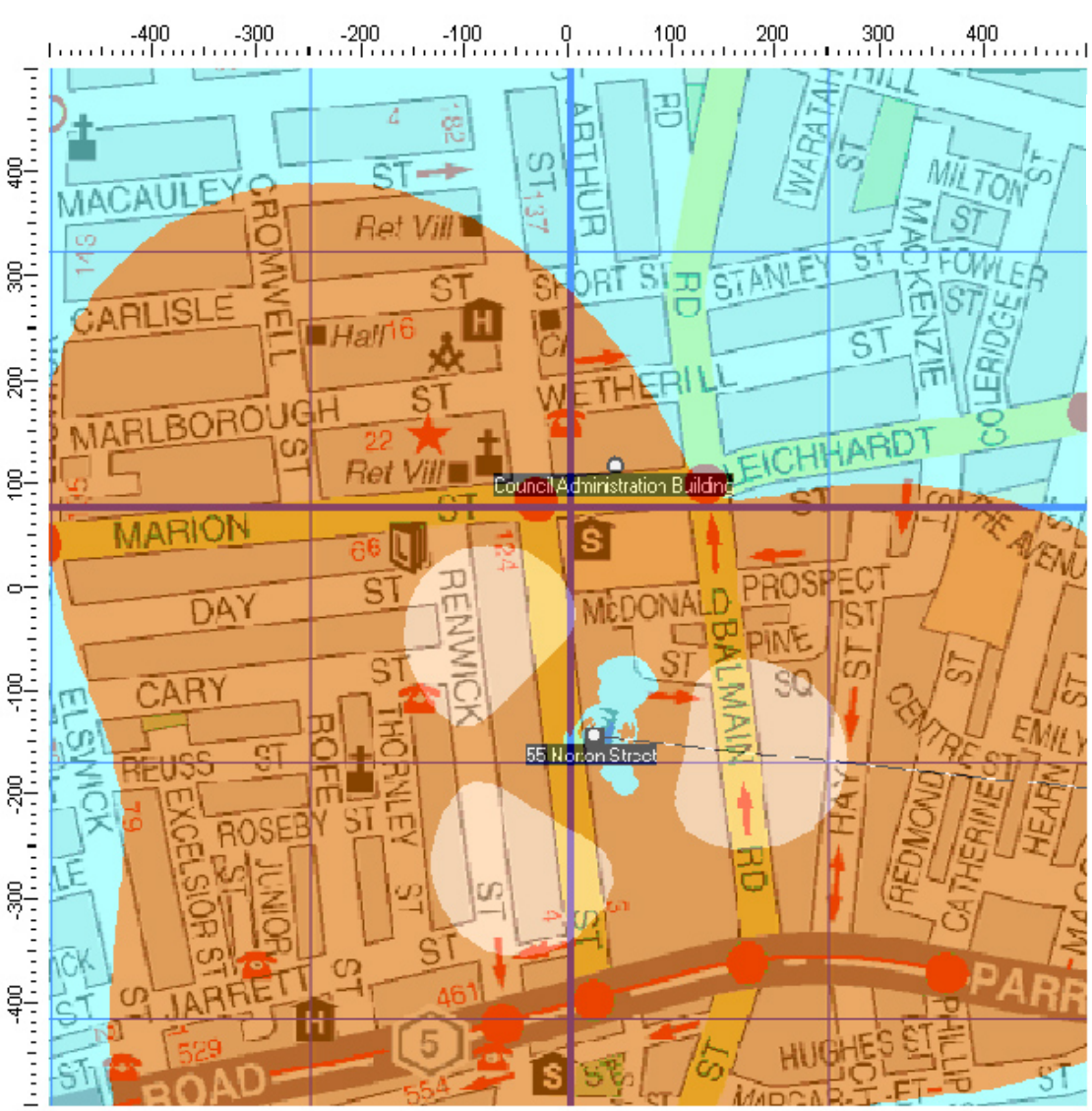
Typical RF Levels Around Base Stations

- Environmental EME Levels around base stations are very low
- Typically 0.0001 to 1% of the international general public safety limits

  (i.e. 1000,000 to 100 times below the safety limit)
- Mobile networks and base stations are designed to operate at the lowest possible transmitter power resulting in low environmental EME levels
- EME levels reduce inside homes and buildings

  residential homes – typically 2 to10 times lower than outside level
  office buildings - typically more than 10 times lower than outside level
- People walking around also affect the environmental EME levels

Example Base Station RF Calculation – Leichhardt NSW

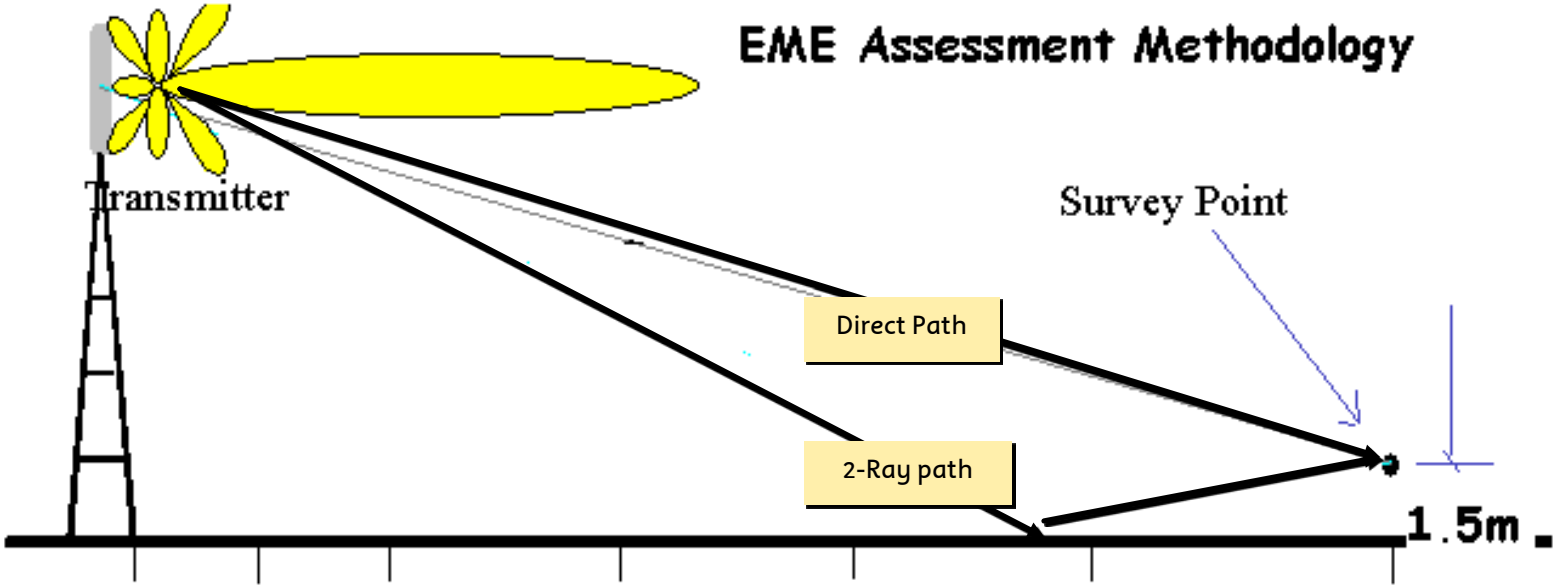


Example EME calculation in community using RF-Map

General Public exposure limit = 100%

Colour	Value [%ICNIRP [PEL]]
	500.0 or greater
	100.0 to 500.0
	10.0 to 100.0
	1.0 to 10.0
	0.1 to 1.0
	0.01 to 0.1
	0.001 to 0.01
	0.0001 to 0.001
	0.00001 to 0.0001
	0.000001 to 0.00001
	0.0 to 0.000001

RF-Map EME Assessment Methodology



RF-Map uses published far-field engineering formulae and near field gain & antenna aperture correction

RF-Map assumes no environmental clutter loss

Choice of direct or 2-Ray (ground reflection) path

RF-Map uses manufacturers' antenna data

How Accurate are the Calculations?

- In 2005, Telstra and Vodafone commissioned independent surveys of base stations, and have confirmed that RF calculations closely align with measurements
- RF-Map software was used to perform the calculations
- The difference between measured & calculated levels varied depending on the urban clutter from homes and environment
- It is important to have accurate base station configuration data - antenna pattern, mounting height, tilt, bearing and transmitter power and feeder losses
- Let's examine the results

Comparison Method 1 - measurements at location of predicted maximum

Site 7
Katoomba - NSW

- THL Australia conducted a survey of 10 Vodafone sites
- Measurement location was selected from the calculation of predicted maximum level using RF-Map
- The immediate area was scanned to detect peak level
- Measurement instrumentation - spectrum analyser SRM3000 & Narda E-field isotropic probe

Site 4
Pymble - NSW

Comparison Method 1 - measurements at location of predicted maximum

THL Australia survey data – 2005 Vodafone site audit

Base station site	*Maximum RF level (%ICNIRP limit)*		*measured / predicted*
	Measured value	*Corrected NSA prediction (2 ray model)*	
Spring Valley Golf Club, CLAYTON SOUTH VIC	0.66%	0.30%	3.4 dB
St Dominics Church, CAMBERWELL VIC	1.51%	0.88%	2.3 dB
Cnr Pt Nepean Rd & Esplanade, SORRENTO VIC	0.059%	0.078%	-1.2 dB
Gordon Fire Station, PYMBLE NSW 2073	0.12%	0.21%	-2.6 dB
Museum of Contemporary Art, CIRCULAR QUAY NSW	0.82%	0.53%	1.9 dB
Water tank compound, Berne St, BATEAU BAY NSW	0.005%	0.007%	-1.6 dB
Blue Mountains Council Offices, KATOOMBA NSW	0.76%	1.01%	-1.2 dB
WBM Building, SPRING HILL QLD	0.30%	0.14%	3.3 dB
Goldline Foods, EAGLE FARM QLD	0.59%	0.19%	5.0 dB
Stratford Works Depot, STRATFORD QLD	0.05%	0.17%	-5.2 dB
		Average	**+0.4dB**
		Std deviation	**3.2 dB**

Comparison of "measured value" & "prediction" *(Corrected NSA 2 ray model)* in table shows close alignment between measurements & calculations

Comparison Method 2 – Detailed series of measurements

- Telstra commissioned RadHaz Consulting, a NATA accredited test laboratory to conduct detailed RF EME measurements at 3 base station sites in Victoria

  Site 1 – Carrum Downs Sectored site in uncluttered open field environment
  Site 2 – Tooradin Omni Site in uncluttered open field environment
  Site 3 – Vermont Sectored site in semi cluttered environment

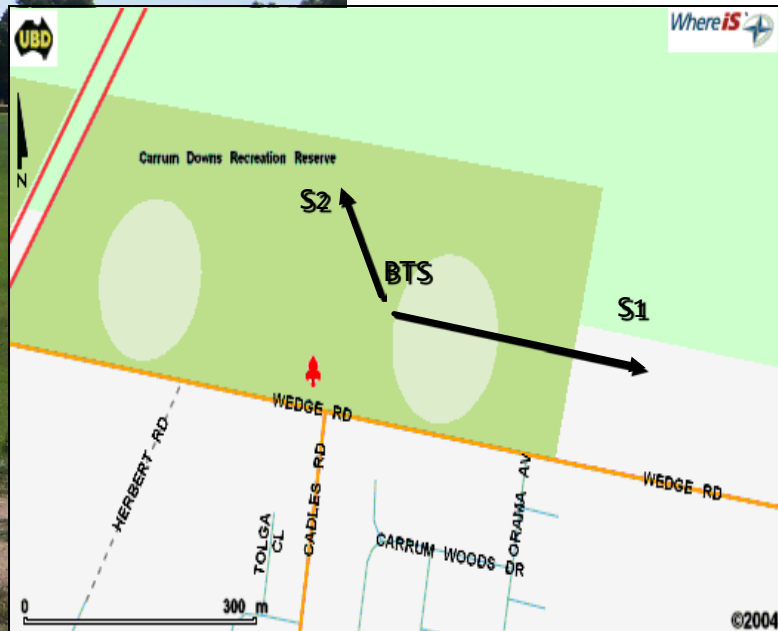
- Detailed RF measurements of the GSM BCCH control carrier were performed in the main beam of nominated sectors at 1.5m above ground.

- Measurement intervals varied from 1m, 5m, 10m & 50m out to a distance of 250 – 500m from the base station (depending on local environment)

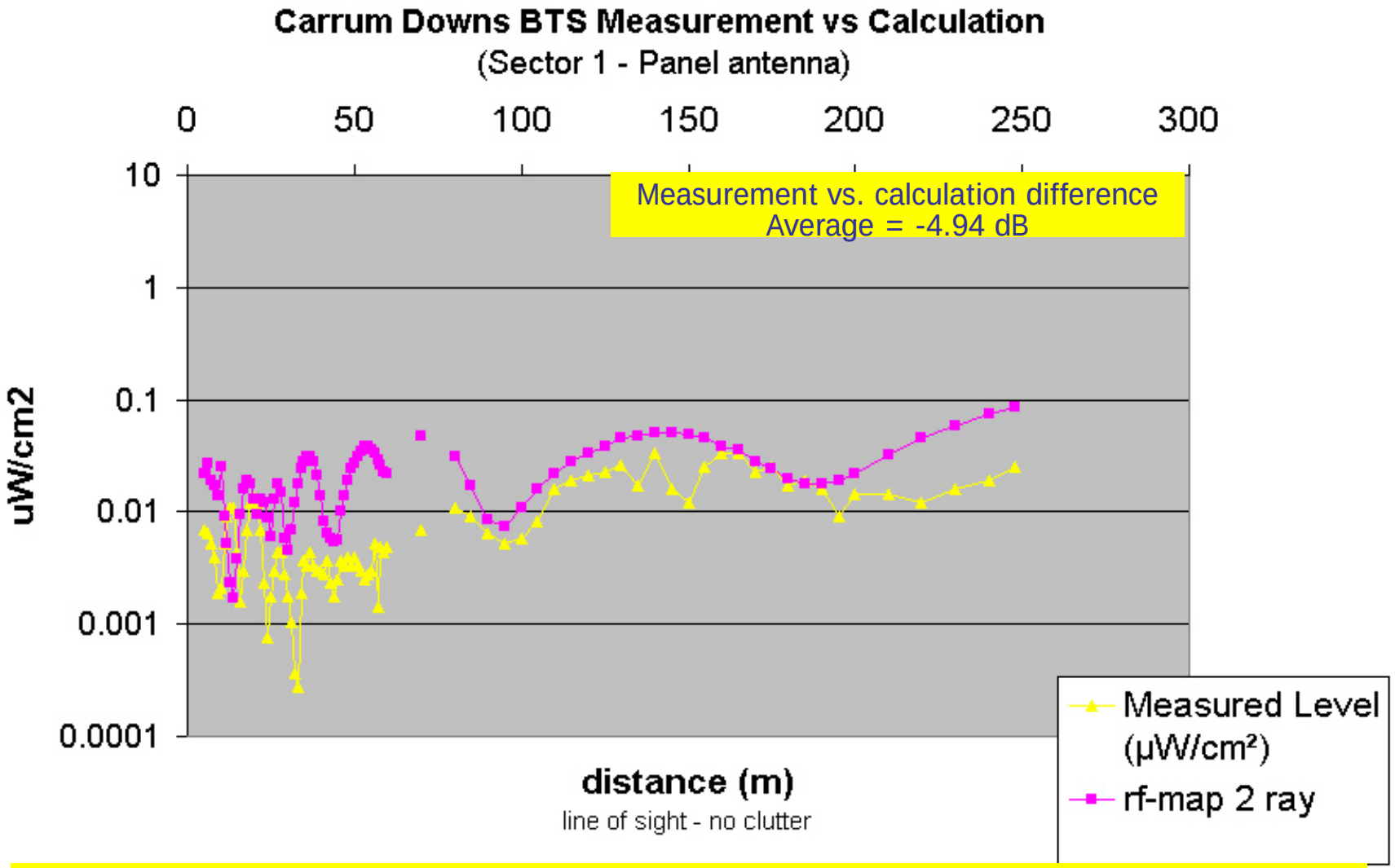
- Measurement instrumentation - spectrum analyser & log periodic antenna
  - spectrum analyser set to max hold and antenna was rotated at measurement location to record max level

- Calculations have been performed using Telstra's RF-Map software to allow a "side by side" comparison of measured and calculated RF levels

Comparison Method 2 – detailed measurements
Carrum Downs Victoria

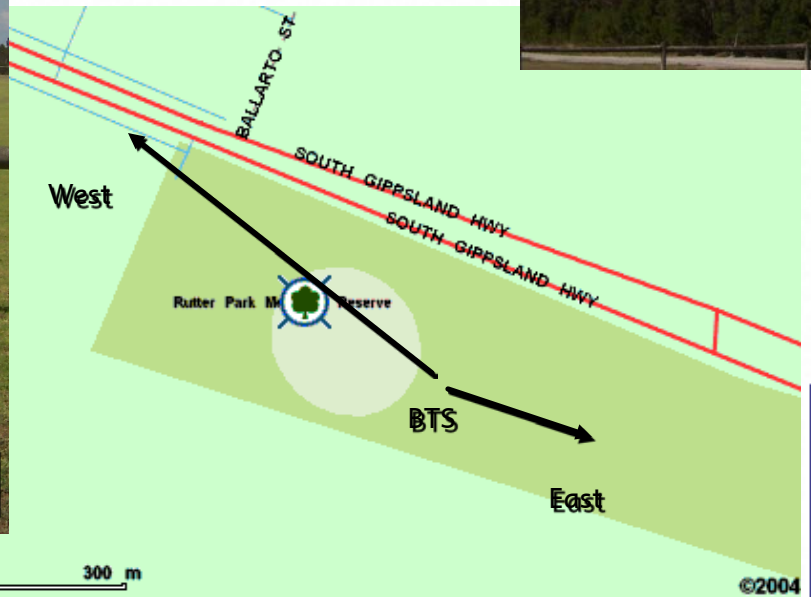


Comparison Method 2 – detailed measurements
Carrum Downs Victoria

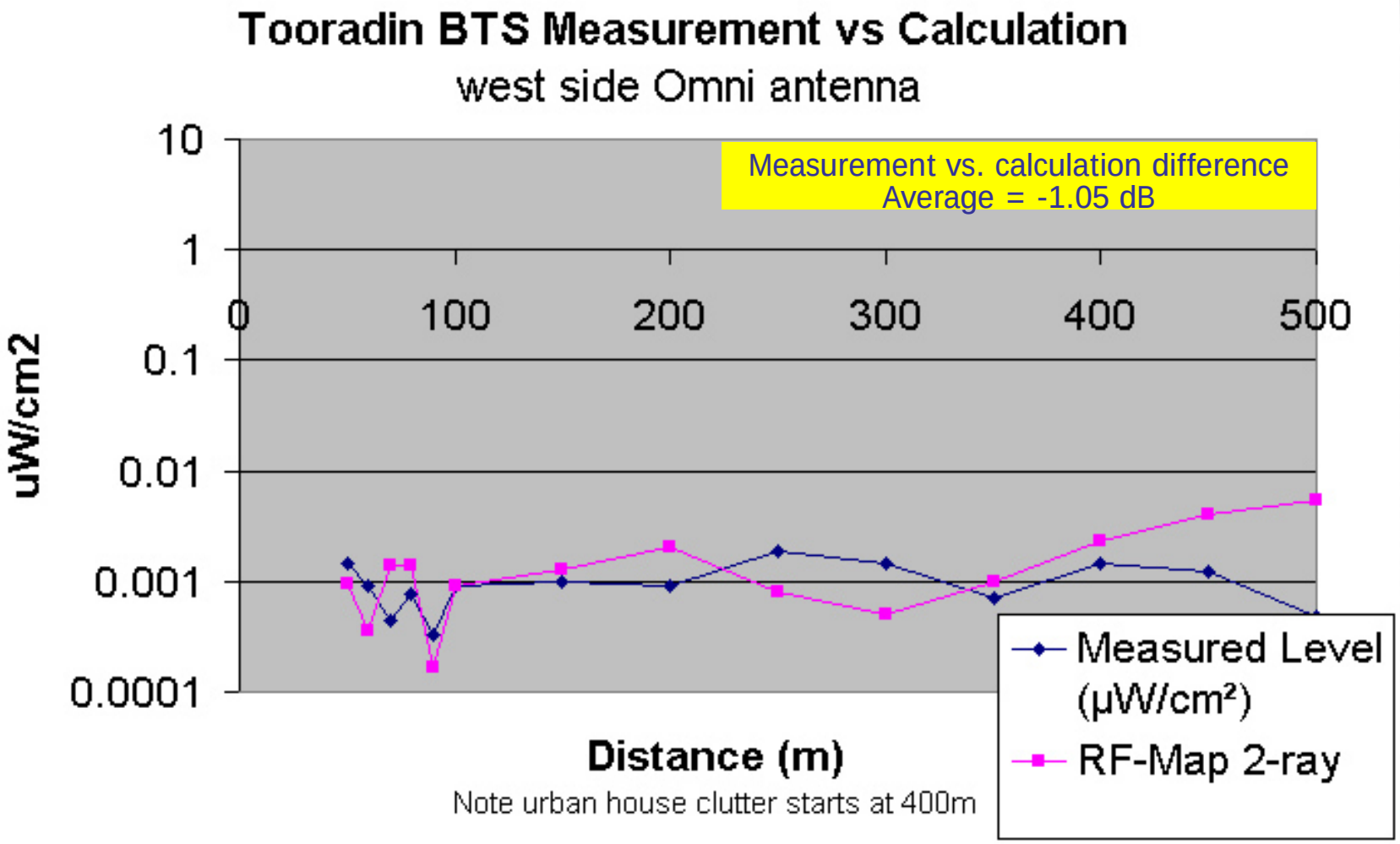


Comparison shows close alignment between measurements & calculations

Comparison Method 2 – detailed measurements
Tooradin Victoria



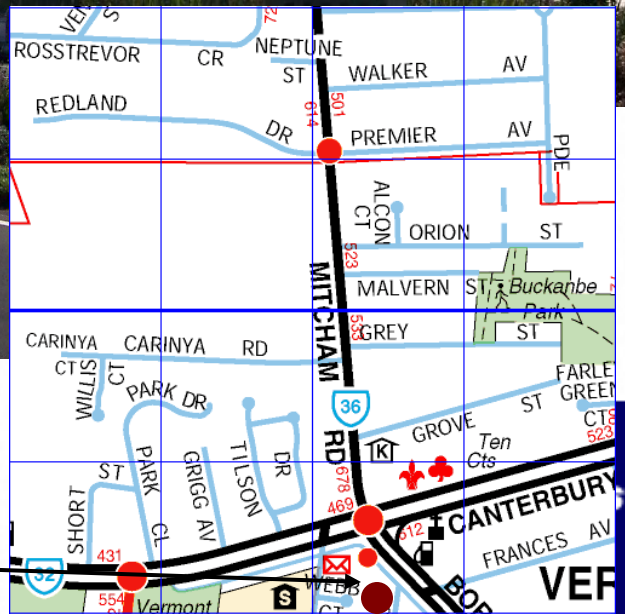
Comparison Method 2 – detailed measurements
Tooradin Victoria



Comparison shows close alignment between measurements & calculations

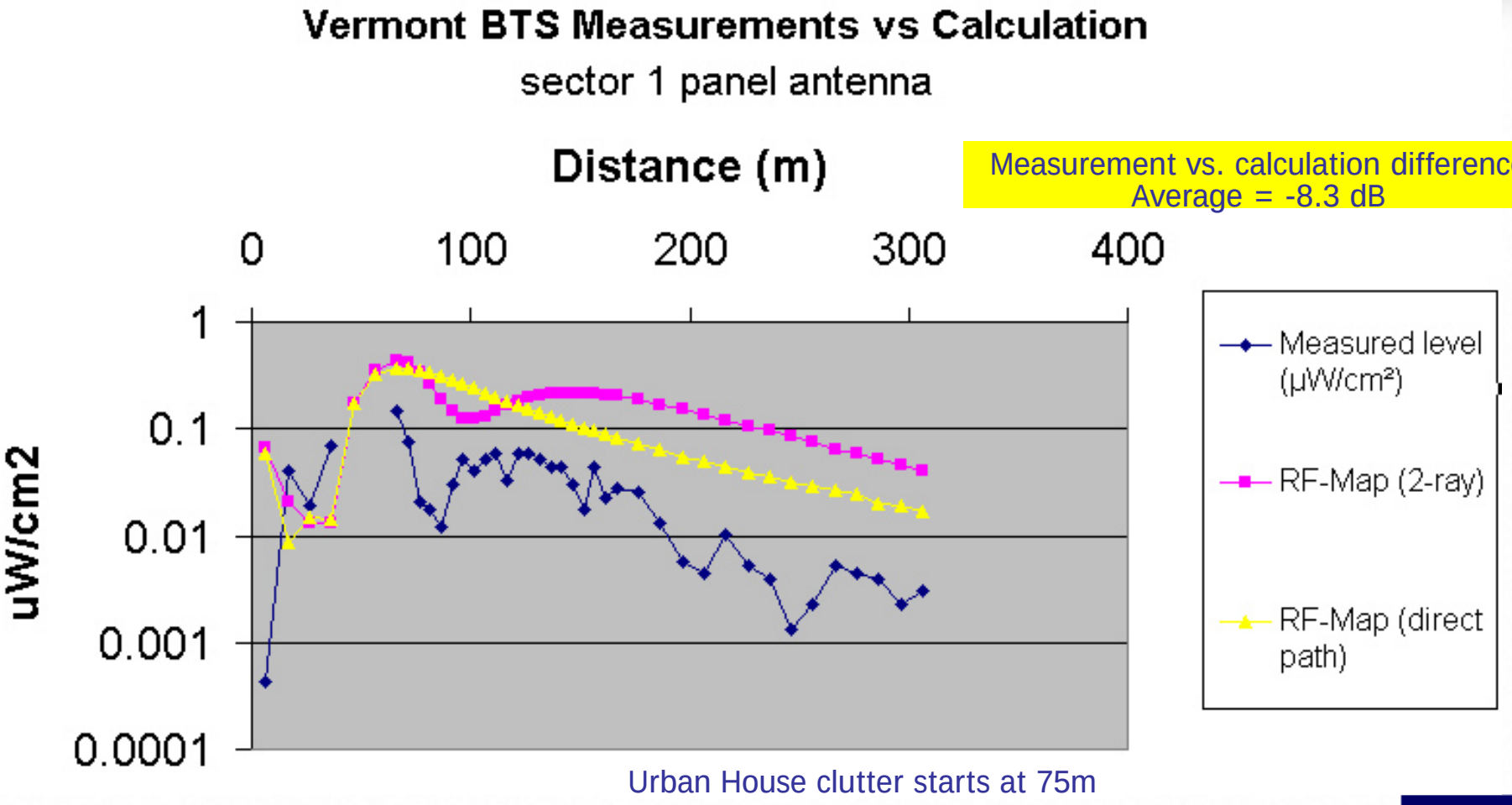
Comparison Method 2 – detailed measurements
Vermont Victoria

Measurements conducted down Mitcham rd



Vermont Base Station

Comparison Method 2 – detailed measurements
Vermont Victoria



Measurement vs. calculation difference
Average = -8.3 dB

Urban House clutter starts at 75m

Comparison shows close alignment between measurements & calculations

Analysis of Comparison

- Both survey methods have demonstrated a close alignment with the calculated levels – typically within ± 3dB to 6dB

- The detailed measurements at the Telstra sites demonstrate

  - close to the base station, the levels vary more due to antenna side lobes
  - the reduction in measured level when the urban clutter increases (homes)
  - the close alignment of measurement & calculation out to a 500m distance
  - the need for multiple measurements / area scan to identify maximum levels
  - the levels near the ground can increase further away from the base station

- The THL survey method provides a relatively quick and accurate procedure for EME surveys

Conclusions

- EME levels around base stations are very low
- Calculations align with measured levels, which provides confidence in relation to the reports
- The Environmental EME reports in Australia using the ARPANSA protocol (max power & max capacity) generally over estimate EME
- Optimum network design is consistent with minimising EME levels in the community from base stations and mobile phone handsets
- Base stations need to be close to mobile users for efficiency & lowest power
- Artificial siting criteria like "base station exclusion zones" if adopted can increase EME levels in the community

Documents & References

- ARPANSA Prediction Methodology Technical Report;

  "Radiated EME Exposure Levels - Prediction Methodologies" - is available at http://www.arpansa.gov.au

- The Microwave Engineers Handbook, Vol.2, Page 34 & 35, Artech House, Inc, 1971

- RF-Map Conference Paper

  - Multiple Site Cumulative EME Assessments Using RF-Map (August 2002) telstra.com.au/ememanagement

- Comparison of radiofrequency environmental measurements to RF-Map predictions for GSM900 base stations: 10 sites- Feb 2005, Dr Vitas Anderson, Brett Moule, THL Australia

- RF EME Survey Report, Telstra Mobile Telephone Base Stations, May 2005, RadHaz Consulting