DAB+ Digital Radio

RF Transmission Planning

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ASBU / WorldDAB - DAB+ Workshop, Amman, Jordan 23-24 August 2017

RF Planning

- Planning levels – mainly ITU / EBU but each country has its own slight variations
- SFN operation
  - Why is this good/useful
  - Efficiency of DAB (relative to FM)
- Interference issues
  - coordination
- Design process
- Coverage examples

RF Coverage – Requirements

Capacity and coverage requirements

How many services (now and later)

- Defines how much spectrum is needed
- E.g. Sydney uses 3 ensembles (5.136MHz) for approx 63 services

Number of services in each Region or Licence Area?

Service capacity includes both audio and PAD

How much of the population must be covered

- Define minimum coverage requirements
- Significant for difficult terrain and large areas
- Increases to (near) 100% of the country as the deployment process approaches Analogue Switch Off (ASO)

RF Coverage – Requirements

Spectrum Requirements

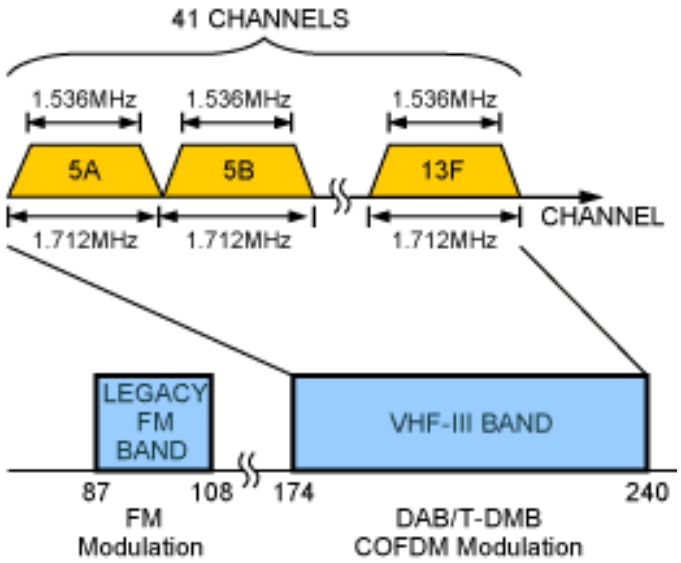
What VHF band III capacity is available?

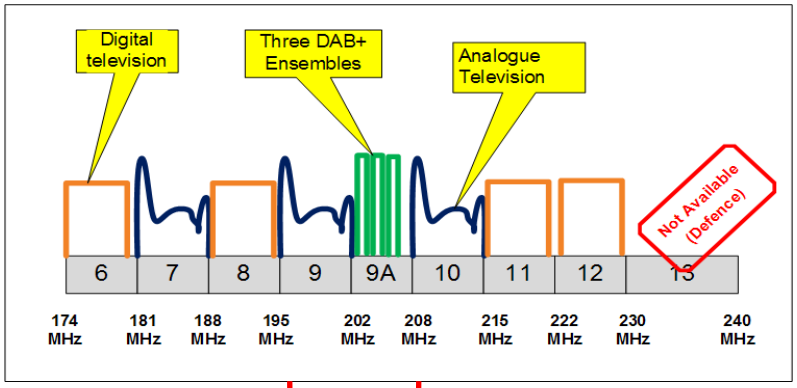
- Which channels?

Multiple Frequency Network planning – cellular design

- Power levels are critical
- Coverage vs Co-Channel Interference (CCI)
- Adjacent Channel Interference (ACI) with other/adjacent cells / LAPs
- spectrum reuse
  - typical cellular design requires >4 times single cell capacity dependant on terrain and coverage requirements

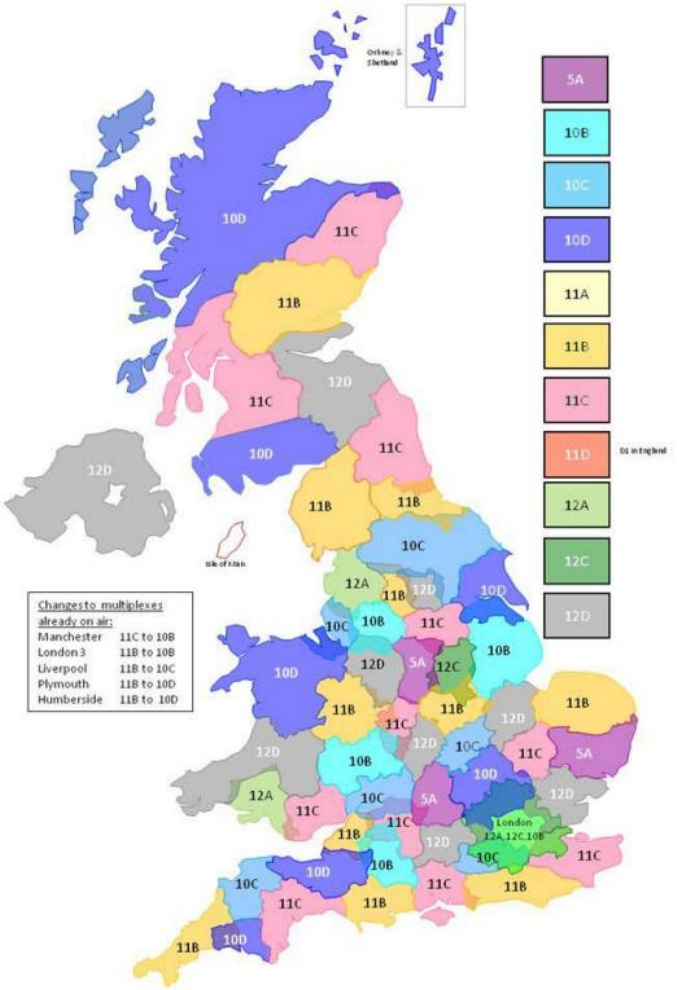
Transmission – Frequency plan





Australian Band III allocation

UK channel allotments



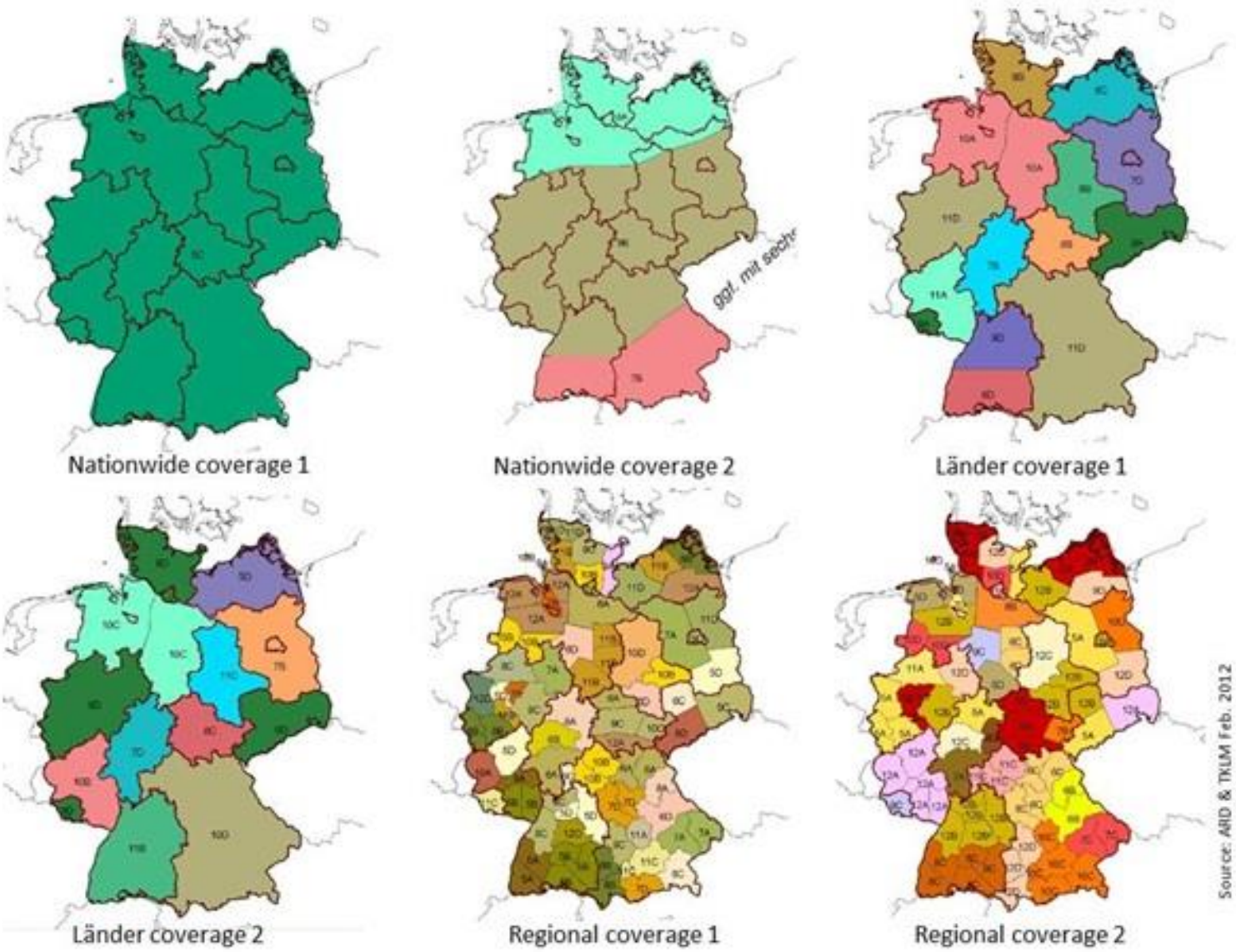
2 DTV channels allocated

14MHz = 8 DAB channels = 8A, B, C, D, 9A, B, C, D

Transmission – Frequency plan

Germany

Full VHF Band III



Transmission

RF spectrum

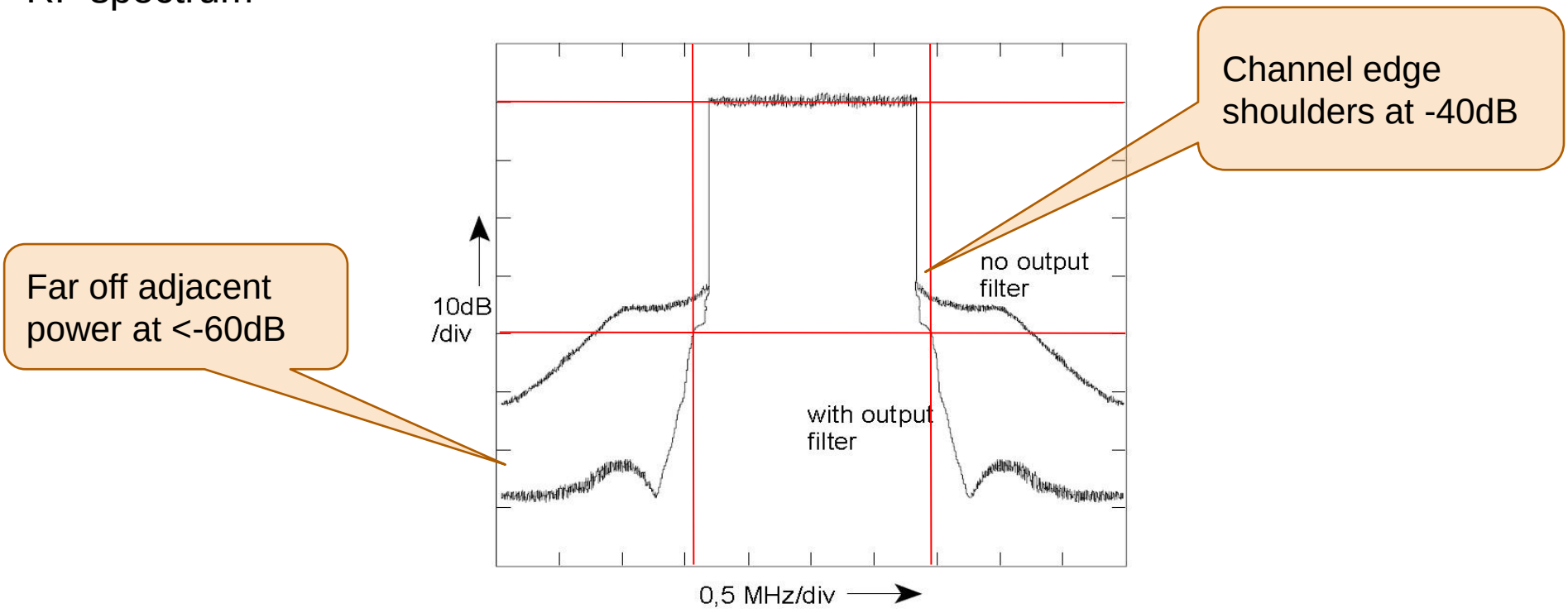


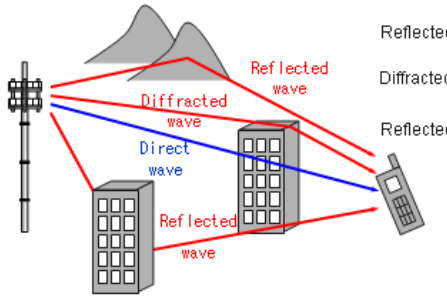
Figure 4.3.4: Example of DAB transmitted signal spectrum (VHF band III)

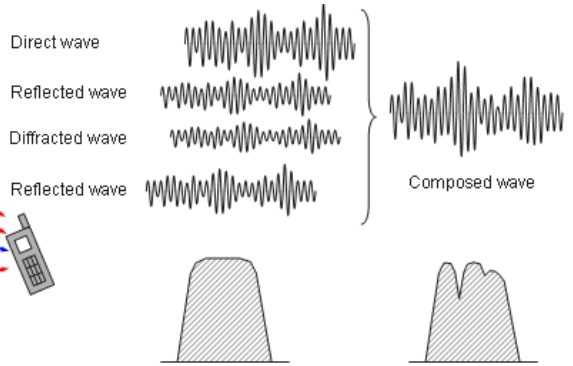
Signal bandwidth = 1536 carriers at 1kHz each => 1.535MHz
Channel bandwidth = 1.712 MHz

Transmission

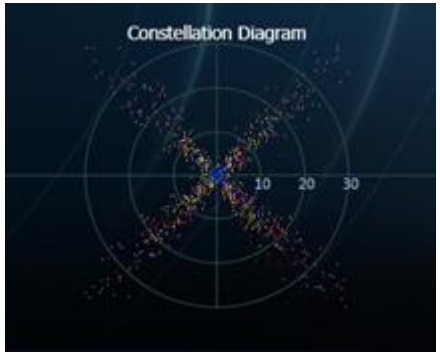
Transmission channels

- Line of Sight / Ricean
- Rayleigh





The received signal is composed of multiple signal paths and USUALLY has no direct line of sight component, i.e. is a Rayleigh channel



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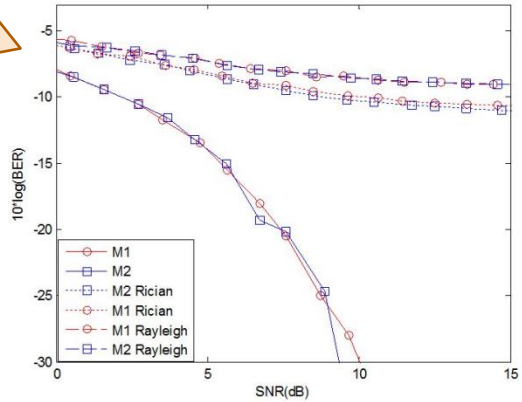
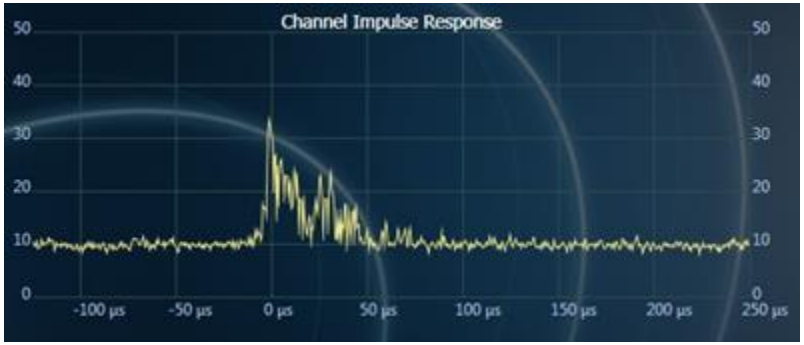




RF Coverage – Levels

Defined by ITU / EBU but each country has its own slight variations

Australian Commercial Radio Planning targets (2017)

	FIELD STRENGTH	
	Urban Indoor & Vehicle	> 60 dBuV/m
	Suburban Indoor & Vehicle	54 – 60 dBuV/m
	Vehicle Only	50 – 54 dBuV/m

Below 50dBuV/m is considered to provide unreliable coverage in vehicles

Some areas may receive marginal coverage but patchy coverage is unsatisfactory

RF Planning – Tools, Methods and Standards

Planning Considerations

ITU

- BS.1660 -includes guidelines for plan… …t is r… …d

EBU

- Recommendation R 1…
  - R… …ssion as de… …SI TS 102 563 for d…
- TR 021 - TEC… …NNING AN…
  - …
- TR 025 - … …NIN… PARAMETE…
  - Rec…
- BPN0… …OAD… …VICES NETWORK PLANNING AND COMPATIBILIT… …EXIS… …G BROADCASTING SERVICES
  - Transmission pla… …g levels, receiver C/N and SFN operation and gain

Science is improving predictions and planning process

EBU Broadcast Network Planning group is reworking the EBU DAB+ planning guidelines given recent measurements and results

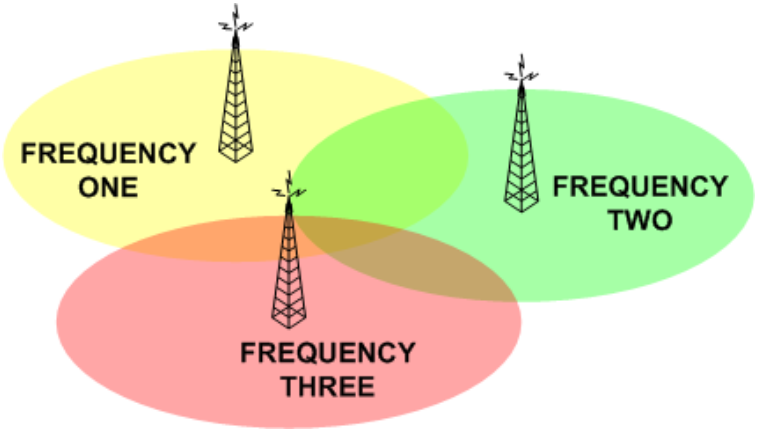
RF Planning - Network Types

Multi-Frequency Networks and Single Frequency Networks

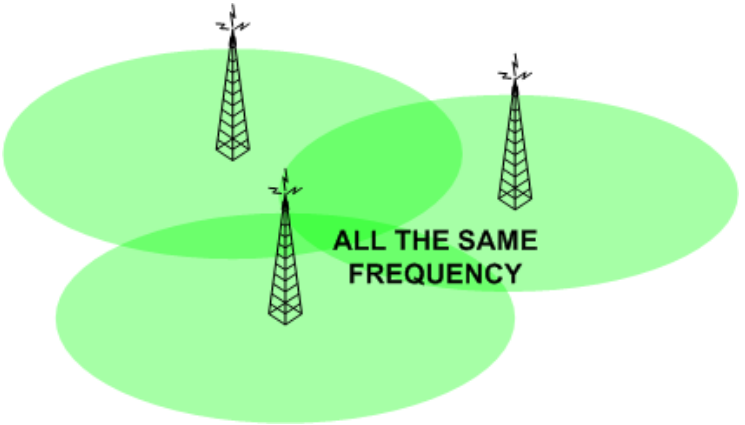
- Single frequency network.
- Multiple transmitters
  - Can be any combination of high, medium and low power transmitters

SFNs are a more efficient use of spectrum

MFN
e.g. Main Tx and 2 Gap Fillers



SFN
e.g. Main Tx and 2 Gap Fillers

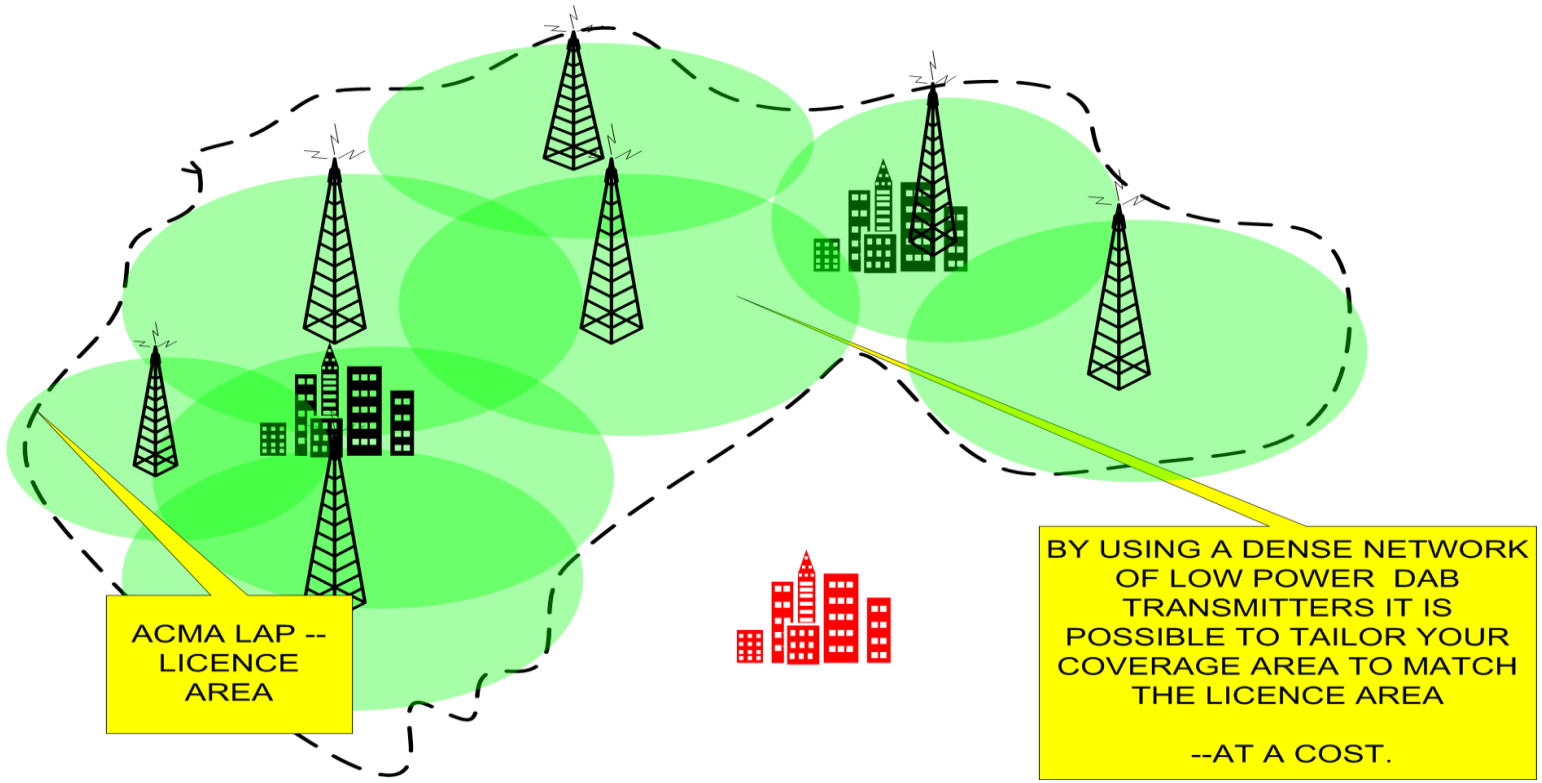


RF Planning - Network Types

RF Network Options

Covering a specific area

e.g. A Licence Area

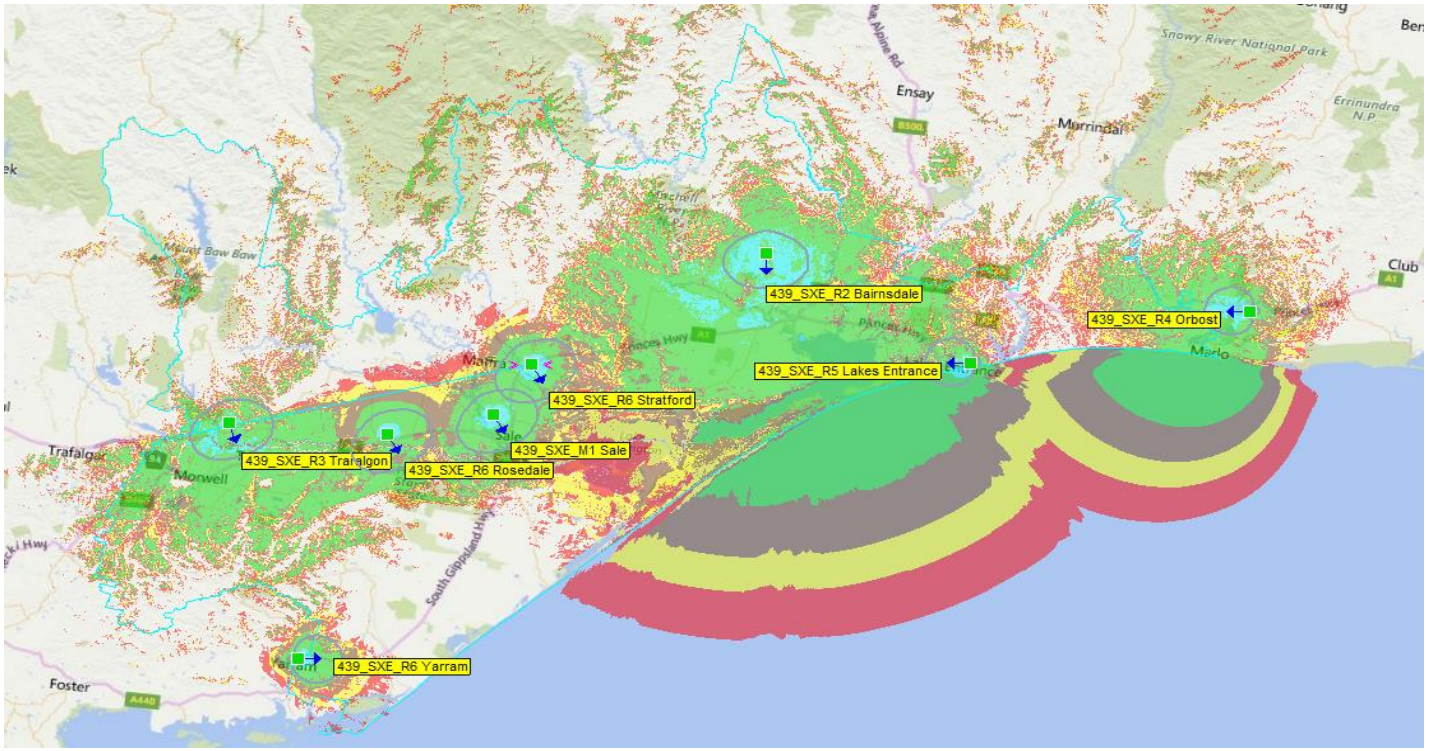


DAB: 7 transmitters on one frequency

FM: 7 transmitters on 7 frequencies

SFN example

SFN coverage in Sale, Victoria, Australia



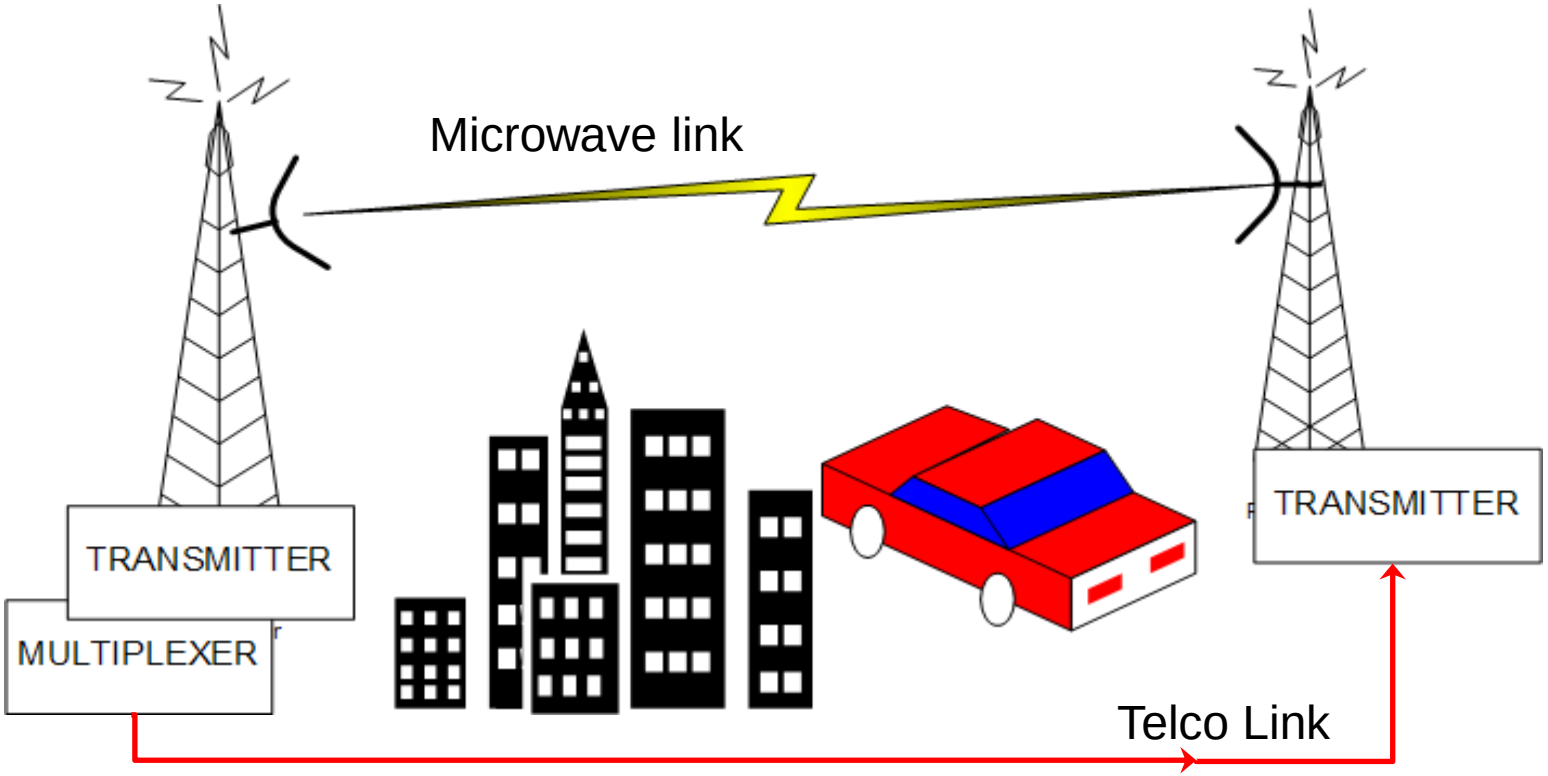
7 transmitters to cover 200km ranging from 1 to 5kW each

RF Planning - Network Types

Link Fed Repeaters

The repeater is fed an ETI/EDI signal via a link

- Microwave
- Telco landline (fibre, dedicated or shared, diversity)



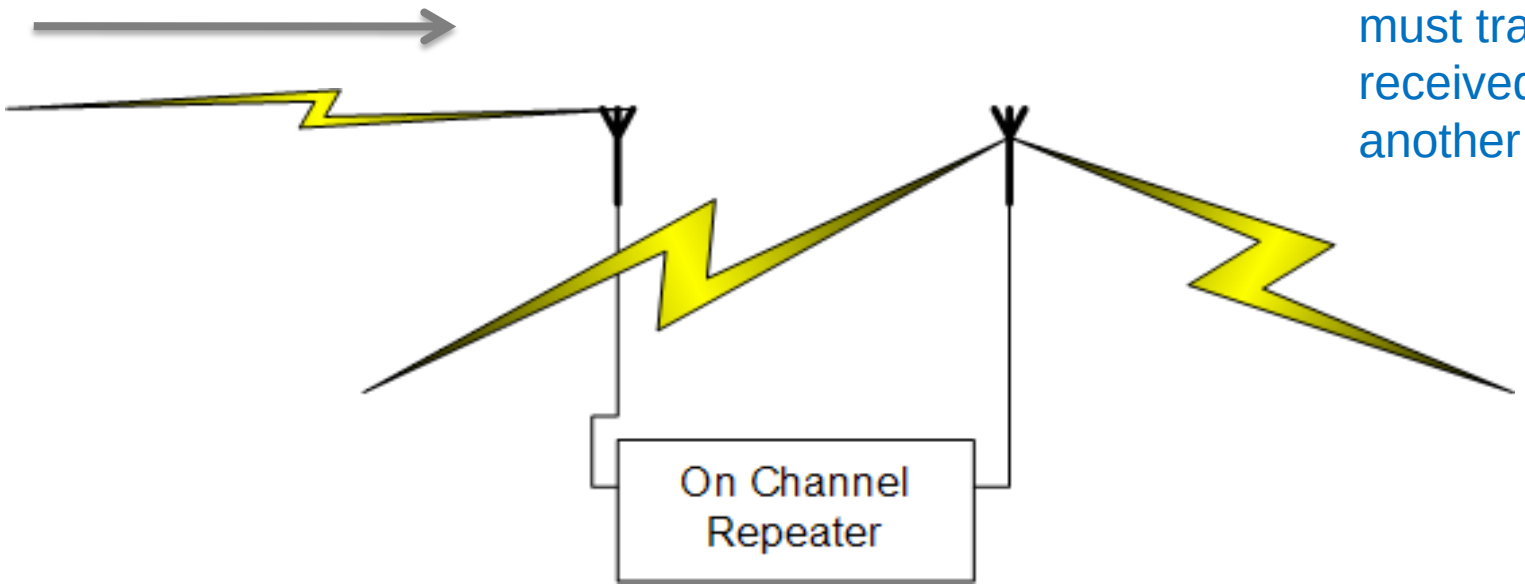
RF Planning - Network Types

On Channel Repeater

Receives the signal off-air and then retransmits on the same frequency

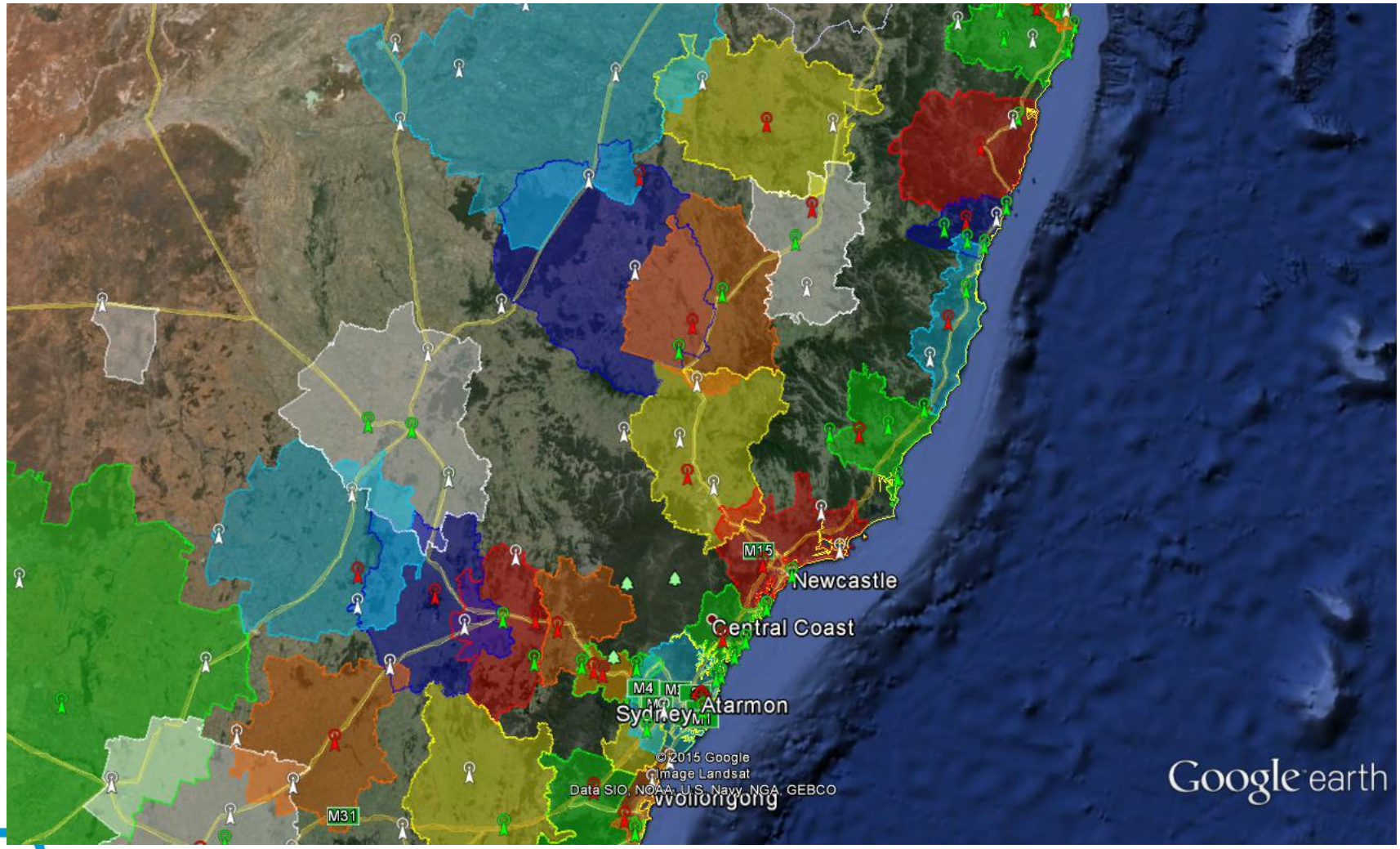
Echo cancelling techniques allow repeaters to be built which can re-transmit on the **same frequency**

For FM the repeater must translate the received signal to another frequency



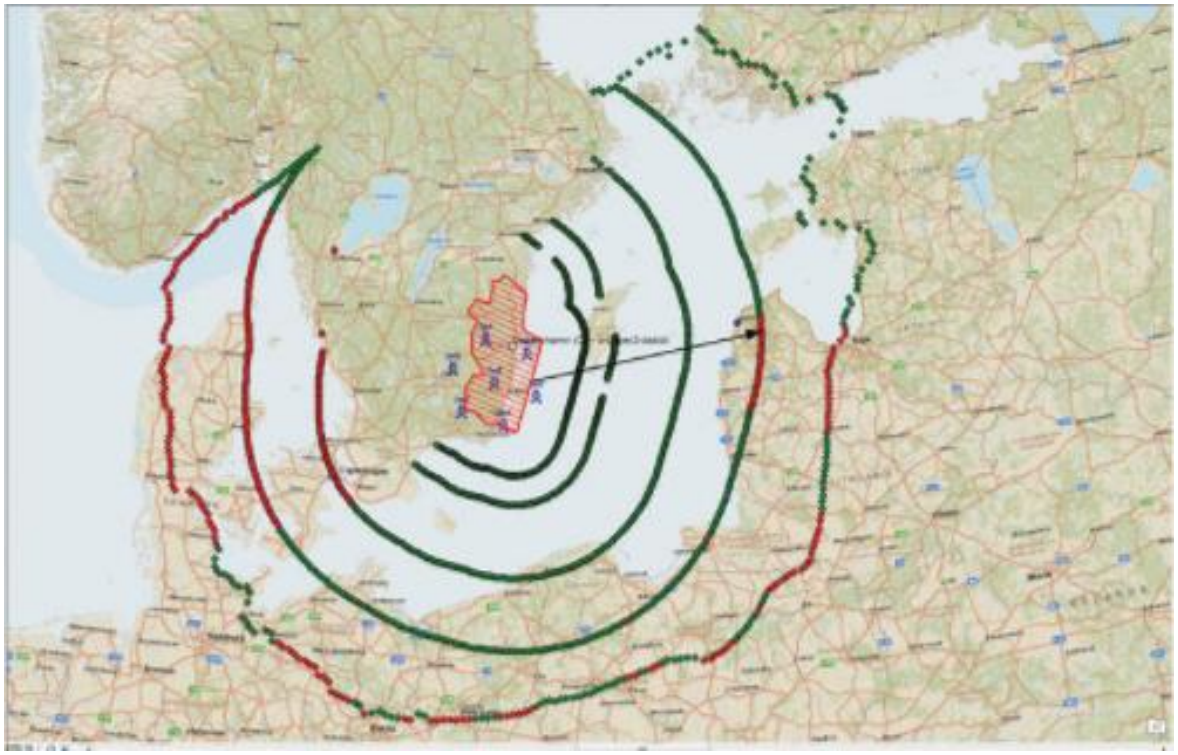
RF Planning – Multi-Frequency Network

Licence areas - Northern NSW example



Cross border coordination

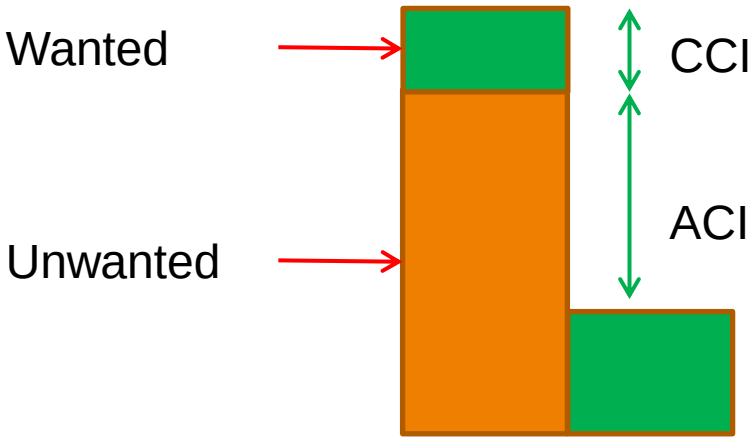
Interference between Sweden and Germany and Denmark



RF Planning – Tools, Methods and Standards

Interference Considerations

ACMA defined Protection Ratios



Affects the re-use distance in multi-frequency networks

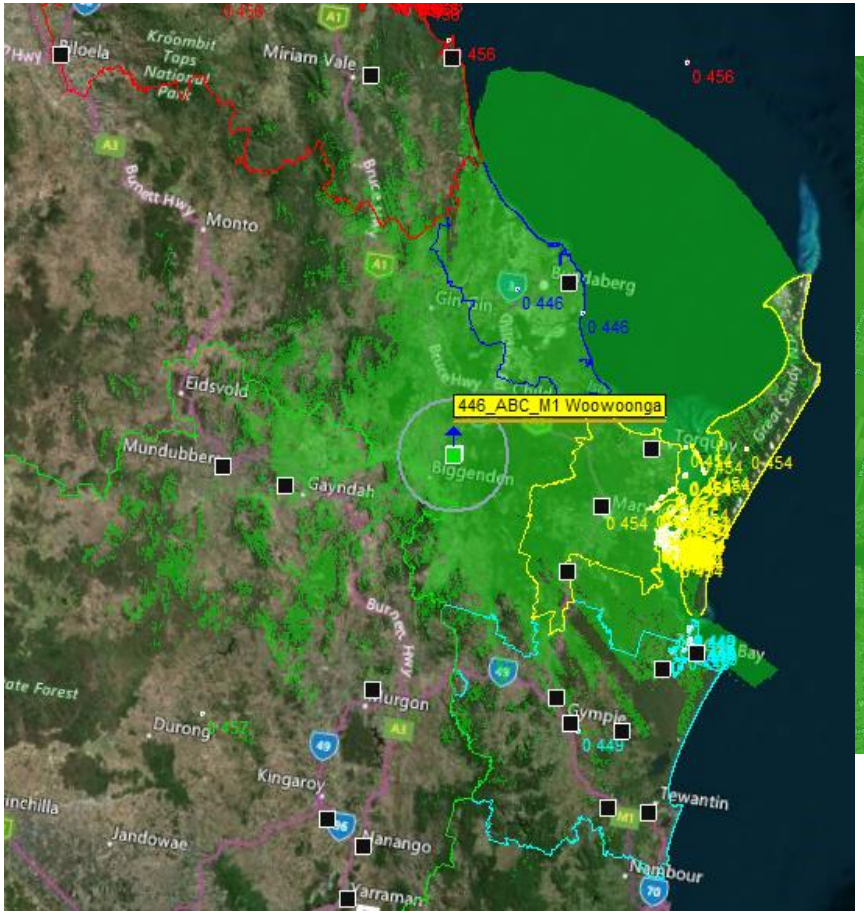
Higher value results in more conservative planning

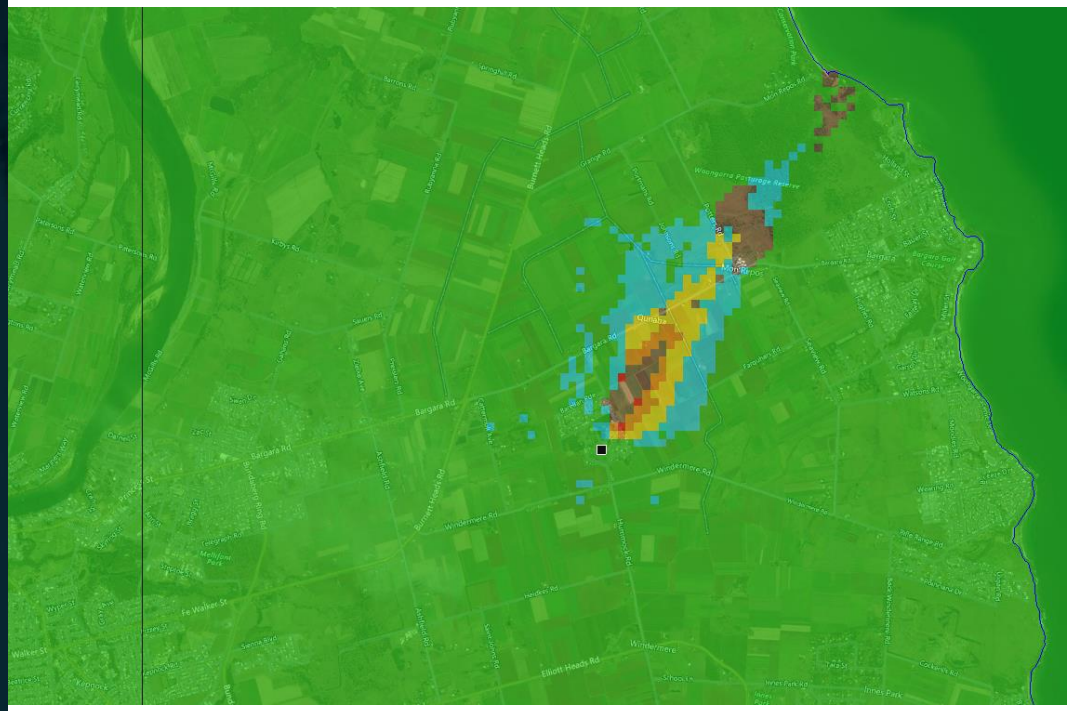
Affects the allowed impact on adjacent channel transmissions in multi-frequency networks

More negative value provides less protection

ACI coverage hole punching

Local transmission punching a coverage hole into a wide area transmission

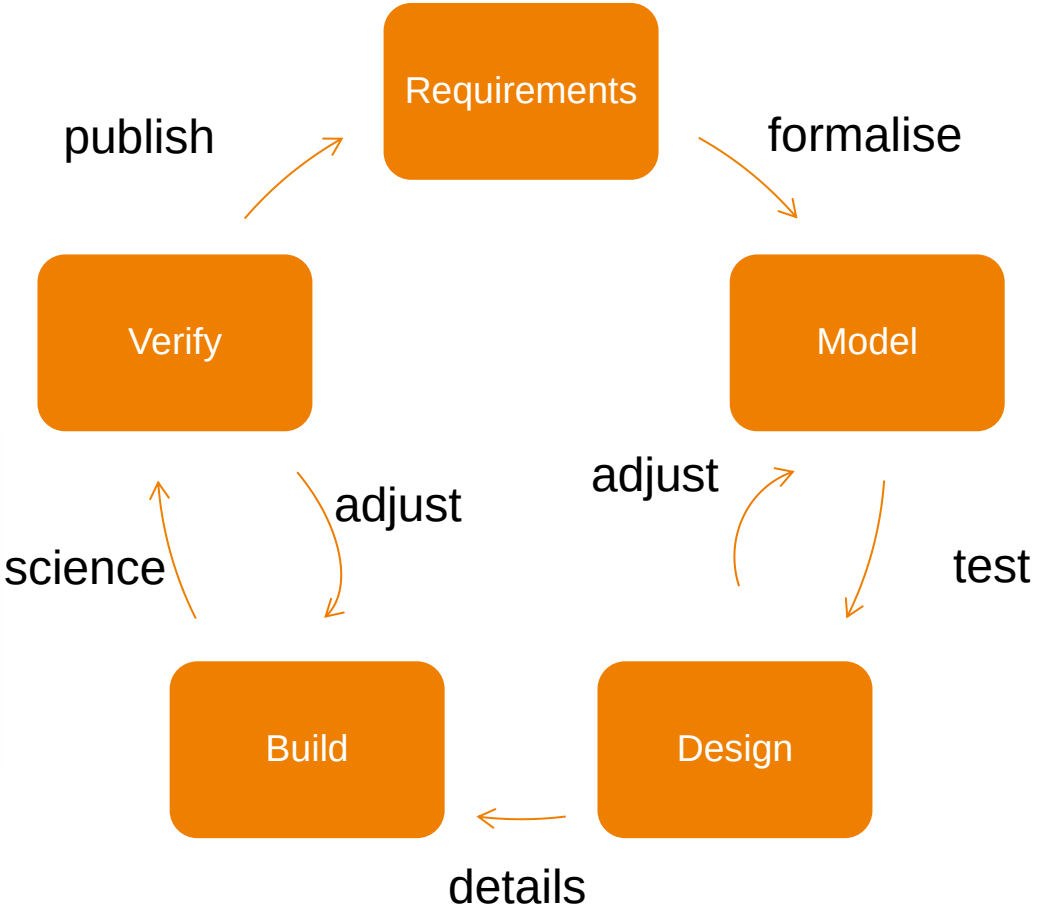




RF Planning – Levels, methods and standards

The Design Cycle

- The first loop is the hardest
- A test transmission will provide the best learning experience
- Use the initial system results to help design future systems



Engineering collaboration helps minimise the system design and deployment effort and maximises benefits to listeners and in turn broadcaster returns

RF Planning – Levels, methods and standards

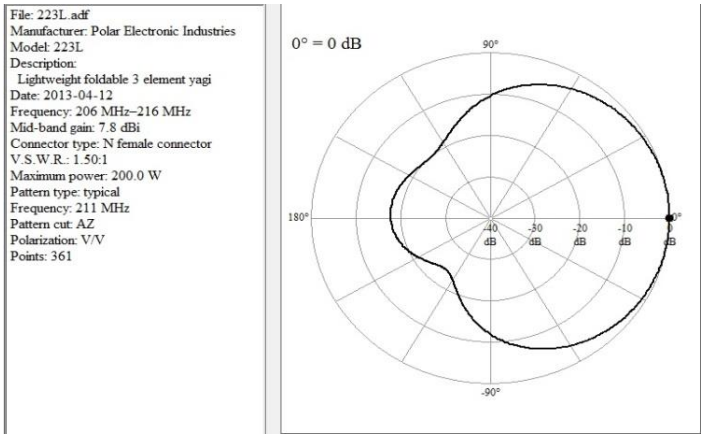
The Design Cycle – Coverage Modelling

- Model coverage then interference
- Main high power site first, then in-fills/repeaters
- Use antenna pattern HRP and down tilt VRP (if required)
- Tuning the coverage model to maximise accuracy
  - Cartography resolution
  - propagation model
  - clutter parameters
- Test transmissions at lower power will allow more accurate design through empirical verification in the field
  - At least for initial sites
  - Is terrain / clutter dependant

RF Planning – Tools, Methods and Standards

The Design Cycle

- A cooperative and collaborative process between both broadcasters and the regulator
- Site selection
  - High sites will provide the best coverage but also the longest distances for CCI
  - Use the same sites for multiple ensembles if possible
  - National and commercial coverage variations
  - Collocate with VHF TV to minimise ACI issues
- Antenna selection
  - Patterns, Down tilt, Gain
    - higher gain = lower power costs but more initial Capex
    - Antenna patterns may need to be shaped to minimise interference
  - DC grounded antennas



Save Money / Make Money

RF Planning - Transmission network design considerations

High Power High Tower v Low Power Low Tower selections

- Higher sites will always provide greater coverage due to increased line-of-sight areas
- Terrain is the largest impact on coverage area, large buildings are equivalent to hills!
- Uneven and shadowed terrain requires increased main site power and/or increased repeaters

Type	Power (kW ERP)	Height above served area (m)	Best use
HPHT	20-50+	>250	wide area coverage but may experience shadowed areas especially in the distant coverage areas Typical coverage radius = 30 – 80km
MPMT	5-20	50-250	undulating areas with no high transmission site Typical coverage radius = 10 – 30km
LPLT	0.3-5	<50	local area coverage Typical coverage radius = 2 – 10km

RF Planning - Transmission network design considerations

Terrain shielding and undulations

Sydney northern beaches

RF Planning - Transmission network design considerations

City building shielding - Melbourne

RF Planning - Transmission network design considerations

HPHT – LPLT Cost implications

- HPHT will usually give best coverage kms^2/$
- City sites can be very expensive, even for LPLT
  - High population density drives prices up even for sites like water towers
  - Telco towers are often too low!
- Site costs are often the largest component of Opex for main AND repeaters
- Site selection for cost optimisation is time consuming – especially for multiple repeater sites in large cities
- The number of main HPHT sites in large cities are often limited

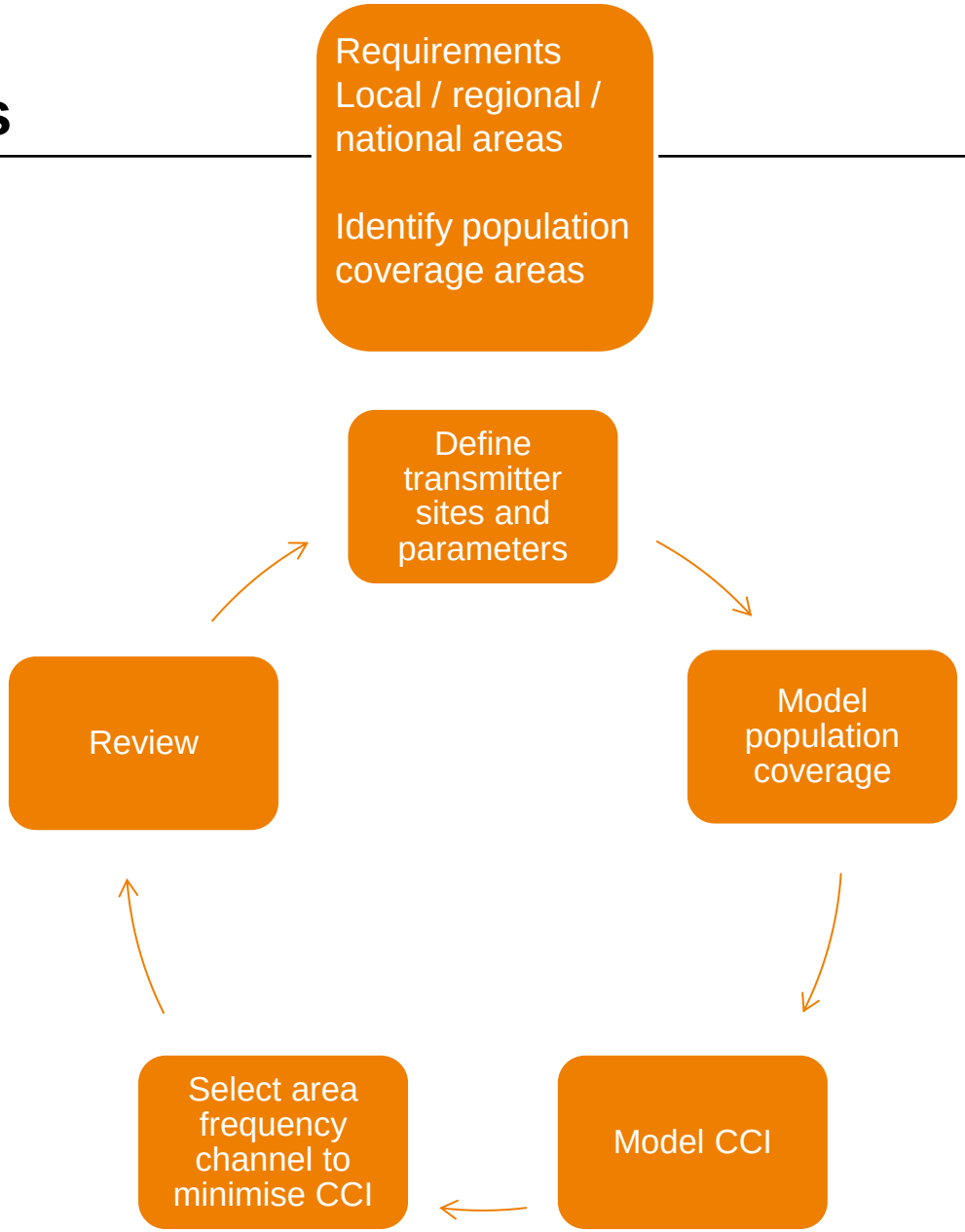
Allotment planning process

Iterate the loop until the population coverage and CCI requirements are met

Sometime cost minimisation will require trade-offs in coverage and/or interference targets

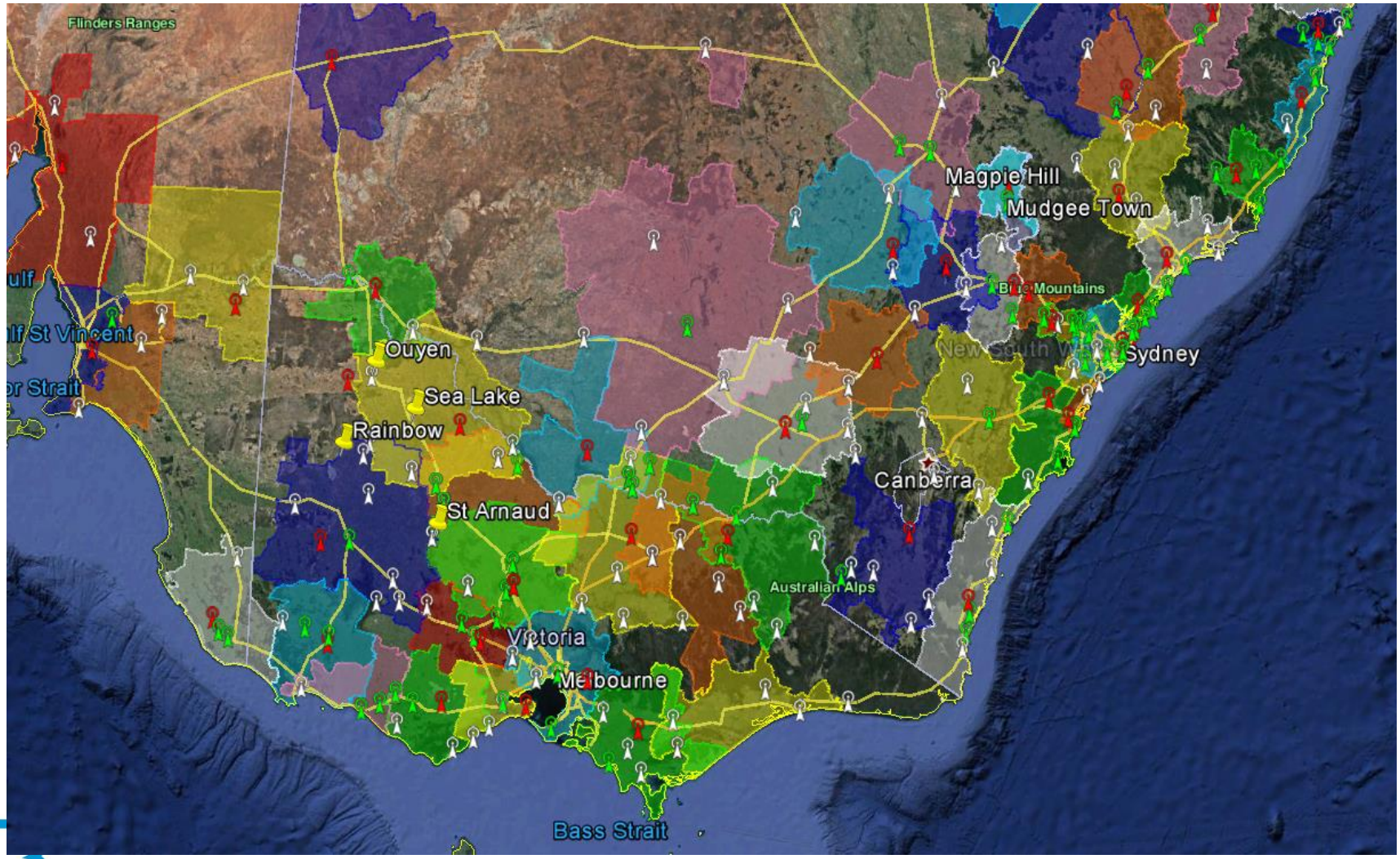
ACI and self-interference will also need to be examined

As sites are built the coverage can be measured and the models adjusted to maximise accuracy as the roll-out progresses



RF Planning – Multi-Frequency Network

Licence areas – South Eastern Australia example



RF Planning - Transmission network design considerations

Frequency Planning

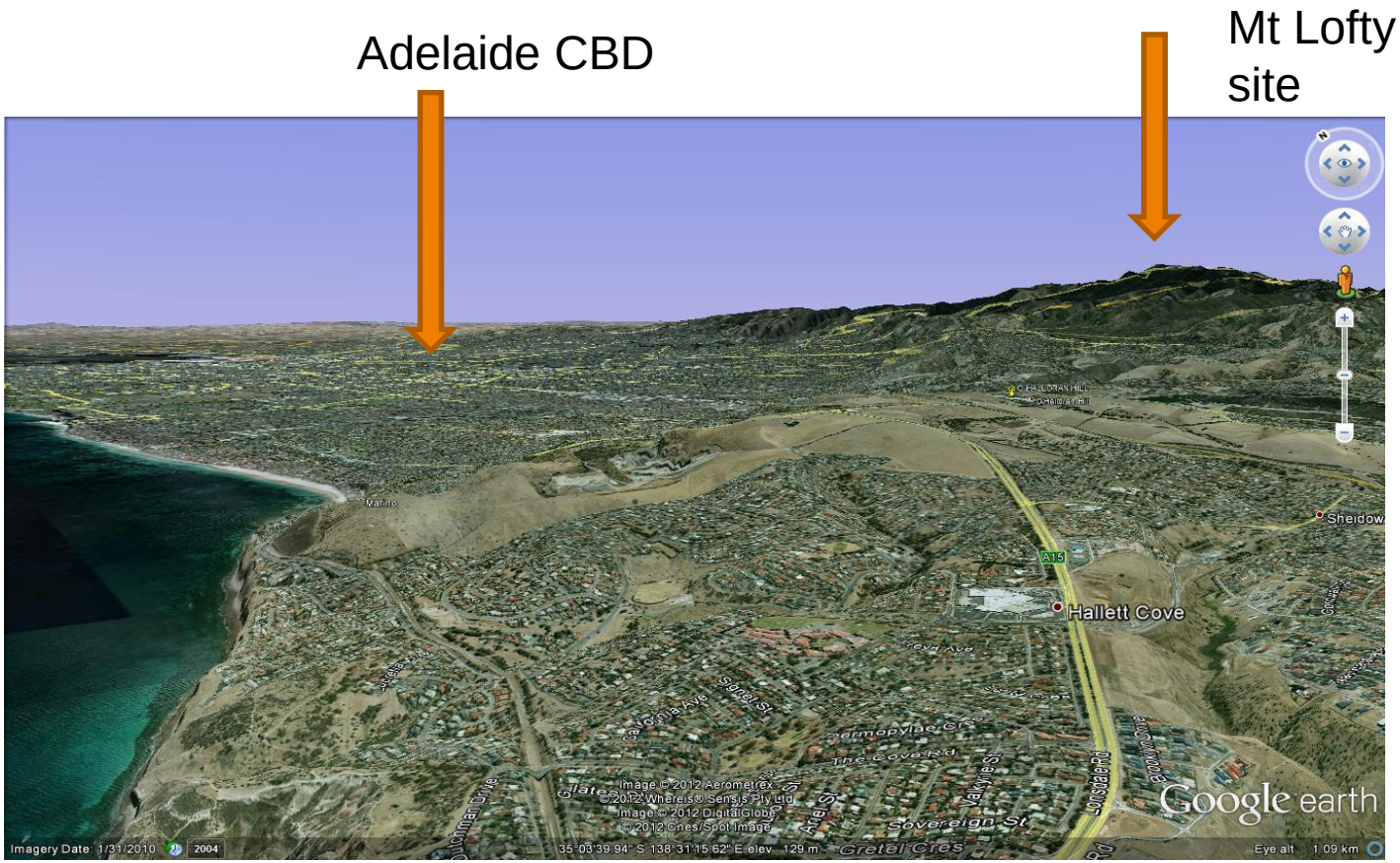
- Cultural considerations - may need to deliver the same/equivalent content in different languages for different areas
- Ensembles with ANY different content will need to use different ensemble frequencies in an MFN configuration within CCI rules
- The terrain of each area may provide natural boundaries to facilitate more efficient frequency re-use
- Existing use of the VHF Band III spectrum must be taken into account to ensure that interference is within defined limits

RF Planning - Design examples

Adelaide Licence Area

RF Planning - Design examples

Adelaide terrain viewed from the south

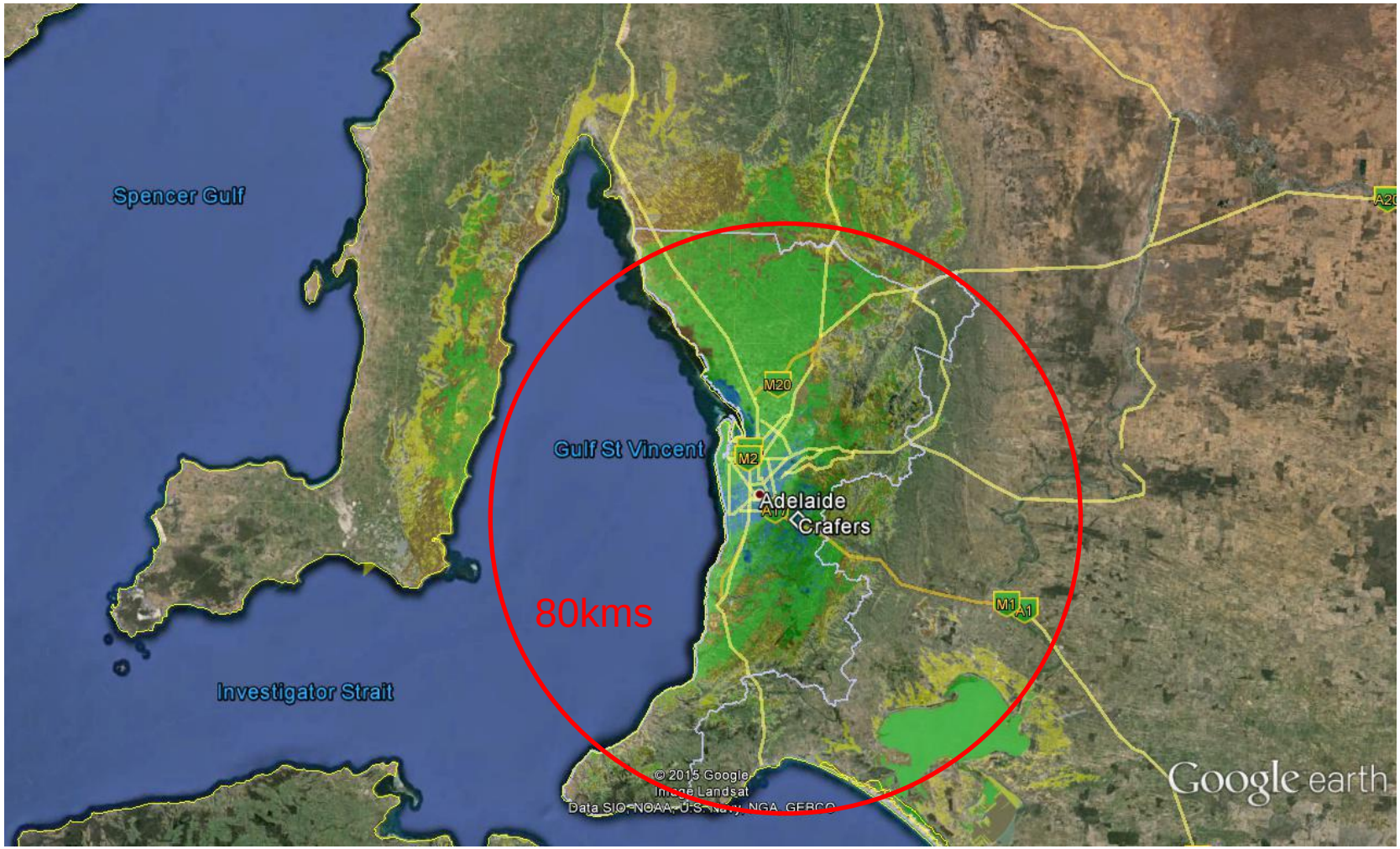


RF Planning - Design examples

Adelaide TV Towers at Mt Lofty

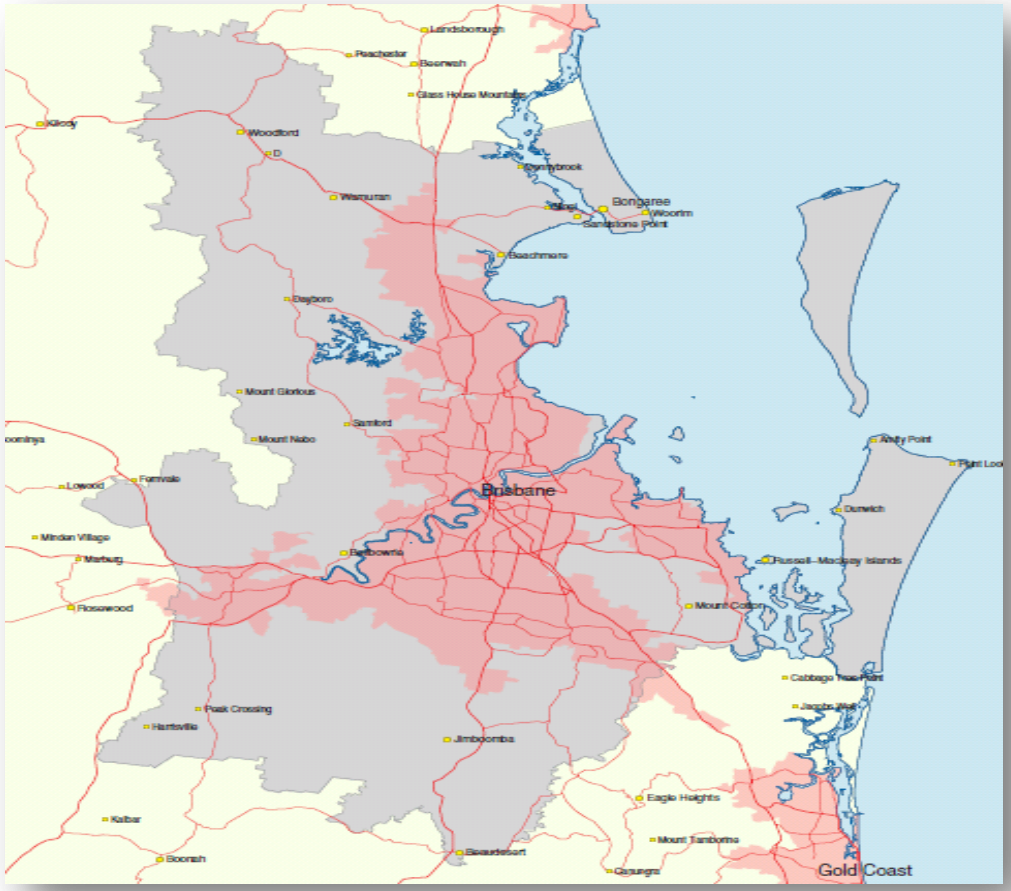
RF Planning - Design examples

Adelaide TV Towers at Mt Lofty



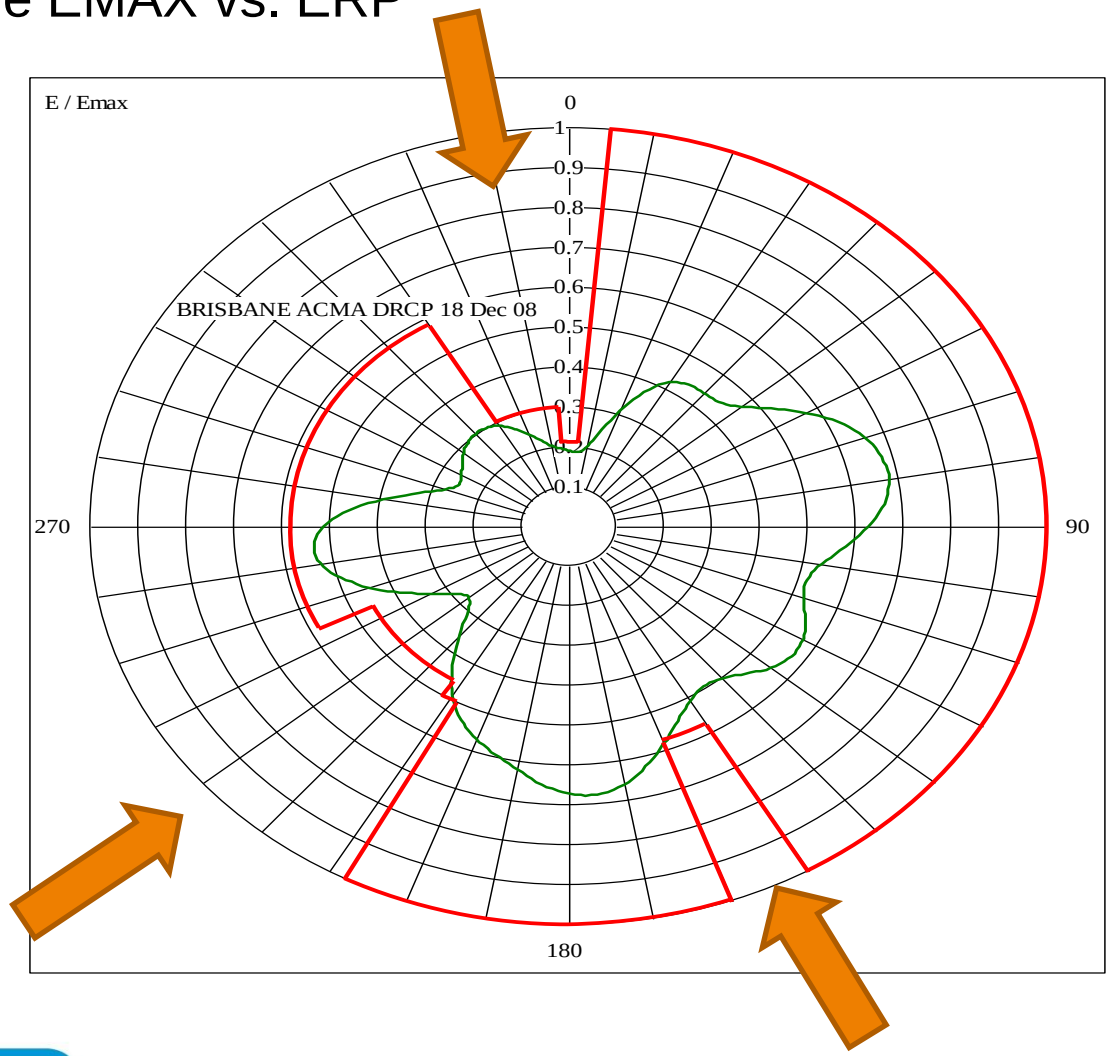
RF Planning - Design examples

Brisbane Licence Area



RF Planning - Design examples

Brisbane EMAX vs. ERP



Variation to the DRCP – Engineering Report for Brisbane

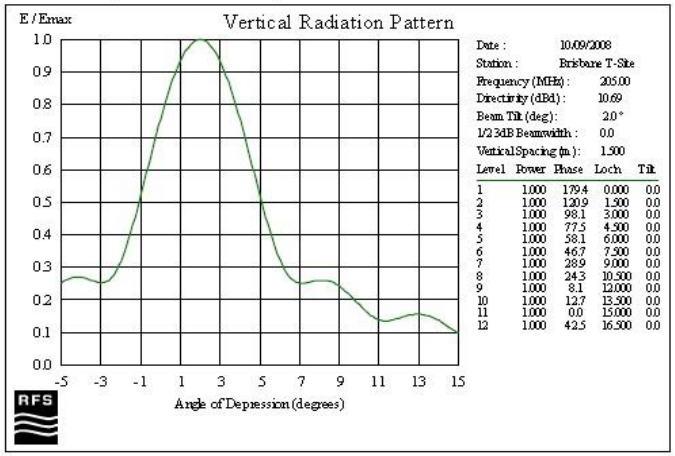
6.2. Appendix 2 DAB Antenna Specification

Following are the antenna technical details for the proposed Brisbane DAB antenna system identified in this report as *'Ant-Spec-11Sep 08'*.

Transmission site: Service: DAB
Site ID: 12749
Site name: Channel 10 Site MOUNT COOT-THA

Antenna details: ERP: To be determined
Antenna height: 191.7 metres
Site height: 207 metres (DEM 9 arc-second)
Antenna specification: As follows:

Antenna VRP Specification: dated 10 Sep 08



Date : 10.09/2008
Station : Brisbane T-Site
Frequency (MHz) : 205.00
Directivity (dBd) : 10.69
Beam Tilt (deg): 2.0°
1/2 3dB Beamwidth : 0.0
Vertical Spacing (m): 1.500

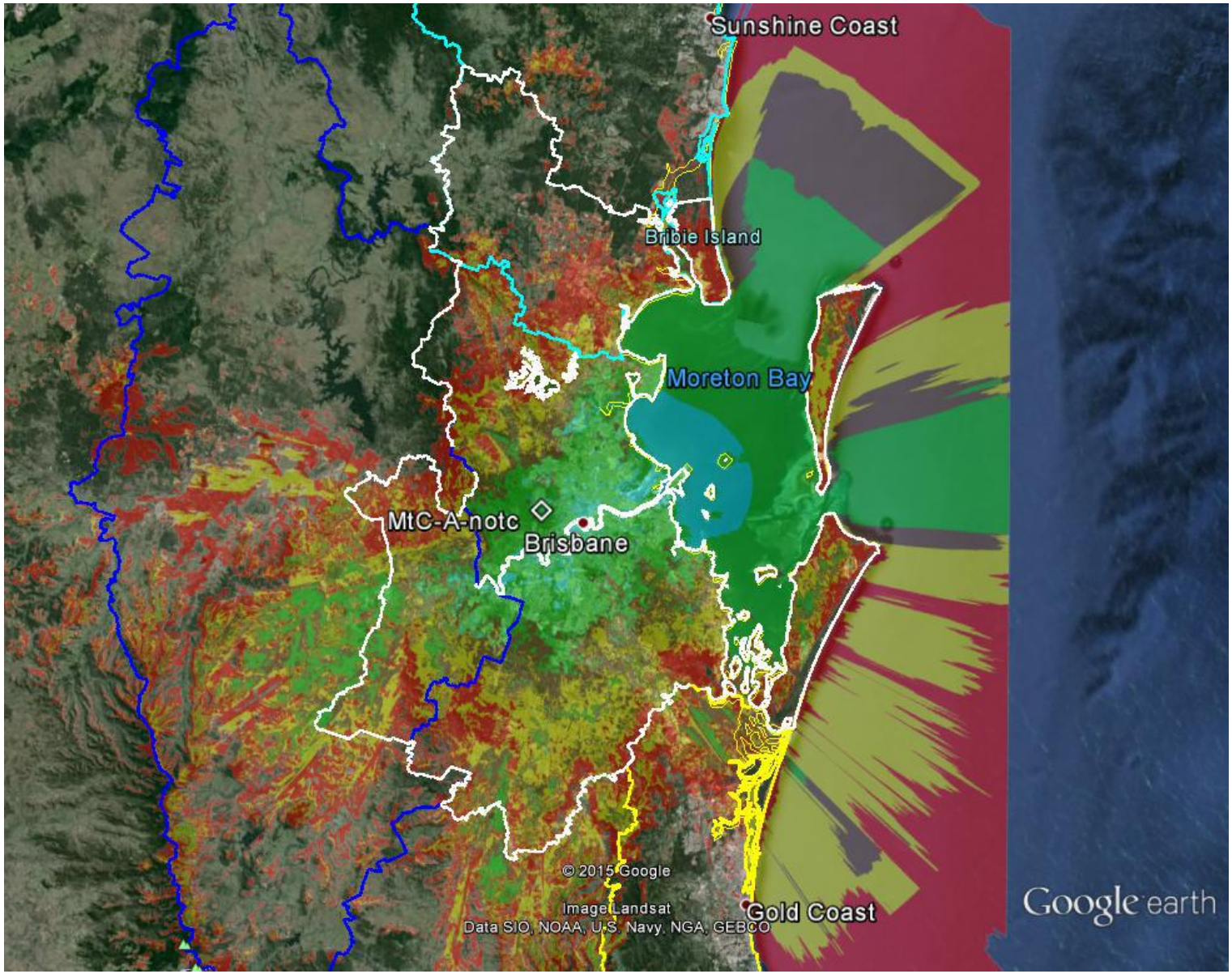
Level	Power	Phase	Loch	Tilt
1	1.000	179.4	0.000	0.0
2	1.000	120.9	1.500	0.0
3	1.000	98.1	3.000	0.0
4	1.000	77.5	4.500	0.0
5	1.000	58.1	6.000	0.0
6	1.000	46.7	7.500	0.0
7	1.000	28.9	9.000	0.0
8	1.000	24.3	10.500	0.0
9	1.000	8.1	12.000	0.0
10	1.000	12.7	13.500	0.0
11	1.000	0.0	15.000	0.0
12	1.000	42.5	16.500	0.0

RF network design must consider interference and well as coverage

RF Planning - Design examples

Brisbane
Licence Area

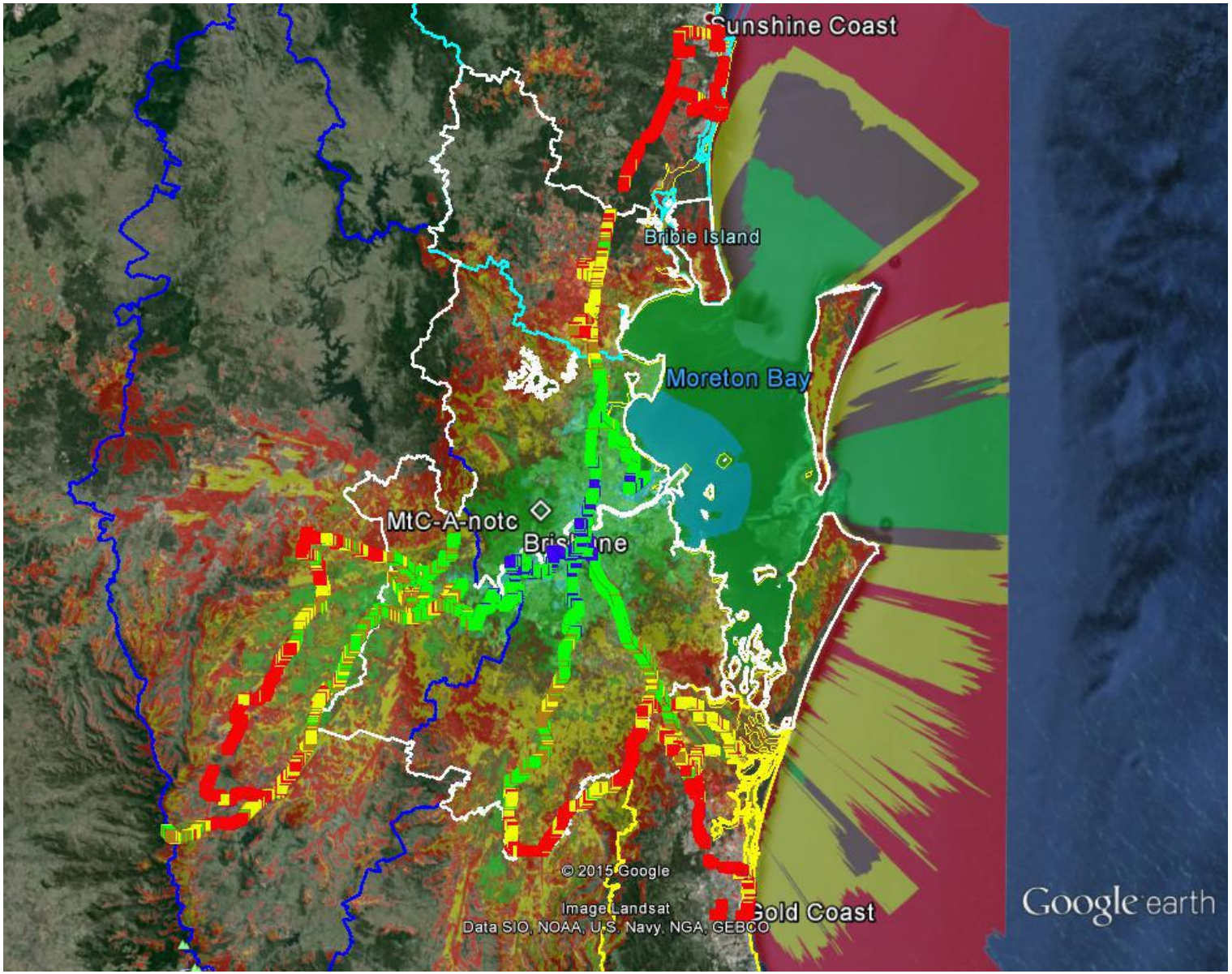
23kW ERP



RF Planning - Design examples

Brisbane Licence Area

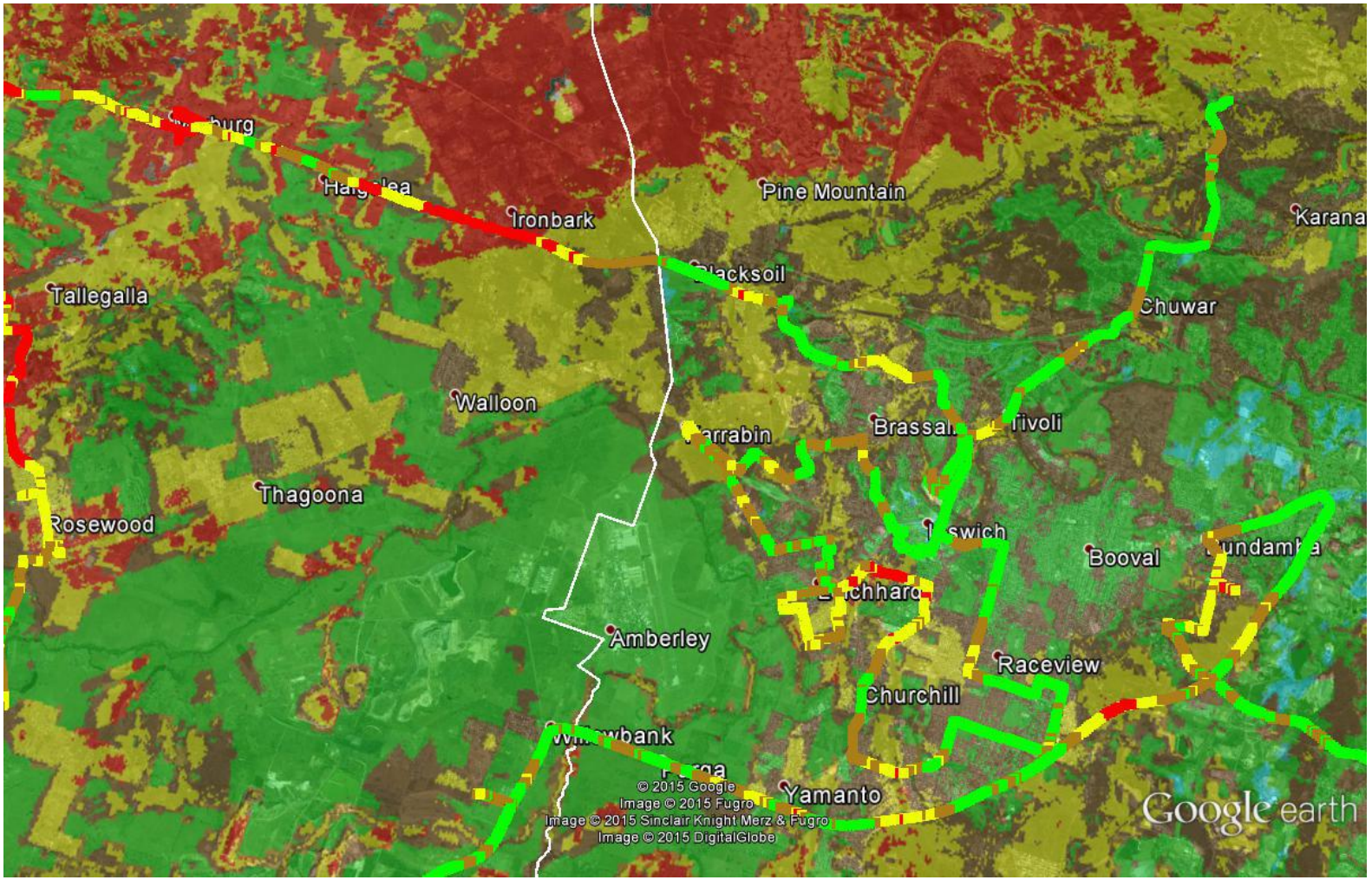
Drive test results



RF Planning - Design examples

Brisbane Licence Area

Ipswich

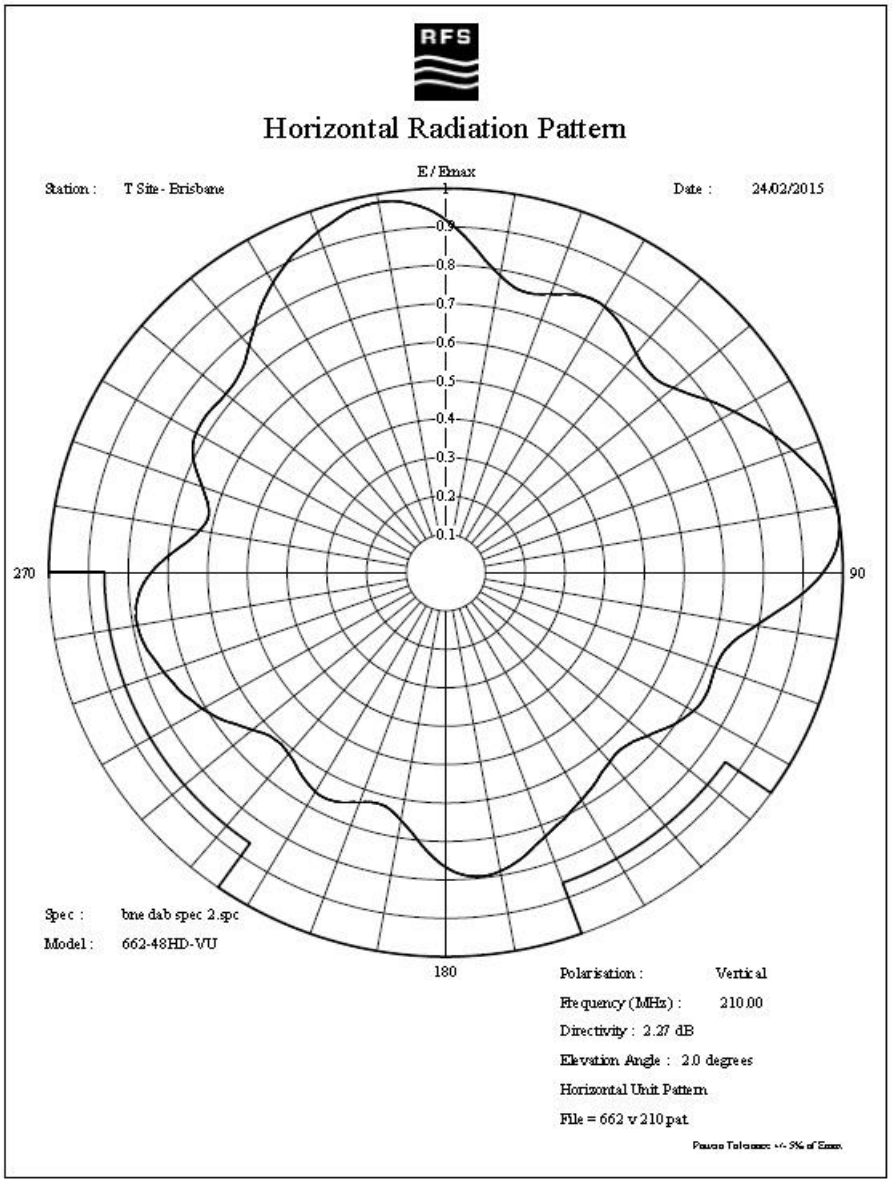


RF Planning - Design examples

Brisbane Licence Area

Proposed high power option

50kW ERP

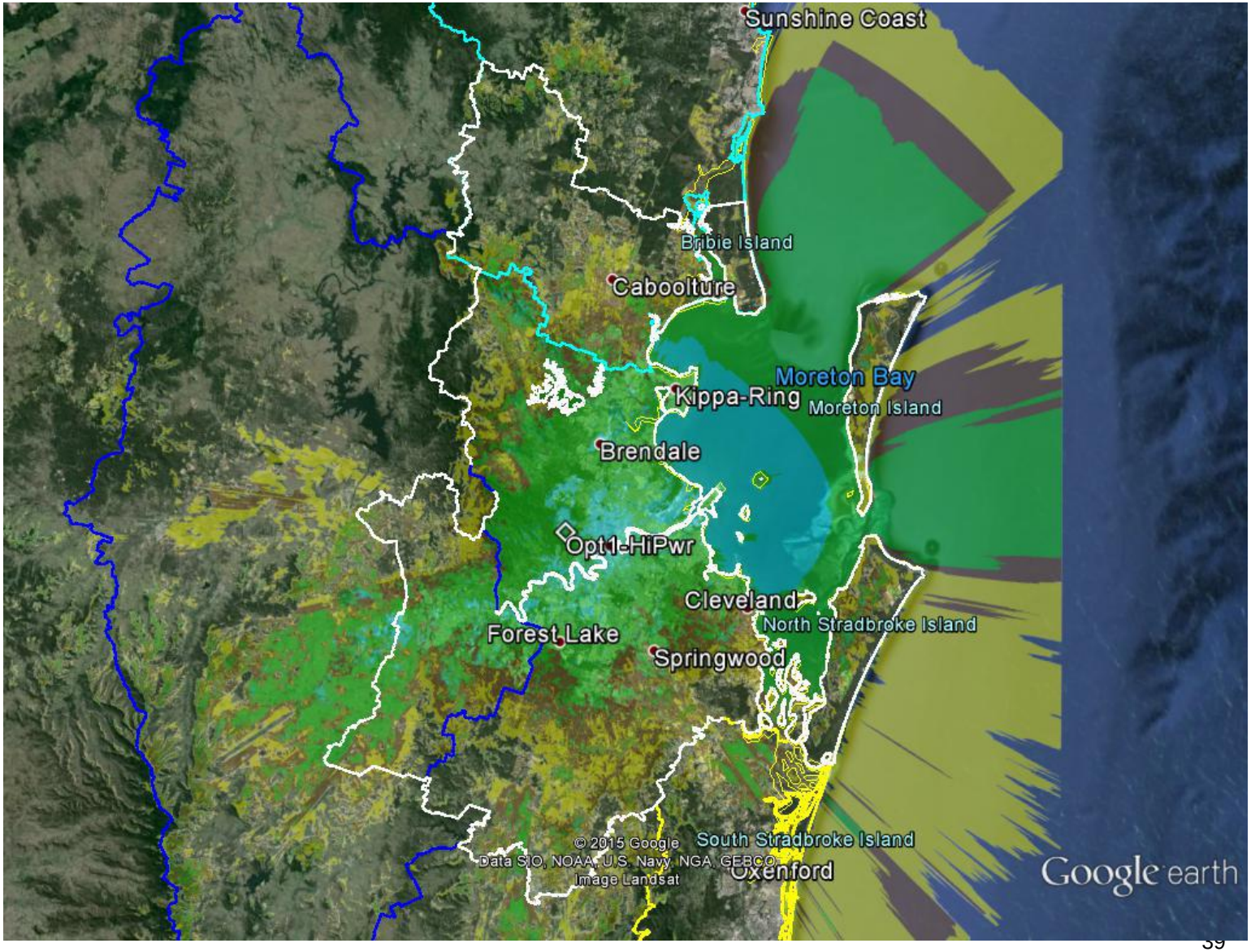


RF Planning - Design examples

Brisbane
Licence Area

50kW ERP

Notch removed

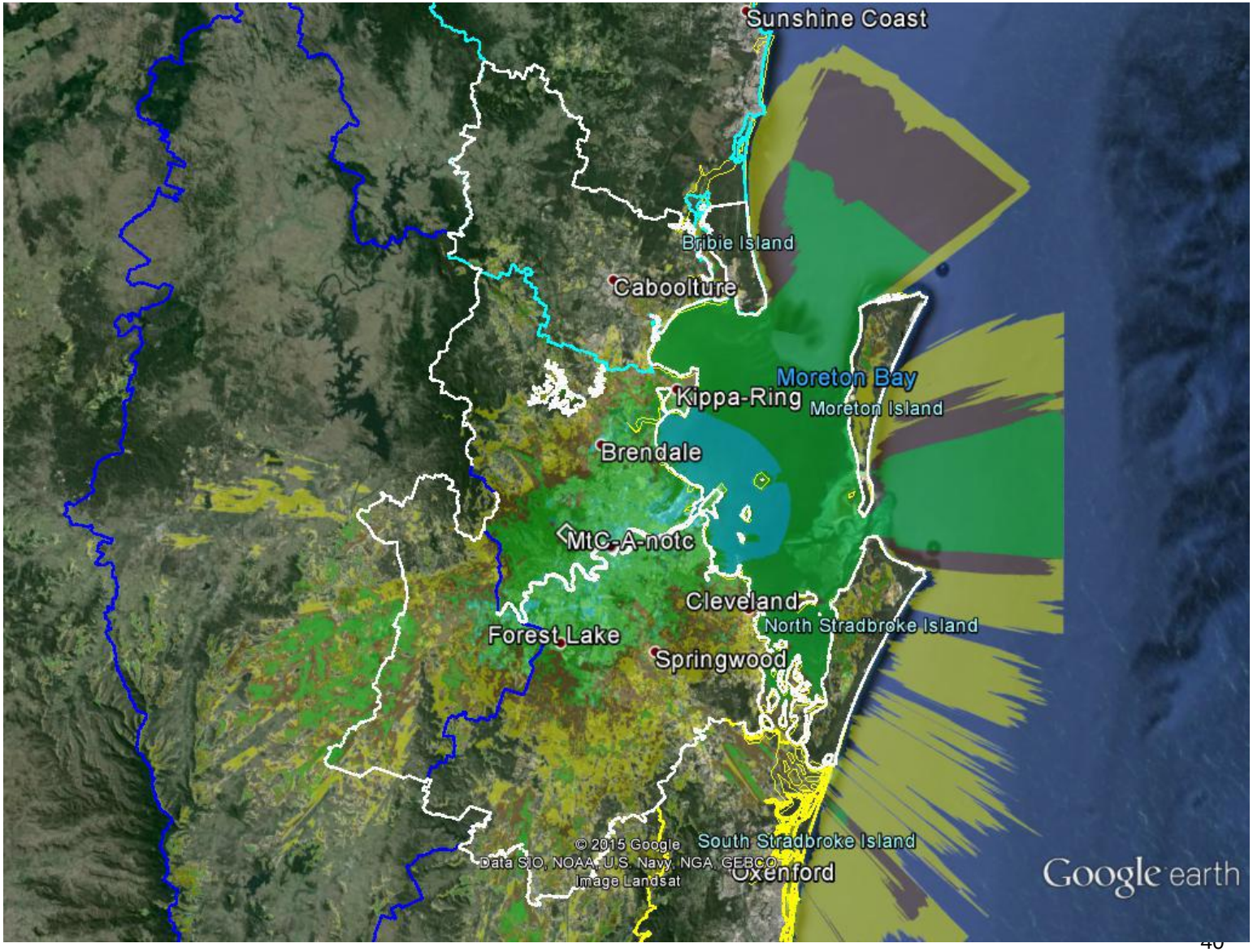


RF Planning - Design examples

Brisbane
Licence Area

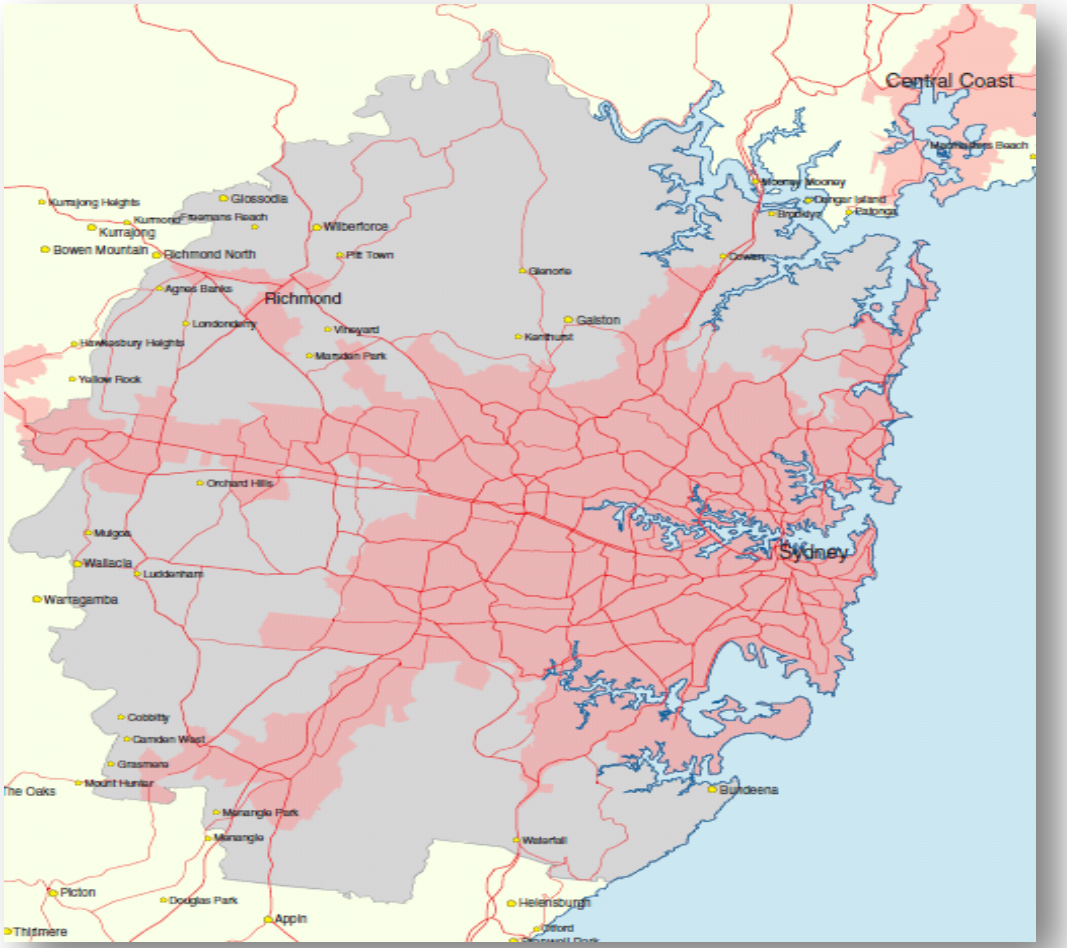
23kW

With notch



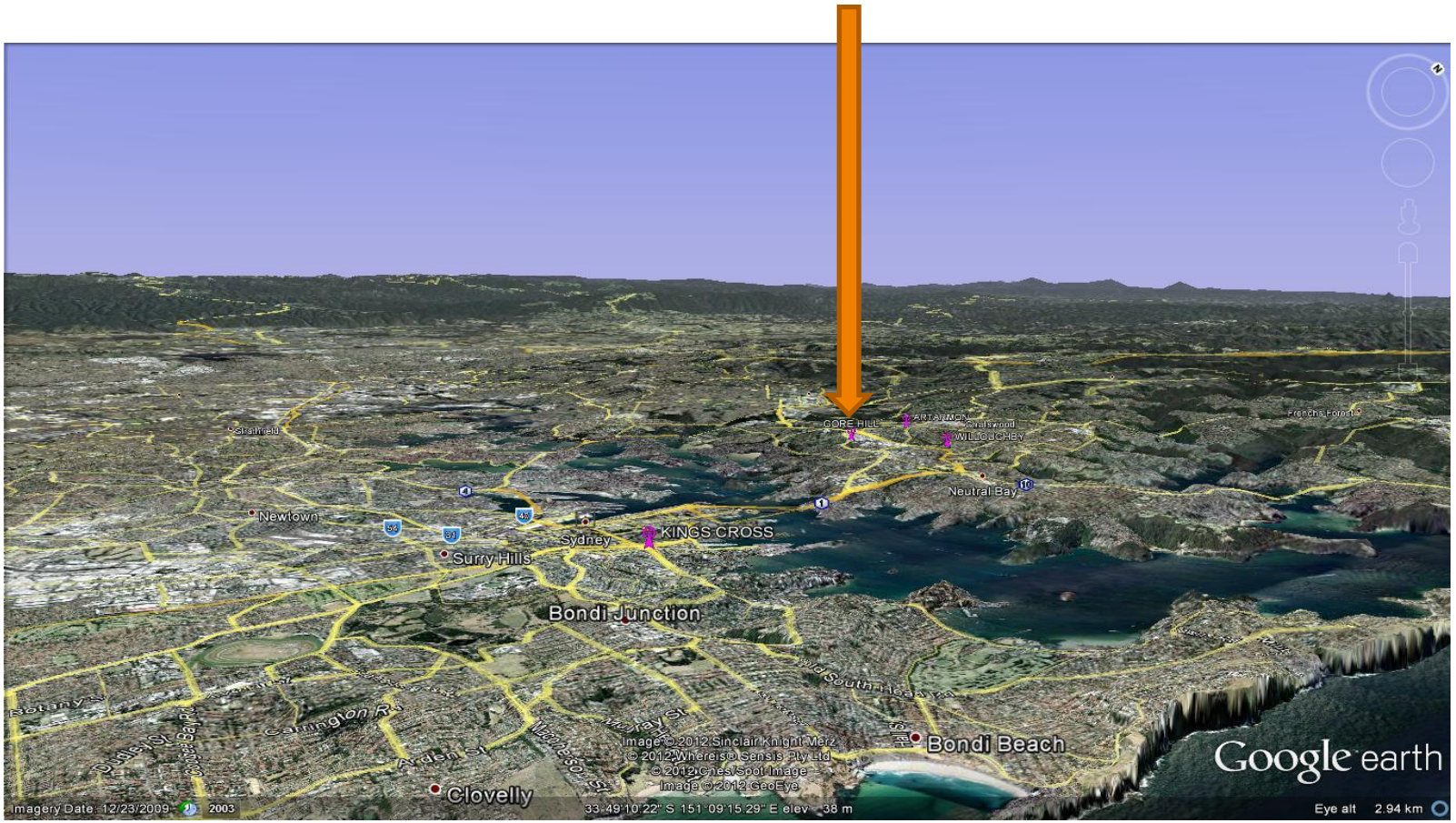
RF Planning - Design examples

Sydney Licence Area



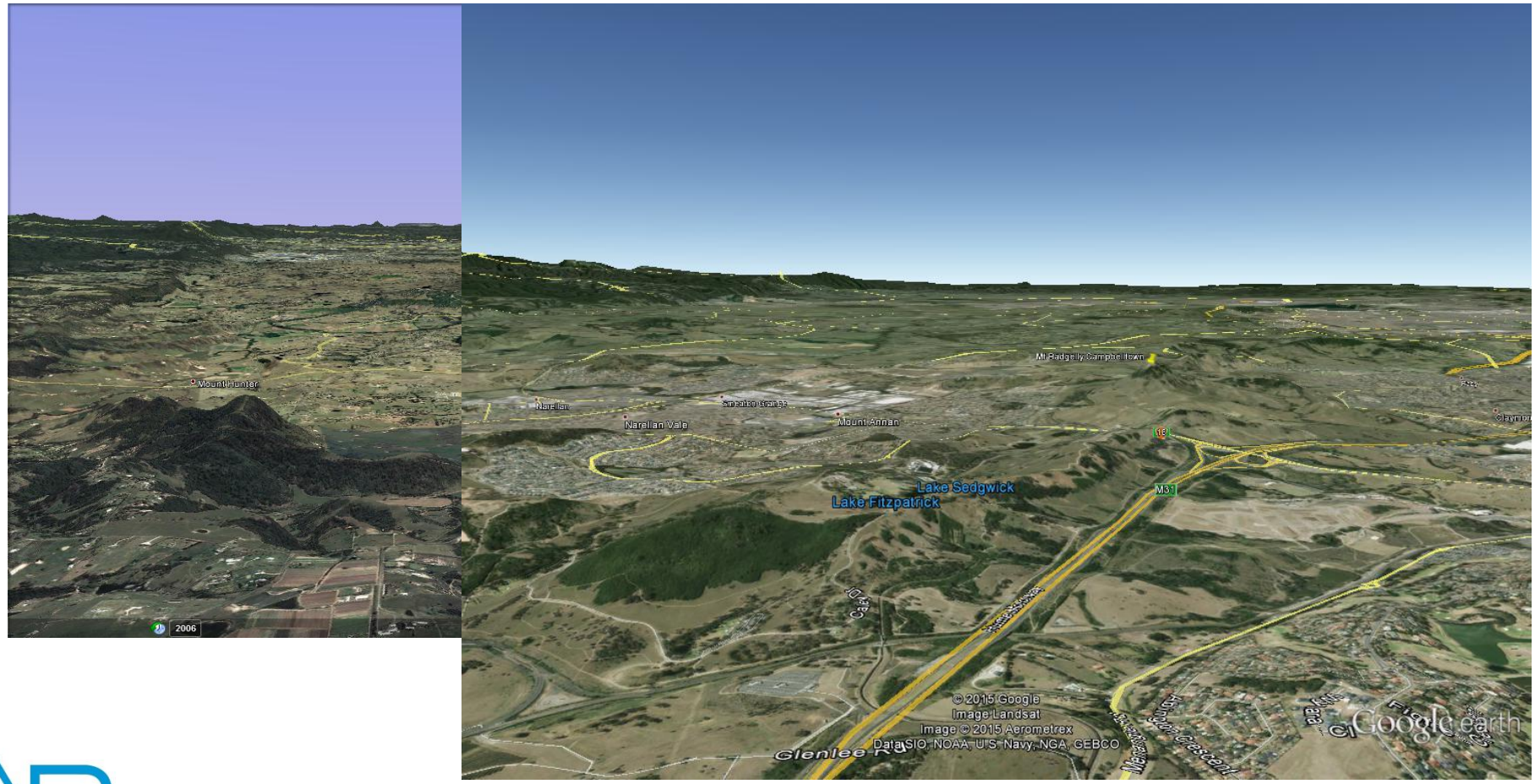
RF Planning - Design examples

Sydney Terrain viewed from the East



RF Planning - Design examples

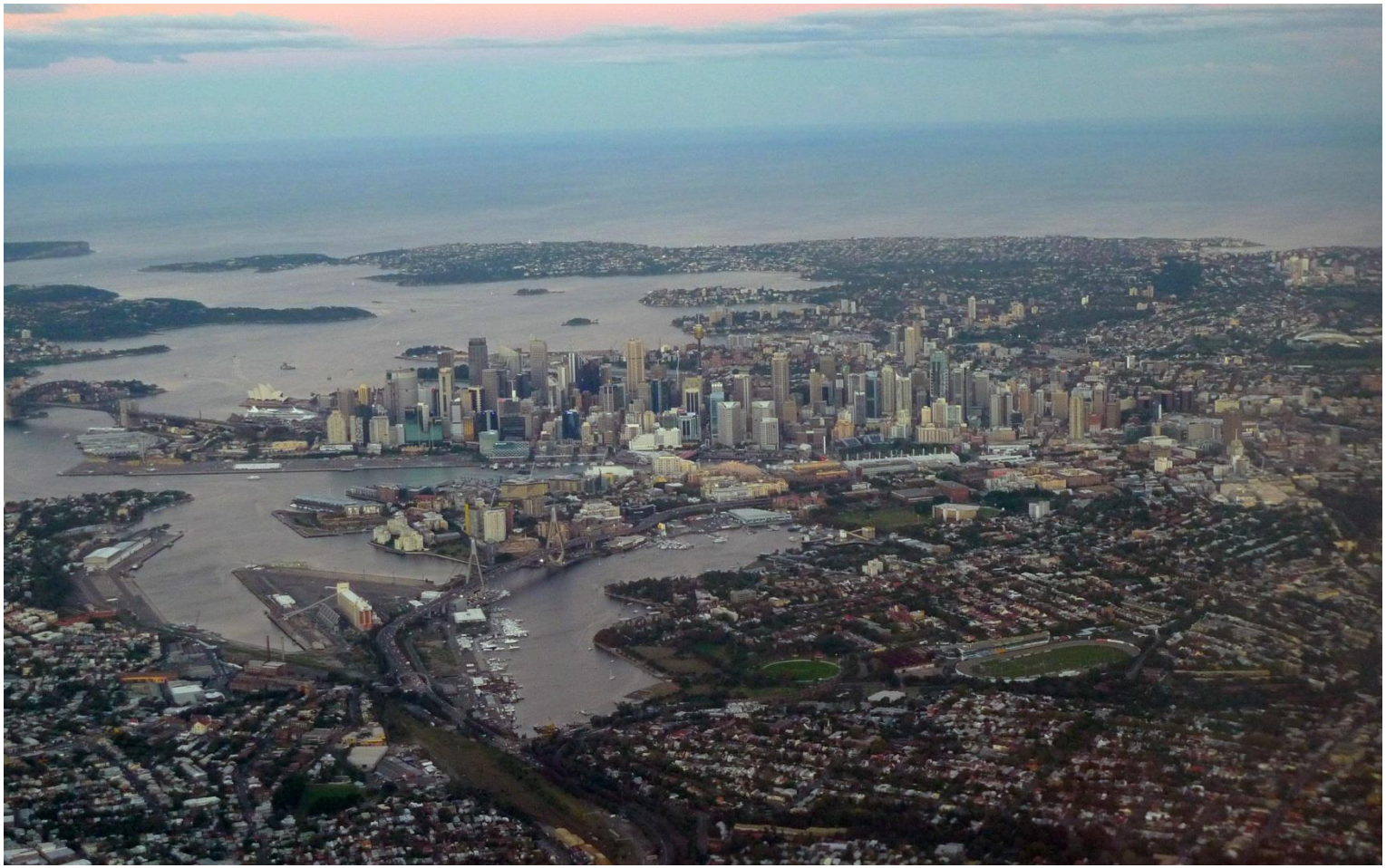
Sydney Terrain – looking north over Camden valley



RF Planning - OCR Case Study

Sydney LAP

Single 50kW Tx



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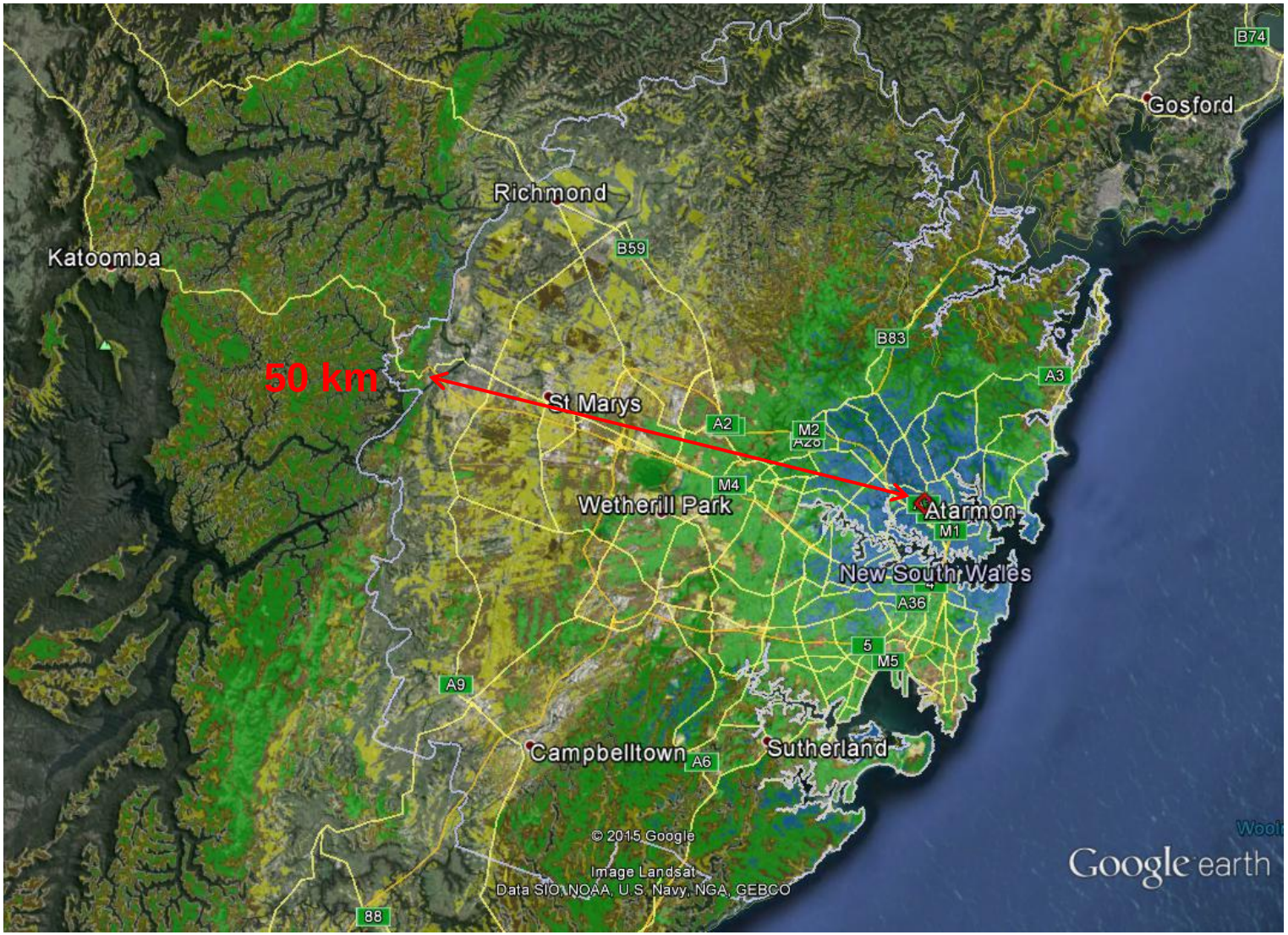
Sydney LAP

Single 50kW tx



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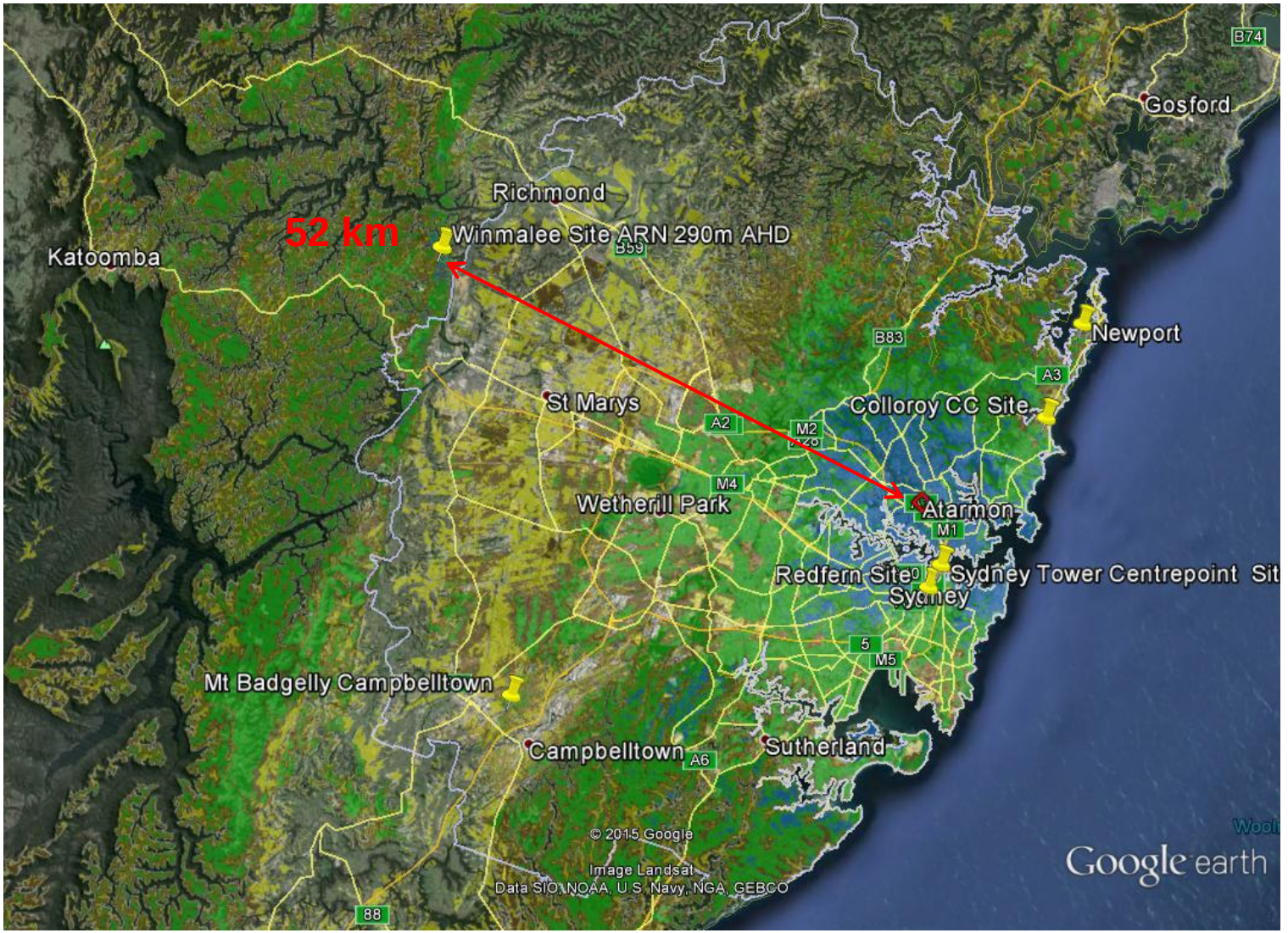
Sydney LAP

Single 50kW tx



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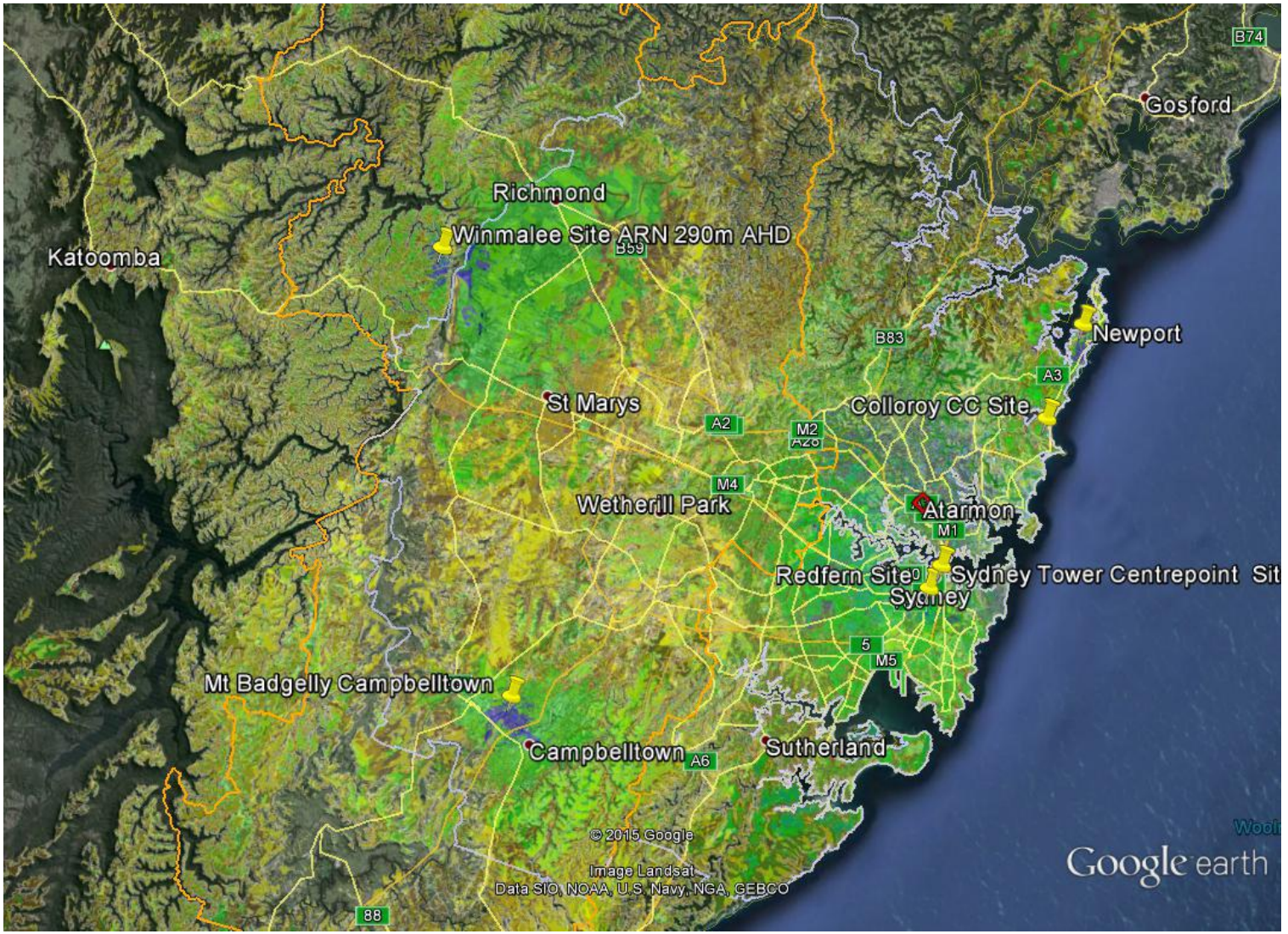
Sydney LAP

Single 50kW tx

6 repeaters

No network gain shown



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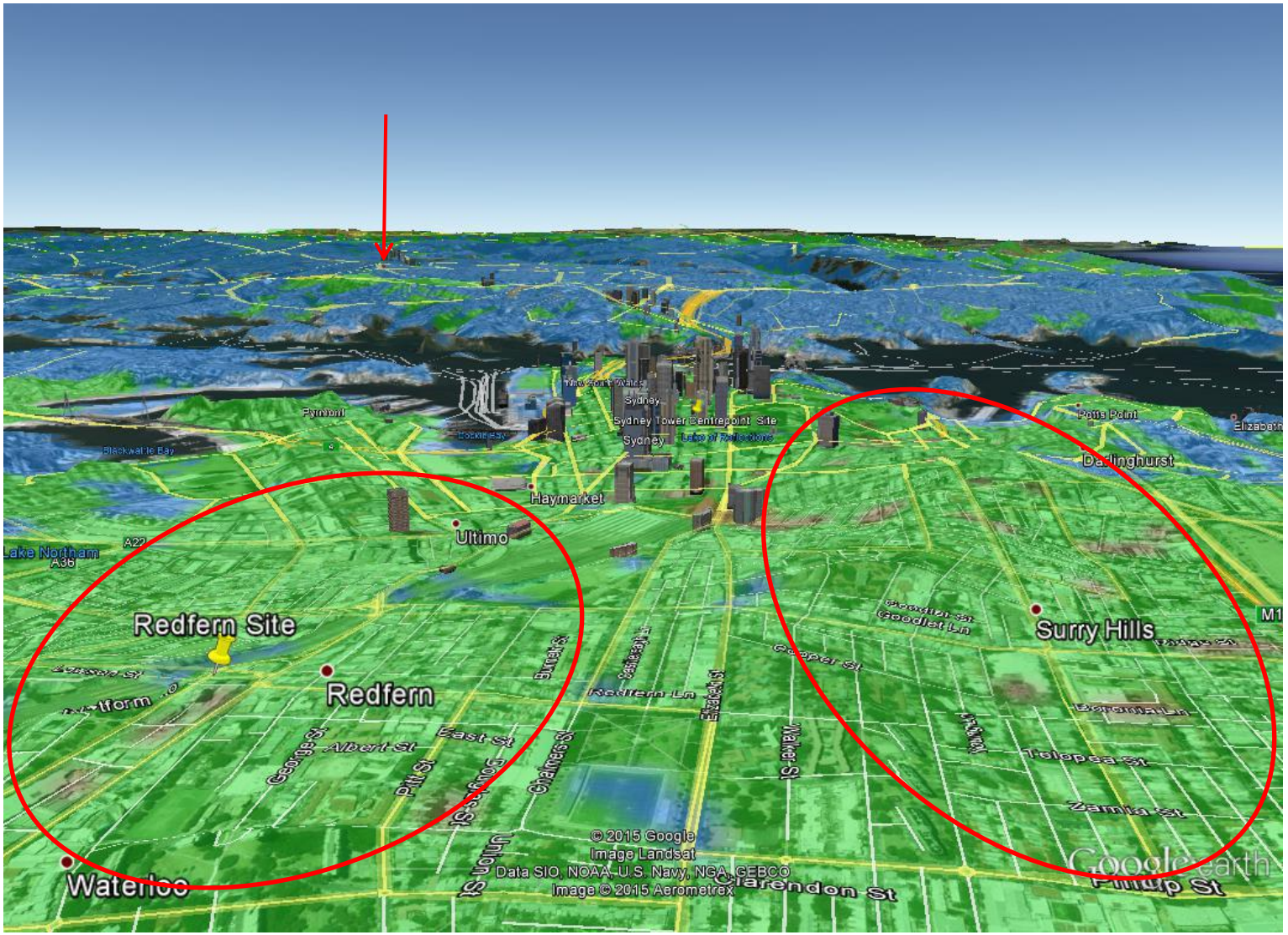
Artarmon main Tx only

50kW

200m AGL

Areas of shadowing shown

Prediction is optimistic due to clutter generalisation



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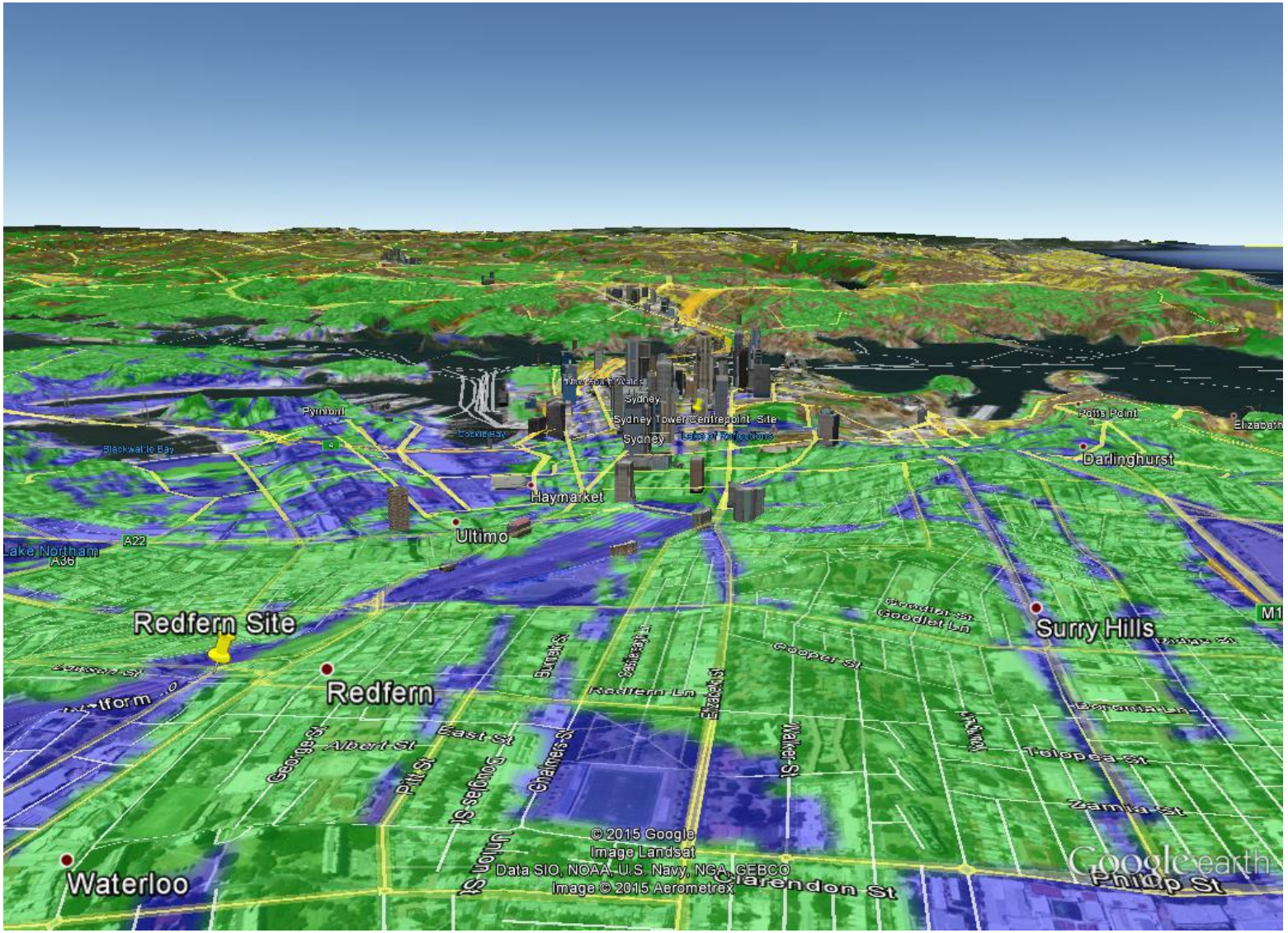
Centrepoint only

300W

125m AGL



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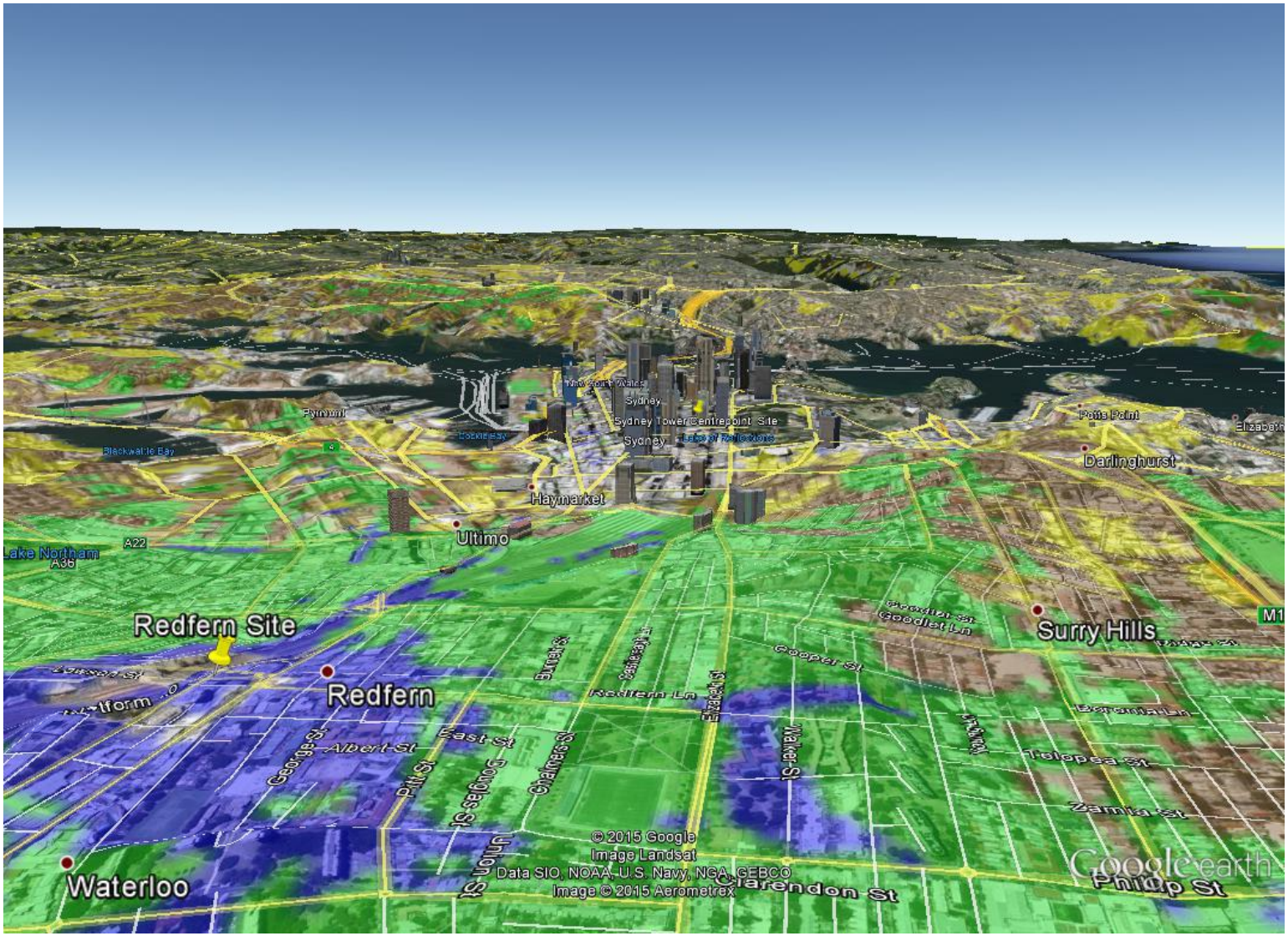
Redfern only

300W

50m AGL



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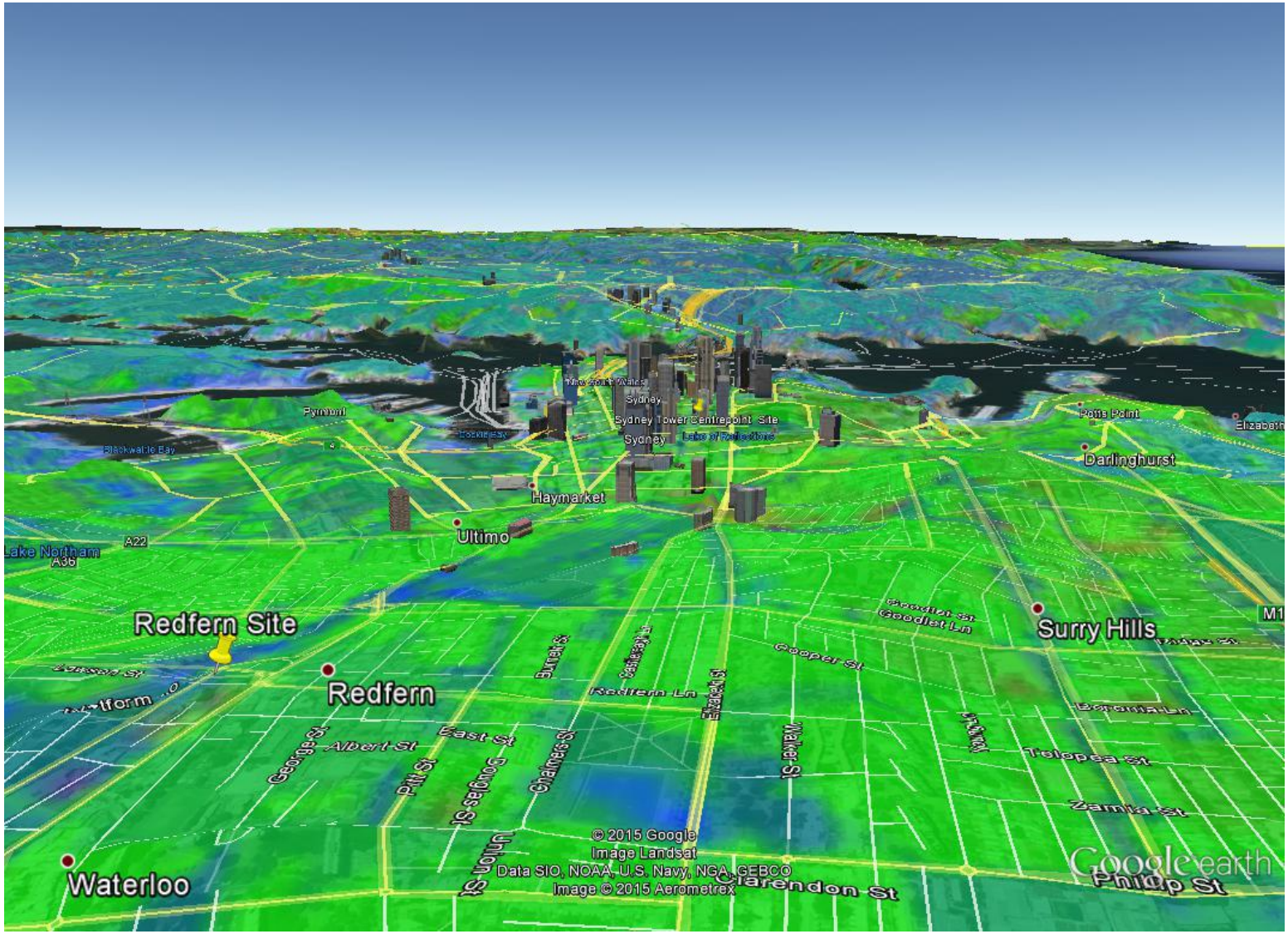
All



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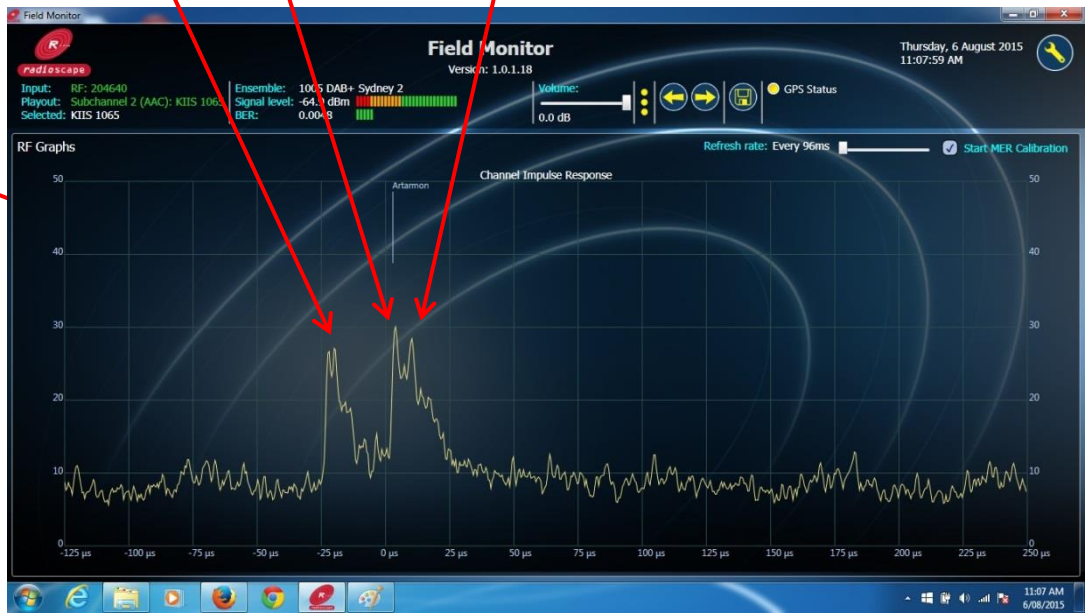
Sydney city centre

Impulse response for an in-building receiver in Surry Hills – 5th floor

Main Tx at Artarmon

Centrepoint repeater

Redfern repeater



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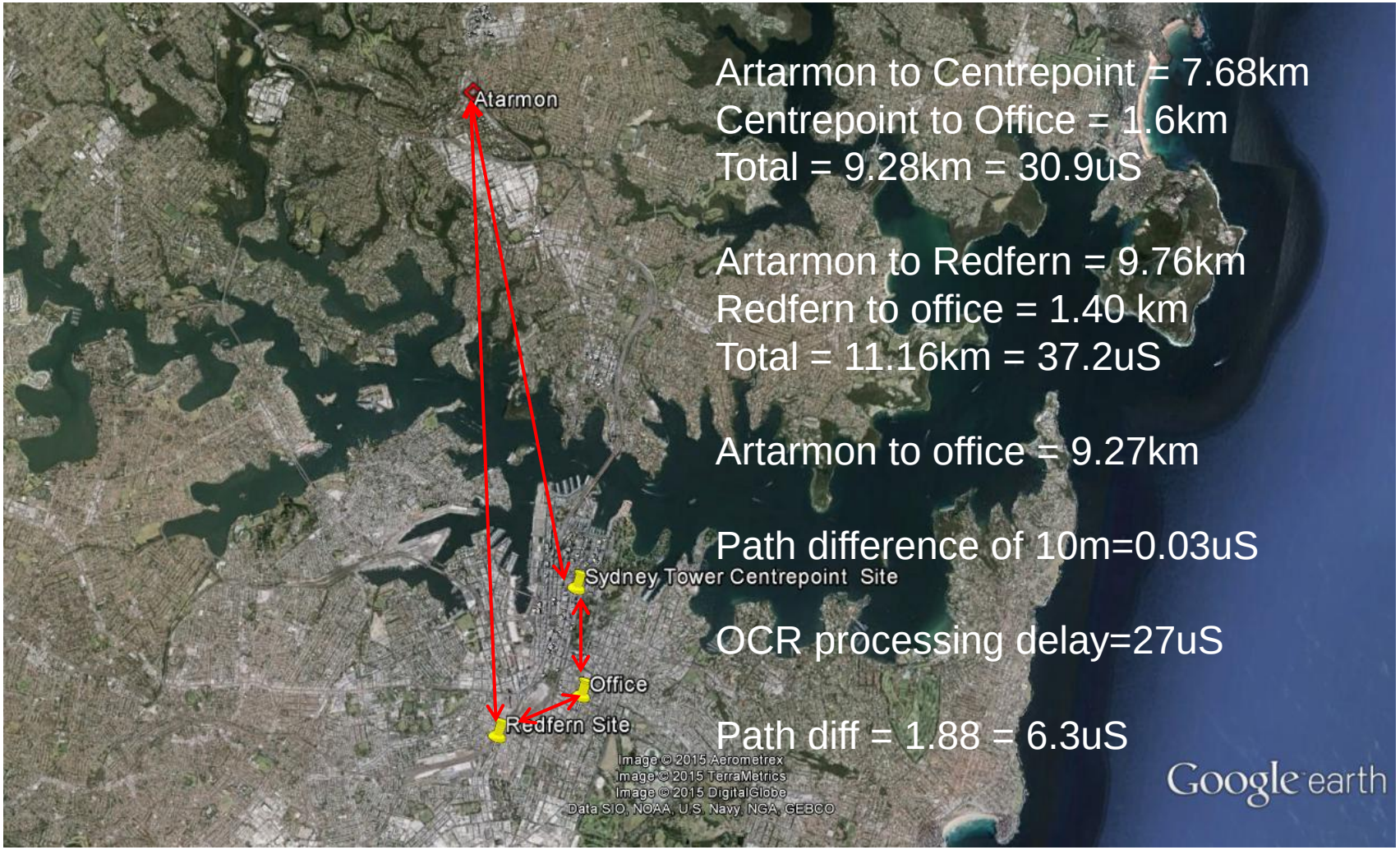

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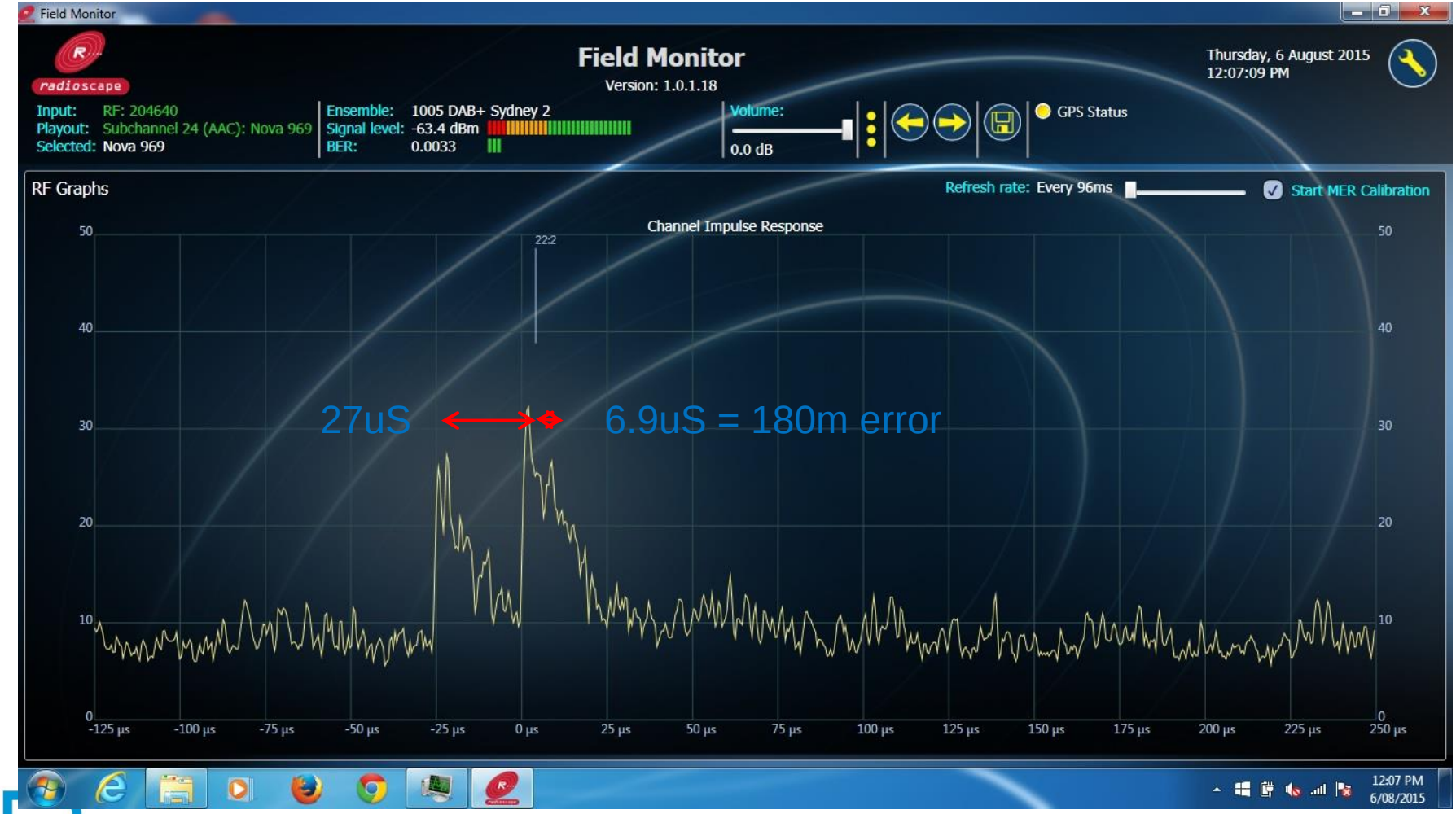
Sydney city centre repeaters

Ch 9B



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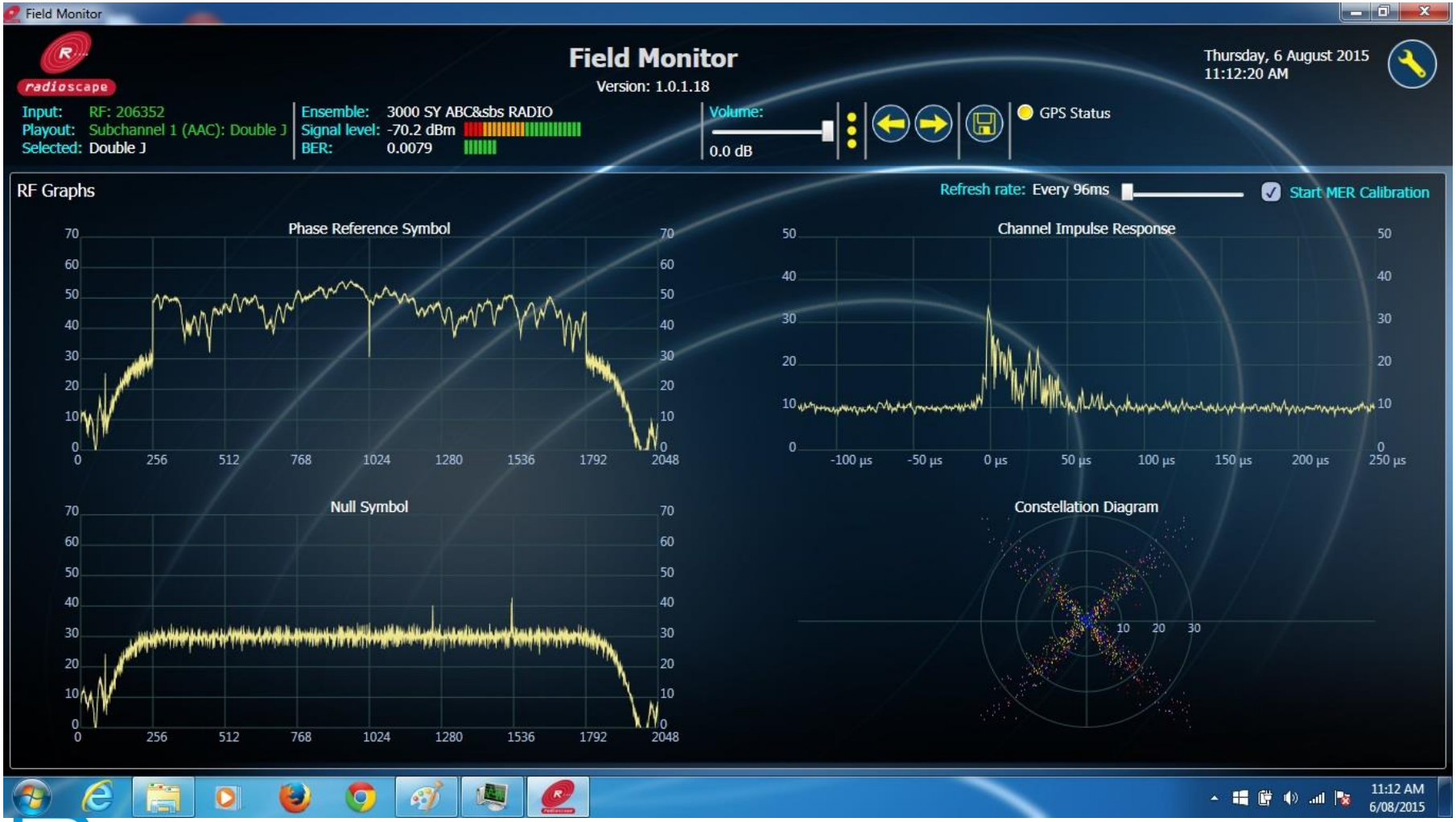
Sydney city centre repeaters

Ch 9C



RF Planning - RF planning

Summary – Top Tips

1. Know what you want to achieve – the BIG PICTURE
2. Be **Collaborative in Engineering** the system – **Competitive on Content**
3. Work with your Regulator to ensure that all parties are considered
4. A successful rollout will require consultation with retailers, automotive etc
5. Use the design cycle to your advantage – process is important
6. RF Coverage modelling is essential
7. Beware of Co-Channel Interference and Adjacent Channel Interference
8. Plan field testing and tune your models – coverage and interference

Thank you

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