SFN design and examples

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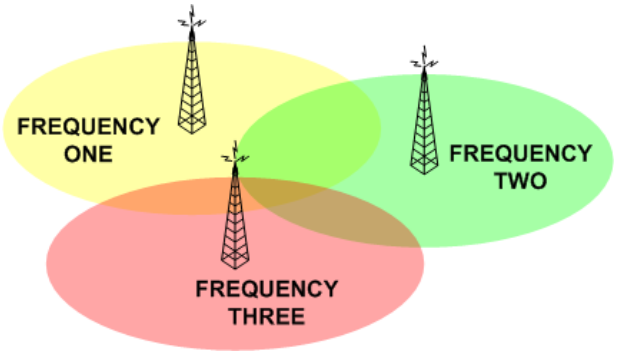
SFN design

1. What is an SFN?
2. SFN planning models and timing
3. Types of repeater
4. Case studies

Network Types

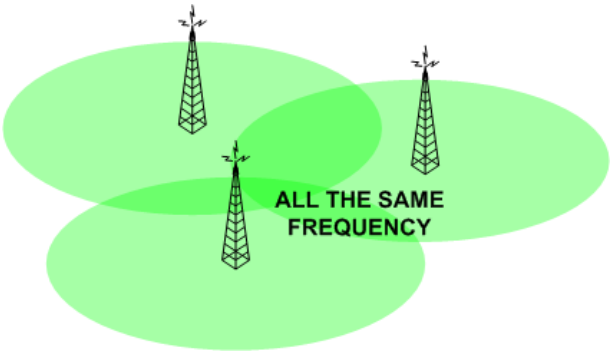
Multi-Frequency Networks (MFN)

Multiple different services per coverage area, Multiple different coverage areas



Single Frequency Networks (SFN)

Same content in each area, Same frequency in each area



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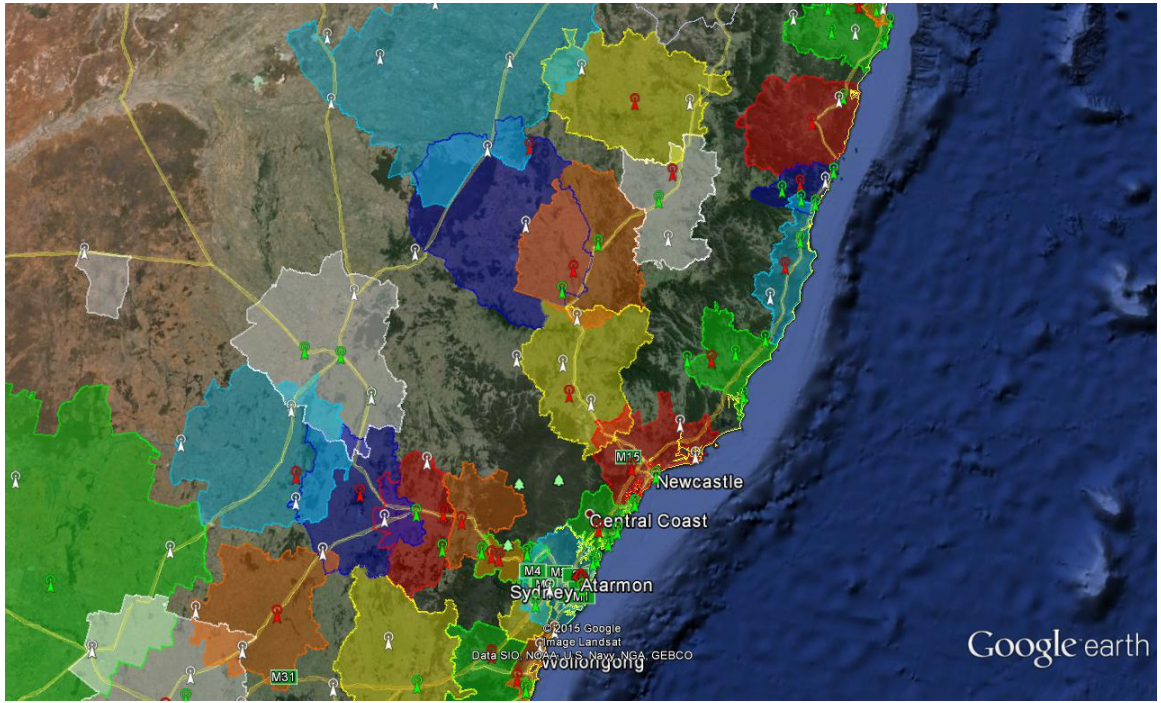
RF Planning – Multi-Frequency Network

Commercial licence areas - Northern NSW example

Each licence area has its own SFN



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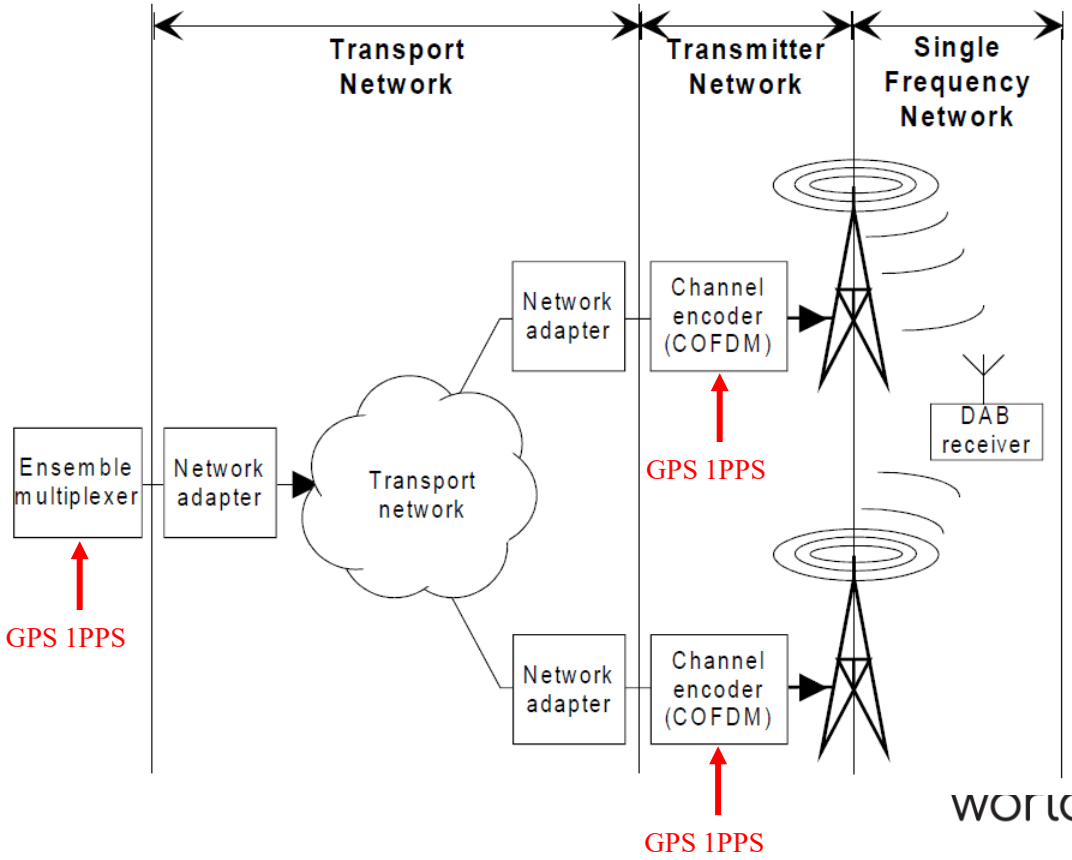
SFN model

The DAB SFN model

ETS 300 799



SFN timing

The transmission launch time is controlled by the TImeSTamp (TIST) parameter in the ETI stream.

All transmitters in an SFN must be time aligned

The multiplex embeds a TIST time stamp in each ETI frame which defines the time it is assembled relative to a coordinated timing reference, e.g. 1PPS

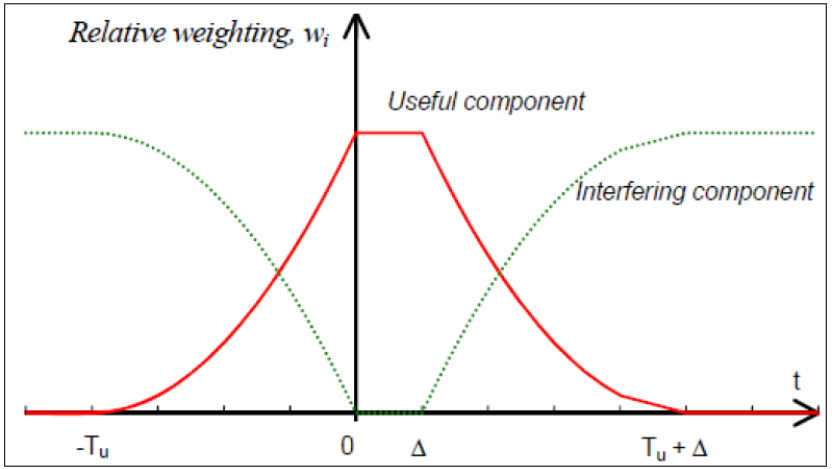
All transmitters are required to be aligned to a 1PPS timing signal derived from GPS/Glonass

Some adjustment of the maximum operating distance and hence the area which may experience interference can be made using the transmission delay of individual transmitters

SFN timing constraints

The DAB signal is designed to allow SFN operation over a distance of 73.8 km

- Guard Interval Δ for Mode 1 = 246 µS
  - SFN distance limit = c Δ = 73.8 km
- Performance impact of out of GI
  - See EBU Tech 3391



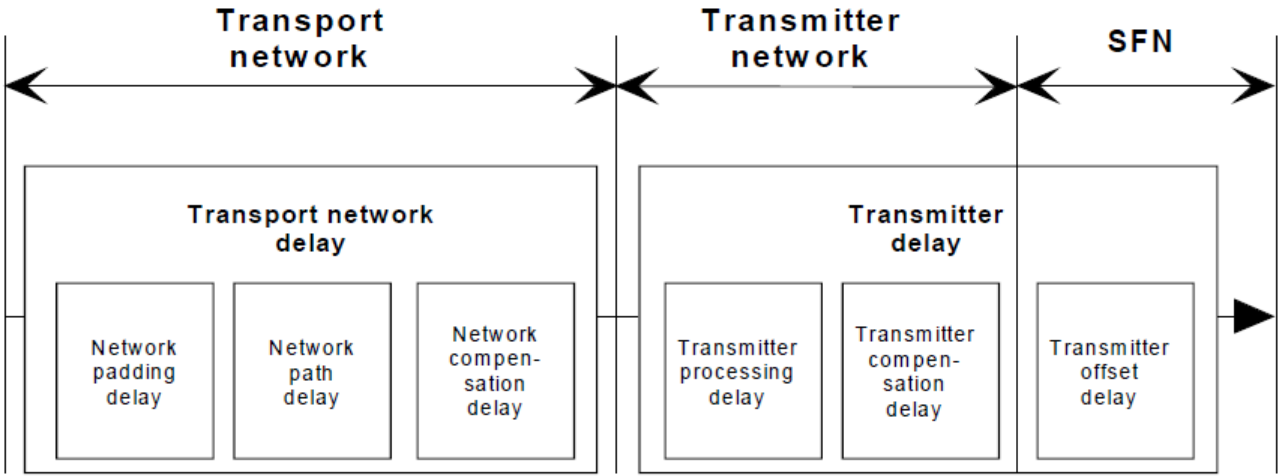
Required protection ratio ζ	Relative delay
0 (i.e. not required)	0 ≤ t ≤ 246 µs (i.e. inside the guard interval)
5 dB	246 < t ≤ 350 µs
13.5 dB	t > 350 µs

Protection ratio for out of GI transmission components

Timing model

The standard terminology for the delays in the systems are shown below

NOTE that transmitter manufacturers sometime use their own terminology



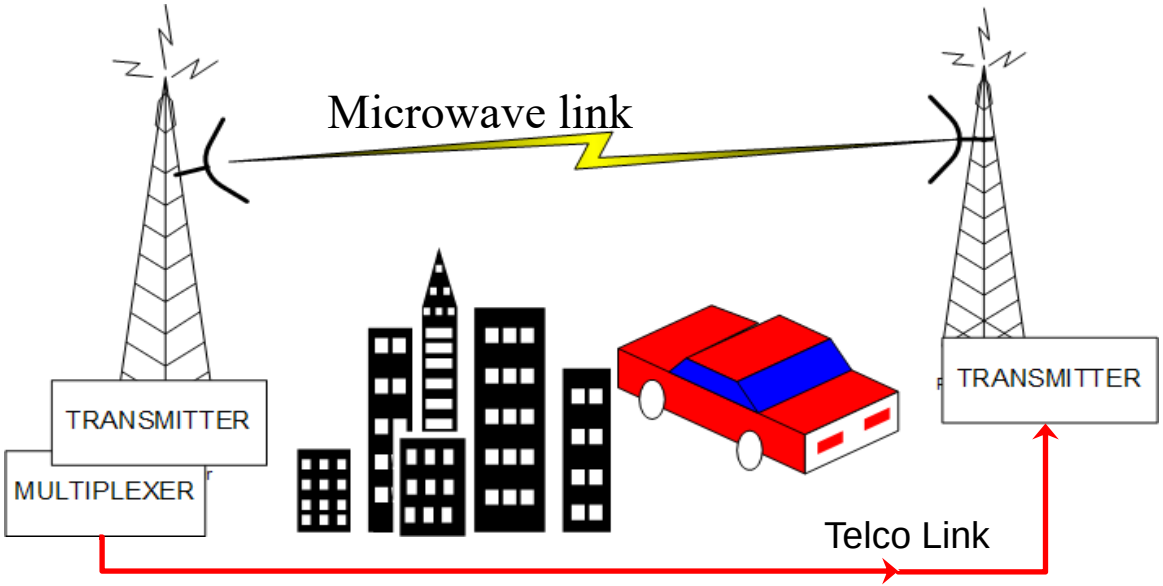
See ETSI ETS 300 799 – annex F

Repeater types – link fed

Link Fed Repeater

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

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



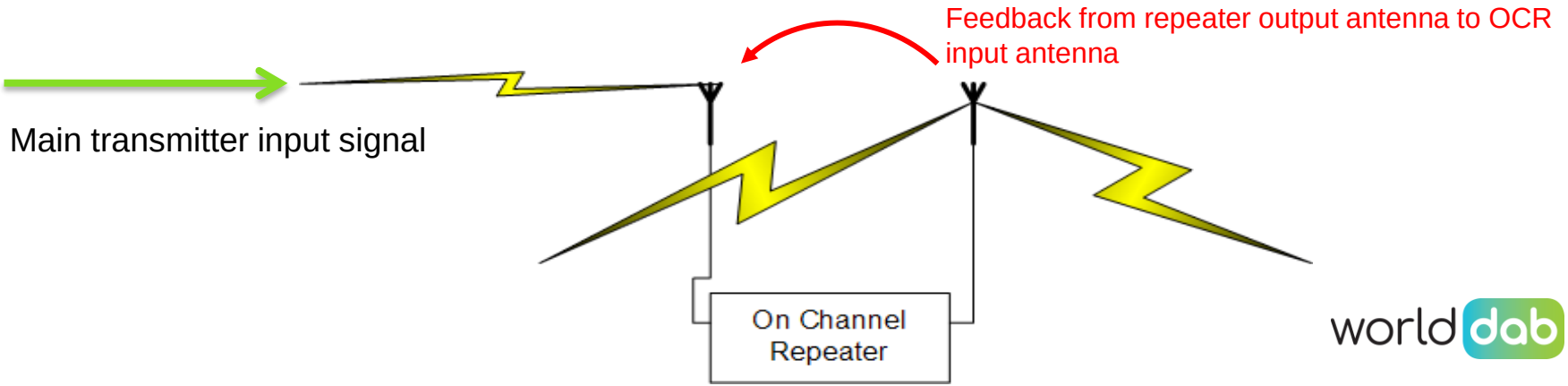
Repeater types – on-channel

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**

The maximum power of the OCR is dependent on
- the input signal power after Rx antenna gain
- The Tx antenna to Rx antenna coupling ratio – Rx and Tx nulls provide most attenuation
- The accuracy of the echo cancelling system – typically 10dB of local signal can be cancelled



Examples - OCR

OCRs are low power e.g. <1 kW

Only issues if

- field strength difference is < CCI PR (12dB)
- time of arrival difference (ToA) is > GI (246 uS)

$$ToA\ difference\ = ABS(\ [OCR\ time\ delay] - Main\ time\ delay)\ \mu S$$

$$ToA\ difference\ = ABS\left(\ \left[\frac{distance\ Main\ to\ OCR}{c} + OCR\ processing\ delay + \frac{distance\ OCR\ to\ Rx}{c}\right] - \frac{distance\ Main\ to\ Rx}{c}\right)\ \mu S$$

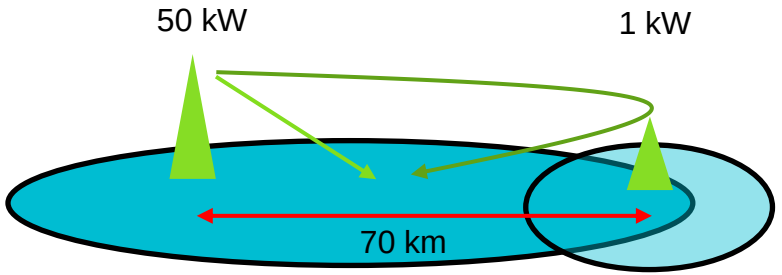
CCI issues only possible if the OCR is > 34 km from the main Tx

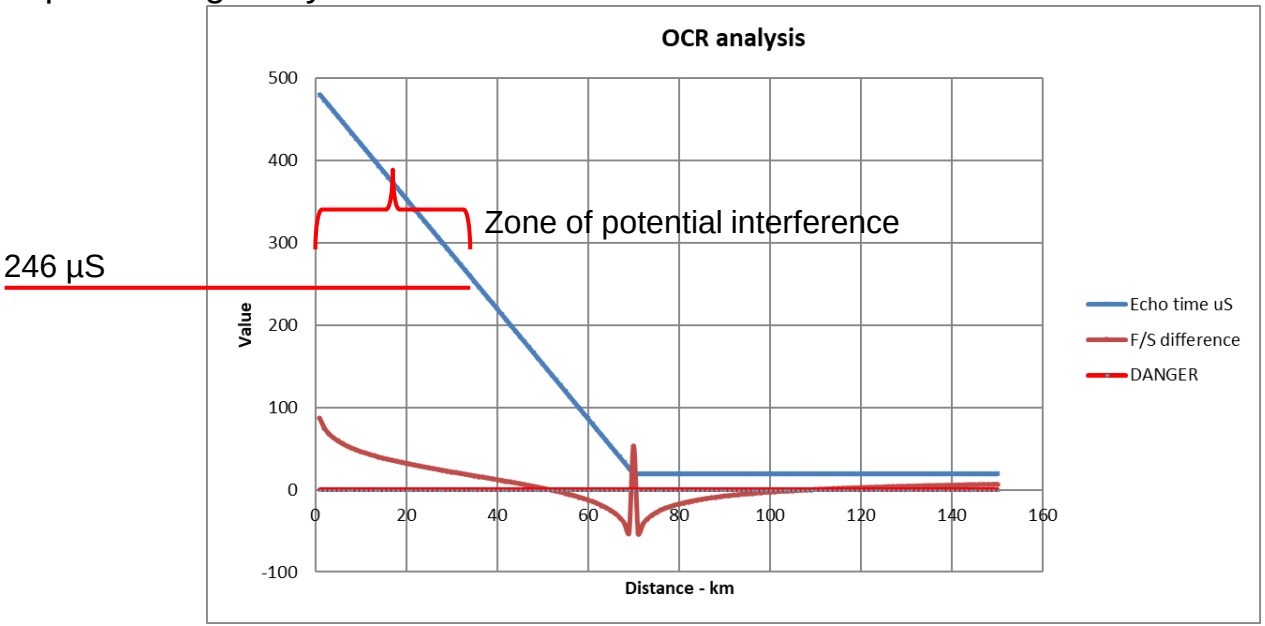
The example model uses Egli's Rayleigh channel model for field strength prediction with exponent 3.8

Examples - OCR

Edge of coverage extension

The time delay of the OCR signal must take into account the time required to travel to the OCR site and the OCR processing delay

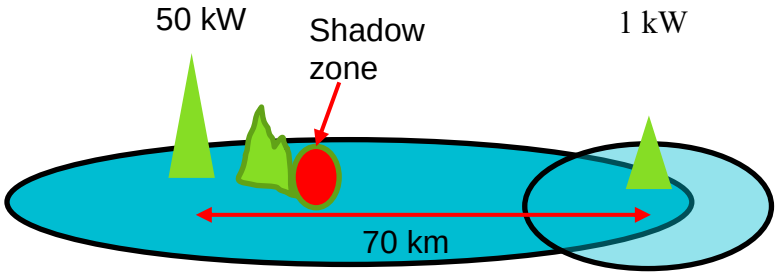




Examples - OCR

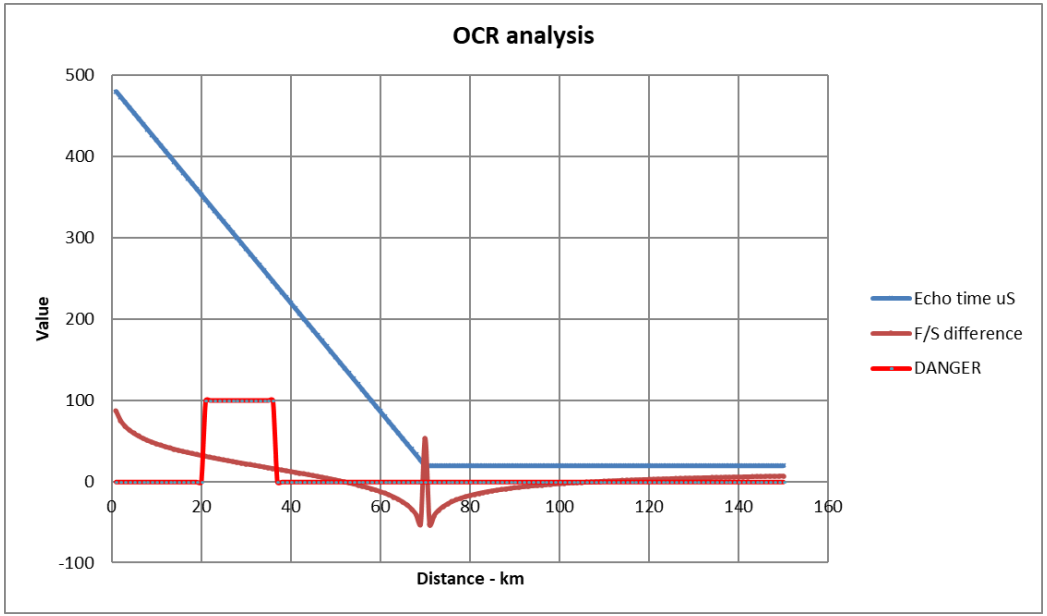
Edge of coverage extension

Impact of shadowing of main signal by high object



Shadow loss of 20 dB causes main signal to weaken below the CCI PR limit = coverage hole

OCRs are useful but care is needed to ensure no unexpected holes in coverage



Examples LFR

LFRs can be various powers from small infill at 1 kW to full main power

Only potential issues if the transmitter site spacing is >73.8 km

Issues only usually occur in shadowed areas

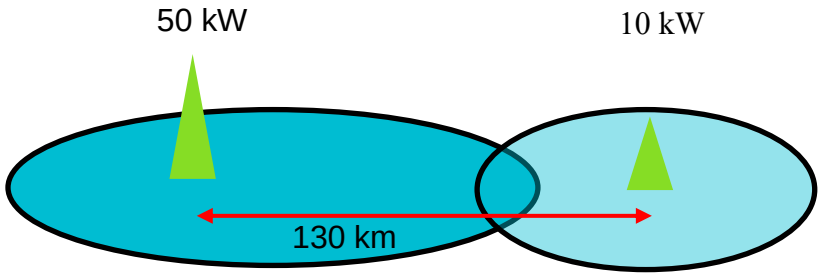
$$ToA\ difference\ = ABS(\ [LFR\ time\ delay] - Main\ time\ delay)\ \mu S$$

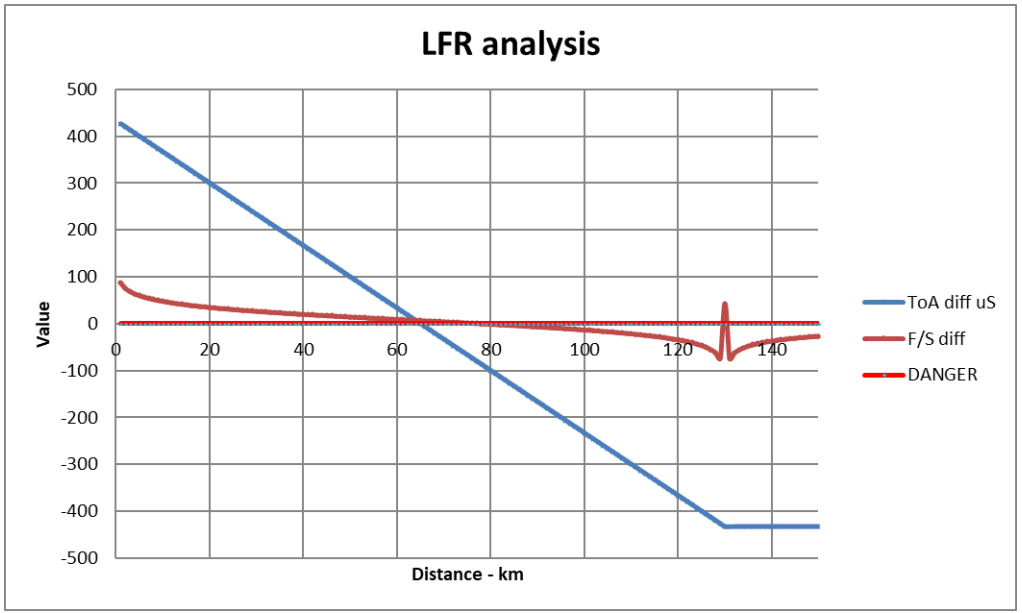
$$ToA\ difference\ = ABS\left(\ \left[\frac{distance\ LFR\ to\ Rx}{c}\right] - \frac{distance\ Main\ to\ Rx}{c}\right)\ \mu S$$

Examples - LFR

Wide area coverage

No shadowing

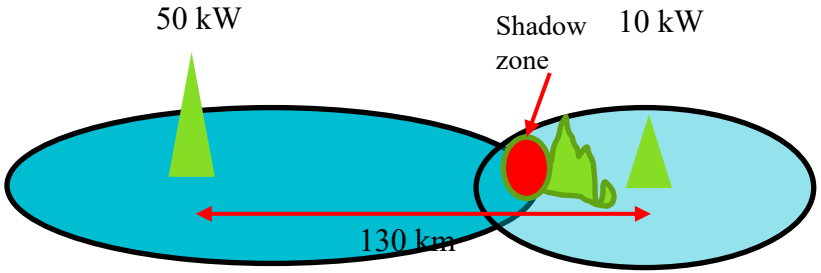


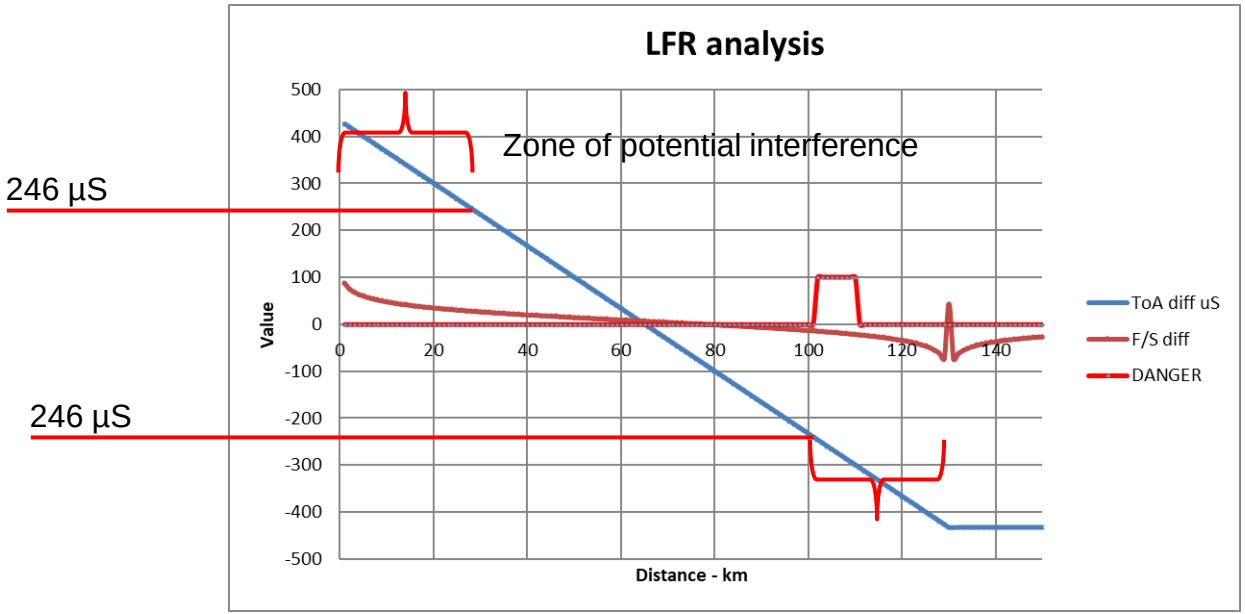


Examples - LFR

Wide area coverage

With shadowing loss (10dB)





SFN Case Study

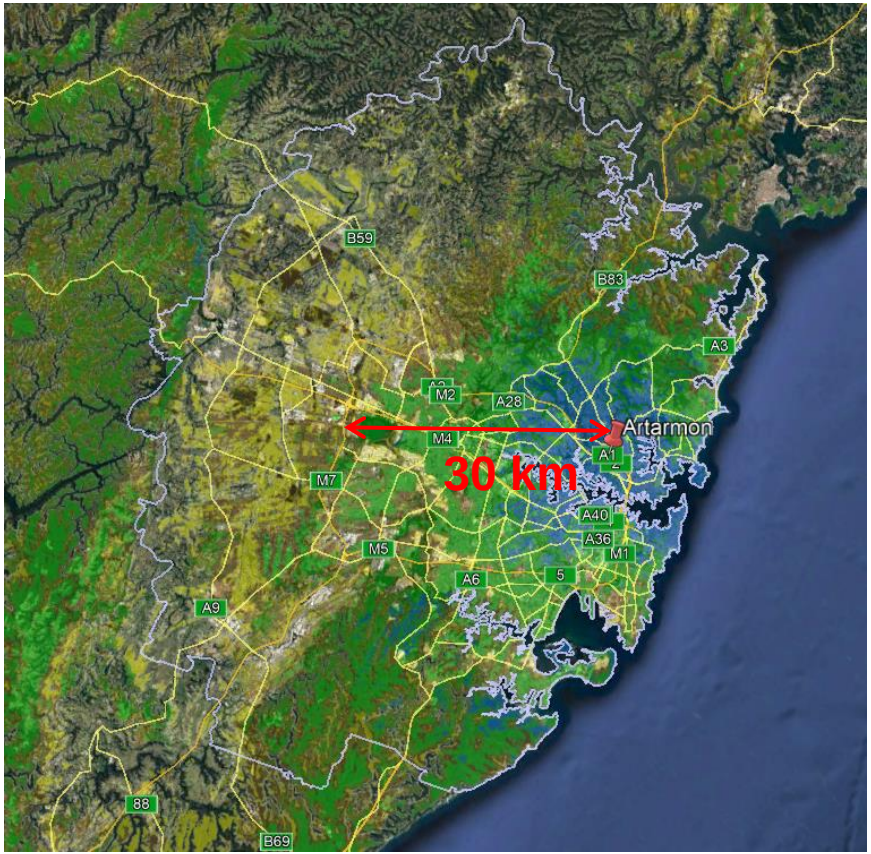
Sydney, Australia

Single 45 kW main transmission

Areas more than approx. 30 km west of the main transmitter only receive vehicle grade coverage

Field strength pallete

- > 80 dBµV/m – dense urban indoor
- > 60 dBµV/m – urban indoor
- > 54 dBµV/m – suburban indoor
- > 50 dBµV/m – vehicle



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SFN Case Study

Sydney, Australia

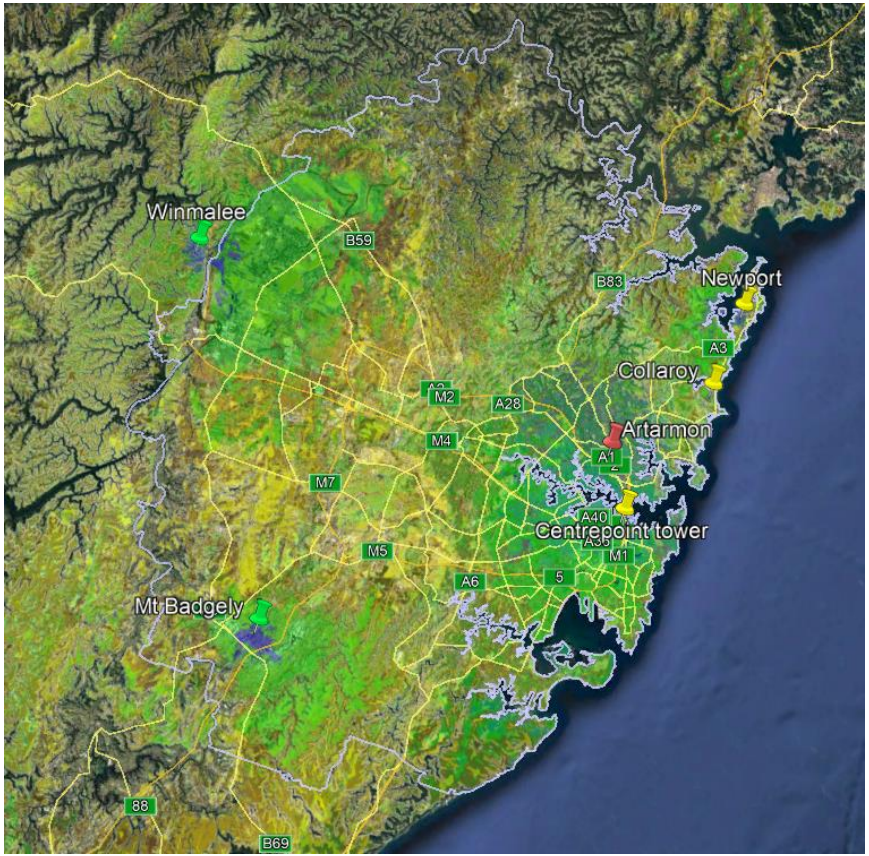
5 repeaters

2 x LFR @ 500W

3 x OCR @ 300W

Largely cover the populated areas with at least suburban grade coverage

Further urban expansion in Western Sydney will require further repeater support for indoor coverage



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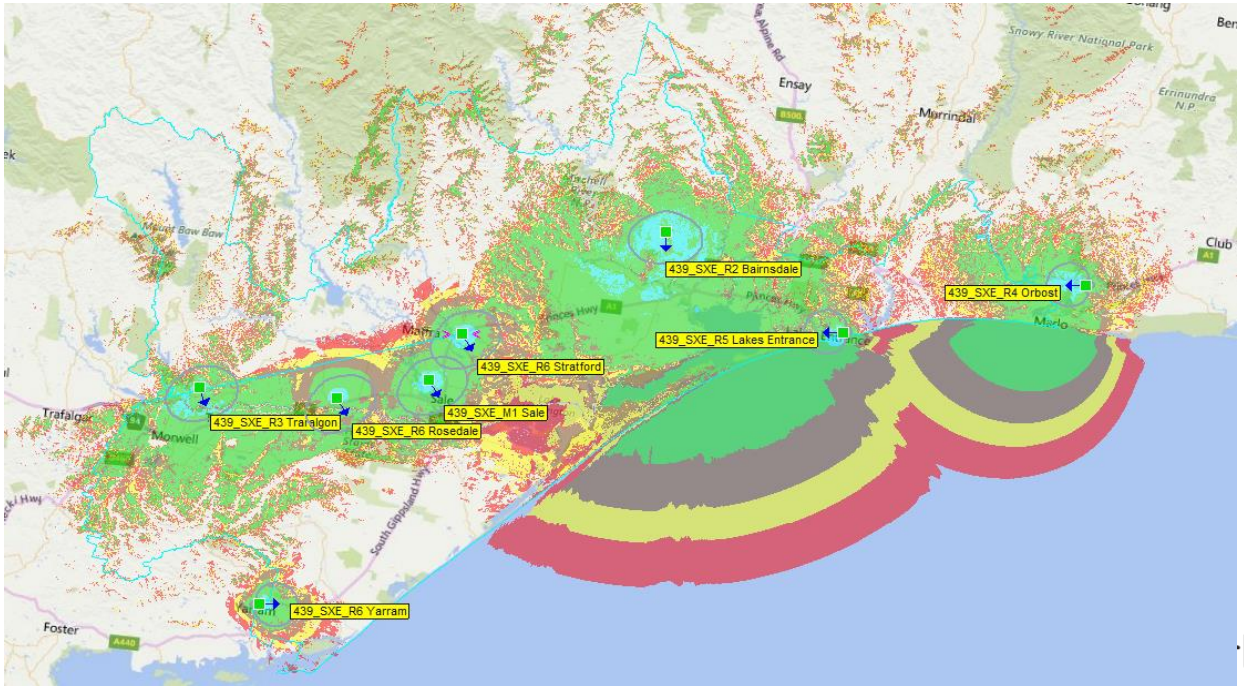
SFN example

SFN coverage in Sale, Victoria, Australia

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



SFN design

Conclusions

1. SFNs are valuable spectrally efficient networks which are commonly used to provide wide area coverage for a multiplex, e.g. national multiplexes
2. SFNs have operating limits in terms of time delays and relative powers of the contributing transmissions
3. SFNs usually live within a MFN structure where multiple multiplexes are provided with different services
4. Link Fed Repeaters are commonly used to provide SFNs
5. On-Channel Repeaters are cheaper to operate but have more stringent operating limits
6. Beware of local shadowing in SFNs to ensure no coverage holes due to self interference (CCI)

Thank you

For further information, please contact:

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