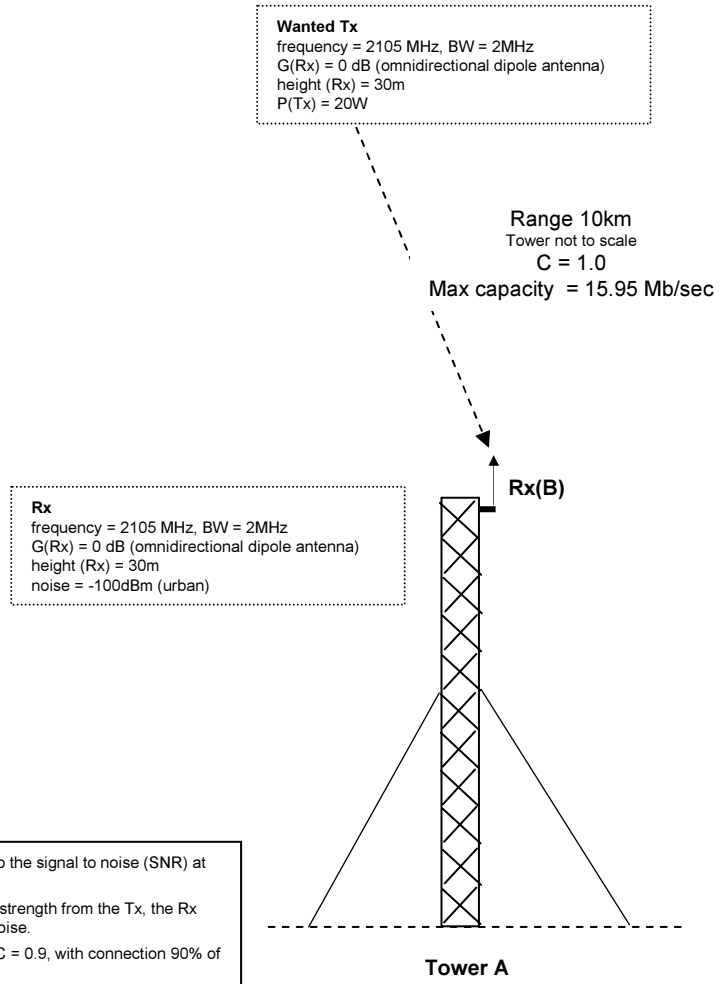
Spectrum Management: Multi Tx interference on near-sited Rx – CIV-GND-VHFUHF-INT-3 scenario 3a

Initial Tx-Rx UHF link before interferer Tx deployed

- It is assumed there is a partially regulated spectrum with a UHF band 2100 - 2110 MHz (2.10-2.11 GHz) allocated to multiple users. Allocations within that band are made for centre frequencies spaced by 200kHz, assuming systems will aim at wideband communications. There are therefore 200 channels.
- Once centre frequencies have been allocated, the bandwidth of systems are not regulated. However systems are being deployed with wider bandwidths than 200kHz, in an attempt to achieve broadband data rates. Hence some systems may have overlapping bandwidths.
- As these systems use UHF frequencies with relatively short wavelengths compared with VHF for example, the range is relatively limited, particularly if low powers are used.
- It is hoped that, if transmitters and receivers using overlapping bandwidths are not co-located on the same towers, the spacing between the towers will ensure minimal interference.

- A broadband UHF link between two towers is shown with a connectivity of C = 1.0 and a maximum possible capacity of 15.95 Mb/sec. It is using a much wider bandwidth (2MHz) than the assumed 200kHz, to achieve broadband capacity. It is also operating against a fairly high urban noise background. This is a baseline performance, to compare that with interference to.
- Another tower will be deployed a few kilometres away with multiple transmitters of relatively low power, but some bandwidth overlap with the Rx on Tower A.

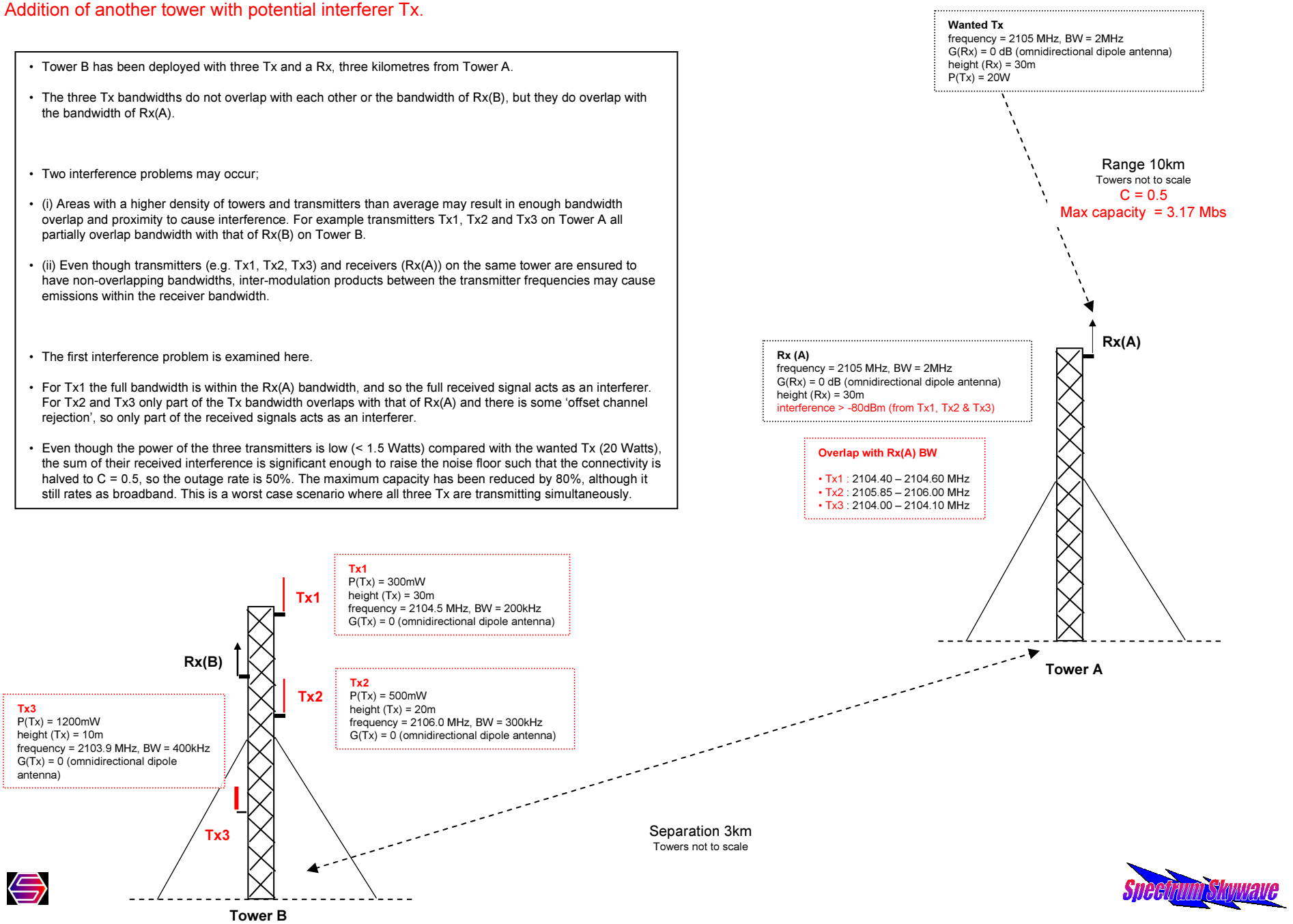


- Connectivity (C) for a link is related to the signal to noise (SNR) at the Rx.
- This is related to the received signal strength from the Tx, the Rx sensitivity (S) and the external radio noise.
- For example a 10dB SNR results in C = 0.9, with connection 90% of the time and outage 10% of the time.
- The higher the SNR, the higher the connectivity.

Spectrum Management: Multi Tx interference on near-sited Rx – CIV-GND-VHFUHF-INT-3 scenario 3b

Addition of another tower with potential interferer Tx.

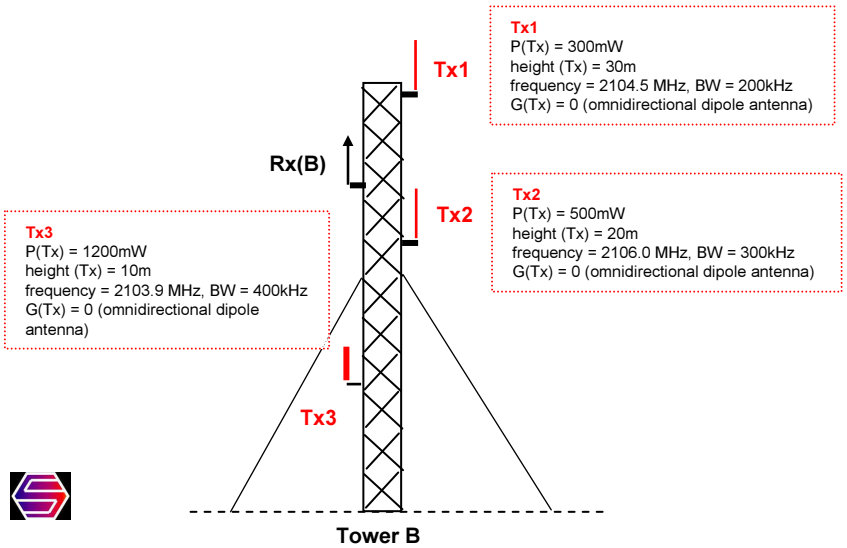
- Tower B has been deployed with three Tx and a Rx, three kilometres from Tower A.
- The three Tx bandwidths do not overlap with each other or the bandwidth of Rx(B), but they do overlap with the bandwidth of Rx(A).
- Two interference problems may occur;
- (i) Areas with a higher density of towers and transmitters than average may result in enough bandwidth overlap and proximity to cause interference. For example transmitters Tx1, Tx2 and Tx3 on Tower A all partially overlap bandwidth with that of Rx(B) on Tower B.
- (ii) Even though transmitters (e.g. Tx1, Tx2, Tx3) and receivers (Rx(A)) on the same tower are ensured to have non-overlapping bandwidths, inter-modulation products between the transmitter frequencies may cause emissions within the receiver bandwidth.
- The first interference problem is examined here.
- For Tx1 the full bandwidth is within the Rx(A) bandwidth, and so the full received signal acts as an interferer. For Tx2 and Tx3 only part of the Tx bandwidth overlaps with that of Rx(A) and there is some 'offset channel rejection', so only part of the received signals acts as an interferer.
- Even though the power of the three transmitters is low (< 1.5 Watts) compared with the wanted Tx (20 Watts), the sum of their received interference is significant enough to raise the noise floor such that the connectivity is halved to C = 0.5, so the outage rate is 50%. The maximum capacity has been reduced by 80%, although it still rates as broadband. This is a worst case scenario where all three Tx are transmitting simultaneously.



Spectrum Management: Multi Tx interference on near-sited Rx – CIV-GND-VHFUHF-INT-3 scenario 3c

Interference to Rx from co-sited multiple Tx.

- Tower B has been deployed with three Tx and a Rx(B). The second interference problem will be examined here, that of inter-modulation products between the transmitters placing interference frequencies in the allocated 2100-2110 MHz range the Rx(B) may wish to use, as well as direct transmission by the Tx.
- The three Tx bandwidths do not overlap with each other or the bandwidth of Rx(B). However the transmissions at the different frequencies may interact with each other to produce emitted power at different frequencies. This is particularly prevalent as systems age and there is some RF leakage, or interaction with the tower via poor earthing.
- Firstly, the direct transmission in the bandwidths used by the three Tx will likely overwhelm any signal received at the Rx(B), so those frequencies are to be avoided and are shown in the box to the right.
- Secondly, if *pairs of Tx* are operating simultaneously there will be various inter-modulation products of both 2nd and 3rd order. The *2nd order product* frequencies are outside the 2100 – 2110 MHz range and will not be considered in detail, although interestingly some are in the 1 – 3 MHz MF/low-HF range that propagates by surface wave, and may affect totally different systems to these UHF ones. Many of the *3rd order product* frequencies are within the band of interest and are shown in the box on the right.
- Thirdly, if all three Tx are operating simultaneously, most of the 2nd order products are in the band of interest. The 3rd order products will not be considered due to their multiplicity. The relevant 2nd order products are shown in the right hand box.
- The three groups of frequencies have been assembled into an 'avoid' list for Rx(B) that should not be used as they likely will contain some interference from the co-sited Tx. This list constitutes 22 of the 200 channels (11%) of 200kHz width in the allocated 2100-2110 MHz. The channels fully or partially affected by inter-modulation product frequencies are 14 of the 22, or 64%. They are possibly lower power than the Tx frequency bands but, due to proximity, probably still strong enough to overwhelm all but the strongest signals at the Rx.



- Within the allocated 2100-2110 MHz allocated band that Rx(B) can use;
- Tx frequency bands
  - Tx1: 2104.4-2104.6 MHz
  - Tx2: 2105.85-2106.15 MHz
  - Tx3: 2103.7-2104.1 MHz
- 2nd order inter-modulation products from pairs of Tx
  - 2,101.80 MHz
  - 2,103.00 MHz
  - 2,103.30 MHz
  - 2,105.10 MHz
  - 2,107.50 MHz
  - 2,108.10 MHz
- 3rd order inter-modulation products from all three Tx
  - 2,102.40 MHz
  - 2,105.40 MHz
  - 2,106.60 MHz
- Total **'avoid' list for Rx(B)** with number of occupied 200kHz channels indicated, assuming channel boundaries are on even multiple of 200kHz.
  - 2,101.80 MHz (2 channels)
  - 2,102.40 MHz (2 channels)
  - 2,103.00 MHz (2 channels)
  - 2,103.30 MHz (1 channel)
  - 2103.70 - 2104.10 MHz (4 channels)
  - 2104.40 - 2104.60 MHz (1 channel)
  - 2,105.10 MHz (1 channel)
  - 2,105.40 MHz (2 channels)
  - 2105.85 - 2106.15 MHz (3 channels)
  - 2,106.60 MHz (2 channels)
  - 2,107.50 MHz (1 channel)
  - 2,108.10 MHz (1 channel)