Porirua Evidence

RF Engineering – Feb 2023 – V0.1

About the author

Name: Grant Wright

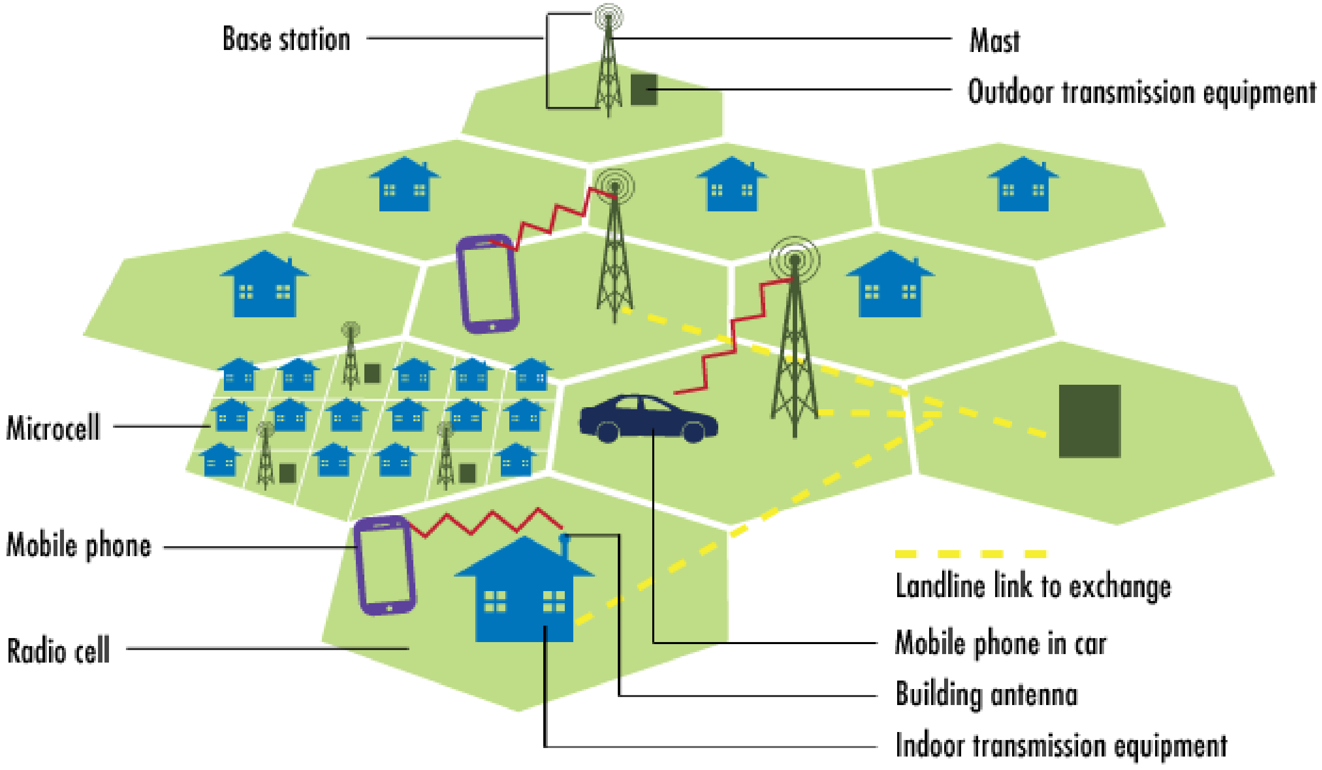
Position: RF Engineer

My name is Grant Wright, I am a Radio Frequency ("RF") Engineer at Spark. I have over 20 years' experience in mobile network design, optimisation and performance management. My qualifications include a Post Graduate Diploma of Technology, and Bachelor of Science degree from Massey University Palmerston North.

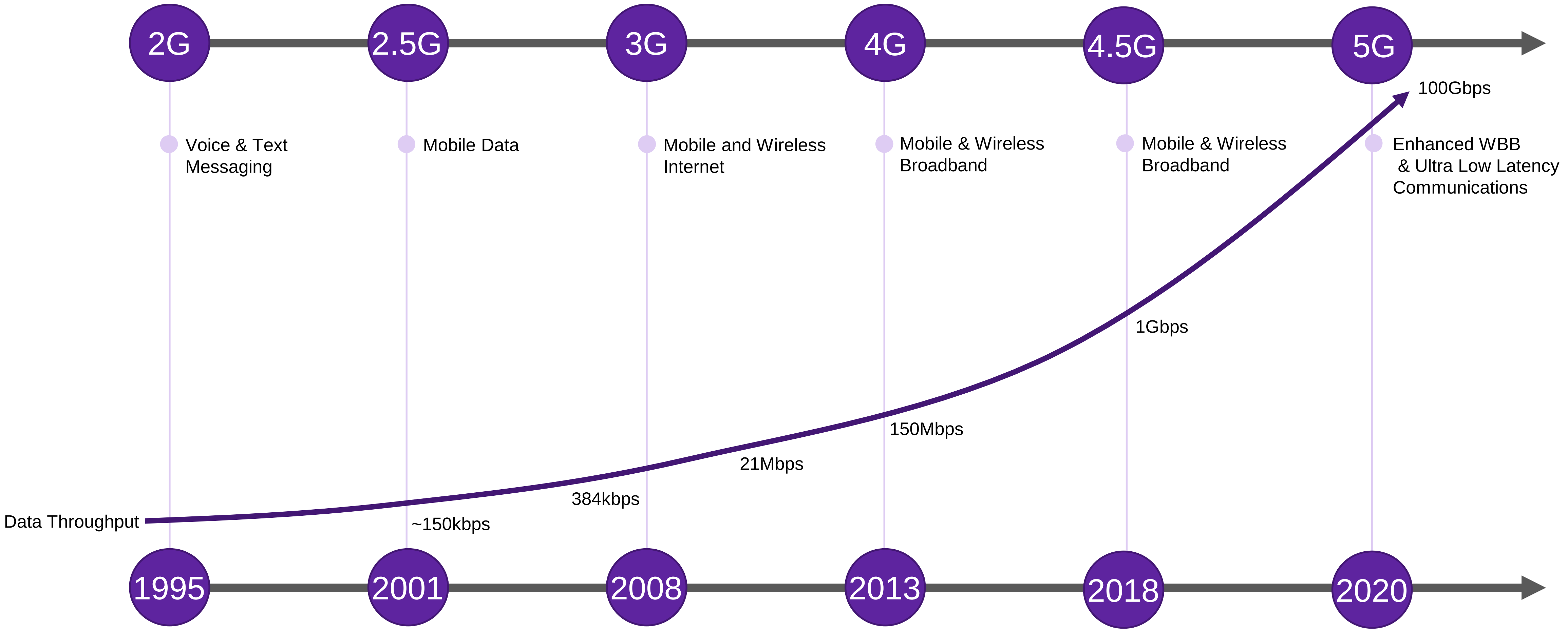
My role at Spark involves design, optimisation and performance management of Sparks 3G, 4G and 5G mobile network, providing the best possible service to the end customer.

Mobile Networks

A mobile network is a communication network where the last link is wireless. Mobile networks consists of macro base stations for higher capacity, wider area coverage, and smaller microcells (also known as small cells) typically for densification for macro capacity offload. Microcells transmit generally at higher frequencies and at lower power creating a smaller coverage area.



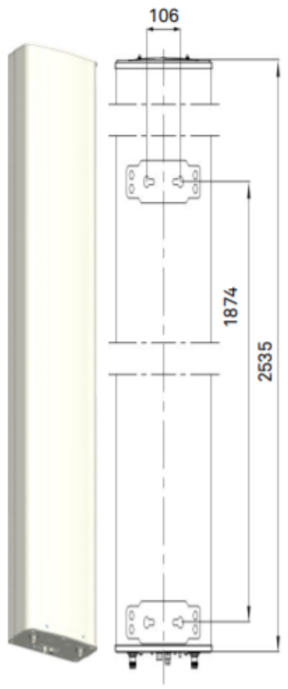
Mobile Technology Development



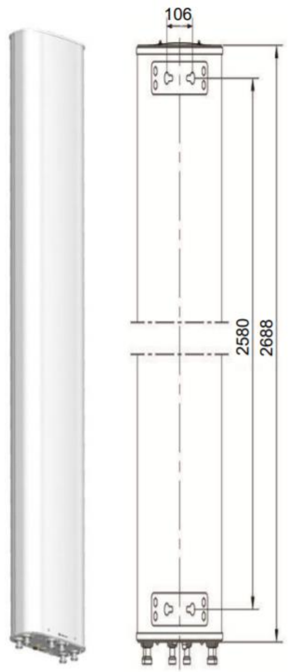
Typical antennas and sizes

Antennas installed vary in size depending on the radio frequency carriers deployed, the environment/area requiring coverage and whether they have the radio hardware integrated inside. Typically, the higher the frequency the smaller the antenna, unless of course the antenna is multi-band i.e. suitable for a wide range of frequencies, in which case the lowest frequency determines the size. Below are a number of antenna examples.

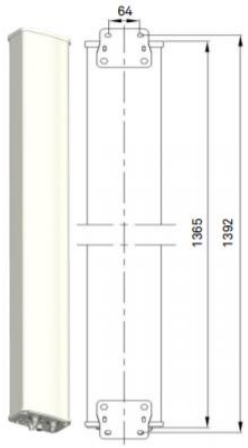
Network expansions currently being undertaken by all NZ Mobile Network Operators most commonly consist of swapping the panel antennas for multi band equipment as well as adding a separate integrated antenna/radio for each sector. For this reason, a 5m extension zone is necessary in order to adequately manage mounting brackets, fibre, power and coaxial cables as well as ensuring adequate clearance over nearby coverage obstacles..



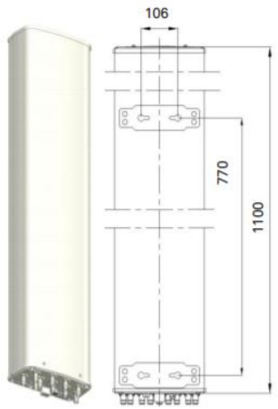
Low Band
(700-900MHz)



Mult-Band
(700-2600MHz)



High Band
(1710-2600MHz)



Very High Band
(3300-3800MHz)

Very High Band
Antenna & Radio Combined
(active antenna)
(3500-3600MHz)

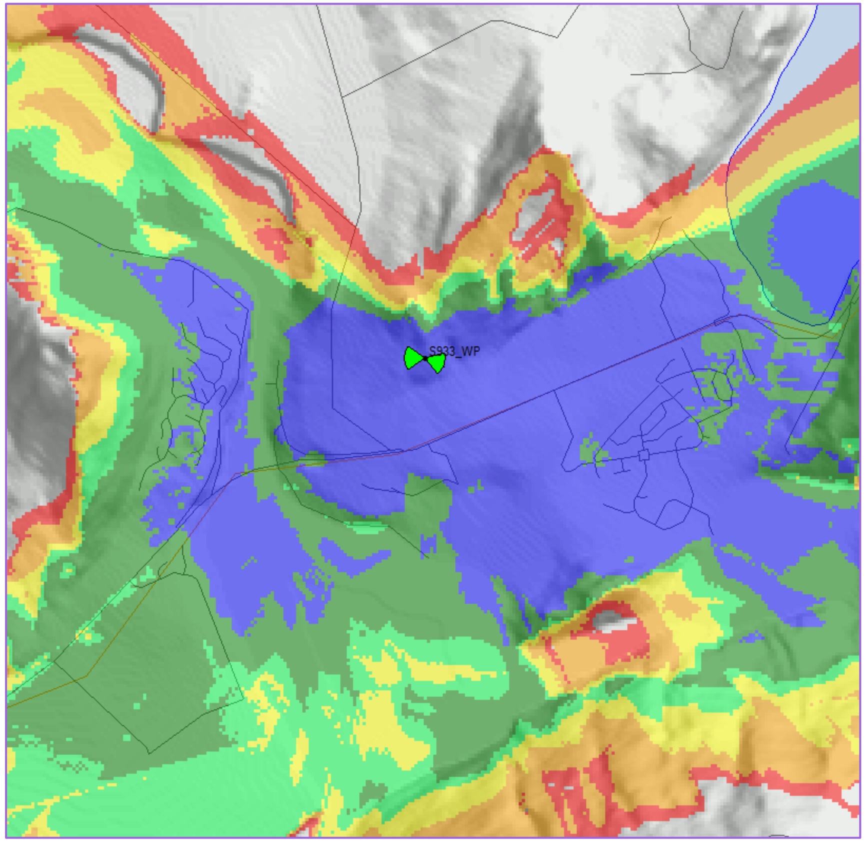
New antenna, network growth

Mult-Band 3 sector
(700-2600MHz)

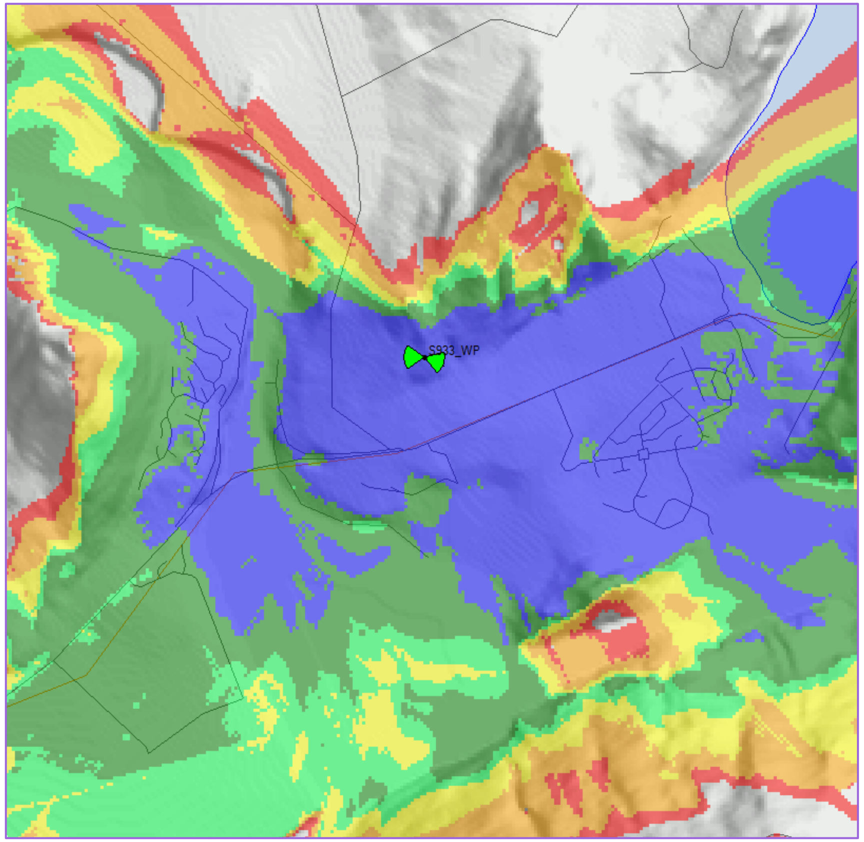
Mast Height vs Outdoor Coverage

In a good location which is above the local clutter and rolling terrain, tower height is not as critical. Elevation of the antenna is provided by the ground height.

The example below of a site location near Queenstown at two heights (8m & 15m) but showing almost identical **outdoor** coverage.



8m Mast Height – Signal Strength (Blue = Excellent -> Red=Poor)



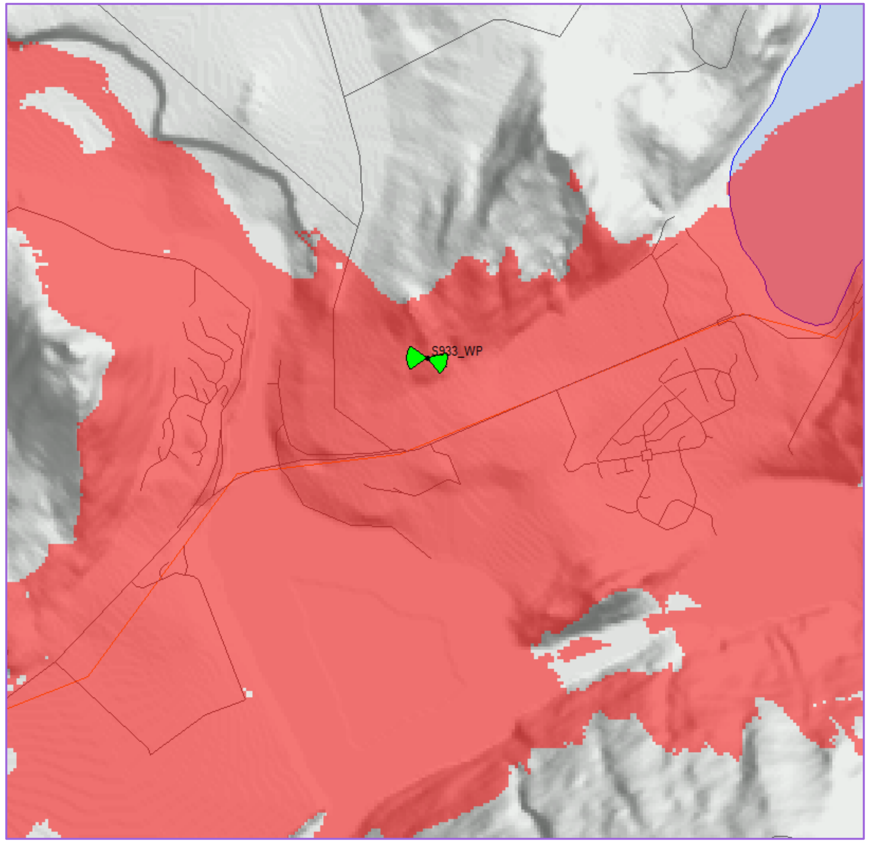
15m Mast Height – Signal Strength (Blue=Excellent -> Red=Poor)

It's important to note that smaller towers introduce their own challenges from a RF exposure perspective

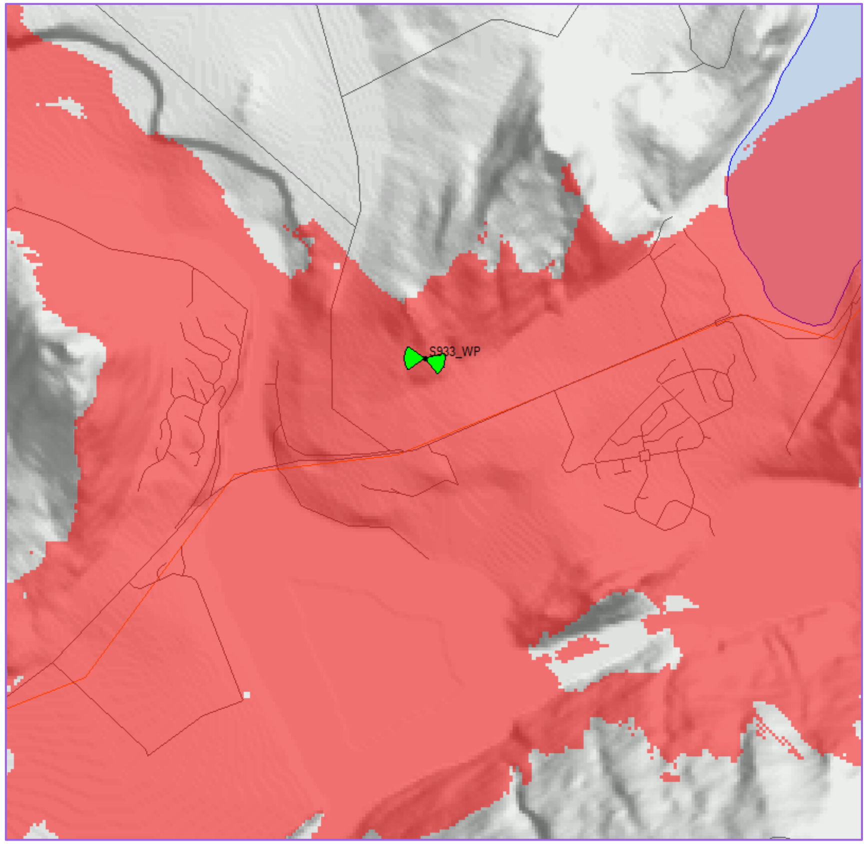
Mast Height vs Indoor Coverage

In a good location which is above the local clutter and rolling terrain, tower height is not as critical. Elevation of the antenna is provided by the ground height.

The example below of a site location near Queenstown (8m & 15m) but showing almost identical **indoor** coverage.



8m Mast Height – Signal Strength (Red = Indoor Coverage)

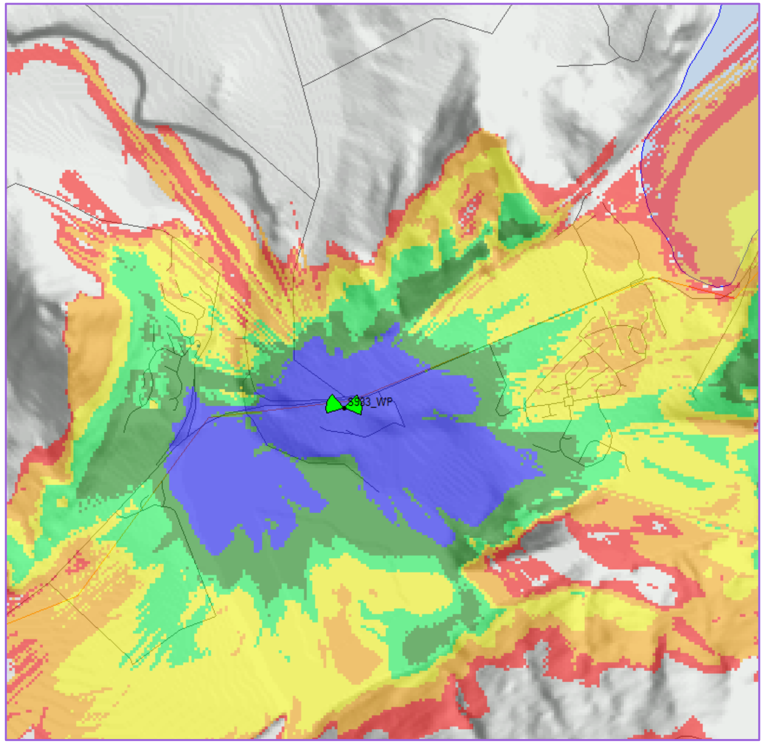


15m Mast Height – Signal Strength (Red = Indoor Coverage)

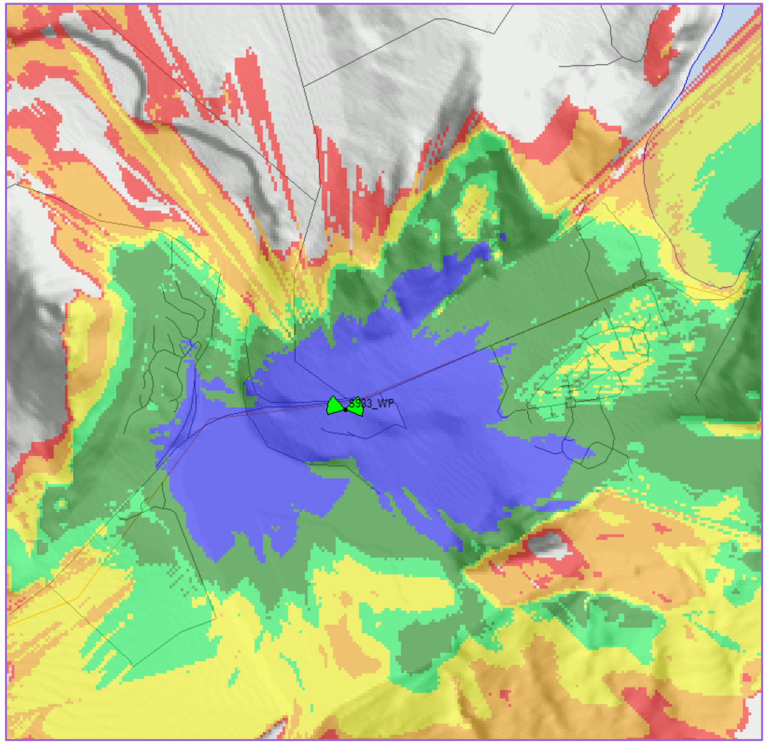
Mast Height vs Outdoor Coverage (2)

However, for street level or compromised locations (i.e. non-line of sight) tower height is extremely important to get above the local clutter otherwise additional sites would be required to provide the same level of coverage, potentially closer to residential areas.

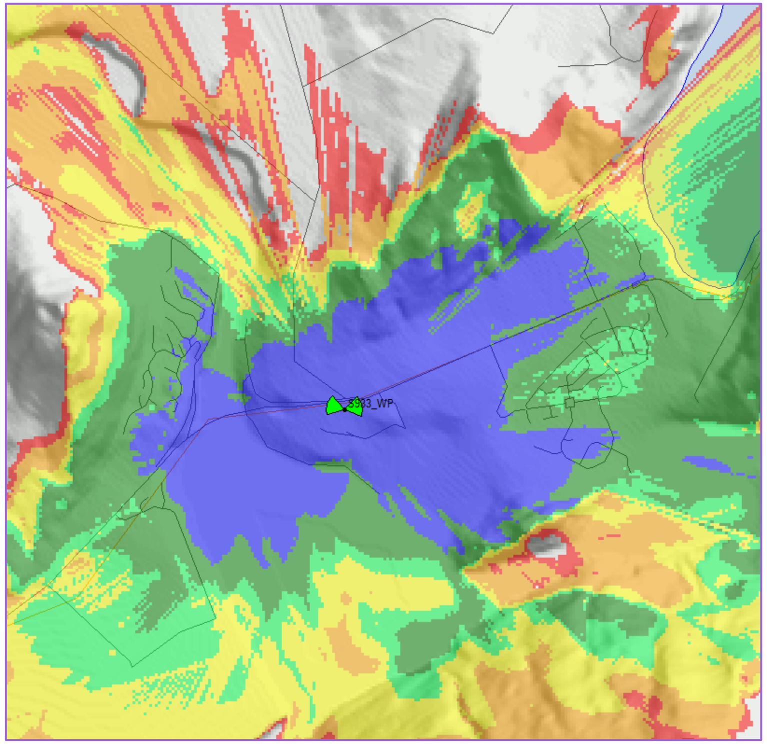
The example below shows coverage from an alternate tower location from the previous slides but at street level showing large differences in **outdoor** coverage based small differences in tower height*.



8m Mast Height – Signal Strength (Blue = Excellent -> Red=Poor)



14m Mast Height – Signal Strength (Blue=Excellent -> Red=Poor)



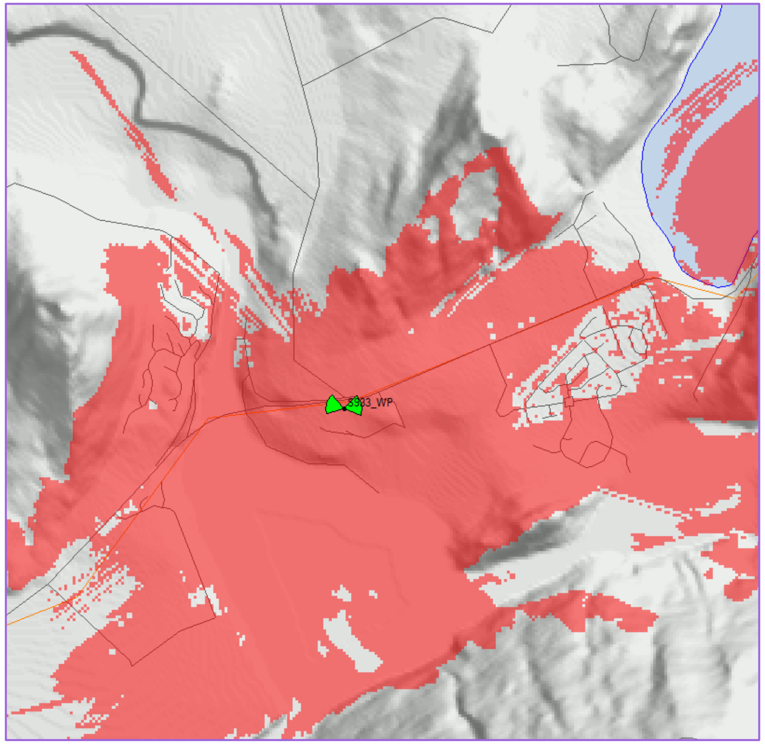
20m Mast Height – Signal Strength (Blue=Excellent -> Red=Poor)

*850MHz prediction shown. Higher frequency bands (>1800MHz) will be affected more by local clutter, resulting in a much smaller coverage area (range).

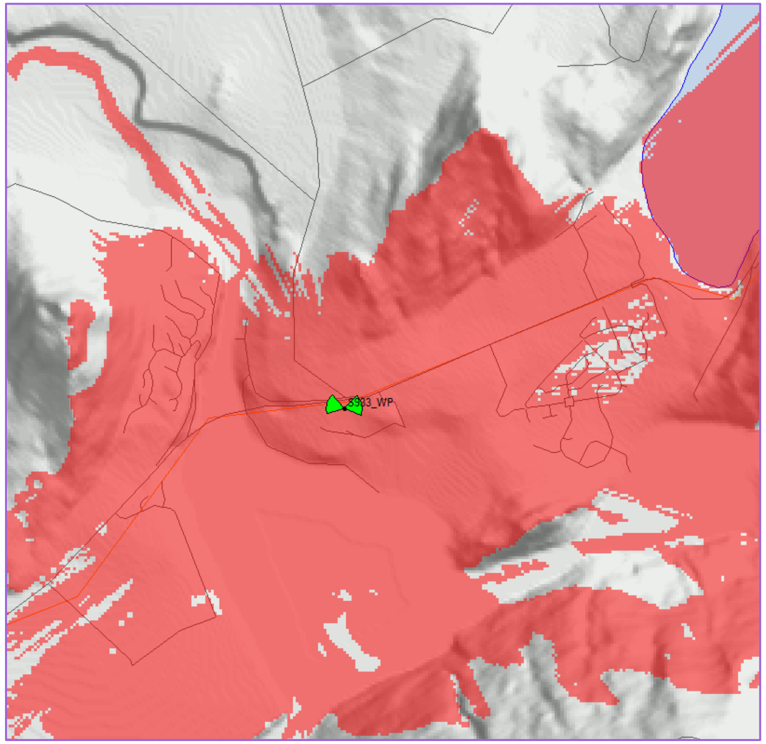
Mast Height vs Indoor Coverage (2)

For street level or compromised locations (i.e. non-line of sight) tower height is extremely important to get above the local clutter otherwise additional sites would be required to provide the same level of coverage, potentially closer to residential areas.

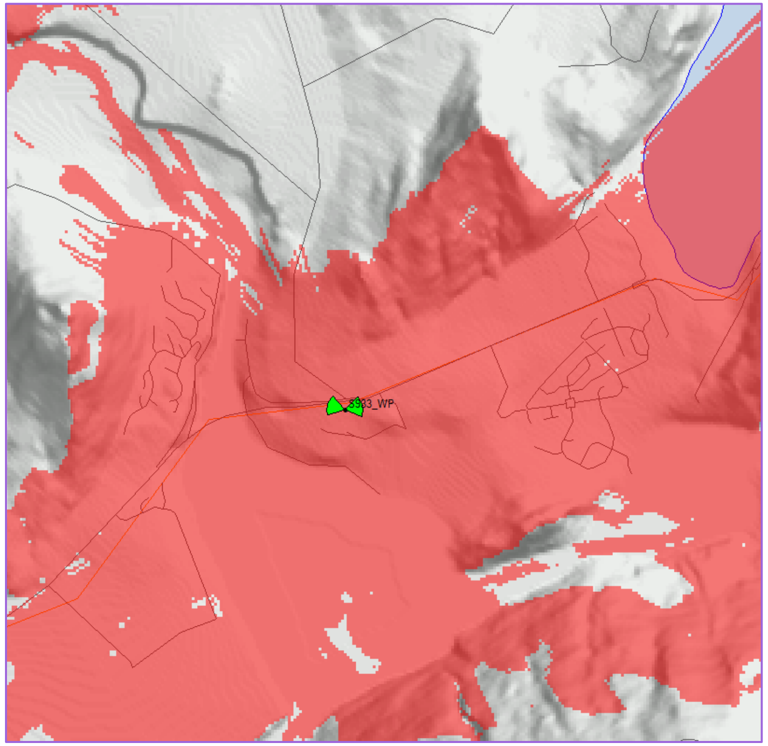
The example below of the alternate tower location at street level showing large differences in **indoor** coverage based on small differences in tower height*.



8m Mast Height – Signal Strength (Blue = Excellent -> Red=Poor)



14m Mast Height – Signal Strength (Blue=Excellent -> Red=Poor)

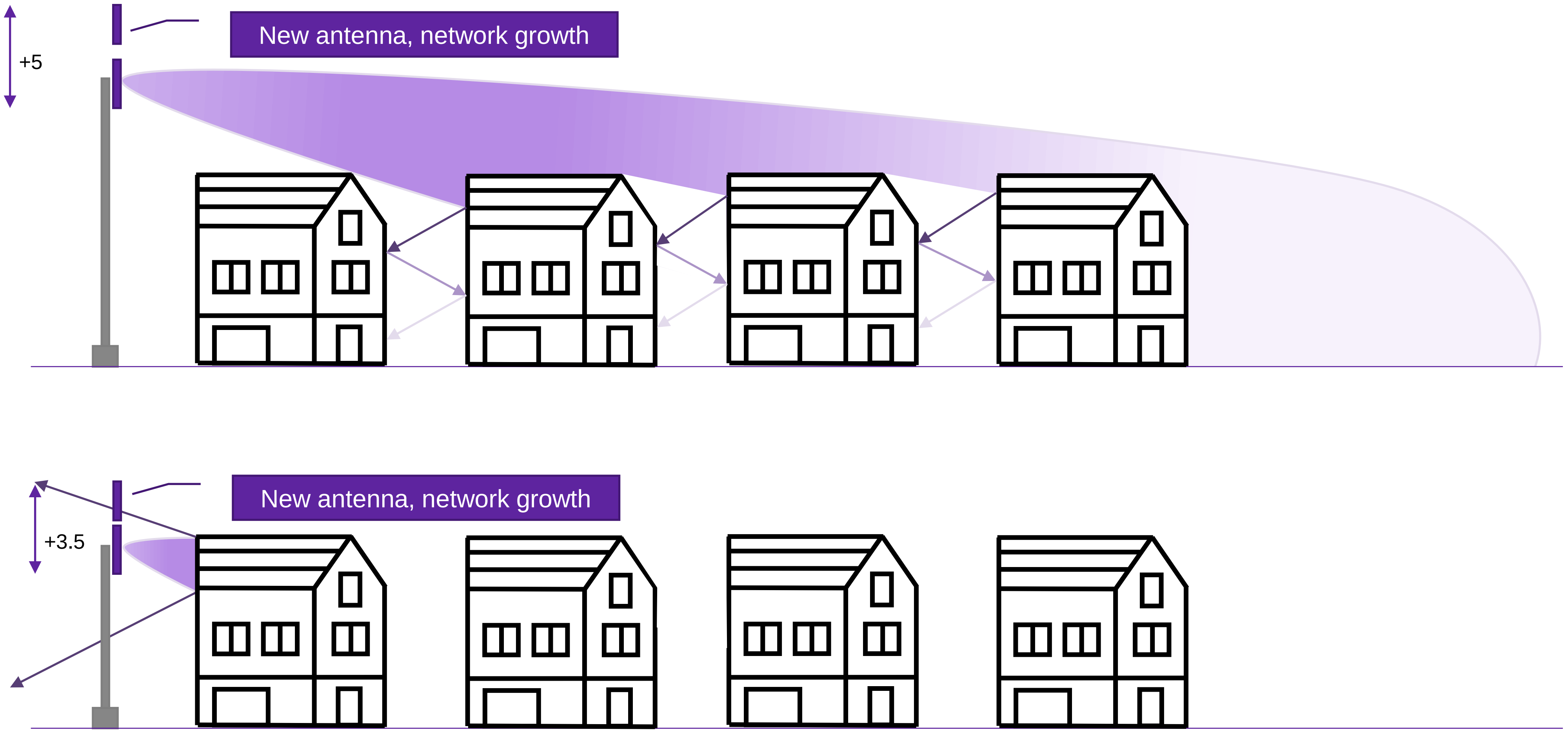


20m Mast Height – Signal Strength (Blue=Excellent -> Red=Poor)

*850MHz prediction shown. Higher frequency bands (>1800MHz) will be affected more by local clutter, resulting in a much smaller coverage area (range).

Obstructions limiting coverage – example

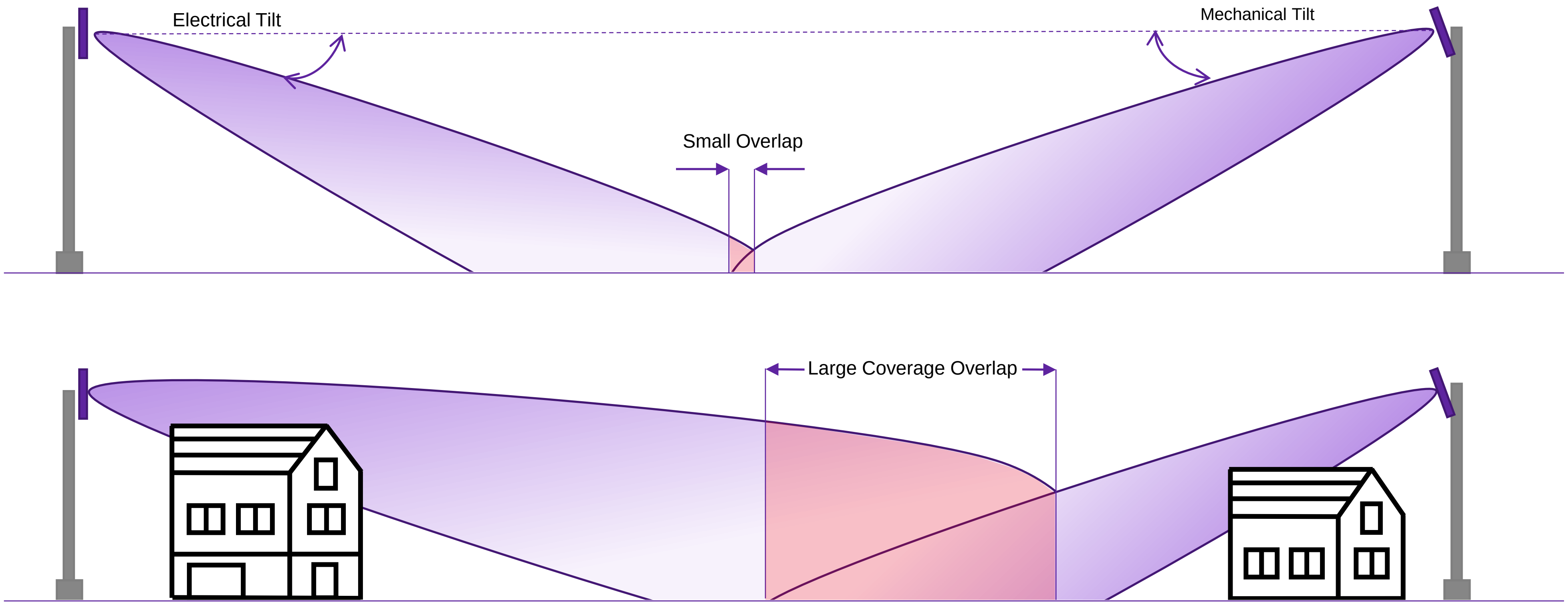
Within Porirua, the +3.5m height allowance for towers is not acceptable. A +5m height extension is required for practical deployment and workability of the 4G and 5G active antenna units.



Obstructions limiting RF optimisation

Put simply, antenna tilt optimization (electrical and/or mechanical) is an important task to reduce the interference to neighboring cell while achieving the maximum possible coverage footprint. Reducing the inter-cell interference increases the signal-to-interference/noise-ratio (SINR) and improves user throughput, network capacity and call quality.

Obstructions in the near field limit the level of tilt optimization and as a result increases the coverage overlap to neighbouring cell footprints, reducing the network quality and capacity.



Co-Location options

Co-location with other mobile network operators (MNO's) is common practice. MNO's can co-locate onto an existing sites or as a new site joint venture between MNO's.

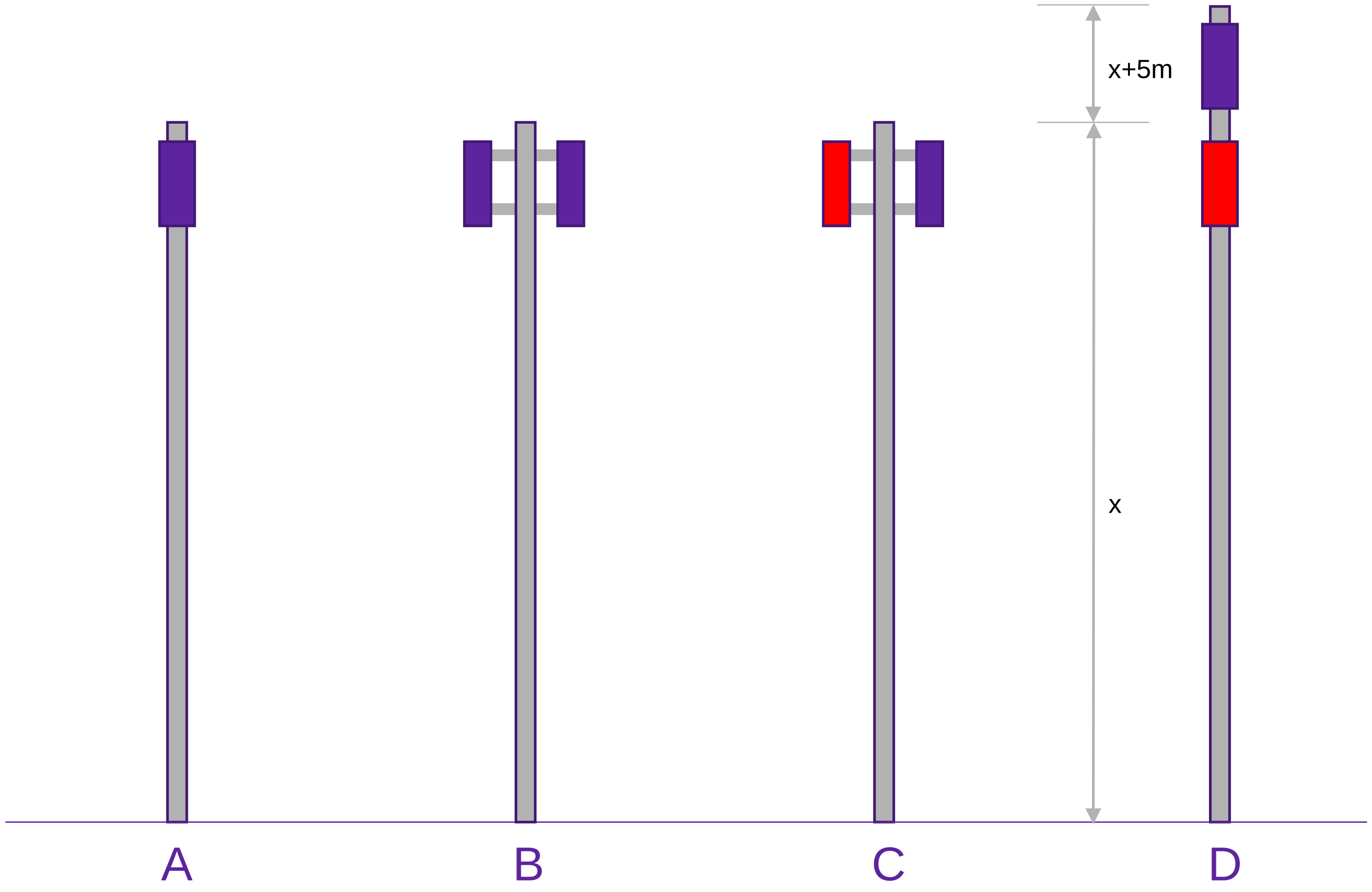
Typically, co-locating on an existing site requires a structure assessment and either an increase in head frame size or an increase in tower height, to allow for the additional MNO antennas/hardware.

A = Single MNO on a cluster (slim) headframe

B = Single MNO's with an armed headframe and two antennas

C = Two MNO's co-located on armed head

D = Two MNO's co-located on cluster head

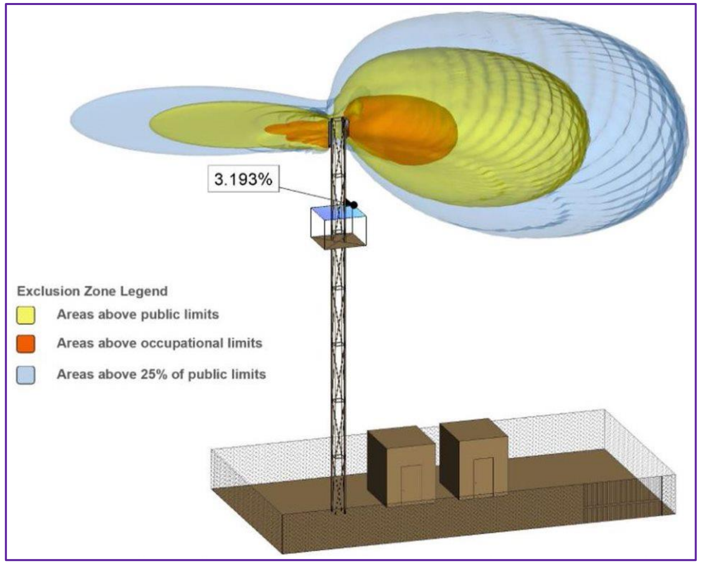


Exposure to radiofrequency fields

All Spark mobile sites comply with NZS 2772.1:1999, which sets out limits for exposure to the radiofrequency radiation produced by all types of radio transmitters, for people exposed at work and for the general public.

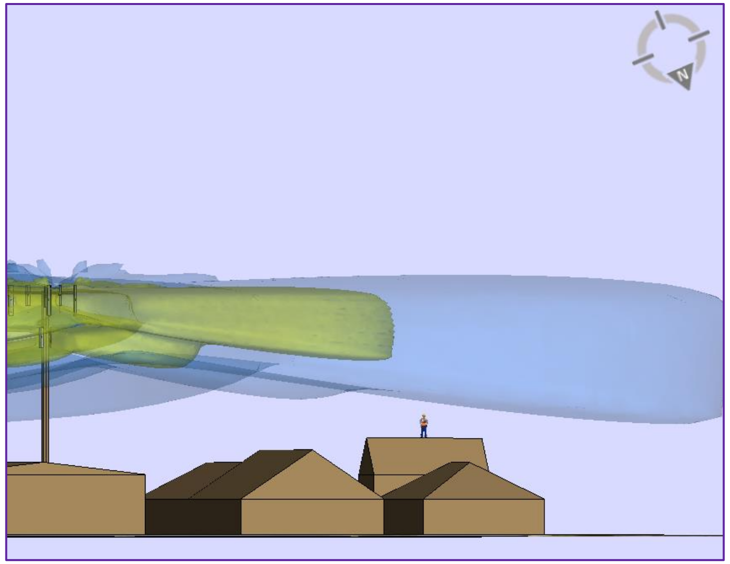
Spark uses an advanced EME compliance software called iXUS to establish and maintain RF Safety Compliance. The tool requires several inputs including tower height, antenna model, transmit powers, nearby building heights and areas accessible to the public. The output graphically displays distances, both horizontally and vertically, that meet compliance including areas between 25% & 100% of the public limit and areas above occupational limits.

The majority of Spark sites are designed to sit below 25% of the public limit. In reality Spark mobile sites sit in the region of 2-3% of the public limit (based on independent site measurements from EMF Services Ltd).



An example of calculated exposure at a given location

An example of RF Lobes – Plan view


An example of RF lobe clearance from an elevation view

Summary

Regardless of environment or clutter class, it is critical that mobile masts and all subsequent antenna expansions are installed at a height that provides sufficient clearance over nearby obstructions to ensure correct performance, coverage and RF exposure compliance (NZS 2772.1:1999)

Within Porirua, the proposed +3.5m height allowance for towers is not acceptable. A +5m height extension is required for practical deployment and workability of the 4G and 5G active antenna units.

Appendix

Path Loss

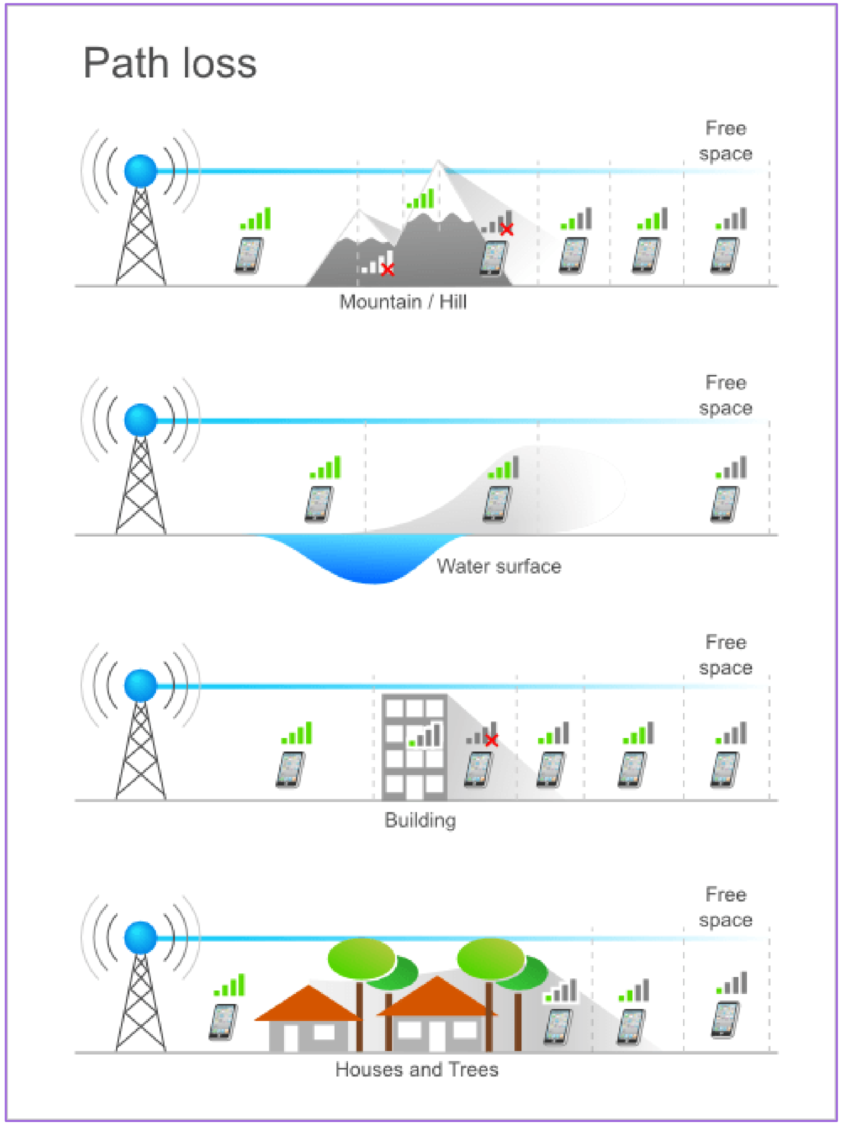
Path Loss, as a radio propagation concept, refers to the phenomenon of the power density decrease (attenuation) of an electromagnetic wave as it propagates through space i.e. from mobile base station to mobile phone (downlink), and vice versa (uplink). Path Loss is a key factor in the design of any wireless communications system.

Path loss can be caused by various factors:

- Free-space loss (distance)
- Fading (frequency dependent)
- Shadowing
- Reflections at large obstacles
- Refraction depending on the density of the medium
- Scattering at small obstacles
- Diffraction at edges

Other important variables in determining the path loss are the environment (urban, suburban or rural), terrain contours, absorption (buildings, walls, vegetation), the distance between transmitter and receiver, and the type and height of antennas.

The formulas for calculating path loss are outside the scope of this document.



Radio Propagation – Range

In mobile communications, the range is the usable distance determining the reach (or maximum cell radius) of the radio wave propagation.

The simplified equation below may be used to determine the range:

$$Pr = Pt + G - Lp$$

Where Pr = Received power,

Pt = Transmitted Power

G = Combined antenna gains at Tx and Rx, including any cable losses

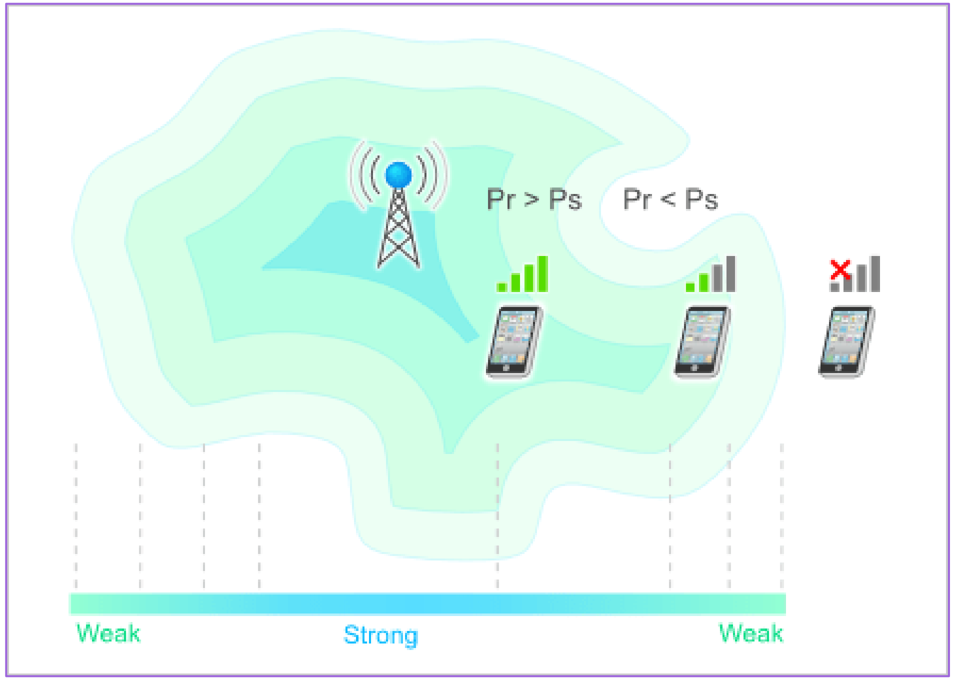
Lp = Path Loss (see previous slide)

The range is defined as the maximum distance at which the received power (Pr) is greater than the receiver sensitivity, which can be symbolized as PS, in both uplink and downlink.

Path loss (Lp) increases with distance, and is symmetric in uplink and downlink, but since the transmitted power (Pt) and the received power (Pr) are different, the link itself may not be symmetric. Therefore, the range of a base station is determined as the distance that allows a maximum path loss value without losing connectivity.

The range is variable and various factors influence it:

- **The base station mast – higher base station masts increase the range**
- **The space – open and flat spaces vs. urban spaces with high buildings, forests, mountains etc**
- The antennas used – sector antennas have greater range than an omni antenna, the size of the antenna also determines the gain i.e. the large the antenna the more directional gain.
- The frequency band – low band (850MHz) radios have better range than higher bands (1800/2600/3500MHz) radios.



Thank You