Poynting

Making wireless happen

A guide to antenna implementation & considerations

Poynting Antennas

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Agenda

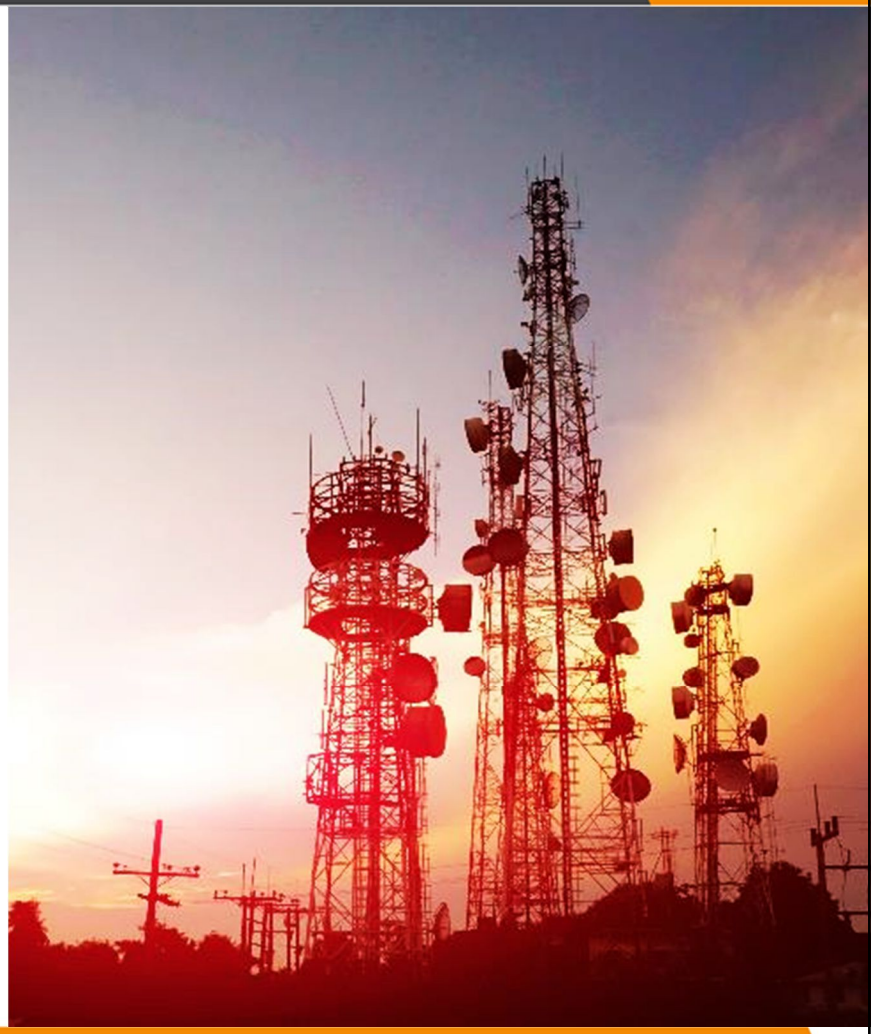
- What do we hear and see
- What makes understanding antennas difficult
- What is the role of antenna?
- What is an antenna ?
- Challenges interpreting specifications
- Application considerations
- Why pay for a better Antenna?

- What are important parameters
- What general antenna clasifications are there?
- What is the relation between Gain & Frequency?
- Antenna Gain specifications
- How does Beam-width influence Gain?
- What is antenna pattern performance?

- Radio Propagation, Frequency Bands & Utilisation
- Radio Propagation & Environment
- Clutter
- Obstacle Clearance
- Environmental Considerations

What we hear and see

- My phone works, so why do I need an antenna?
- I have a strong signal, then I do not need an antenna
- Gain, gain, gain, gain....
- My tiny, thin, cheap antenna „works"
  - „Works" is a dum word....
  - Anything could work, you could be close to a base station
  - You could be on a frequency band where it happens to perform OK



What makes understanding antennas difficult

- We are spoilt as everything seems to work somehow
- We are impatient and do not want to wait
- „it just a piece of copper (pcb) or aluminum“
- Most of us do not understand the technology
- Comparing antennas is difficult. Antennas should be judged over a period of time.
- Many external factors influence the performance total connectivity solution (operator aspect, environment, antenna quality, reflections, traffic....)

First you spend, than you drive

What is the role of an antenna?

- Create a stable and reliable connection between are transmitter and receiver
- Create clean signal without noice between the transmitter and receiver
  - The cleaner the signal (the less noice) the quicker and better routers can negotiate information packages to be transmitted or received with the operator → higher down- & upload speed can be achieved

VS

What is an antenna?

- Does not create energy
- Does not amplify signal

- Does focus energy

- Most important properties of an antenna are:
- Radiation pattern (focus pattern)
- Willingness to accept energy

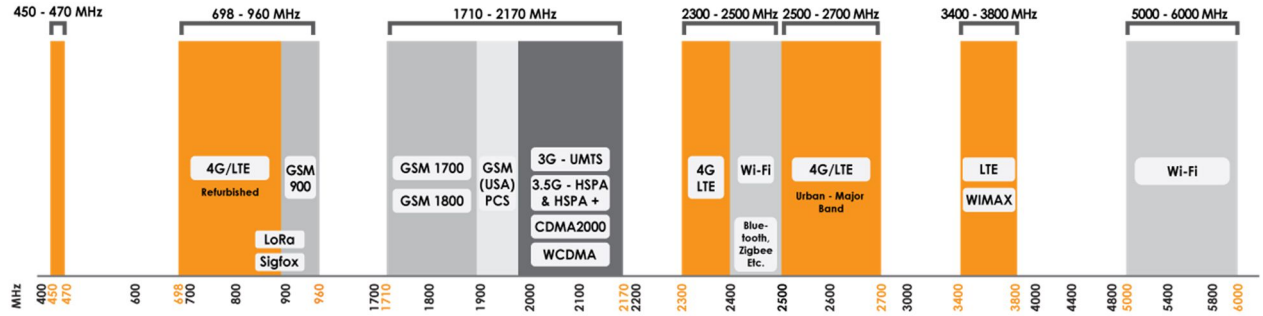
What you should know about gain

- Gain is the ability of focus and strenghten engergy in a certain direction measured in dBi.
- Gain is always directly releated to a frequency
- Gain relects to directivity or openings angle / beam-width
- A high gain is not necessarily better

Antenna radiation **patterns** and **gain** change as the **frequency changes**.

What are important antenna parameters?

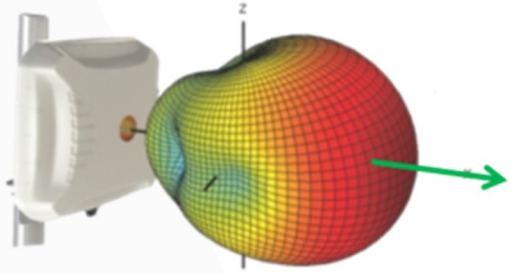
1. Frequencies
   - What operating frequency spectrum is covered by the antenna
2. Gain
   - The strength or boost the antenna provides on a certain frequency
   - Focussed in a certain direction
   - Is measured in dBi.
   - The bigger the antenna, the higher the maximum gain.
3. Polarization
   - refers to the orientation of the electric field (E-plane) of the radio wave with respect to the Earth's surface
   - e.g. Horizontal, Vertical, Circular and Cross-Polirised
4. Radiation pattern
   - The direction in which the energy / strength or boost is directed
   - The radiation pattern is various per frequency
     - The Elevation – how much is the energy directed to the moon or sun
     - The Azimuth – what is the area or opening angle of the antenna
5. Willingness to adapt energy



General antenna classifications

Directional

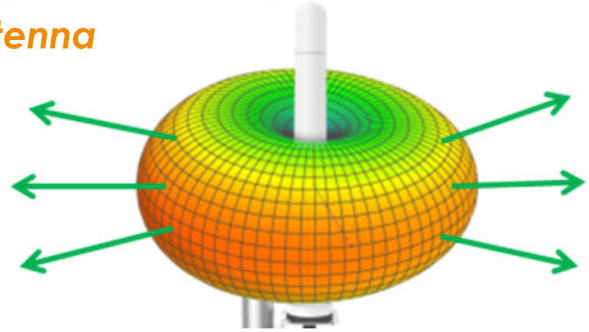
sending and receiving in one specific direction



- Antennas that have to be pointed in the direction of the signal source
- Directional antennas offer a higher gain.
- These antennas work best when:
  - they are mounted high
  - and with the best possible line of sight to the signal source

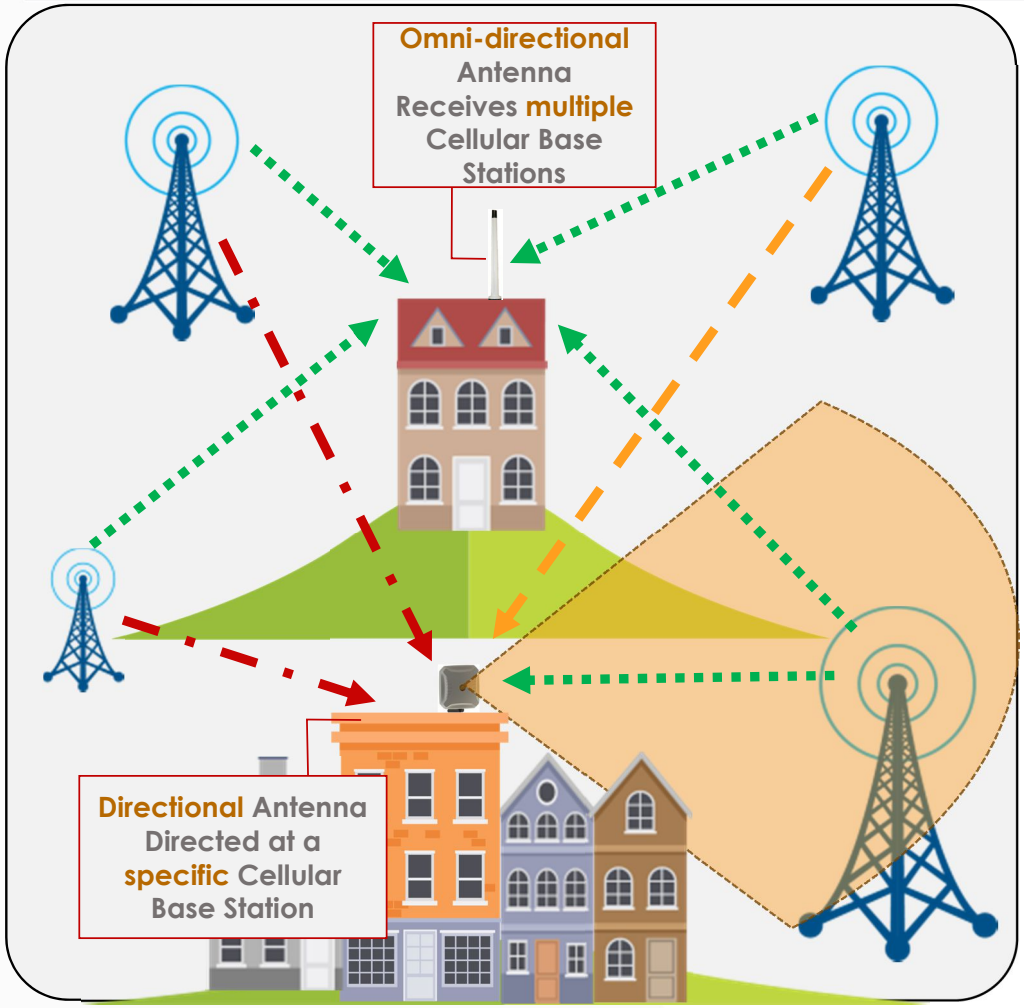
OMNI-Directional

sending and receiving qualities all around (360°) the antenna



- OMNI antennas receive a signal from any direction, but pick the strongest source.
- Omnidirectional antennas are easier to install
- OMNI antennas do not have to be mounted in a specific direction
- OMNI antennas automatically connect to the nearest source of a signal

Omni vs. Directional Antenna



Customer Premises Equipment Perspective

Omni-directional antenna:

- Allows mobile/router to 'roam' amongst various cells (incl newly built cells)
- Ease of installation
- Lower gain, but more redundancy (from other base stations)

Directional Antenna:

- Reduces interference from other directions
- Higher throughput, but limited to specific base station capacity
- Dependant to cellular tower availability

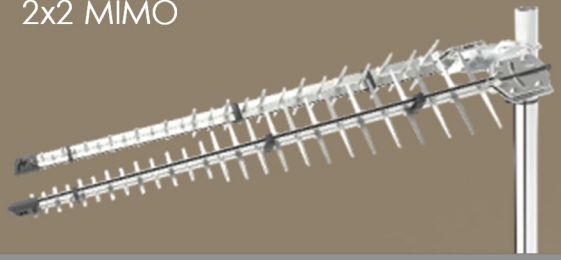
Multiple Input Multiple Output (MIMO)

Single Input, Single Output (**SISO**)

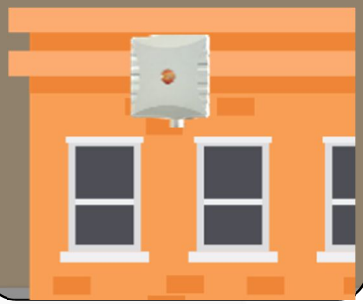
Can be used in MIMO technologies !!! (just lower throughput – confirm router hardware)

Multiple Input, Multiple Output (2x2 **MIMO**)

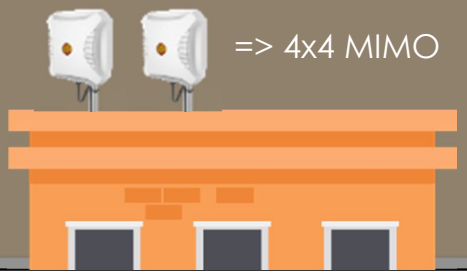
2 x SISO Antennas => 2x2 MIMO



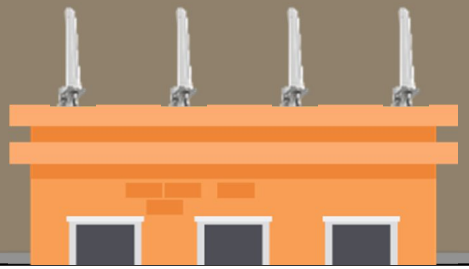
Multiple Input, Multiple Output (4x4 MIMO)



2x Integrated 2x2 Antennas => 4x4 MIMO

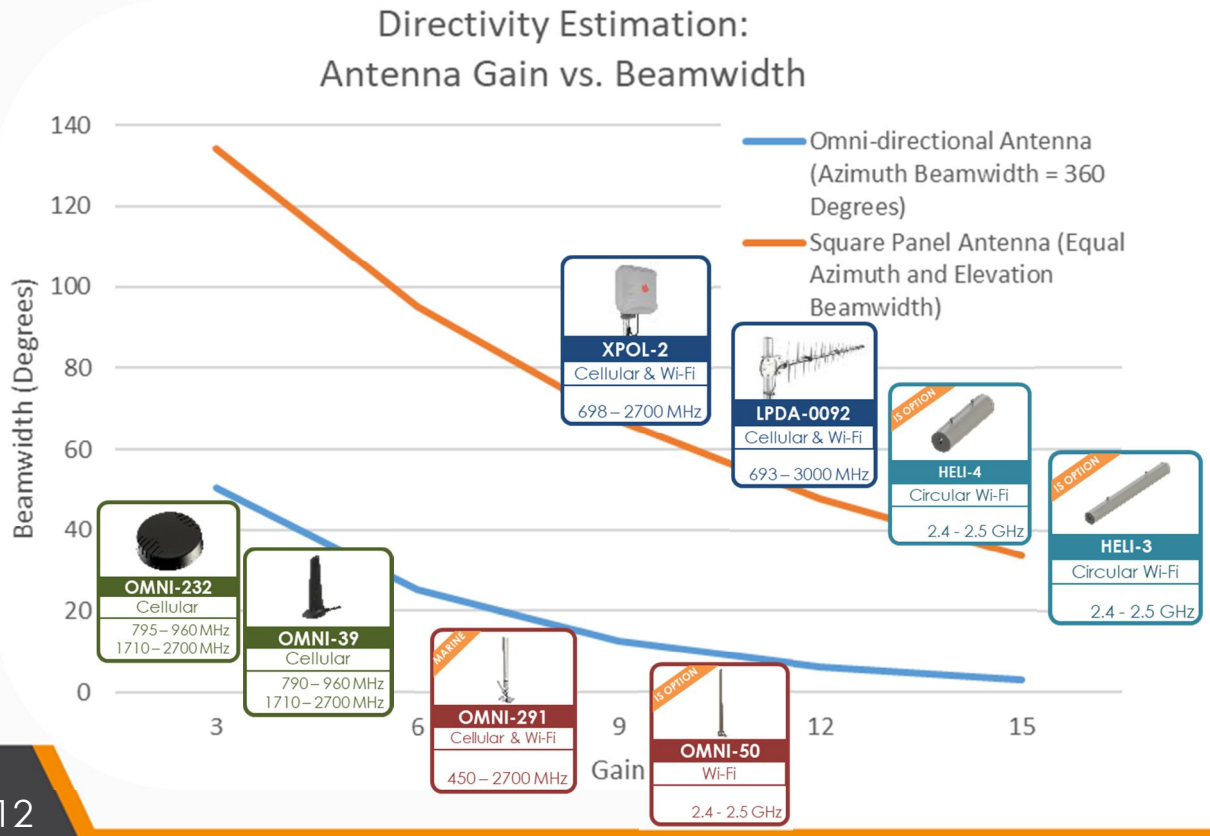


4x SISO Antennas => 4x4 MIMO



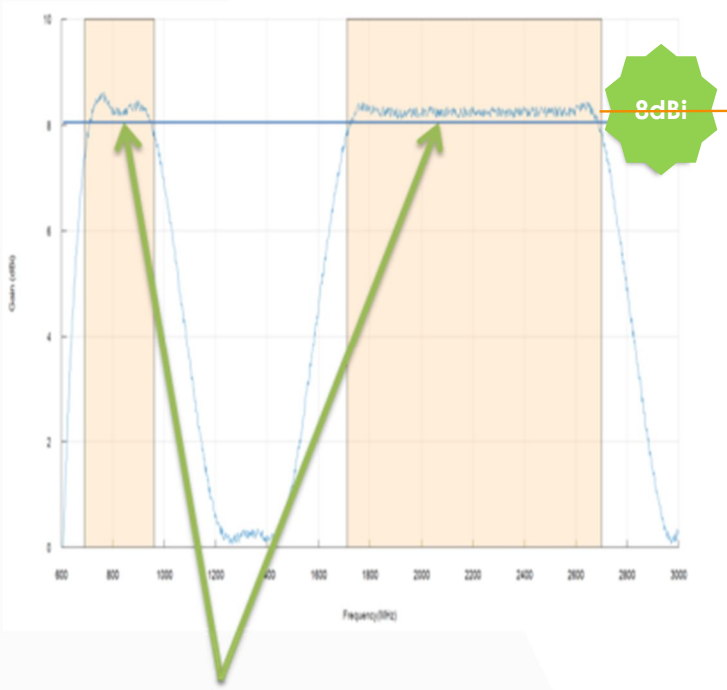
Low gain vs. high gain Antennas

Higher Gain is not always better! Example: Omni Antenna

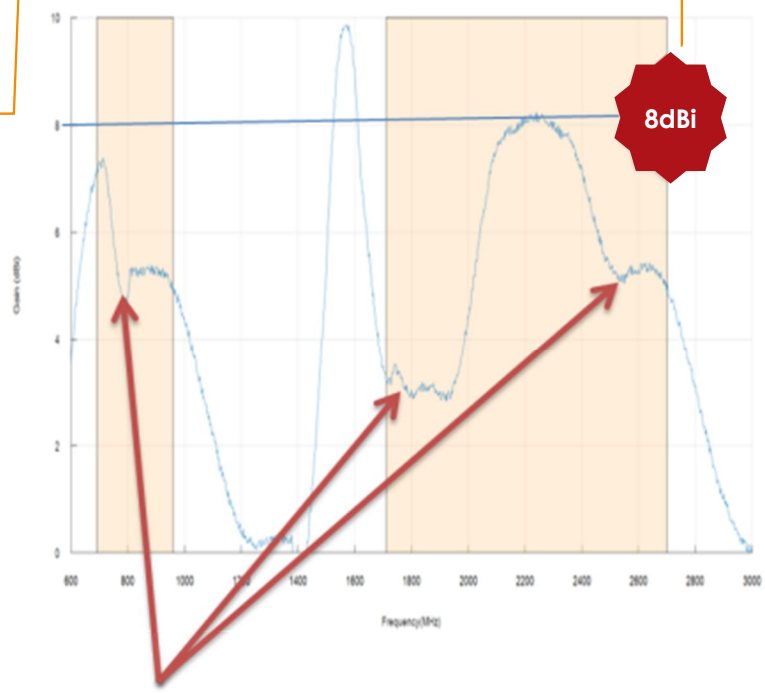


Antenna Gain Specifications

Both antennas have the same gain according to the spec sheets, so why is the one performing better that the other?



Idealistic Gain Across the whole Band



Poor Gain Across most of the band

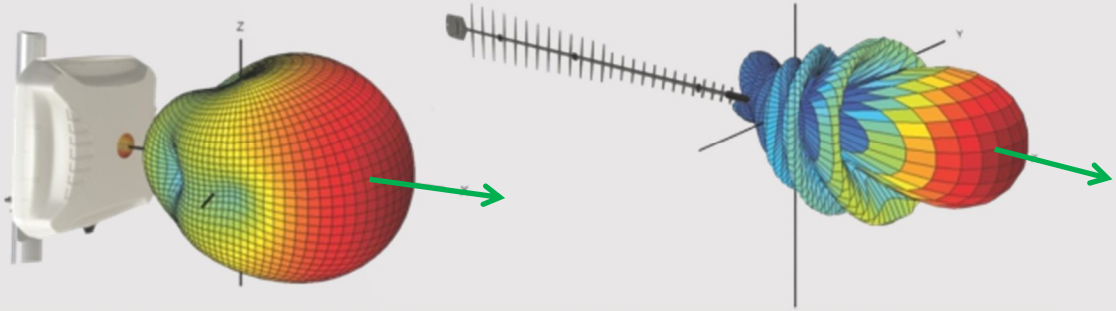
Antennas with equal spec gain are not equal !!

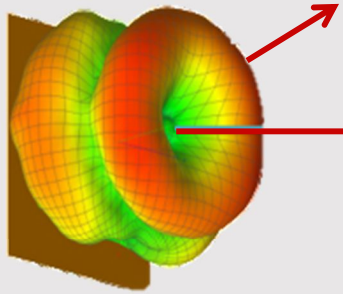
What is antenna pattern performance?

HIGH PERFORMANCE ANTENNAS
(Real Examples: Power radiated in desired direction)

POOR PERFORMANCE ANTENNA
(Hypothetical Examples)

Directional Antennas

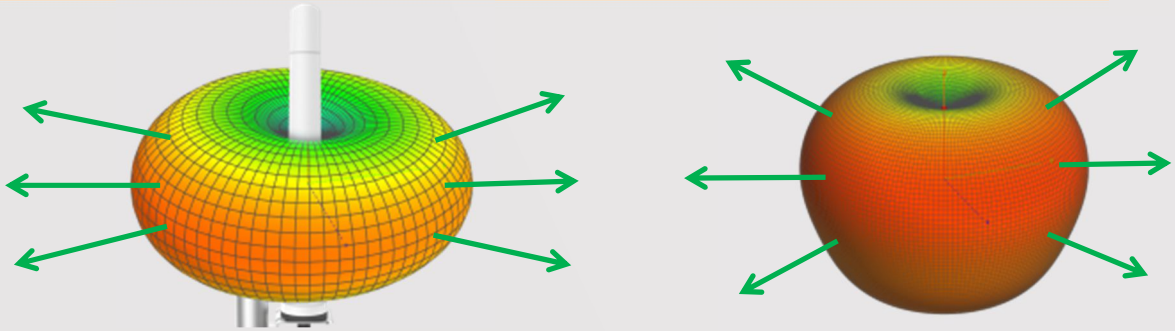


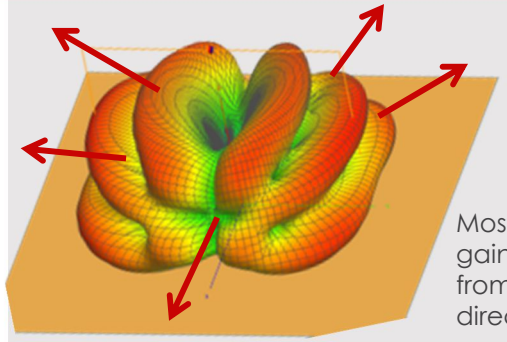


Most of the antenna gain is lost, away from the target direction

Centre of the beam is performing poorly at only 1dBi gain

Omni Antennas



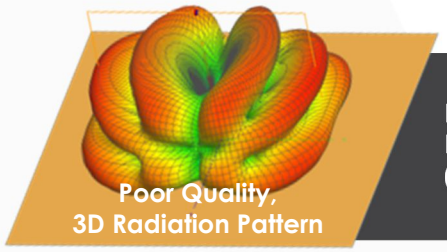


'Dead spots' on antenna radiation pattern severely impacts performance

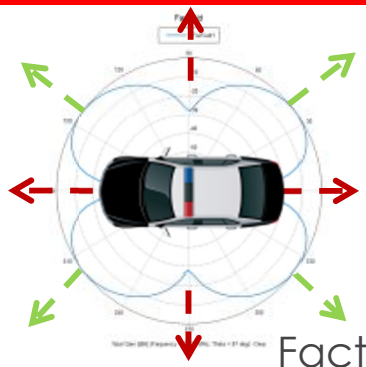
Most of the antenna gain is lost, away from the target direction

Application Considerations

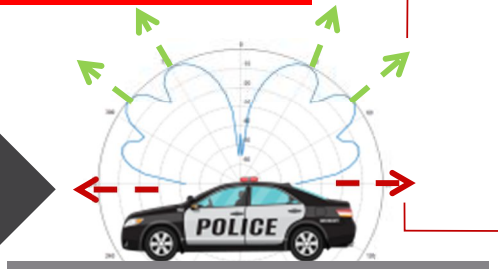
What does a **poor performing** Omni antenna pattern look like?



Horizontal Radiation Pattern (Top View)



Vertical Radiation Pattern (Side View)



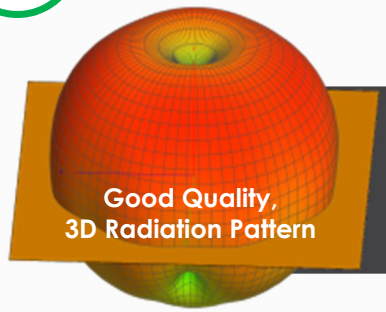
HIGH GAIN towards the **sky** ➔ Not beneficial

LOW GAIN towards the **horizon** ➔ This is where you rather want the antenna to perform

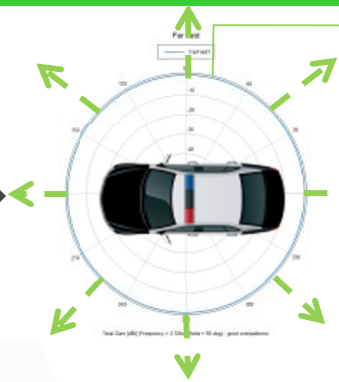
Factors affecting your RF experience

IRREGULAR horizontal beam-width ➔ many reception **variations** around the vehicle

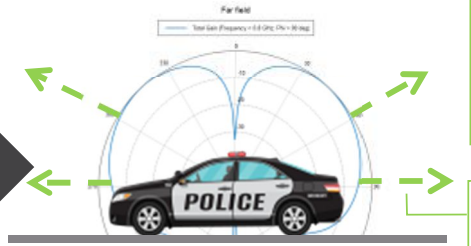
What does an **ideal performing** Omni antenna pattern look like?



Horizontal Radiation Pattern (Top View)



Vertical Radiation Pattern (Side View)

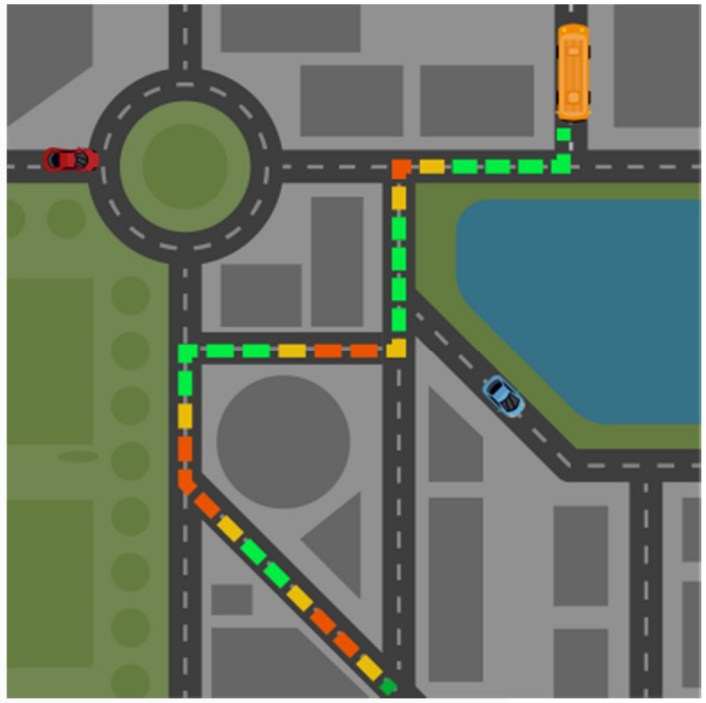


GOOD horizontal beam-width ➔ reception **consistent** around the vehicle

GAIN where it **matters**

Key:
Poor Gain/Performance
Good Gain/Performance

..when using a good vs. poor antenna on a vehicle

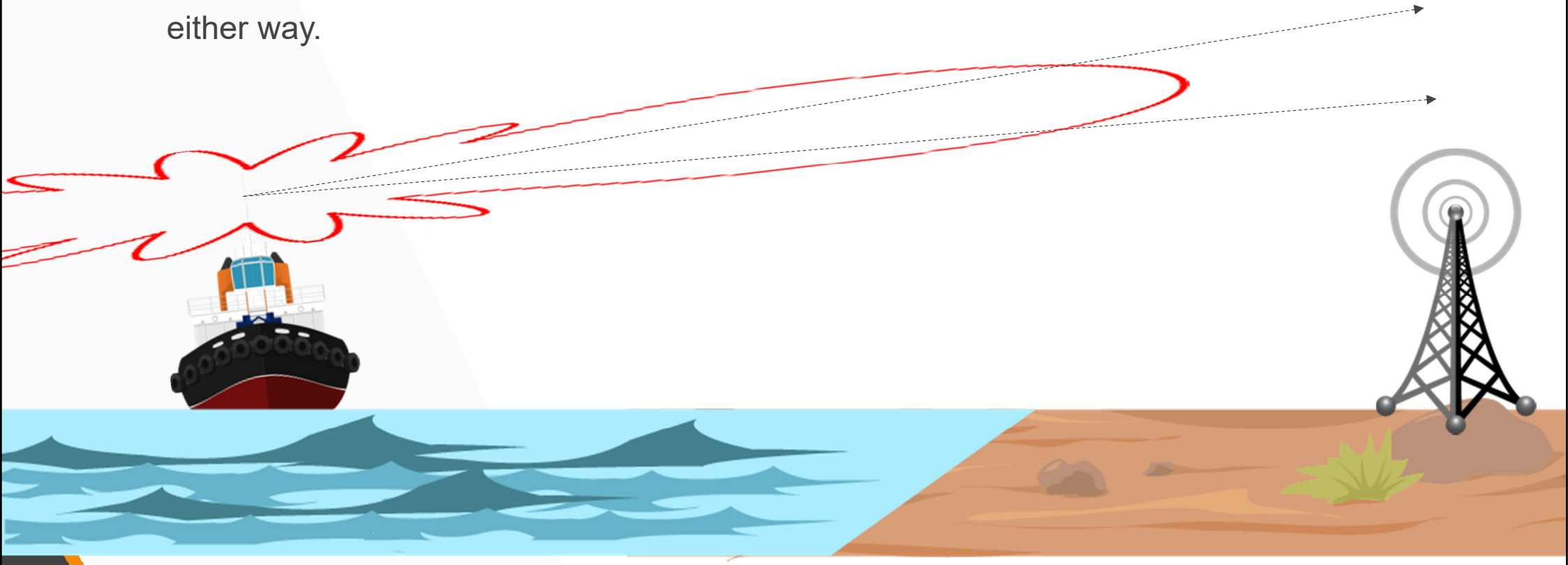


VS

- A good antenna will provide better connectivity to the network & therefore better reliability of your solution.
- A good quality router PLUS a good quality antenna EQUALS = quality solution.

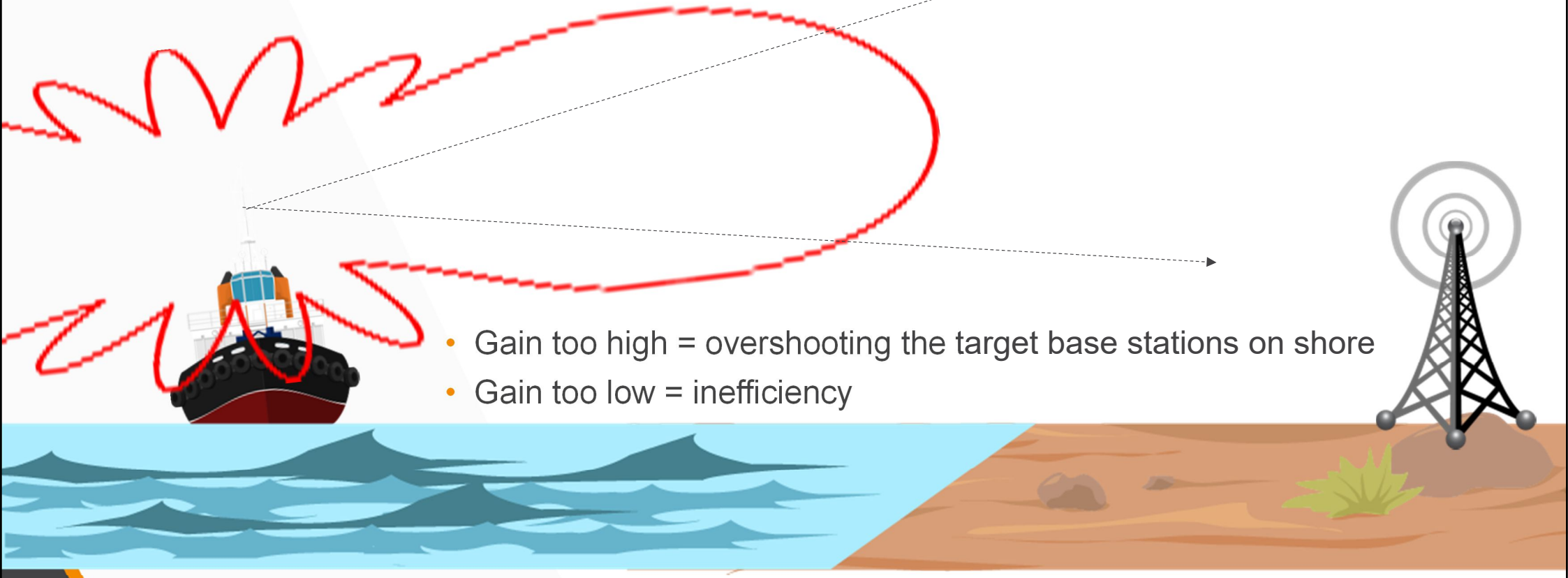
Marine Antennas Impact of high Gain

- A ship rolls to 10° on moderate seas, either way, sometime more (vessel and sea conditions)
- Antenna Gain of 9 dBi => 12° Antenna elevation beam-width => allows for +6° roll and -6° roll either way.



Marine Antennas Impact of high Gain

- Antenna gain of 4 to 7 dBi => 20° to 40° elevation beam-width => allows for 10° to 20° roll either way.



- Gain too high = overshooting the target base stations on shore
- Gain too low = inefficiency

Radio Propagation, Frequency Bands & Utilisation

Lower Frequency Bands = Better penetration
Longer distances – smaller data packages

Higher Frequency Bands = Poorer penetration
Shorter distances – larger data packages

Rural	Suburban	Urban	Commercial & Industrial	Dense Urban
Agricultural/farming, open fields, grass lands, small villages, etc.	Sparse residential, Freestanding Houses, etc.	Dense housing, 2 to 3 storeys	Factories, Commercial Buildings (typically 3-5 storeys), etc.	City Centres (CBD), High-rise buildings, etc.

Mobile Cellular Coverage

Cell Density

Mobile Cellular Utilisation (Capacity Demand)

LPDA vs. Yagi Antenna vs. Panel Antenna

DIRECTIONAL

			
Type	Yagi-Uda (aka Yagi)	Log Periodic Dipole Array (aka LPDA)	Panel
Visually	Driven element with reflector & radiators	Array of elements with different lengths	Rectangular, flat & unobtrusive
Bandwidth	Narrow Frequency Band	Widest Frequency Band	Frequency Band depends on design
Future Proof	Low	High	High
Reliability	Medium to High	High	Medium to High
Performance (Pattern, Gain, Etc.)	High	High	High
One product for many technologies & bands	Low	High	Medium to High
MIMO	Requires Additional Antenna	Requires Additional Antenna	Integrated 2x2, 4x4, etc.

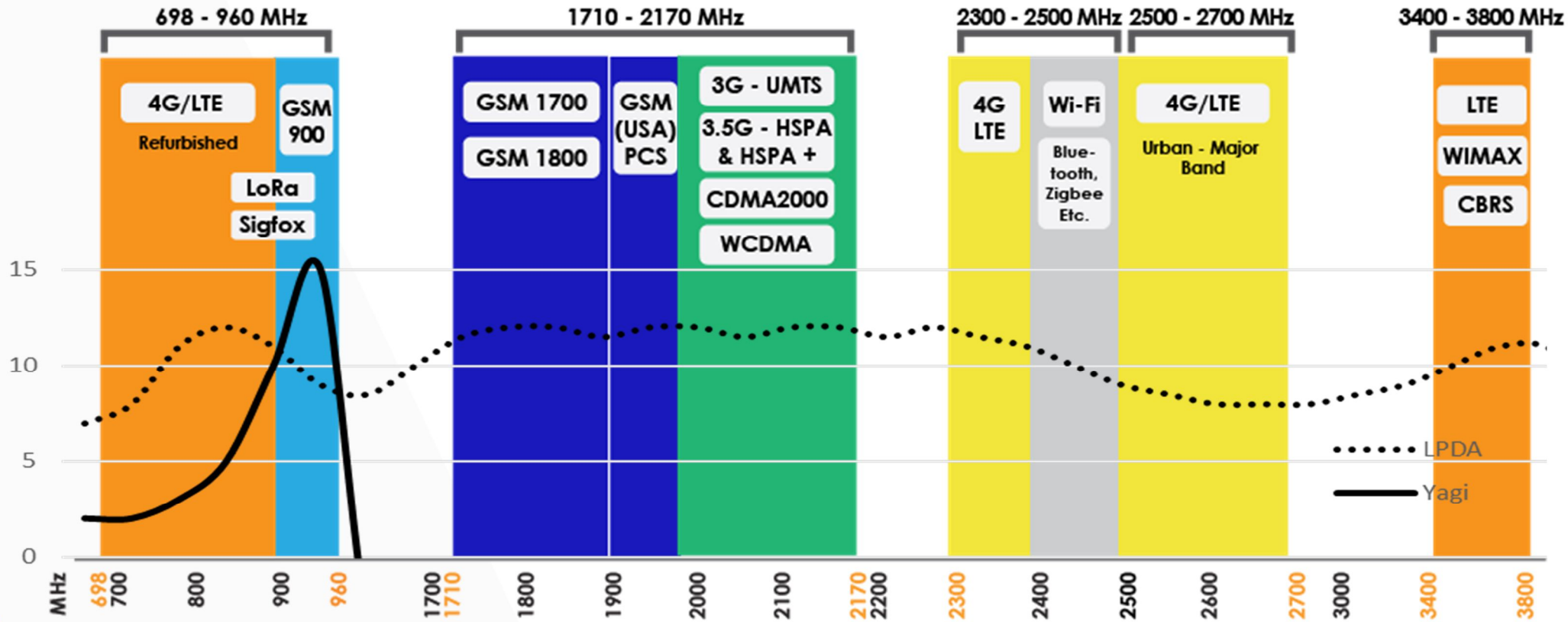
Omni Antennas – for wide band applications

OMNI-DIRECTIONAL

Type	Simple 'cheap' wire Omni	Linear Wideband Omni	Low Profile Antenna
Visually	"Thin" rubber or wire antenna	Thicker Antenna Diameter	Low height, flat antenna
Bandwidth	Narrow Frequency Band	Wide Frequency Band	Medium to Wide Frequency Band
Future Proof	Low	High	High
Ruggedness & vandal proof	Low	Medium	High
Performance (Pattern, Gain, Etc.)	Medium (Elevation Pattern Breakup)	High	Medium
One product for many technologies & bands	Low	High	High

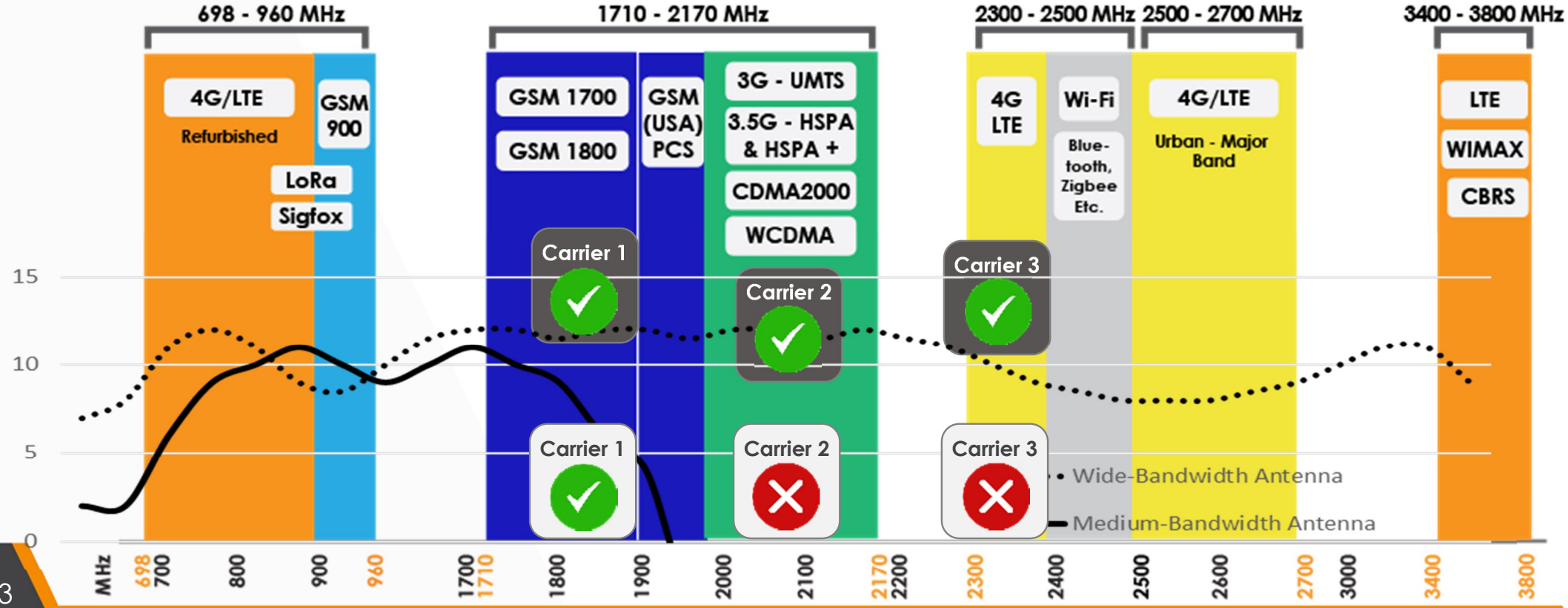
Why should you use wideband antennas?

- New technology evolution to new bands

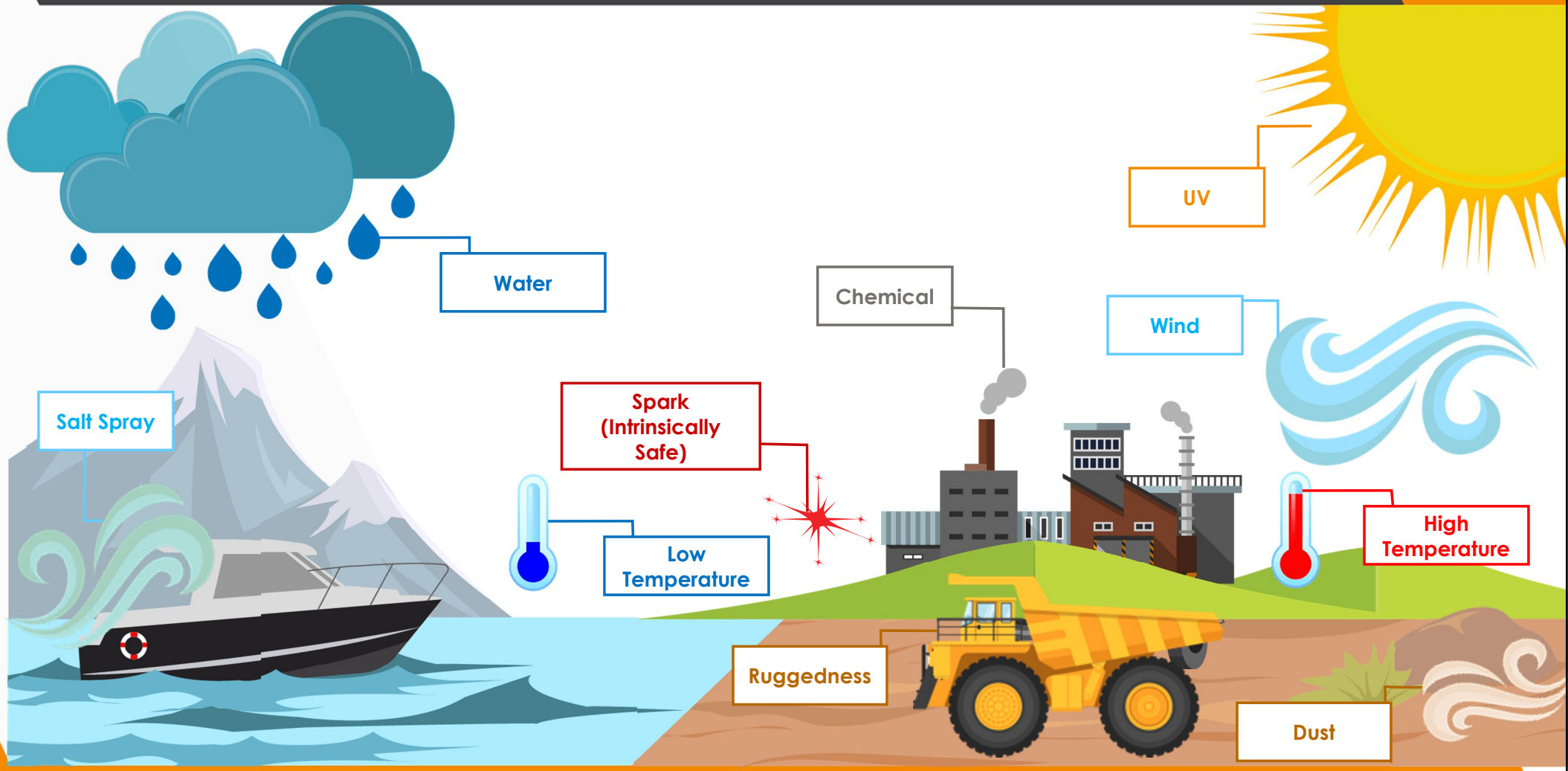


Why should you use wideband antennas?

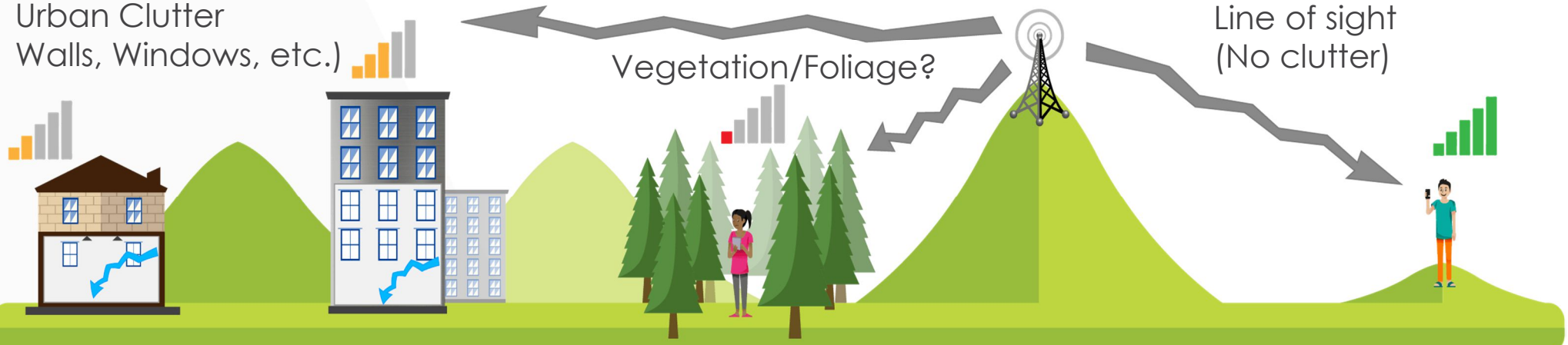
- Enable future technologies => LTE-A (Carrier Aggregation) and 5G Ready
  - Simultaneous data transmissions use more then one frequency in parallel
  - Carries use more frequencies to better manage base station capacities



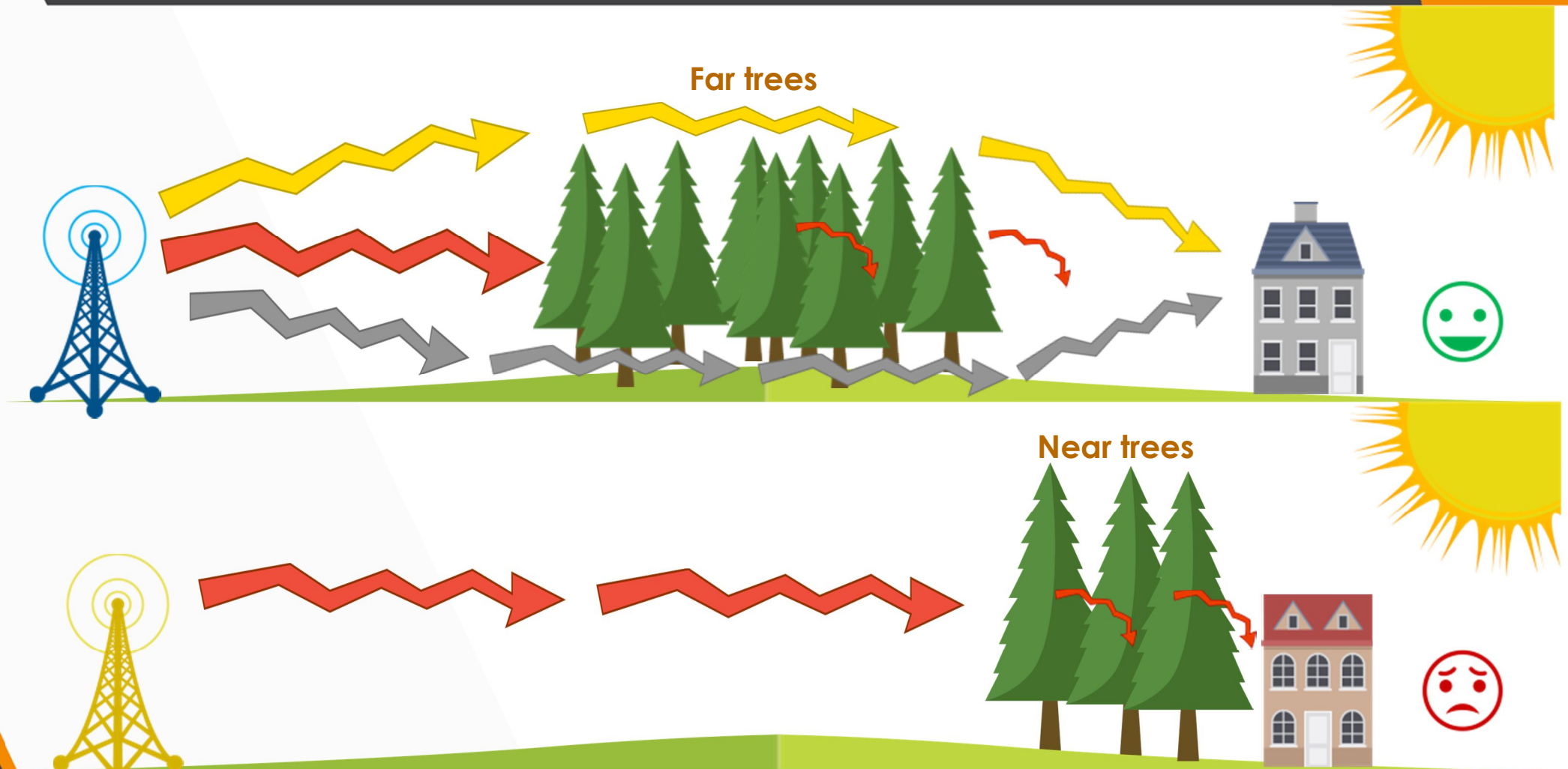
Environmental Aspects



Radio Propagation & Environment



Trees (and other obstacles) & Rain



Clutter

Signal Strength Attenuators* (Clutter):

Higher Attenuation

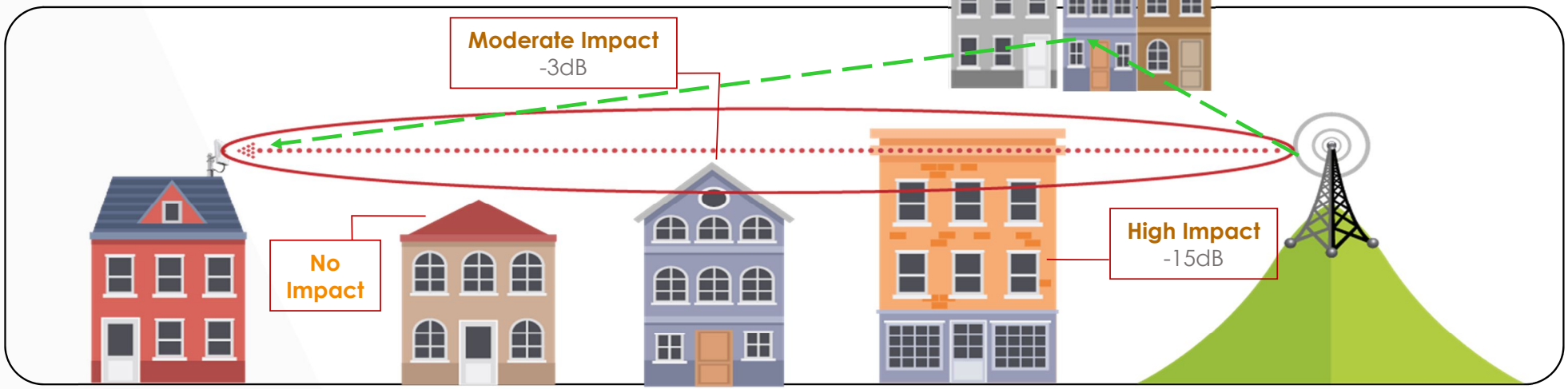
Lower Attenuation

- Reflective glass and double glazing
- Bricks/concrete/rock/metal
- Trees close by customer
- Normal glass, dry/hollow walls, etc.
- Trees blocking line of sight, but away from customer
- Rainfall
- Free Space

*Attenuator = any device designed to reduce the power of a wave or electrical signal without distorting it.

Obstacle Clearance

Far Obstacles & Freznel Zone



Near Obstacles

Why pay for a better Antenna?

- Antenna performance is critical for any wireless connection, hence on your bottom-line.
- Consequential costs of communications failure is much larger than the cost of the antenna.
- Cost of installation alone, often exceeds antenna price (due to recalls & reinstalls).