LMS4000 & NCL1900 900-MHz Radio Propagation

This application note is an update to the previous LMS3000/LMS3100 900 MHz Radio Propagation note. It provides general guidelines to estimate CCU3000 & NCL1900 radio coverage. Compared to alternative technologies, 900 MHz radios will provide excellent radio propagation, both in line-of-sight (LOS) and non-line-of-sight NLOS situations. This includes **Indoor** subscriber installations.

Although sharing several fundamental radio characteristics with the 2.4 GHz band, the 900-MHz radio band behaves very differently, since it has much stronger diffraction and penetration capabilities. To design for saturation coverage at 900 MHz is very different from traditional LOS or Near-LOS products.

The CCU/NCL1900 radio coverage is determined by the following (in no particular order):

1) Radio dynamics:
    - Transmitter output power
    - Receiver sensitivity (specify to a given BER at a ftp data rate)
    - Antenna gain including cable losses
    - Base station antenna type – null fill for indoor penetration
    - Antenna height
    - RF environment – in-band & out-of-band interference

2) Terrain
    - Flat
    - Hilly
    - Rolling
    - Depression
    - Water
    - Mountainous

3) Clutter (Land Usage)
    - Trees – leaf, needle, height, density
    - Buildings – single storey to multi-storey
    - Streets – single-lane to multi-lane
    - Fields – grass, crops, orchards

4) Indoor Penetration
    - Building materials – glass, siding, brick, stucco with metal lathe, concrete
    - Size of windows
    - Location of subscriber unit relative to base tower

Among these factors, higher transmitter output power and lower receiver sensitivity, combined with maximal antenna gain, can help extend coverage. However, FCC and Industry Canada regulate the maximum output power from the antenna. For instance, FCC mandates that the EIRP at antenna level for 900 MHz ISM band products be no higher than +36dBm, which is equivalent to 4 Watts. WaveRider specifies its receiver sensitivity at ftp data transfer rates, not airlink speeds and not at reduced throughput speeds.

Even in NLOS conditions, 900 MHz propagation can benefit from diffraction and penetration capabilities to allow reliable links. Factors affecting coverage include heavy foliage, thick exterior walls and buildings located close together. The following drawings show how terrain and clutter combined with antenna height can affect coverage.

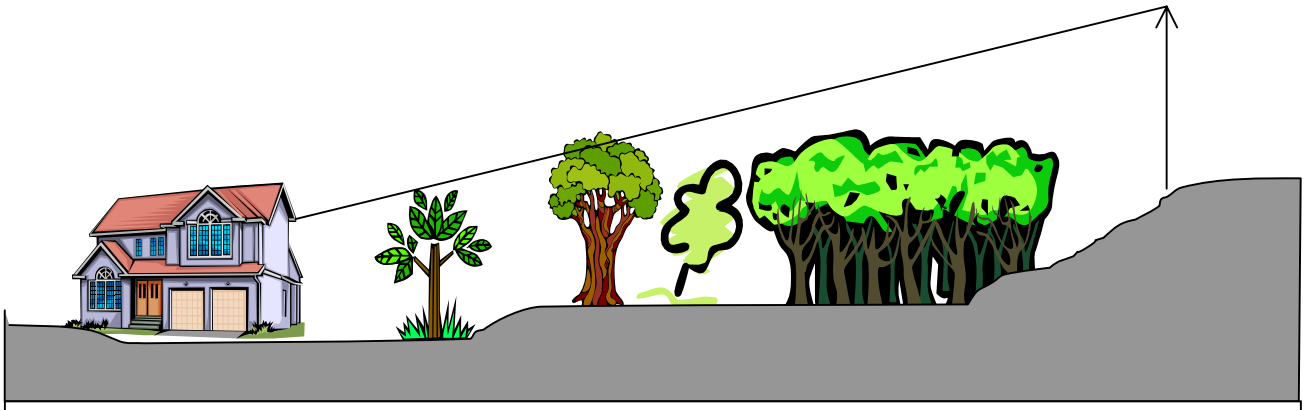

Figure 1: NLOS example. Less clutter is in the direct transmission path of the radio signal. This example may result in distances near the high end of the estimates.

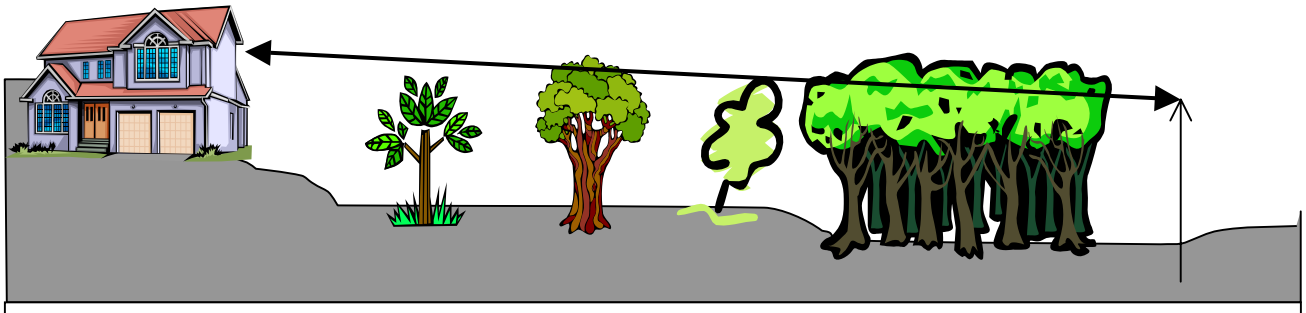

Figure 2: NLOS example. More foliage is in the direct transmission path of the radio signal. This example may result in distances near the lower end of the estimates.

The following table outlines the possible radio coverage breakdown with typical scenarios. Keep in mind that the results are general "rules of thumb". The actual results can vary significantly depending on the surrounding environment. These ranges have been updated to reflect actual subscriber installations.

TYPICAL RADIO COVERAGE

Typical Radio Coverage (radius from the CCU/NCL1900 antenna):

Subscriber Installation	**LOS**	**LOS** (through window)	**NLOS** (Can see rooftops from base antenna)	**NLOS** (Cannot see rooftops from base antenna)
Indoor antenna	na	As far as 3 mi (5 km)	As far as 2 mi (3.2 km)	As far as 1 mi (1.6 km)
Outdoor antenna	As far as 25 mi (40 km)	na	As far as 5 mi (8 km)	As far as 3 mi (5 km)

Notes and assumptions:

1. LOS (Line-of-sight) means first Fresnel zone clearance exists between the subscriber (EUM) antenna and the base station (CCU3000/NCL1900) antenna. At 25-miles (40-km), the required antenna height over flat earth is 187-ft (57-m).
2. Typical CCU/NCL1900 antenna height of 130-ft (40 m) and typical EUM antenna height of 13-ft (4-m) are assumed over a gently rolling terrain.
3. The CCU3000/NCL1900 EiRP has been maximized to +36 dBm in all cases. The EUM outdoor antenna (typical 12” Patch antenna) has a gain of 10-dBi, and the indoor antenna (WaveRider Diversity) 4.4 dBi.
4. The coverage in an urban environment is not applicable to extreme areas, like metropolitan central downtown areas that have many tall buildings closely located.
5. Coverage with WaveRider indoor antenna varies largely depending on the composition of the exterior walls and the structure of the subscriber premises. The penetration loss on glass window or exterior wall can vary from 6 to 15 dB. Typical window installations assume 8 dB loss.
6. Additional indoor range could be achieved by the use of the high gain Panel antenna mounted indoors, e.g. in an attic.

Picture 1: Typical urban area (high-density trees and/or buildings)

Picture 2: Typical suburban area (medium distance between trees and buildings)

Picture 3: Suburban area with open and flat terrain.

Picture 4: Suburban area with partial line-of-sight (distance to CAP tower: 1.2 mi / 1.9 km)

Picture 5: Rural area with non-line-of-sight (The CAP tower is 3.6 mi /5.8 km away behind the knoll across the road and cannot be seen.)

Picture 6: Suburban area with non-line-of-sight (0.56 mi / 0.91 km from CAP site)