Network connectivity – Base Station and mobiles at UHF frequencies – scenario 9a

Baseline obstruction version (flat terrain <1m undulations, minimal buildings, no significant vegetation – forest/jungle)
All units using basic radios – Base station has better (higher power P(Tx), better sensitivity S(Rx)) than mobiles
Benign radio environment – Environmental noise < S(Rx) at 'Rural' level.

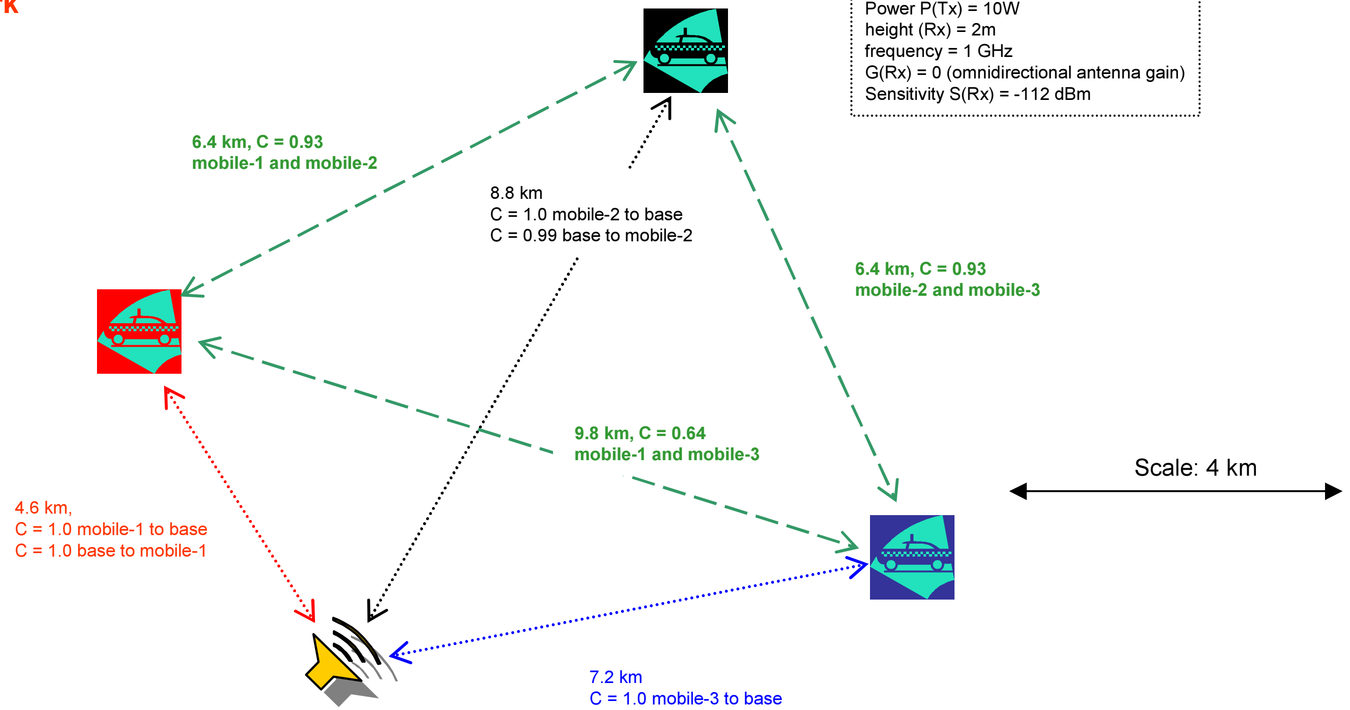
Examine the effect of a built up area on the network

• To establish a baseline system to examine the effects of a built up area (BUA), parameters will be set to establish workable connectivity.

•The mobiles have been given a transmitter power of 10W and antenna mountings of 2m height to establish a reasonable level of connectivity across all the links.

• The noise background has been set at 'rural', below the sensitivity of the receivers at this 1 GHz frequency and 200kHz bandwidth, so the more sensitive base station receiver advantages are realised.

mobiles
Power P(Tx) = 10W
height (Rx) = 2m
frequency = 1 GHz
G(Rx) = 0 (omnidirectional antenna gain)
Sensitivity S(Rx) = -112 dBm



Base Station
Power P(Tx) = 20 W
frequency= 1 GHz
G(Tx) = 0 dB (omnidirectional antenna gain)
height (Tx) = 10m
Sensitivity S(Rx) = -116 dBm

• 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.

Baseline Network Connectivity

• For the 'centralised - duplex' (between mobiles and base station) sub-net, the connectivity is 5.99 across the 6 links (99.8%).

• For the 'full' net the connectivity is 10.99 across the 12 links (91.6%), the 'centralised - duplex' sub-net (between mobiles and base station) provides 55% of that connectivity and the 'mobile to mobile' sub-net provides the remaining 45%.

Network connectivity – Base Station and mobiles at UHF frequencies – scenario 9b

Modified obstruction version (flat terrain <1m undulations, BUA , no significant vegetation – forest/jungle)
All units using basic radios – Base station has better (higher power P(Tx), better sensitivity S(Rx)) than mobiles
Benign radio environment – Environmental noise < S(Rx) at 'Rural' level.

Examine the effect of a built up area (BUA) on the network

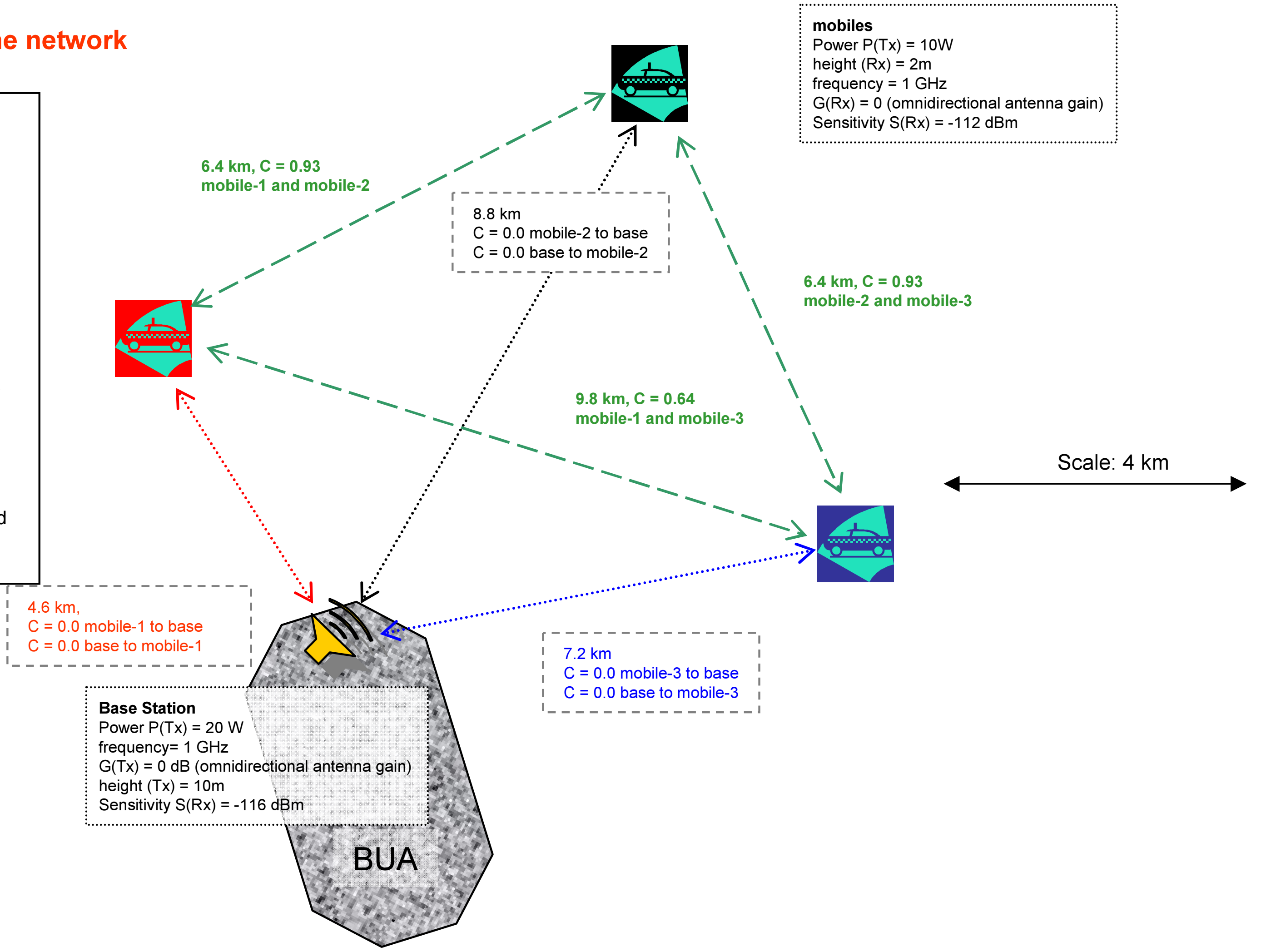
• The base station is located **~50m from the edge** of a built-up area (BUA) in the direction of the other units.

• The buildings are assumed to be higher than the 10m height of the base station antenna such that LOS to the mobiles passes through the buildings. Across 50m the radio signals are assumed to be passing through 3 to 4 buildings.

• The wavelength at 1 GHz is only 30 cm which is far too small for the radio waves to propagate propagate over or around typical 10+m high structures.

• Usually in a BUA the radio noise increases (e.g. from 'rural' to at least 'suburban') but that effect will be ignored here to isolate the effect of buildings on propagation.

• The affected paths are the 'centralised - duplex' (between mobiles and base station) sub-net. In this case all of these links have been severed, with connectivity reduced to zero.



Modified Network Connectivity

• For the 'centralised - duplex' (between mobiles and base station) sub-net, the connectivity is 0.0 (reduced from 5.99) across the 6 links (0%, reduced from 99.8%).

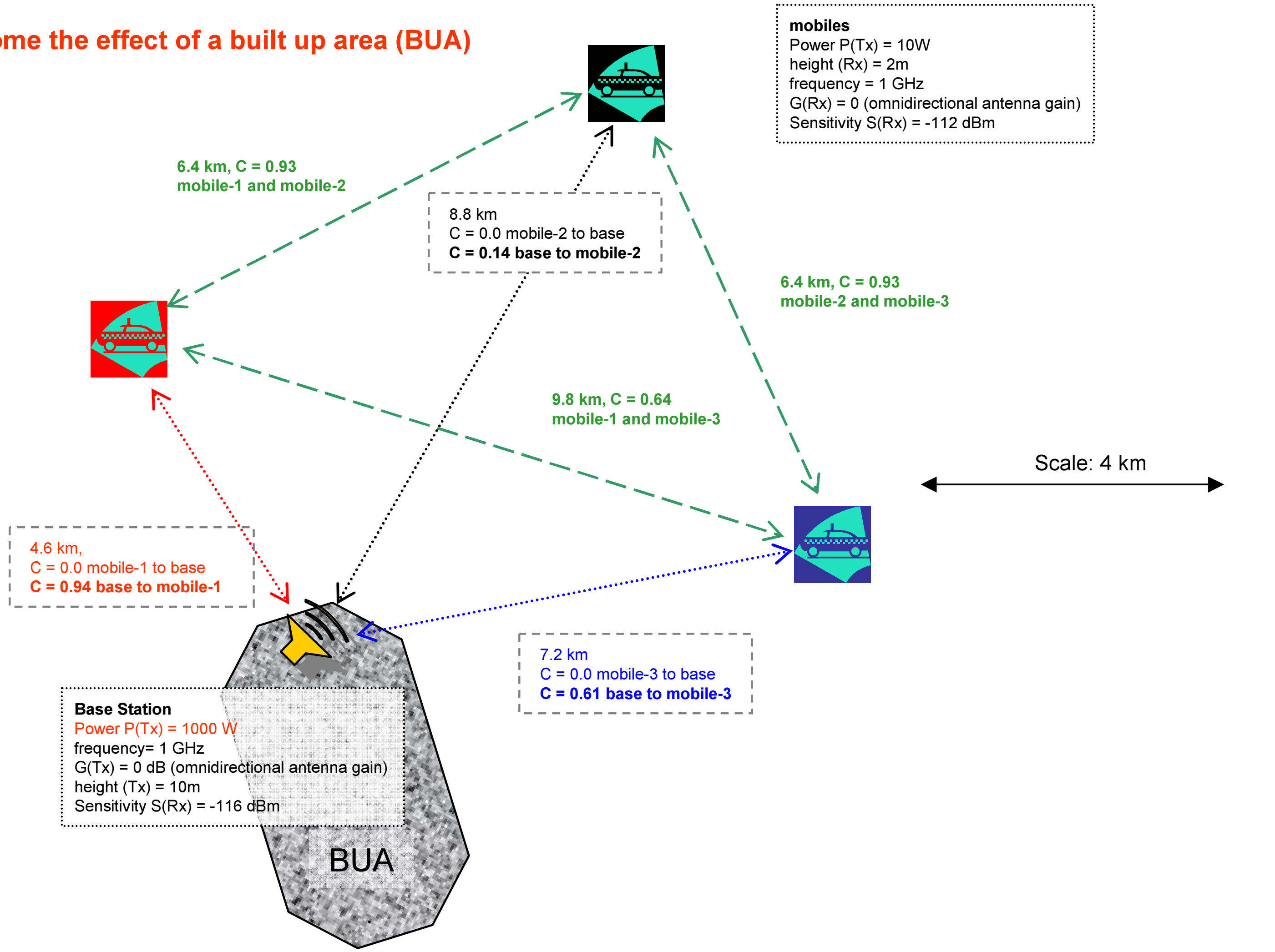
• For the 'full' net the connectivity is 5.0 (reduced from 10.99) across the 12 links (41.6%, down from 91.6%), the 'centralised - duplex' sub-net (between mobiles and base station) provides 0% of that connectivity (down from 55%) and the 'mobile to mobile' sub-net now provides 100% (up from 45%).

Network connectivity – Base Station and mobiles at UHF frequencies – scenario 9c

Modified obstruction version (flat terrain <1m undulations, BUA , no significant vegetation – forest/jungle)
All units using basic radios – Base station has better (higher power P(Tx), better sensitivity S(Rx)) than mobiles
Benign radio environment – Environmental noise < S(Rx) at 'Rural' level.

Examine using higher transmitter power to overcome the effect of a built up area (BUA) on the network

- The base station is located **~50m from the edge** of a built-up area (BUA) in the direction of the other units.
- Using only 20W power is not enough to maintain connection to the mobiles. This scenario will examine the effect of increasing base station power.
- Note that an alternate solution of increasing receiver sensitivity involves considerable expense and it can only be increased by a relatively small amount. So to improve the mobile-to-base station links higher transmitter power at the mobiles would need to be used.
- The most effective solution is to raise the base station antenna above the buildings, for example by placing it on the rooftops. However it is interesting to see how advantageous that is by illustrating how much transmitter power is required to overcome the building attenuation.
- If base station power is increased 5x to 100W the connectivity to the closest mobile-1 is still only 0.36, barely useable. So a significantly higher power is required.
- If the base station power is 1000W (1 kW) the connectivity to mobile-1 is 0.94 which is substantial.
- However the connectivity to the furthest mobile-2 is only 0.14 which is very weak. 2kW gives C = 0.57 and 5kW gives C = 0.83. 5kW is an enormously powerful transmitter to be using over such ranges and expensive to purchase and operate. This highlights the limitation of using transmitter power to try and overcome attenuation by obstacles.
- If the antenna could not be raised above the buildings then a combination of higher transmitter power and high gain directional antennas may be used rather than just increasing power.



Modified Network Connectivity

- For the 'centralised - duplex' (between mobiles and base station) sub-net, the connectivity is 1.69 (increased from 0.0) across the 6 links (28%, increased from 0%). This is still low as the mobiles cannot reach the base station.
- For the 'full' net the connectivity is 6.69 (increased from 5.0) across the 12 links (55.8%, increased from 41.6%). The 'centralised - duplex' sub-net (between mobiles and base station) provides only 25% of that connectivity and the 'mobile to mobile' sub-net provides 75%.