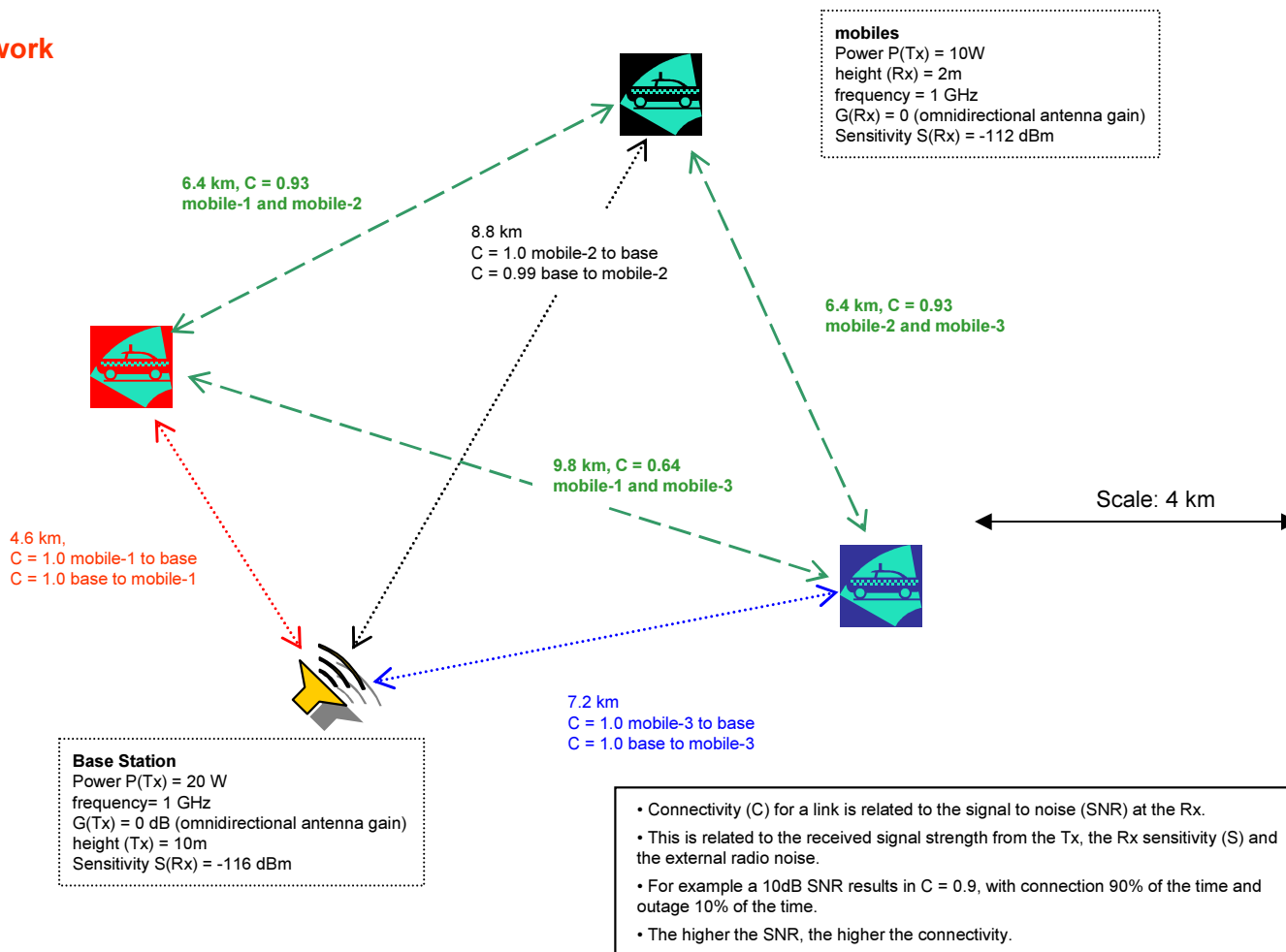Baseline obstruction version (flat terrain <1m undulations, minimal buildings, no significant vegetation – forest/jungle)
All units using basic radios – Base station has better (higher power P(Tx), better sensitivity S(Rx)) than mobiles
Benign radio environment – Environmental noise < S(Rx) at 'Rural'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

Examine the effect of dense vegetation on the network

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

• To establish a baseline system to examine the effects that dense vegetation has on connectivity, 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.

6.4 km, C = 0.93
mobile-1 and mobile-2

8.8 km
C = 1.0 mobile-2 to base
C = 0.99 base to mobile-2

6.4 km, C = 0.93
mobile-2 and mobile-3

9.8 km, C = 0.64
mobile-1 and mobile-3

4.6 km,
C = 1.0 mobile-1 to base
C = 1.0 base to mobile-1

Scale: 4 km

7.2 km
C = 1.0 mobile-3 to base
C = 1.0 base to mobile-3

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%.

Spectrum Skywave

Network connectivity – Base Station and mobiles at UHF frequencies – scenario 8b
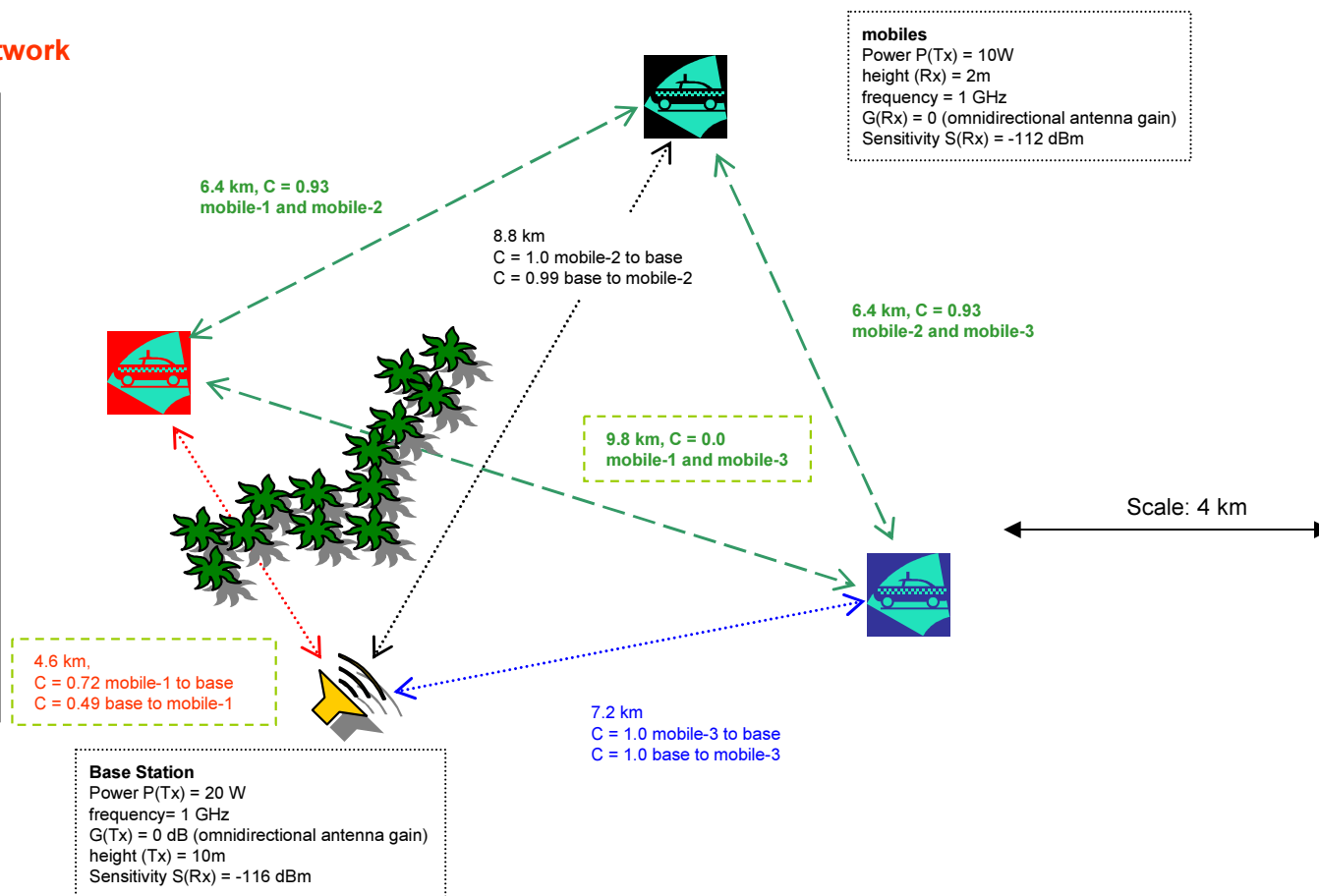Modified obstruction version (flat terrain <1m undulations, minimal buildings, significant vegetation)
All units using basic radios – Base station has better (higher power P(Tx), better sensitivity S(Rx)) than mobiles
Benign radio environment – Environmental noise < S(Rx) at 'Rural' level.

Examine the effect of dense vegetation on the network

• A line of dense vegetation, high enough (>10m) that the LOS signal passes through it, runs inside the network area between units.

• The dense vegetation would be of type forest or jungle.

• The length of radio path that the vegetation lies across is assumed to 150 metres deep.

• For comparison, the vegetation lies across the strongest links between mobile-1 and the base station and also the weakest between mobile-1 and mobile-3.

• The strongest link between mobile-1 and the base station has been reduced from perfect C = 1.0 to only moderate C = 0.72 connectivity. The reverse path has been reduced to quite weak C = 0.49 connectivity.

• As well as the connectivity it is useful to examine the loss in channel capacity. For a 200kHz bandwidth the capacity of the mobile-1 to base station link has been reduced from 2.4Mbs to 0.46Mbs, a drop of 80%.

• The weak inter-mobile link has been severed by the vegetation. The link between mobile-1 and mobile-3 is so tenuous that only 20m of dense vegetation would cut it.

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

6.4 km, C = 0.93
mobile-1 and mobile-2

8.8 km
C = 1.0 mobile-2 to base
C = 0.99 base to mobile-2

6.4 km, C = 0.93
mobile-2 and mobile-3

9.8 km, C = 0.0
mobile-1 and mobile-3

Scale: 4 km

4.6 km,
C = 0.72 mobile-1 to base
C = 0.49 base to mobile-1

7.2 km
C = 1.0 mobile-3 to base
C = 1.0 base to mobile-3

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

Modified Network Connectivity

• For the 'centralised - duplex' (between mobiles and base station) sub-net, the connectivity is 5.2 (reduced from 5.99) across the 6 links (86.7%, reduced from 99.8%).

• For the 'full' net the connectivity is 8.92 (reduced from 10.99) across the 12 links (74.3%, down from 91.6%), the 'centralised - duplex' sub-net (between mobiles and base station) provides 58% of that connectivity (up from 55%) and the 'mobile to mobile' sub-net provides the remaining 42% (down from 45%).

Modified obstruction version (flat terrain <1m undulations, minimal buildings, significant vegetation)
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.

Using transmitter power to overcome the effect of dense vegetation on the network

• If the transmitting and receiving antennas cannot be elevated above the vegetation the most obvious solution is to try increasing the transmitter power to counter the increased signal attenuation.

• If the mobile-1 transmitter power were increased 5x to 50W the link to the base station has connectivity increased from 0.72 to 0.94 and capacity increased from 0.46Mbs to 0.82Mbs.

• However even 50W is not quite enough to re-establish the link from mobile-1 to mobile-3. If the power were increased to 100W then the connectivity would be 0.42.

• Hence dense vegetation can be seen as an effective attenuator of signal at these relatively high UHF frequencies. The attenuation would be less at lower VHF or MF/HF frequencies.

Mobiles 2 and 3
Power P(Tx) = 10W
height (Rx) = 2m
frequency = 1 GHz
G(Rx) = 0 (omnidirectional antenna gain)
Sensitivity S(Rx) = -112 dBm

6.4 km, C = 0.93
mobile-1 and mobile-2

8.8 km
C = 1.0 mobile-2 to base
C = 0.99 base to mobile-2

6.4 km, C = 0.93
mobile-2 and mobile-3

Mobile-1
Power P(Tx) = 50W

9.8 km, C = 0.0
mobile-1 and mobile-3

Scale: 4 km

4.6 km,
C = 0.94 mobile-1 to base
C = 0.49 base to mobile-1

7.2 km
C = 1.0 mobile-3 to base
C = 1.0 base to mobile-3

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

Spectrum Skywave