



Cambridge White Spaces Trial

Co-existence of White Space systems with Terrestrial Digital TV
Systems

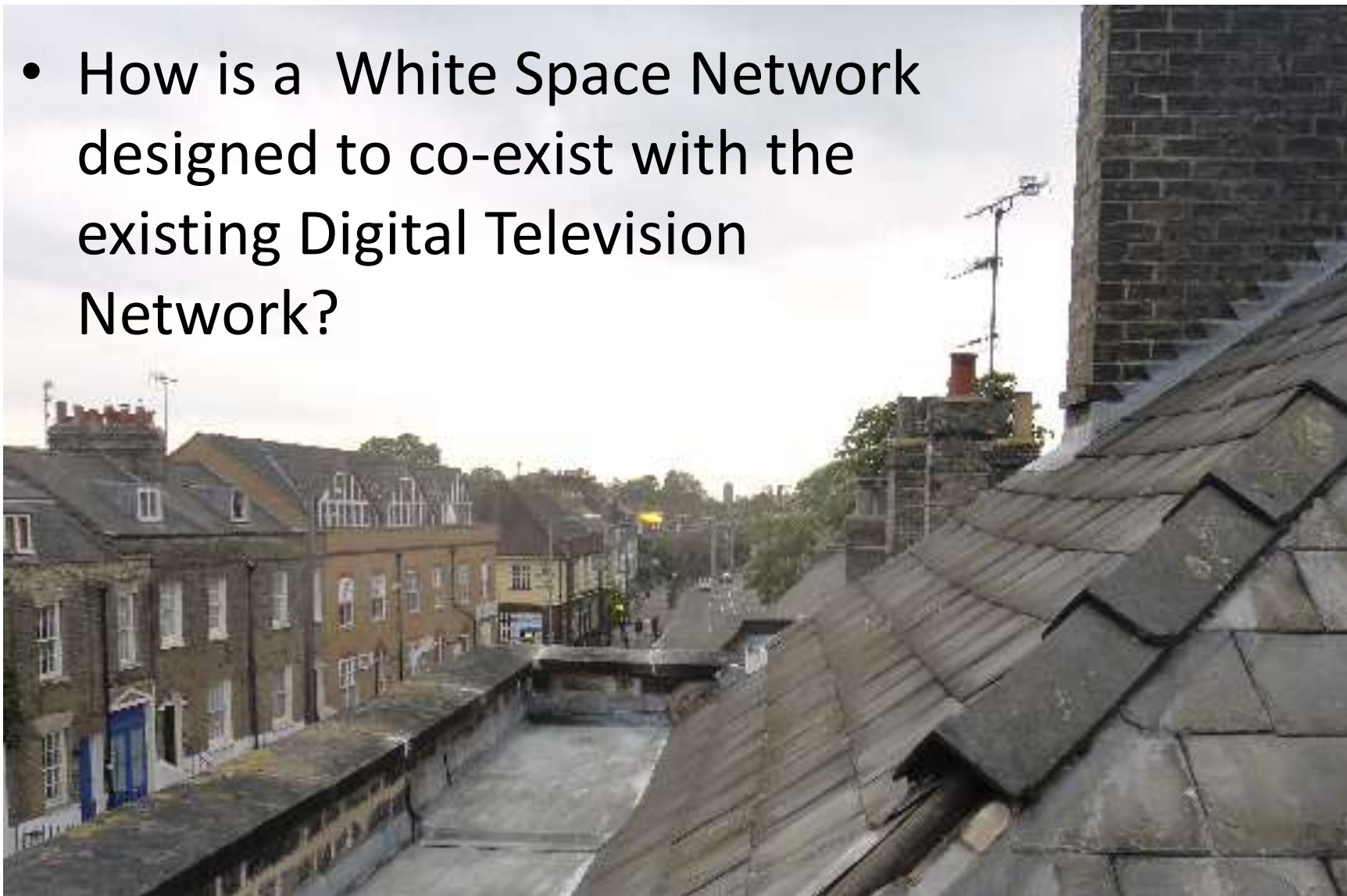
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13th December 2011



Typical urban Cambridge roof top scene

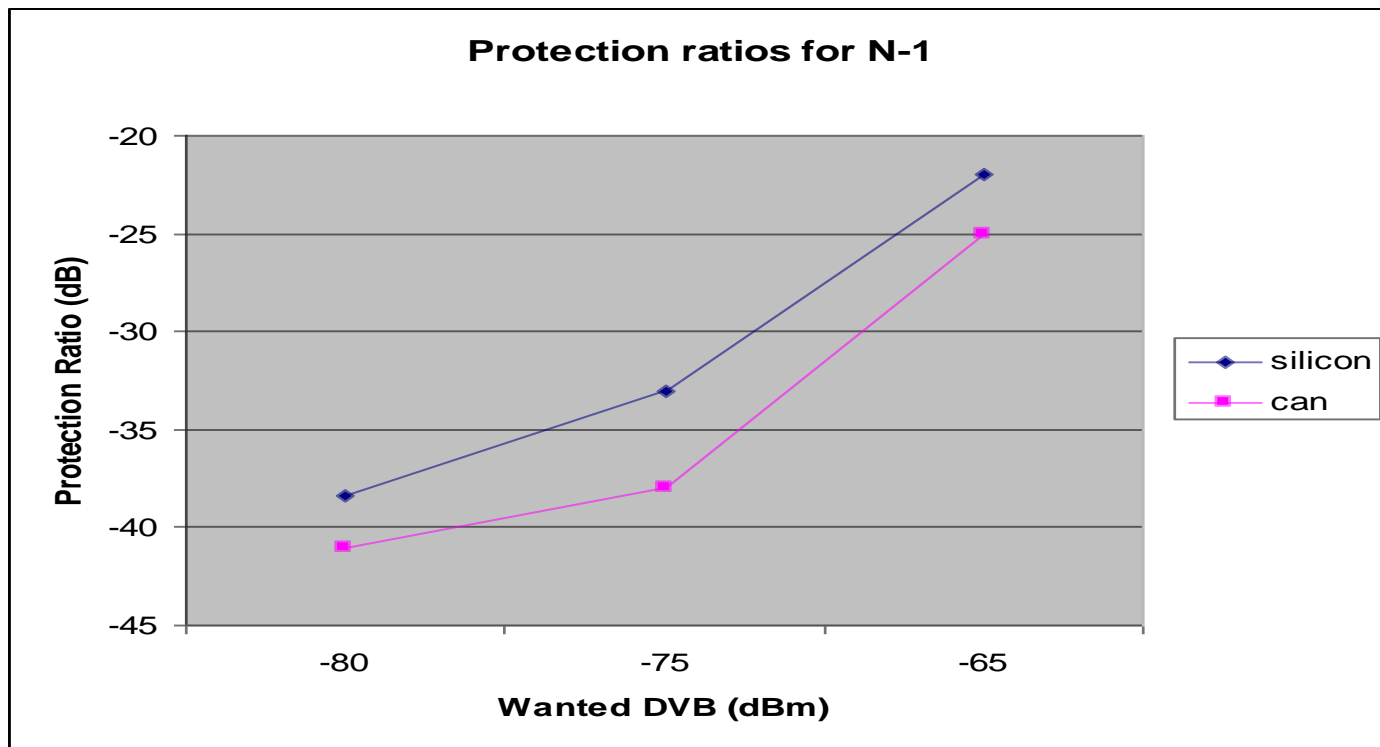
- How is a White Space Network designed to co-exist with the existing Digital Television Network?



Three key factors needed to be understood to allow networks to be designed to co-exist

- Protection ratio
- Coupling factors – the derivation of two standard geometries
 - WS Base station to 10 m roof top DTT reception
 - WS consumer unit (CU) to 10 m roof top reception
- Statistical methods for combining these factors to estimate impact of a TVWS network on a DTT Network

Protection ratios – Some results from the trial

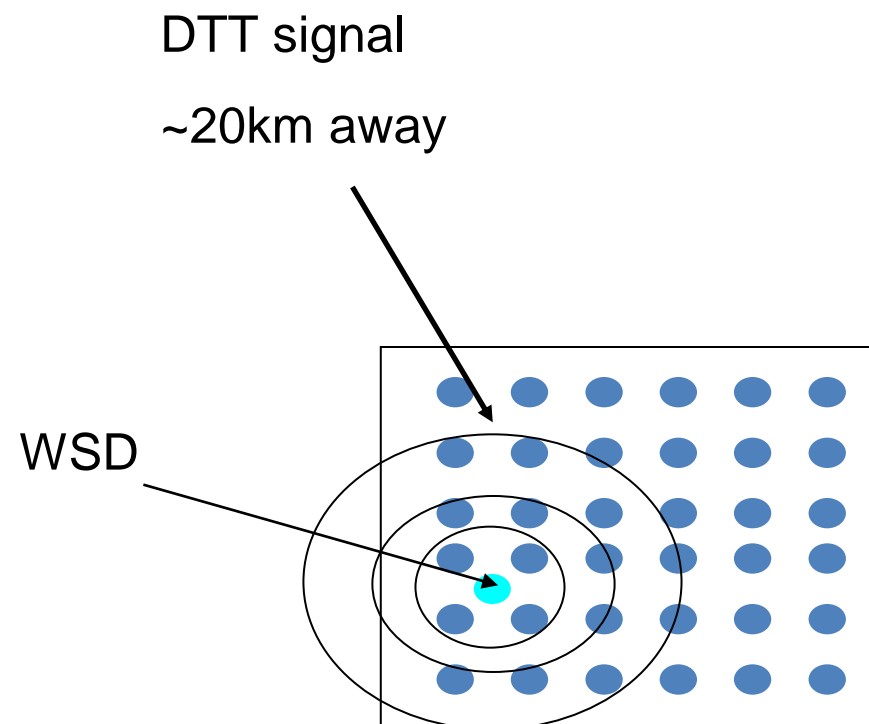
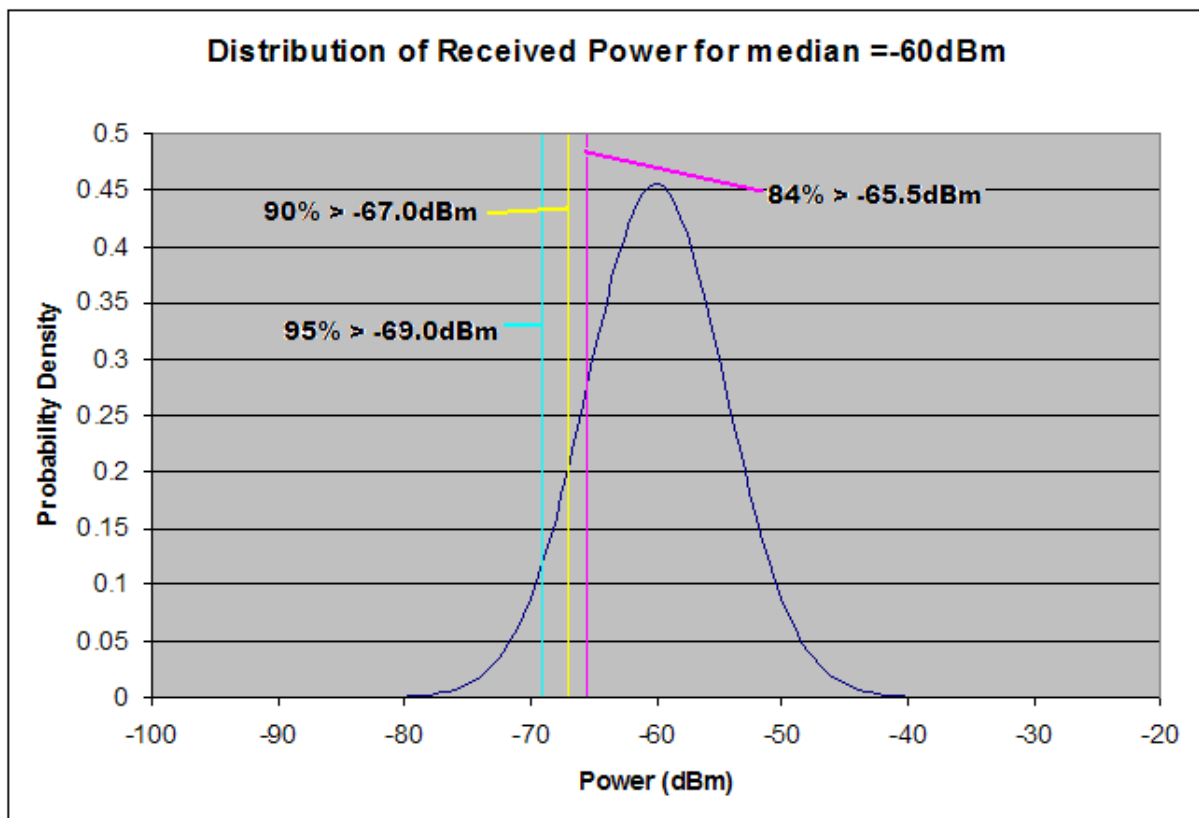


Protection ratio is worse for stronger wanted DVB.

Probably cross-modulation and/or AGC effects dominate

The protection ratio results are very variable and significant further work is required in this area. In this presentation we will assume that the protection ratio is -40 dB for N-2 and the WS device output is noise like and has very low (better than -60 dB) out of band spurious

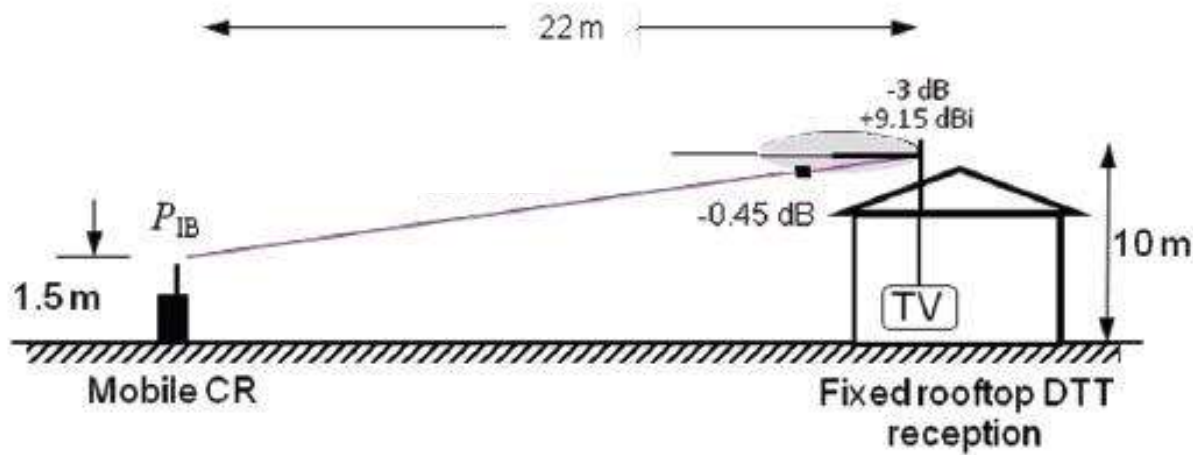
Interpreting percentage locations when interference is within pixel



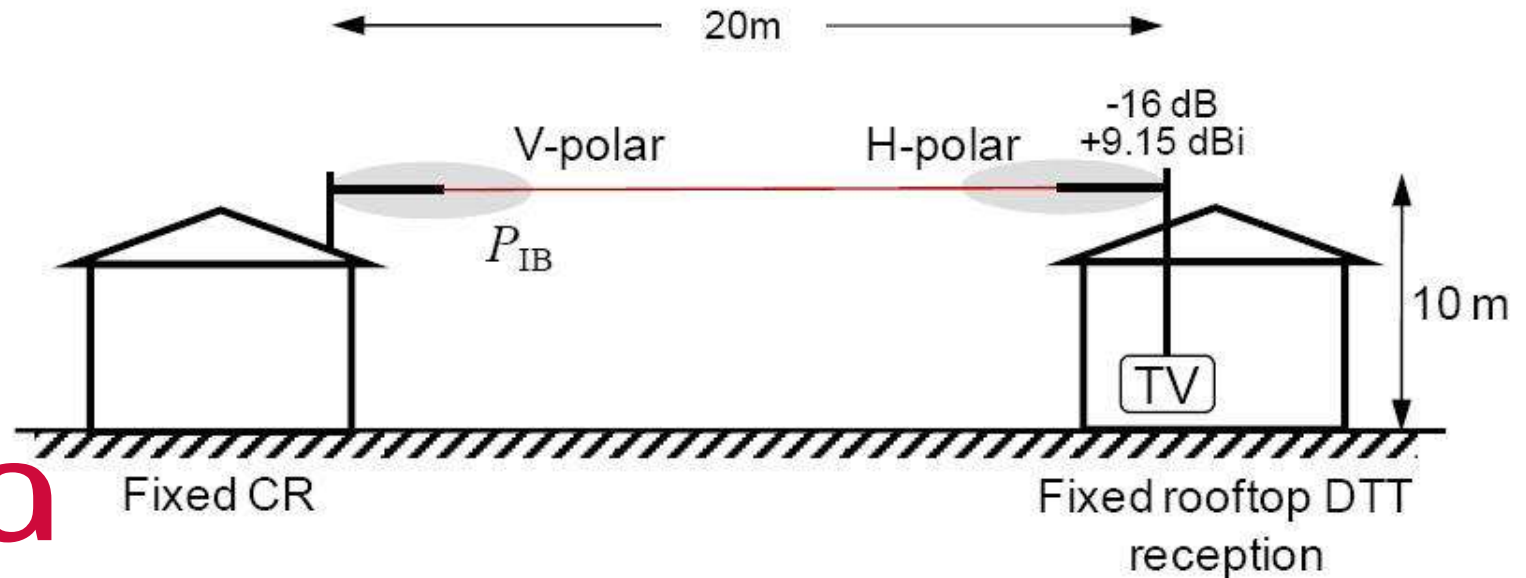
CINR is not uniform over pixel
100m X 100m pixel

Coupling

Reference Geometry 1



Reference Geometry 2



Measurements in Cambridge Reference Geometry 1



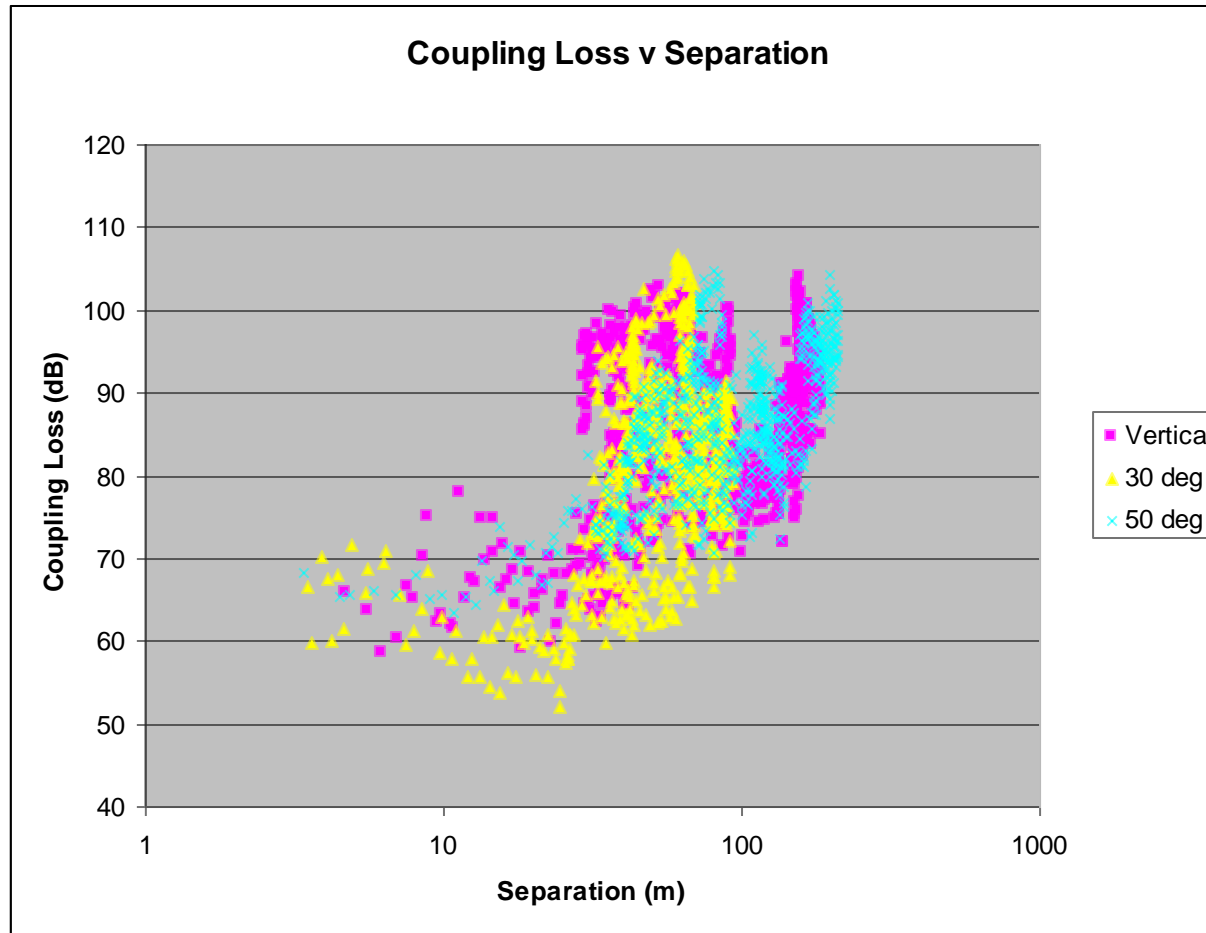
Antenna 6

Antenna 1



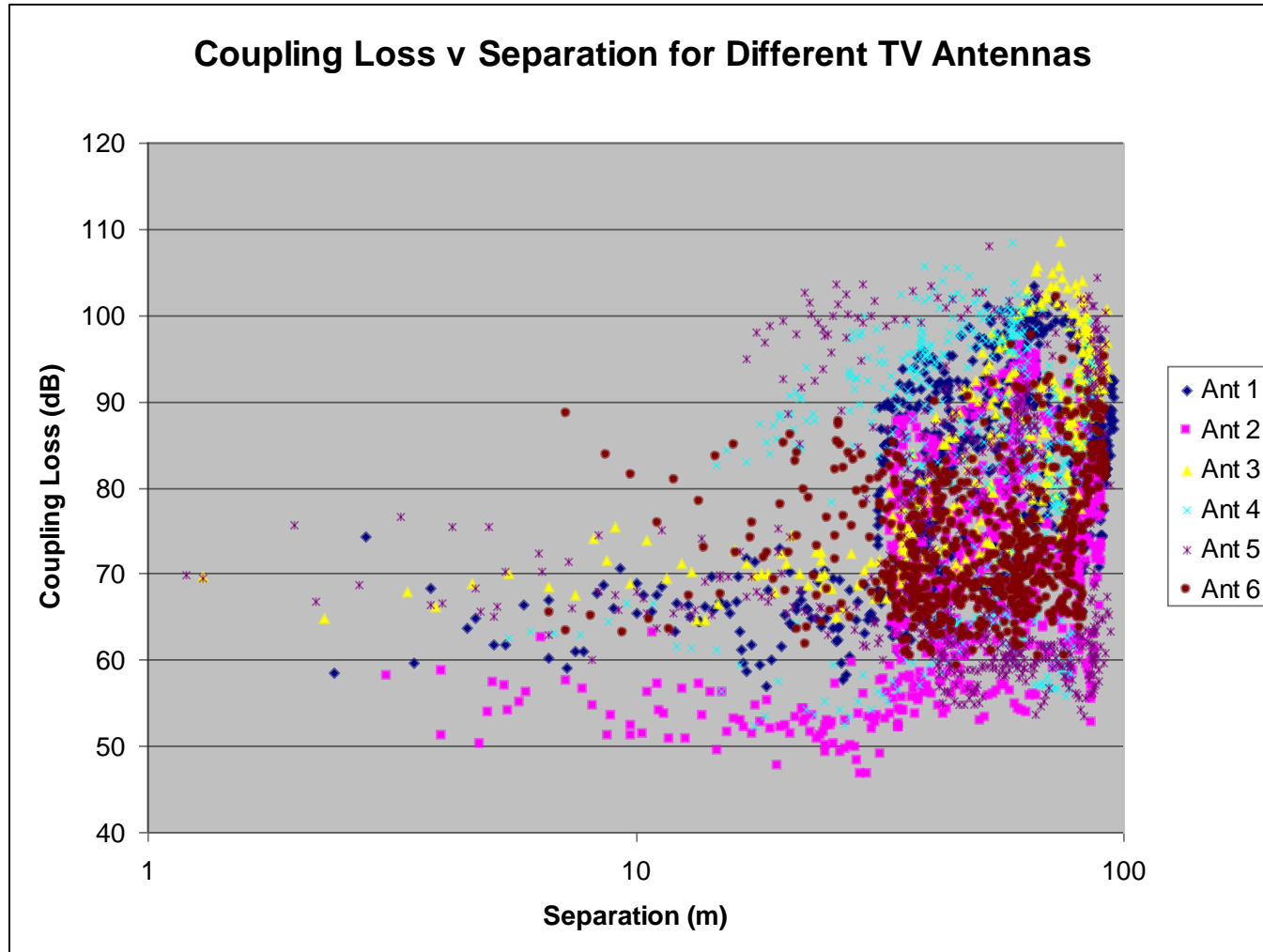
Results

Reference Geometry 1



Results

Reference Geometry 1



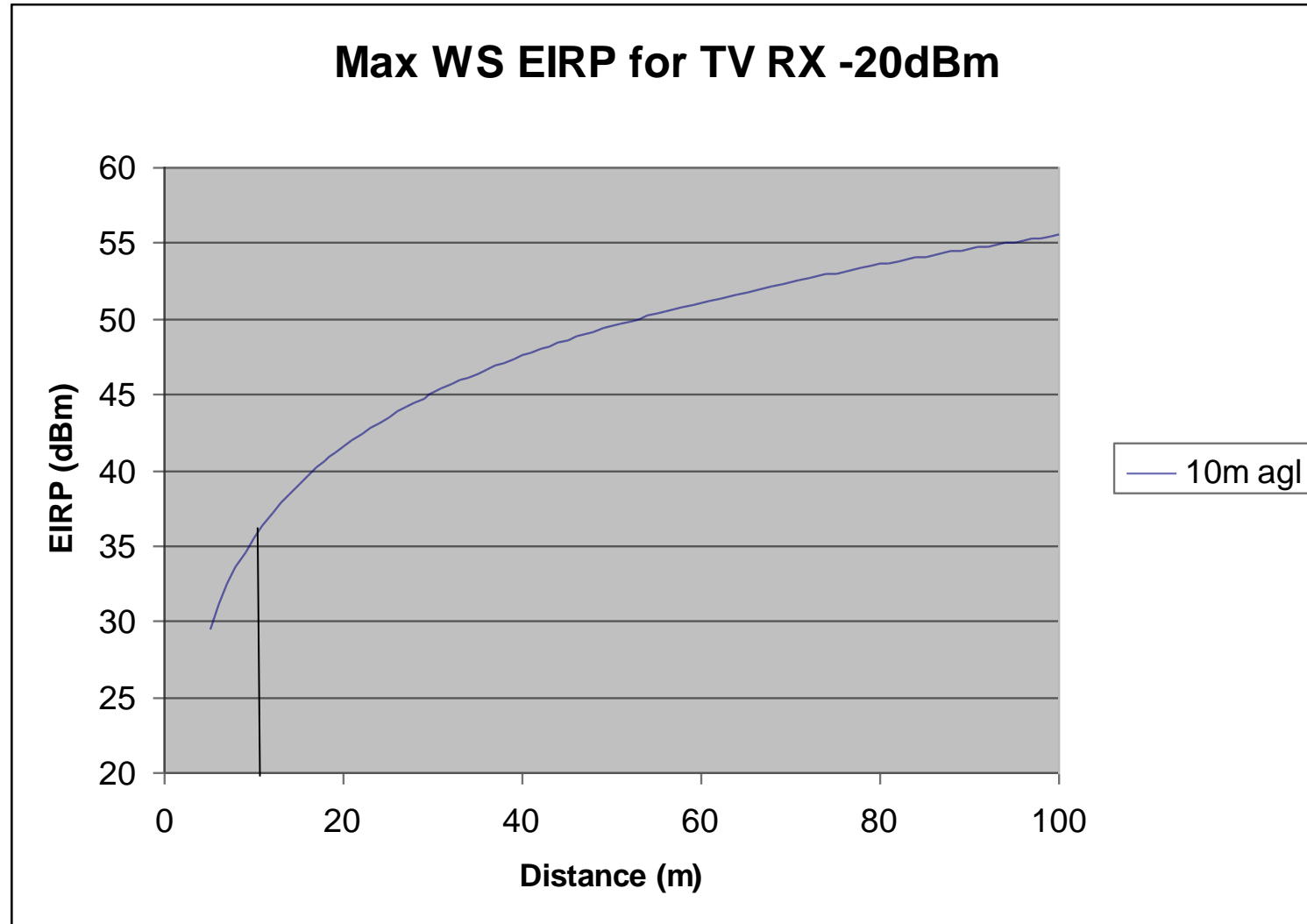
Key results from the trial

- Confirmation of the coupling loss reaching a minimum at 22m in Reference Geometry 1
- Confirmation of the polarisation discrimination between a vertically polarised WS BS and a horizontally polarised DTT receiver both at 10m agl is -16dB for Reference Geometry 2
- Protection ratio curves as seen earlier

Application of results

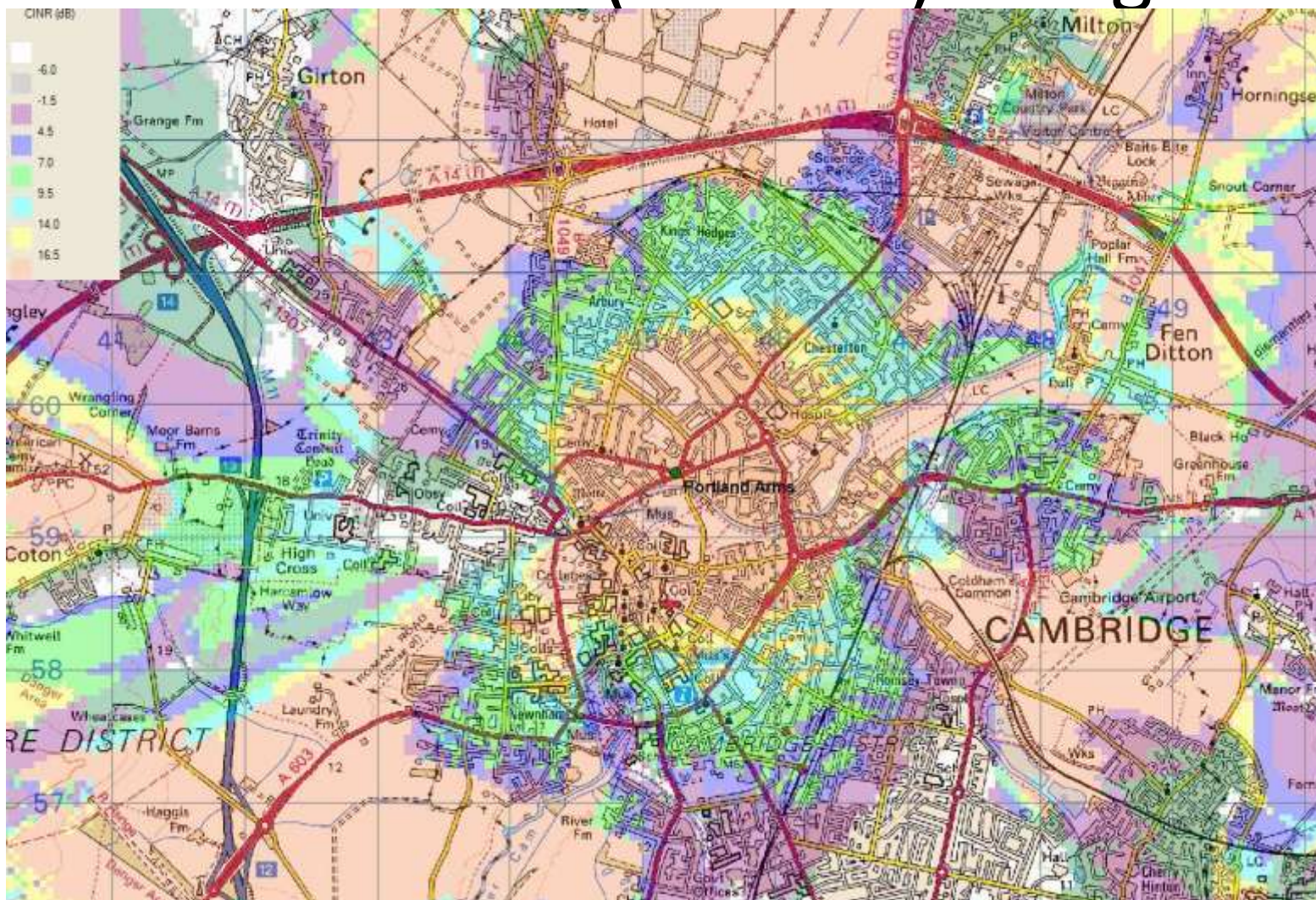
- Assume that DTT received levels in the area are good and **all locations** are above -60 dBm so for 95% locations the median will be 51dB
 - Using a protection ratio of -40 dB the input into the front end of the DTT receiver can then be -20 dBm before any DTT reception is lost
 - For down link see curves on next slide
 - For uplink WS max ERP is 30 dBm
 $(-20 \text{ dBm} - (-50^*)) = 30\text{dBm} = 1 \text{ W}$
- *Arqiva has measured coupling factors as low as -45 dB

Distance v EIRP WS BS (Very good DTT reception)



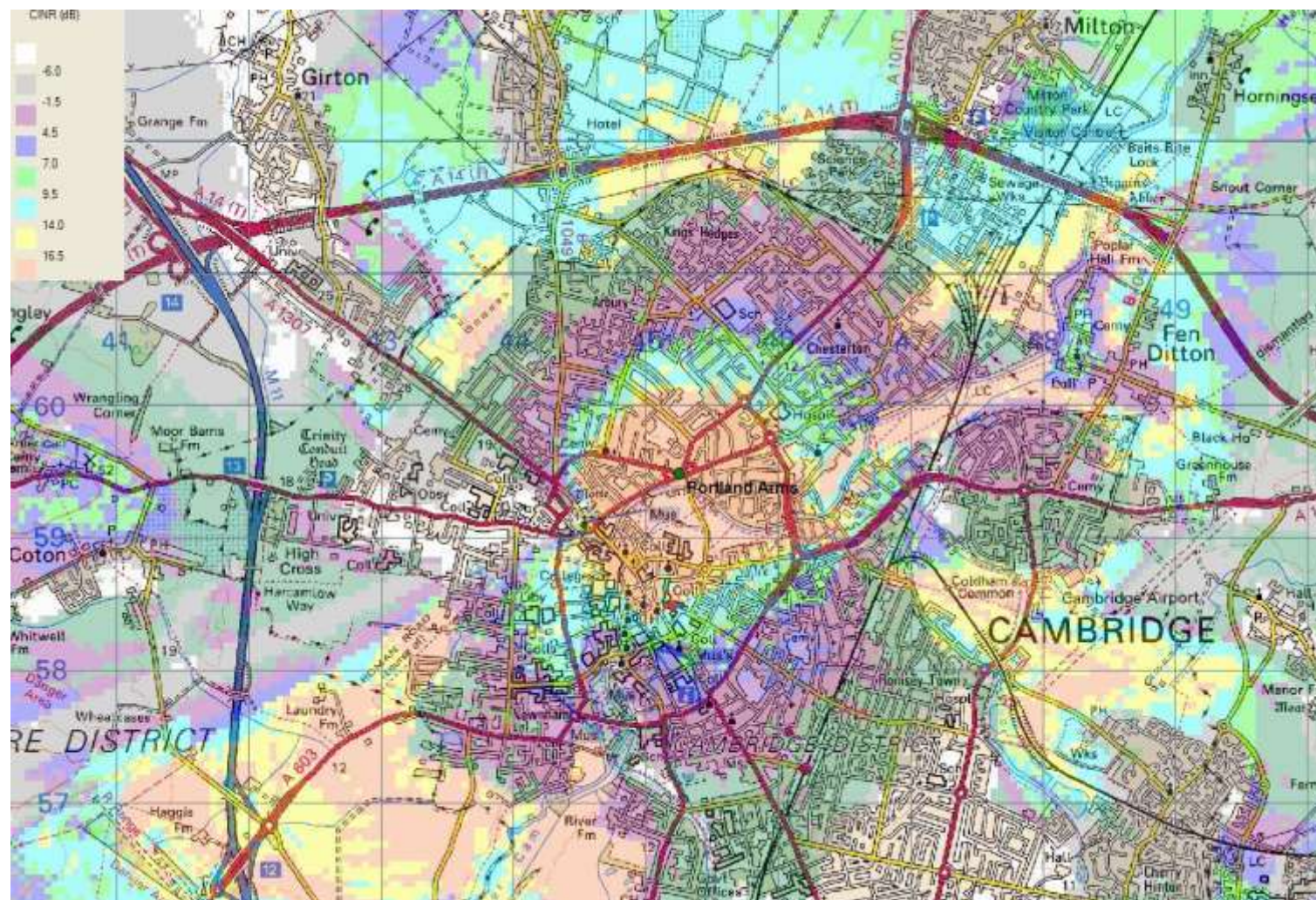
Coverage WS down link no DTT interference

WS BS 5W (37 dBm) 10 agl



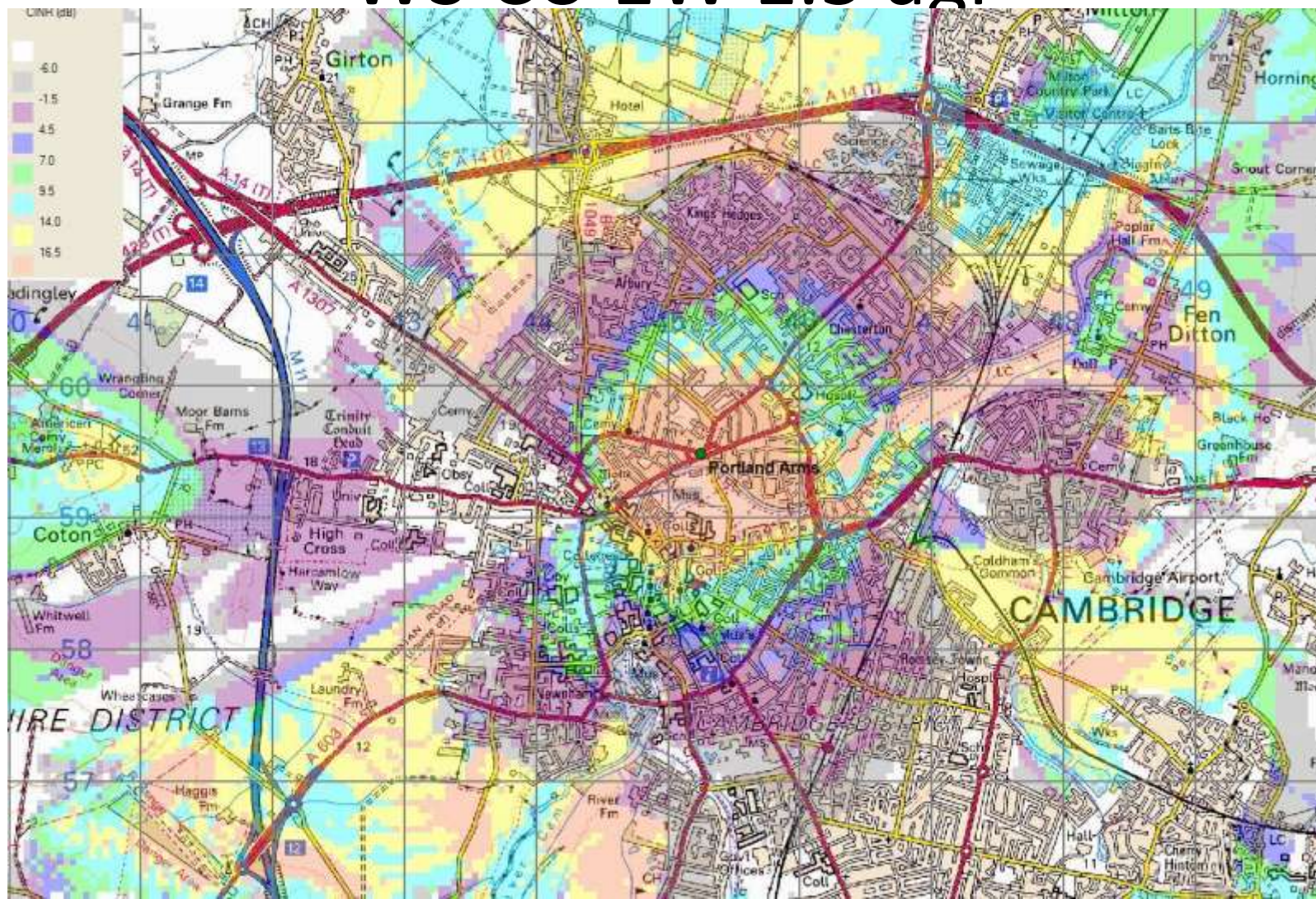
Coverage WS down link with DTT interference

WS BS 5W 10 agl



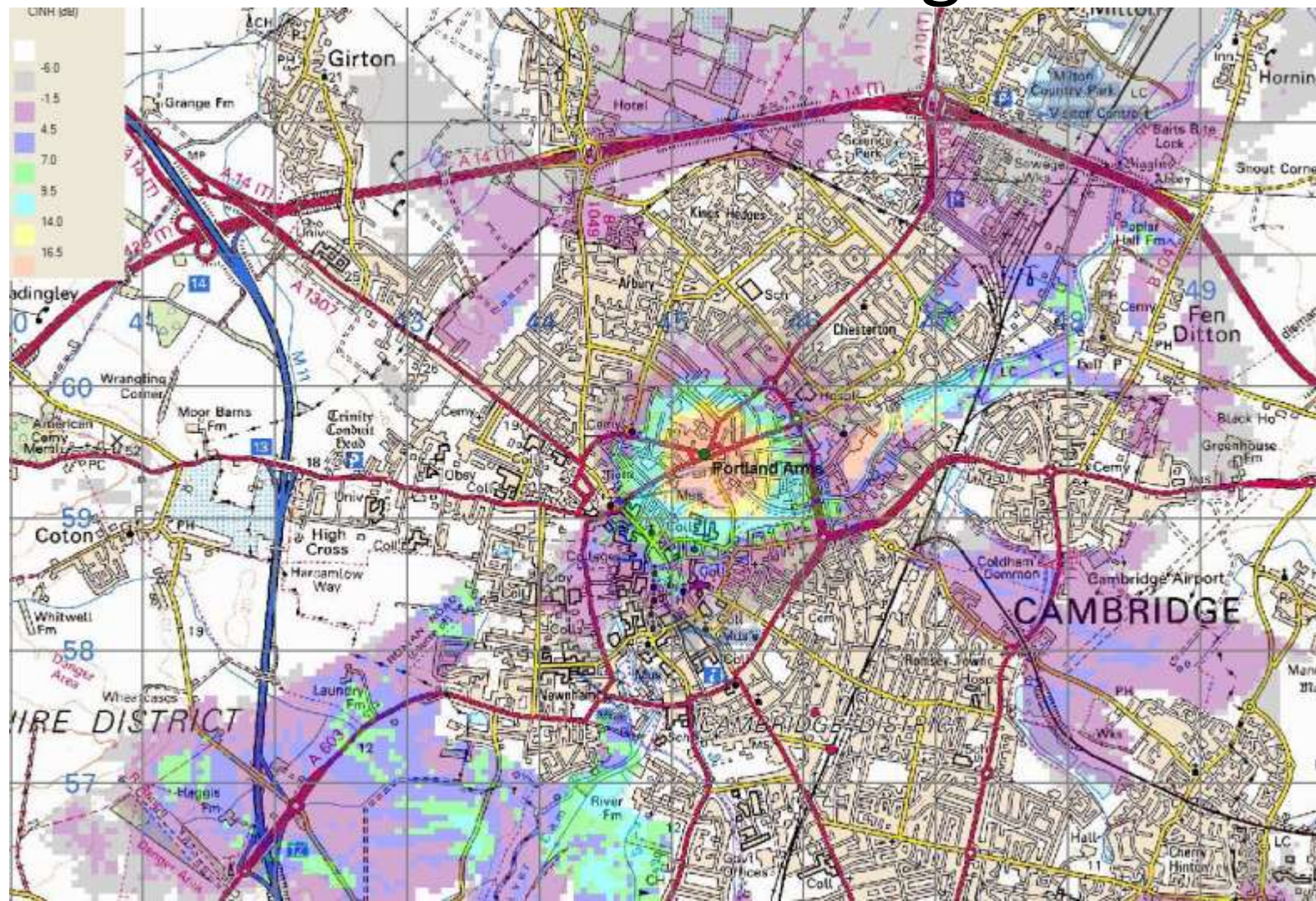
Coverage WS up link no DTT interference

WS CU 1W 1.5 agl



Coverage WS up link with DTT interference

WS CU 1W 1.5 agl

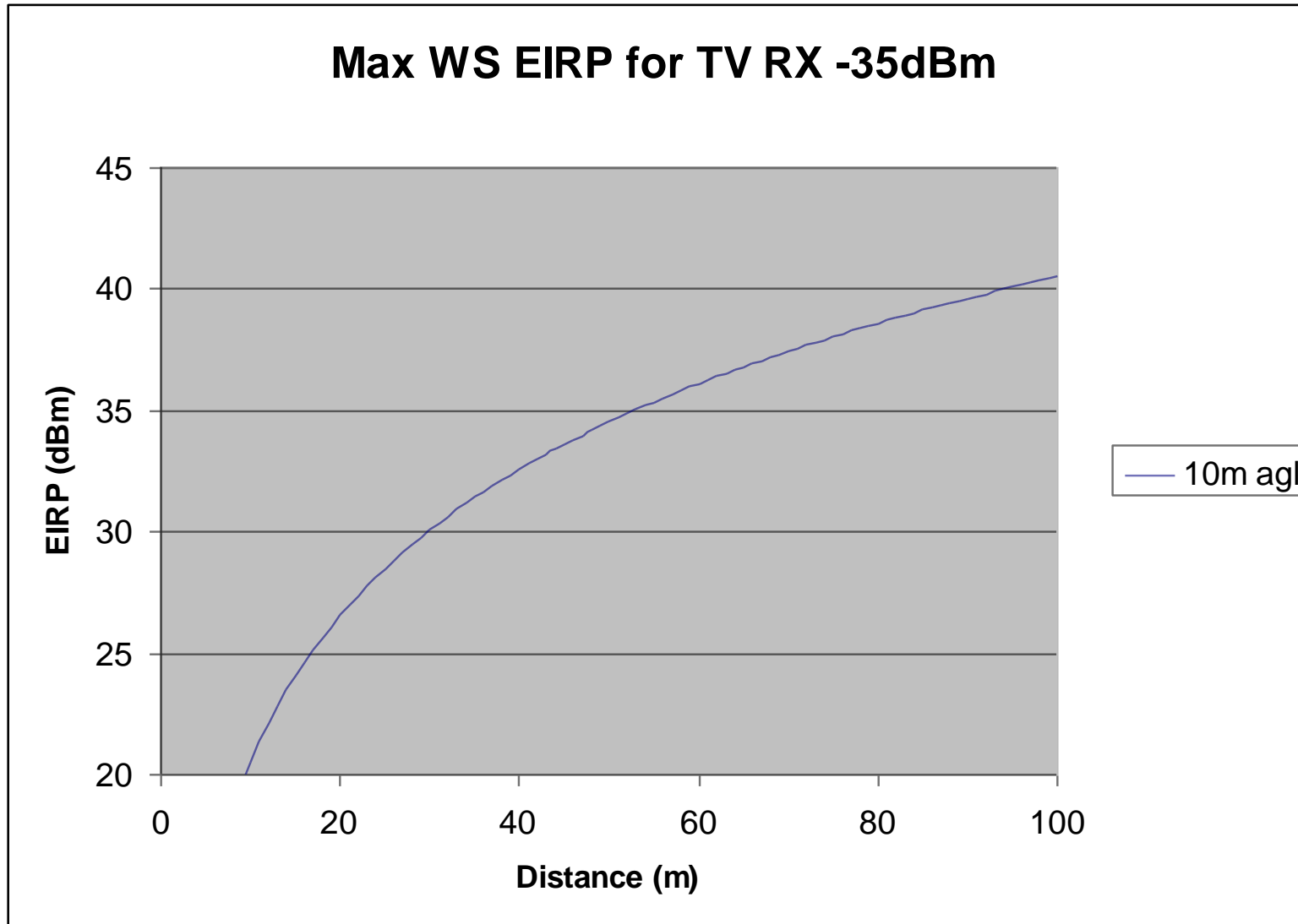


Application of results

- Assume that DTT received levels in the area are approaching the edge of service and **all locations** are above -75 dBm so for 95% locations the median will be -64 dBm
- Using a protection ratio of -40 dB the input into the front end of the DTT receiver can then be -35 dBm before any DTT reception is lost
- For down link see curves on next slide
- For uplink WS max ERP is 15 dBm
 $(-35 \text{ dBm} - (-50)) = 15 \text{ dBm} = 31 \text{ mW}$

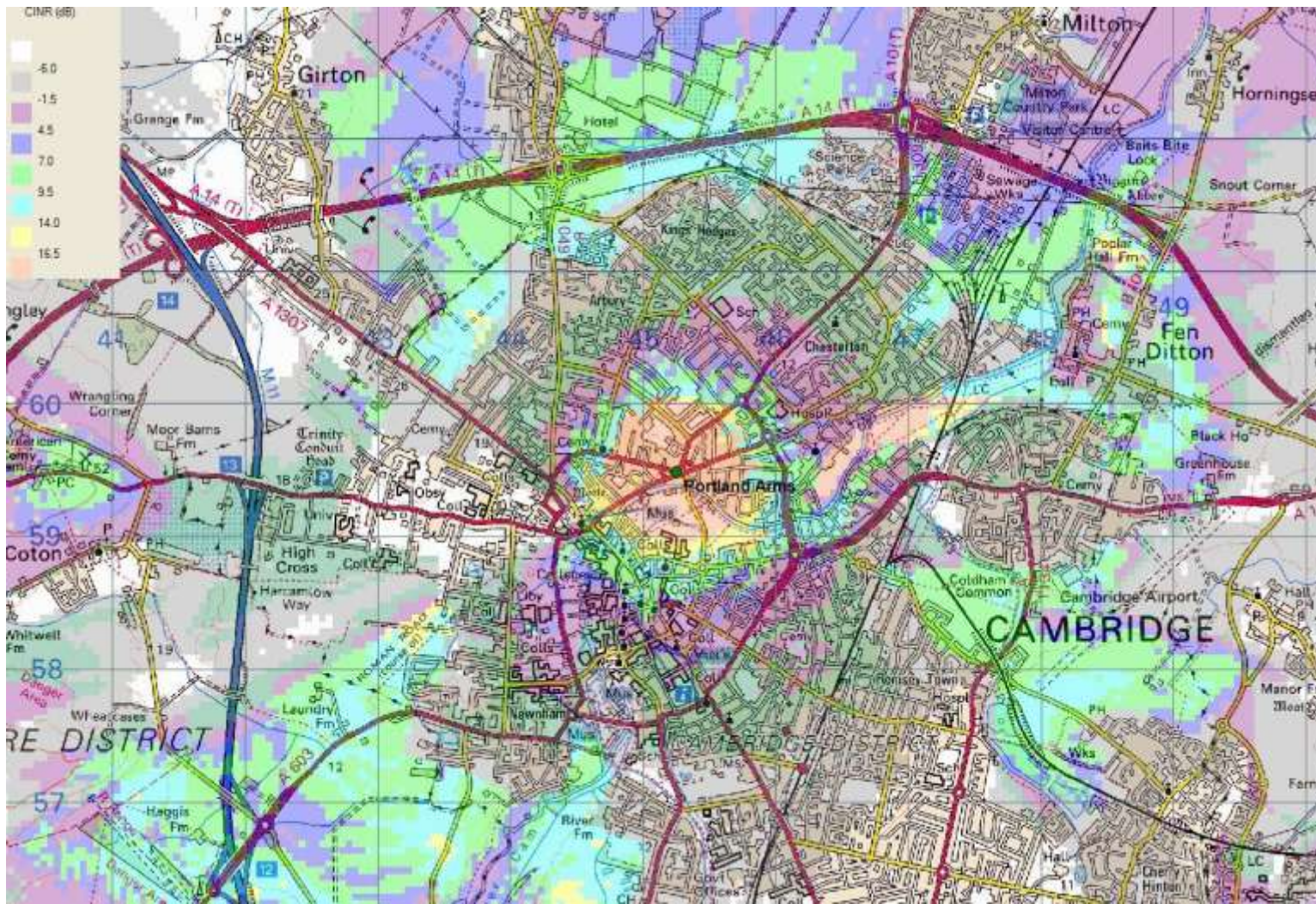
*Arqiva has measured coupling factors as low as -45 dB

Distance v EIRP WS BS (Poor DTT reception)



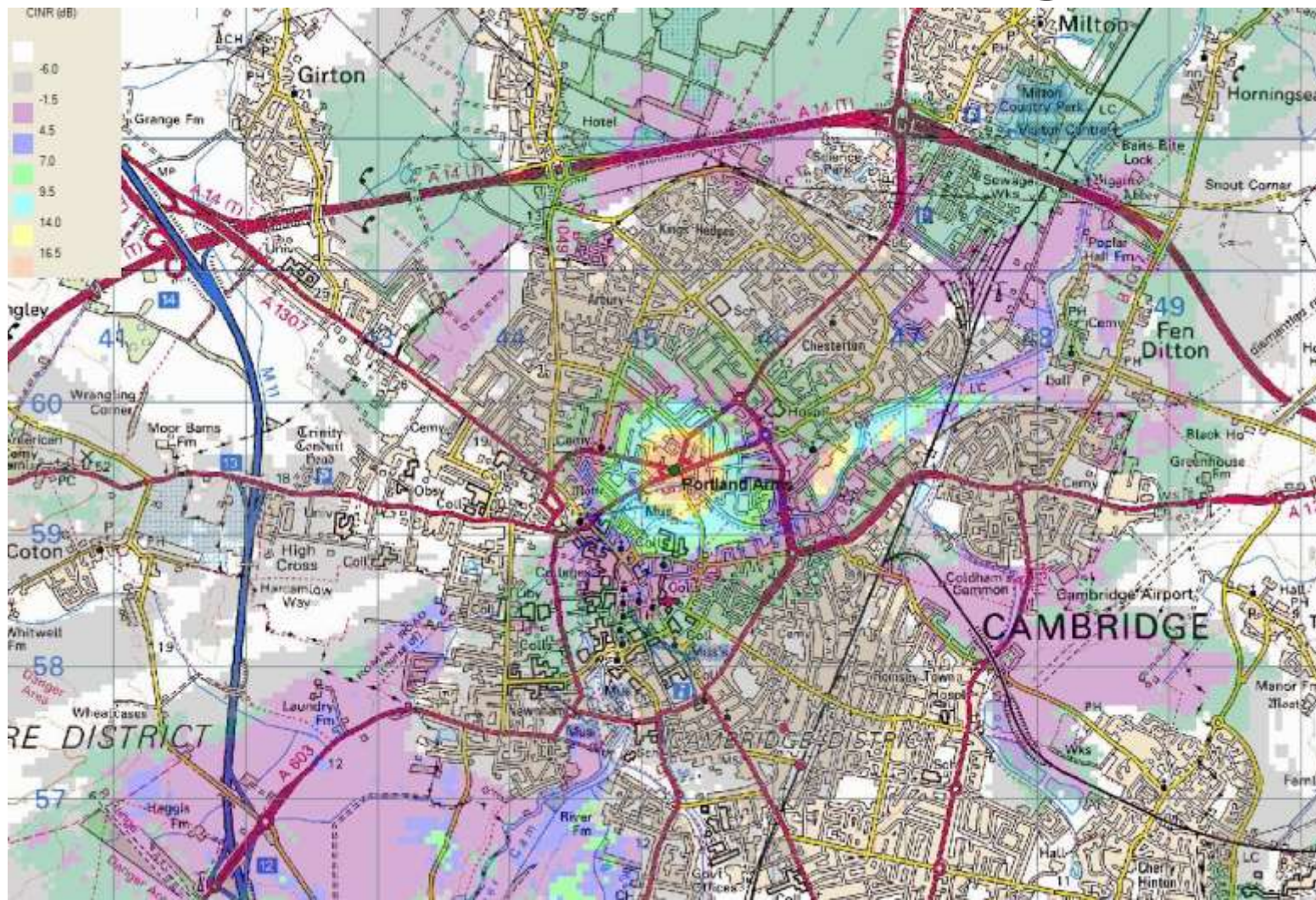
Coverage WS down link no DTT interference

WS BS 22dBm 10 agl



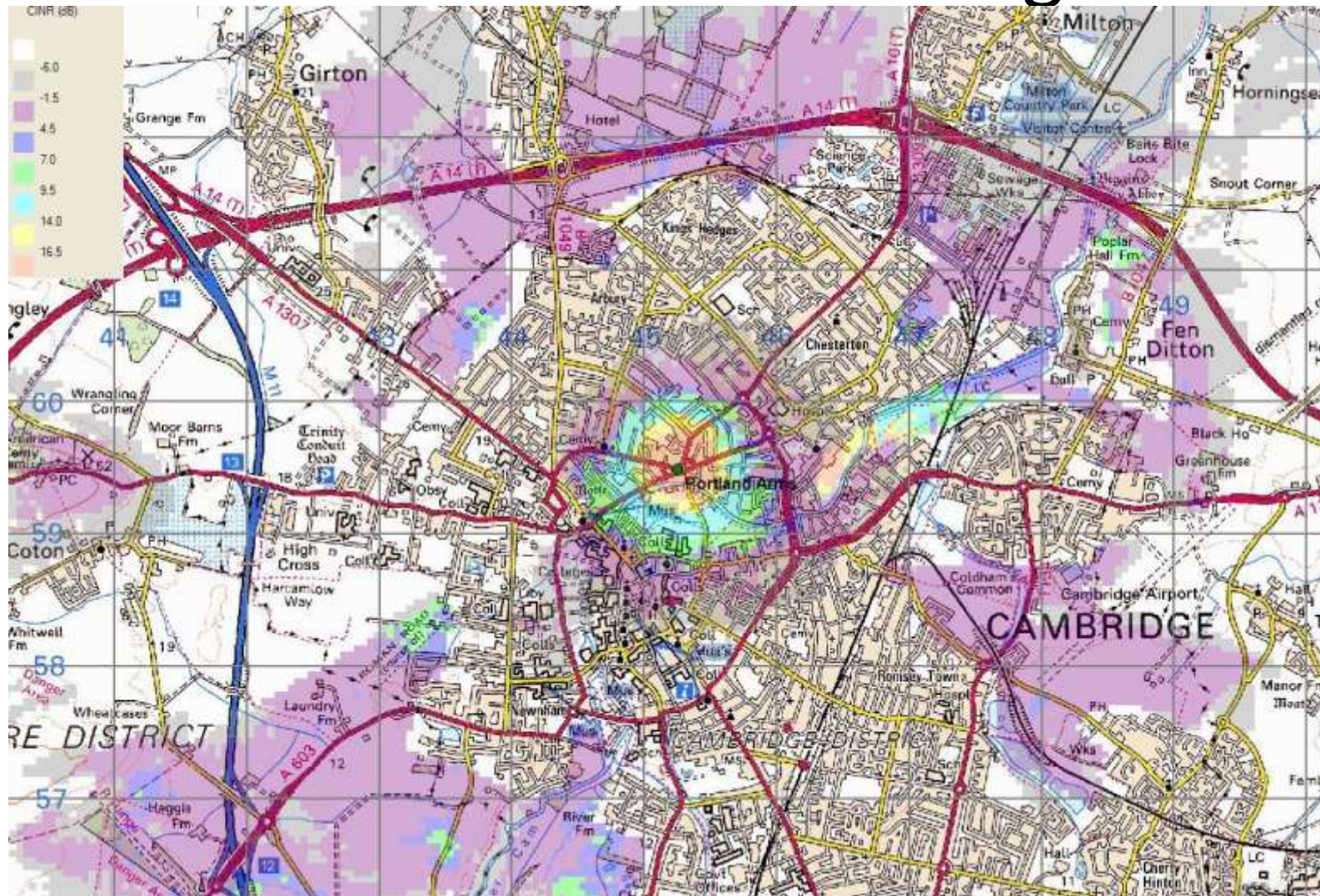
Coverage WS down link with DTT interference

WS BS 22dBm 10 agl



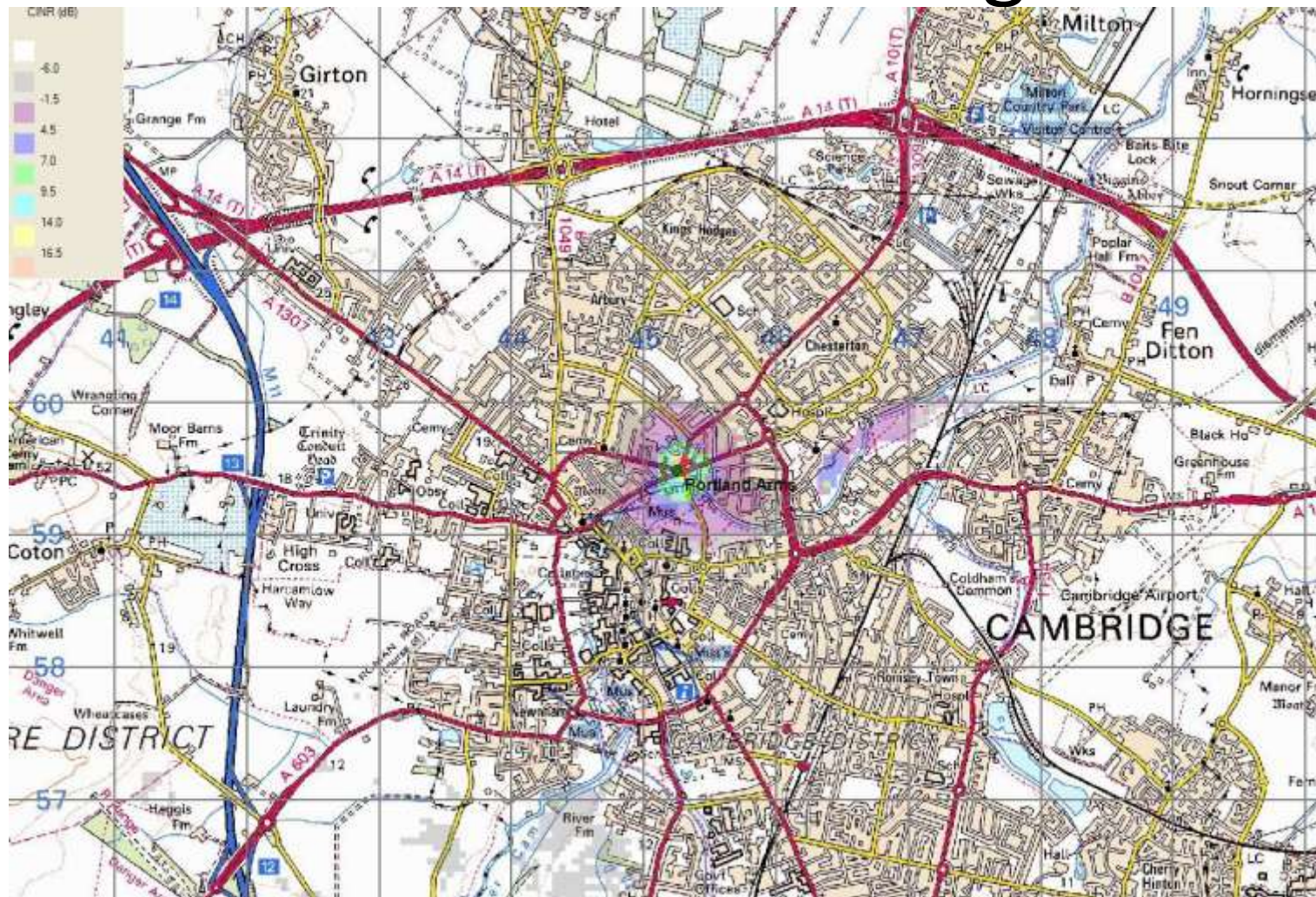
Coverage WS up link no DTT interference

WS CU 15dBm 1.5 agl



Coverage WS up link with DTT interference

WS CU 15dBm 1.5 agl



Conclusion and further work

- The maximum transmit powers for WS BS and devices is set by:
 - How close to a DTT receiver – Geometry
 - Can this be a variable in the data base?
 - The worst case minimum separation WS BS at 10m to DTT receiver at 10 m (Geometry 2) could even be as low as 5m
 - The DTT field strength in the area of the WS BS – Which can be predicted by the UK planning tool (UKPM) used by Ofcom/BBC/Arqiva
 - The protection ratio of the devices in the vicinity of the WSBS – DTT receiver performance for the particularly frequency relationship (WS to DTT) and WS modulation scheme – Further work
 - How many households can be impacted i.e. lose their DTT reception – yet to be agreed by Ofcom/Government

Further work

- More data on protection ratios for DTT receivers is needed
- All the work so far has been on 10 m fixed roof top reception, Geometry 1 & 2 – do we need to protect portable reception as well and define a 3rd Geometry?
- Little work done so far on protecting PMSE devices
- Can a data base be constructed so that a variable geometry can be used?