800 MHz & 2.6 GHz Combined Award – Additional technical information and simulation results

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Contents

Section 1

Downtilts

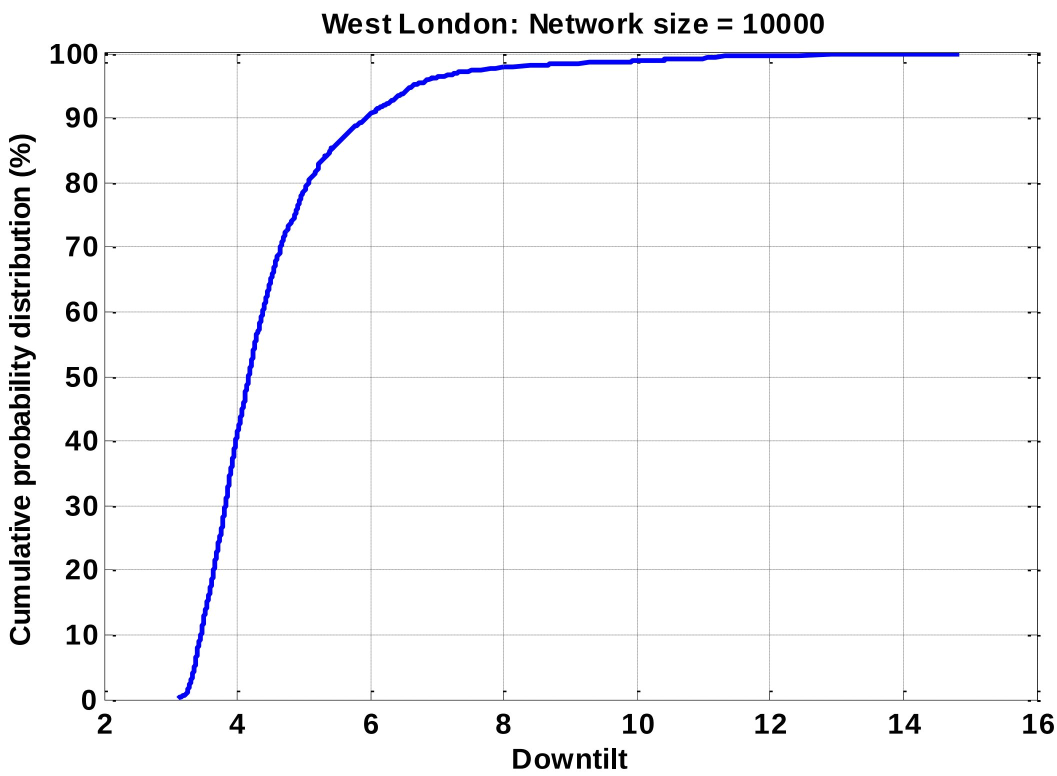
1.1 Introduction

We have been asked to provide the distribution of antenna downtilts which the Ofcom LTE model calculates for West London 10,000, 14,000 and 18,000 sites at 800 MHz, 1800 MHz and 2600 MHz.

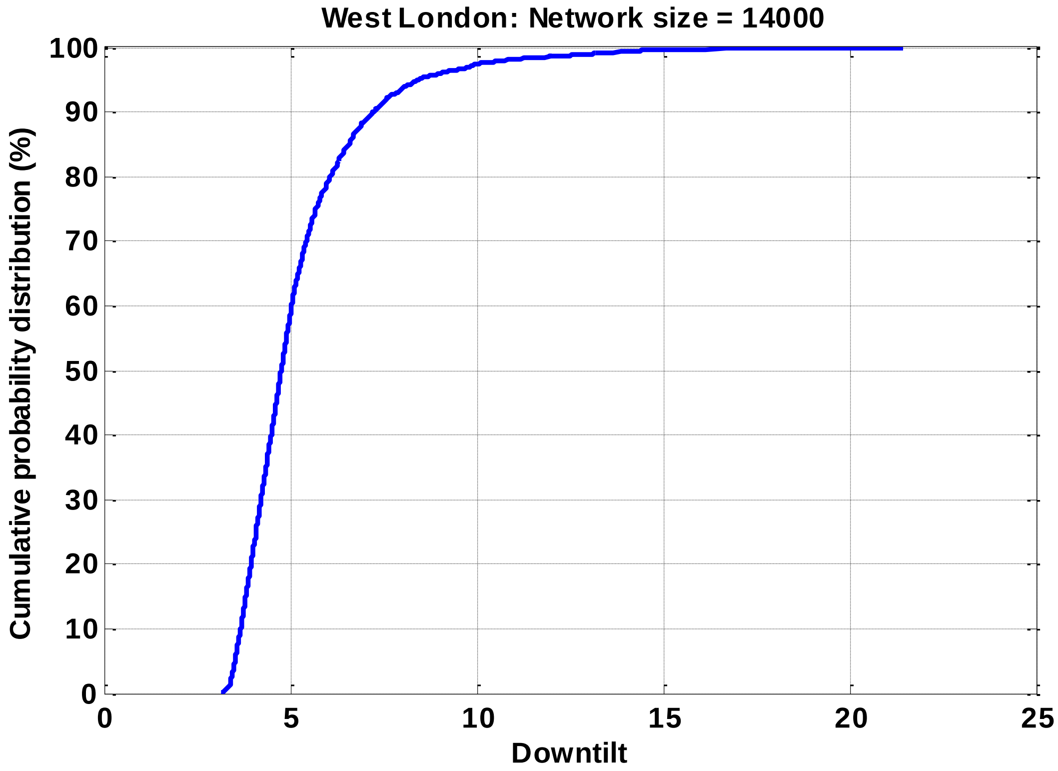
It should be noted that the downtilt optimisation algorithm in Ofcom LTE model is independent of frequency (as we use the same antenna vertical beam width for all frequencies).

Downtilt values in the graphs below are in degrees.

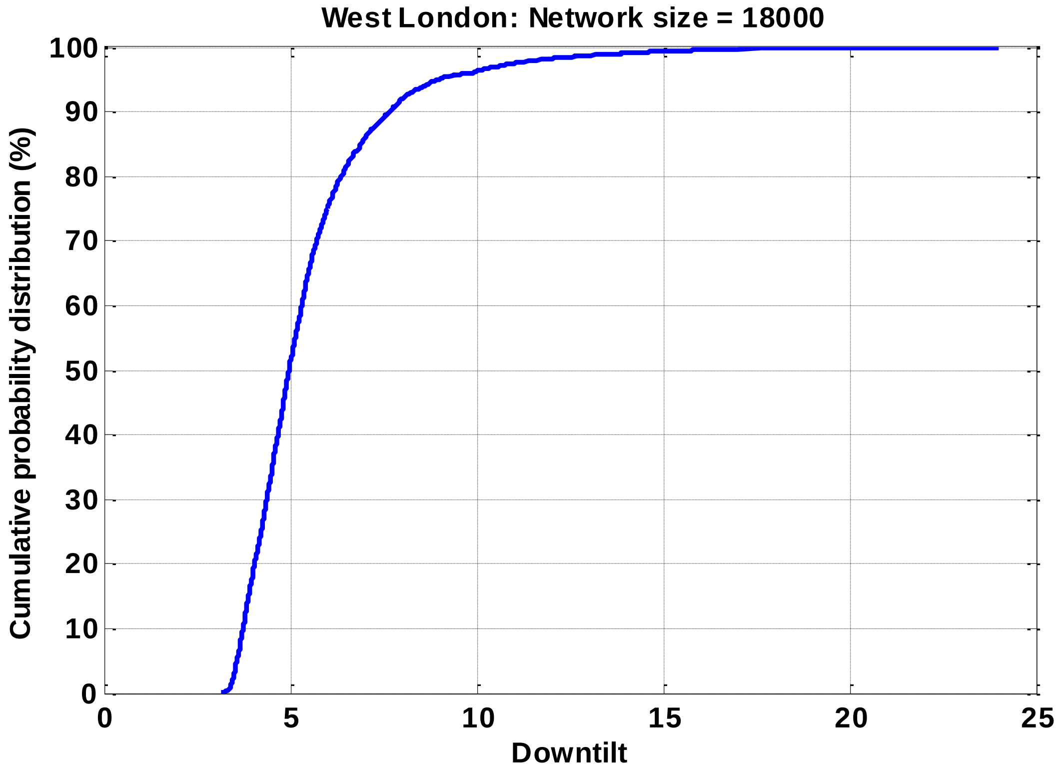
1.2 West London 10,000 sites



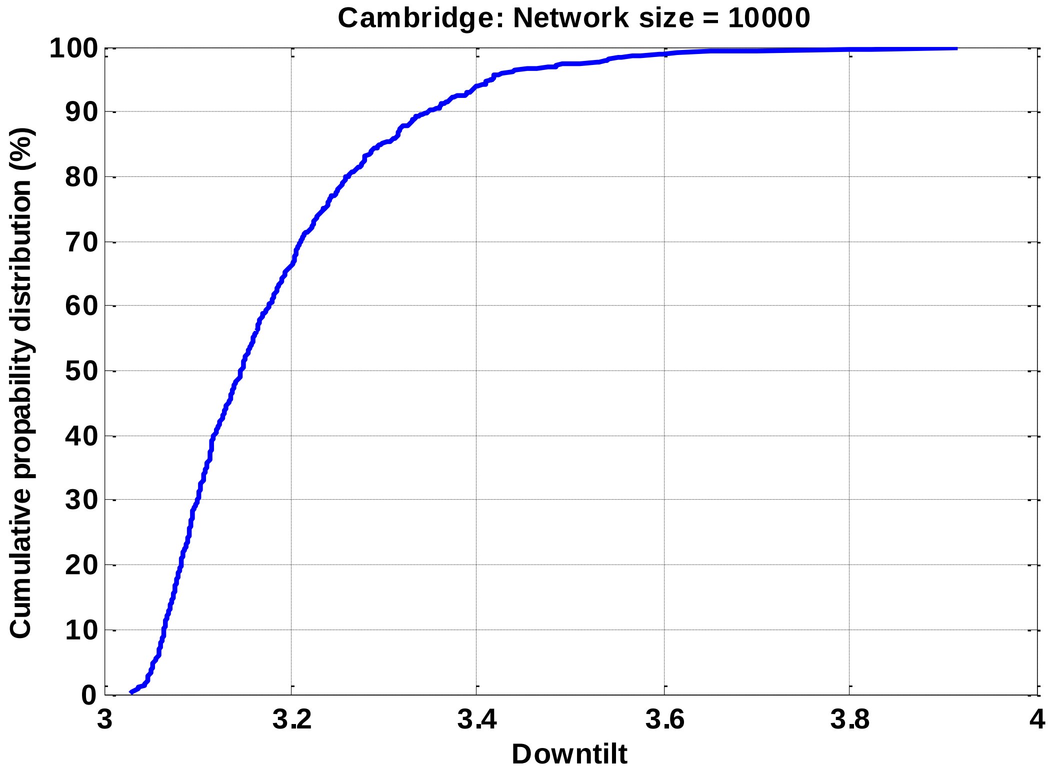
1.3 West London 14,000 sites



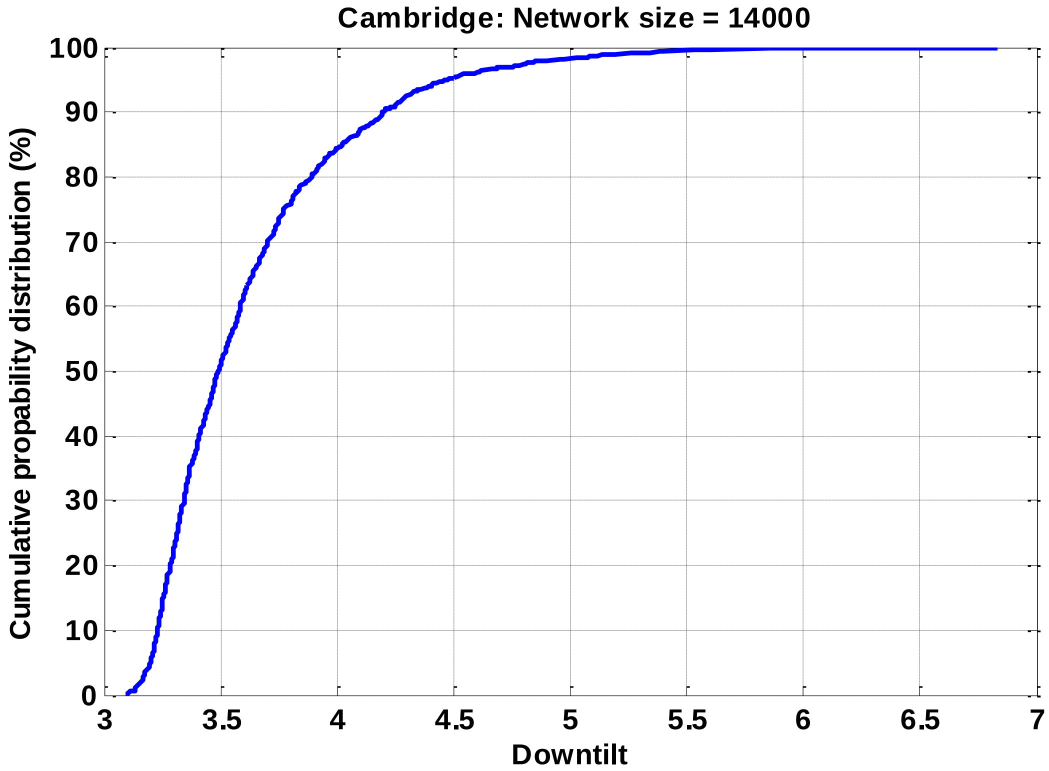
1.4 West London 18,000 sites



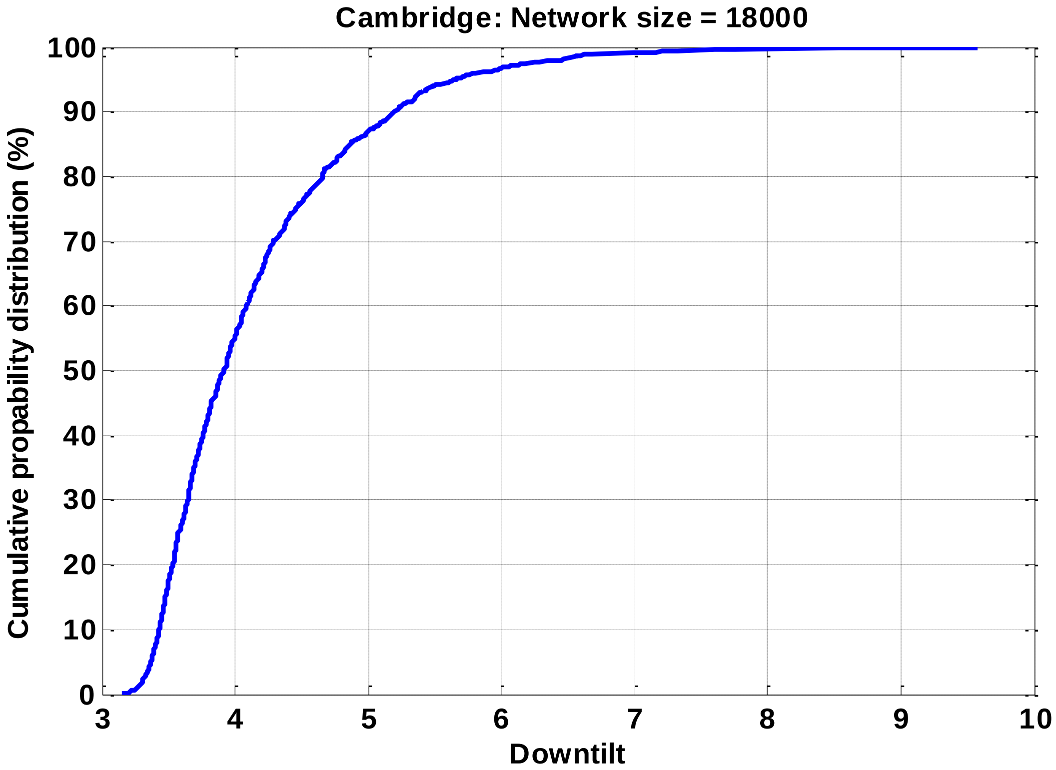
1.5 Cambridge 10,000 sites



1.6 Cambridge 14,000 sites



1.7 Cambridge 18,000 sites



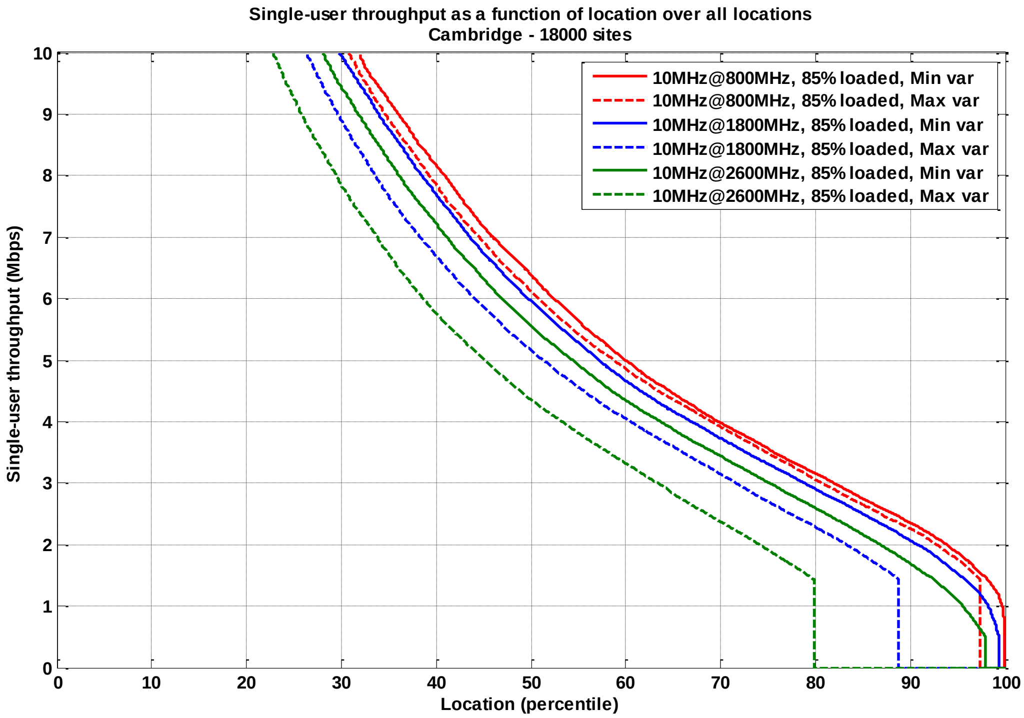
Section 2

Additional results for the Cambridge area

2.1 Introduction

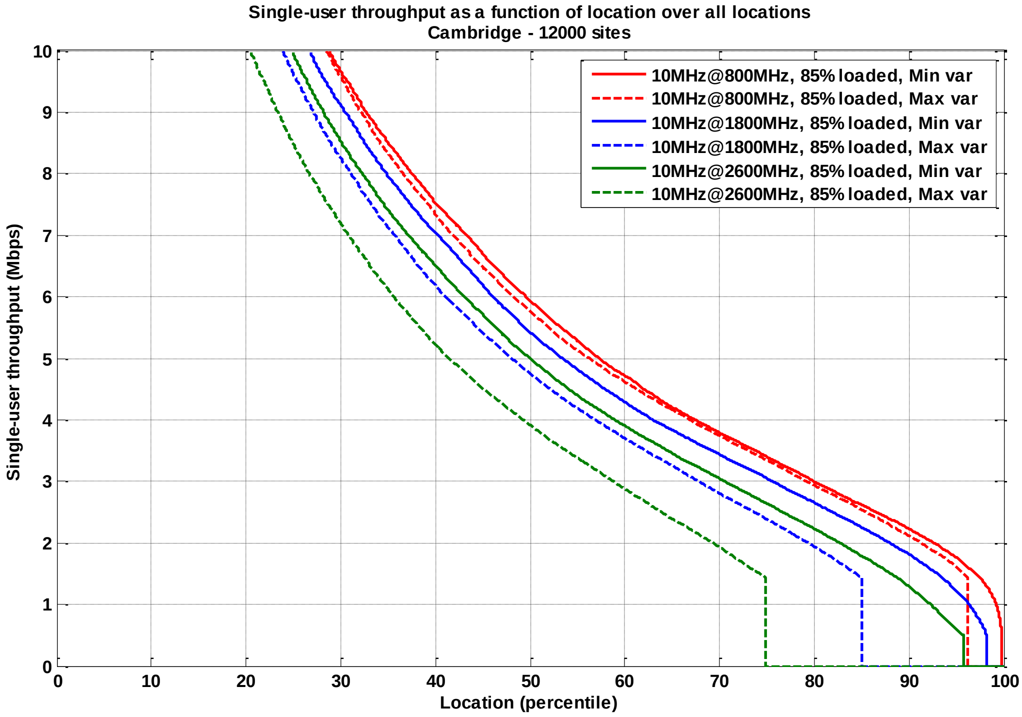
We have been asked to provide the equivalent results for the Cambridge areas for figures 25, 26, 31, 32, 43, 44, 47, 48, 49, 50, 67, 68, 69 and 70 from Annex 7 of the January 2012 consultation[1].

2.2 Figure 25

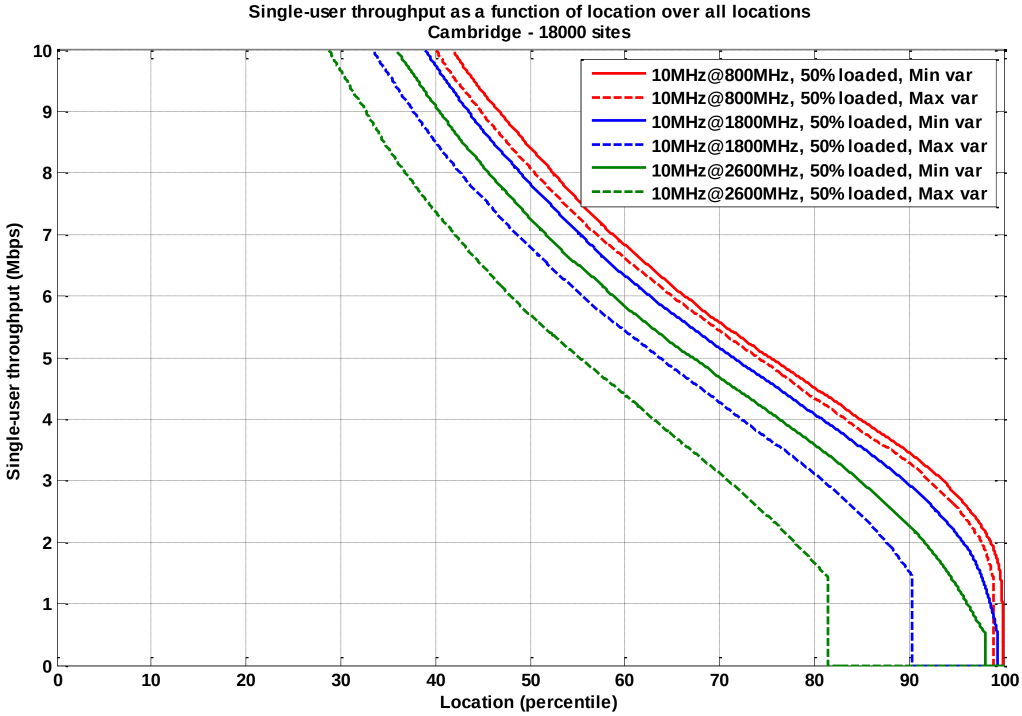


[1] "Second consultation on assessment of future mobile competition and proposals for the award of 800 MHz and 2.6 GHz spectrum and related issues", dated 12 January 2012.

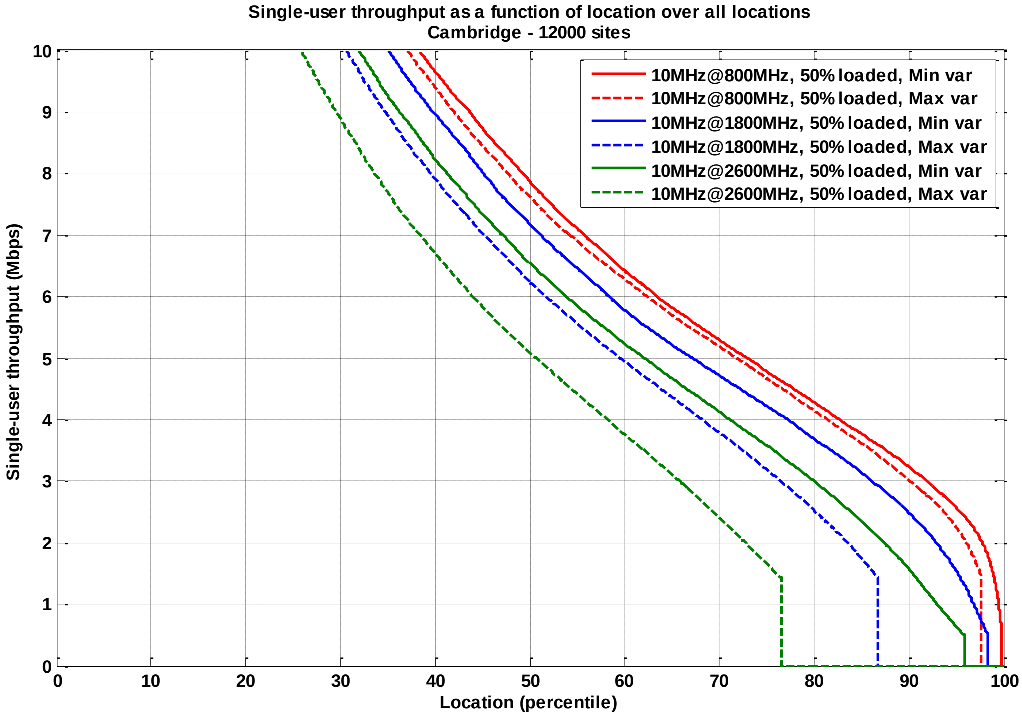
2.3 Figure 26



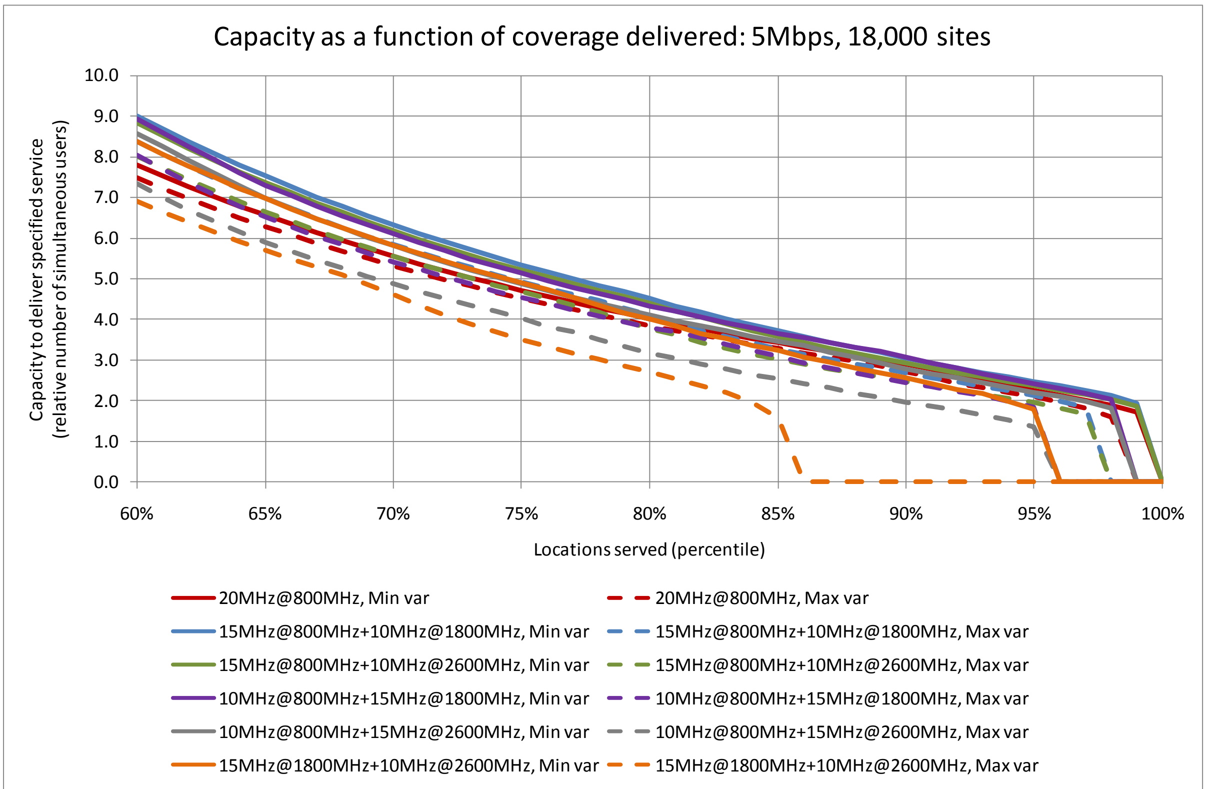
2.4 Figure 31



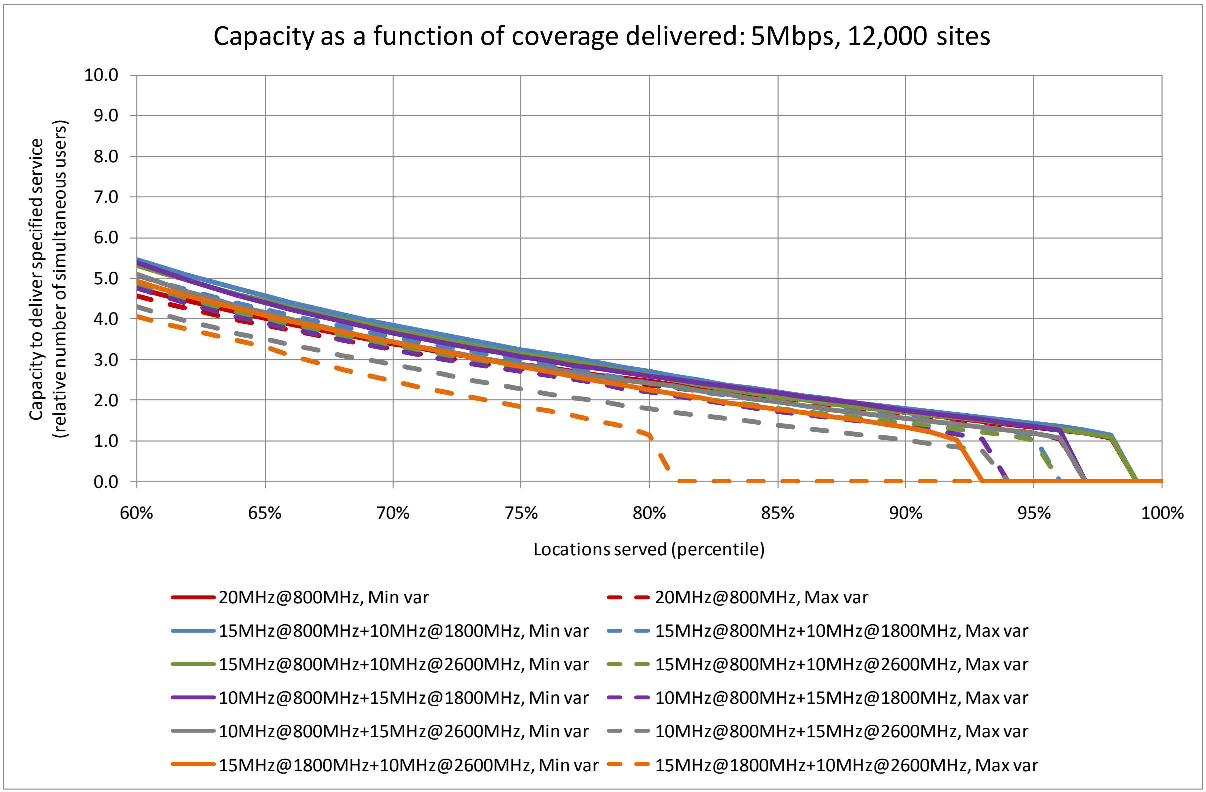
2.5 Figure 32



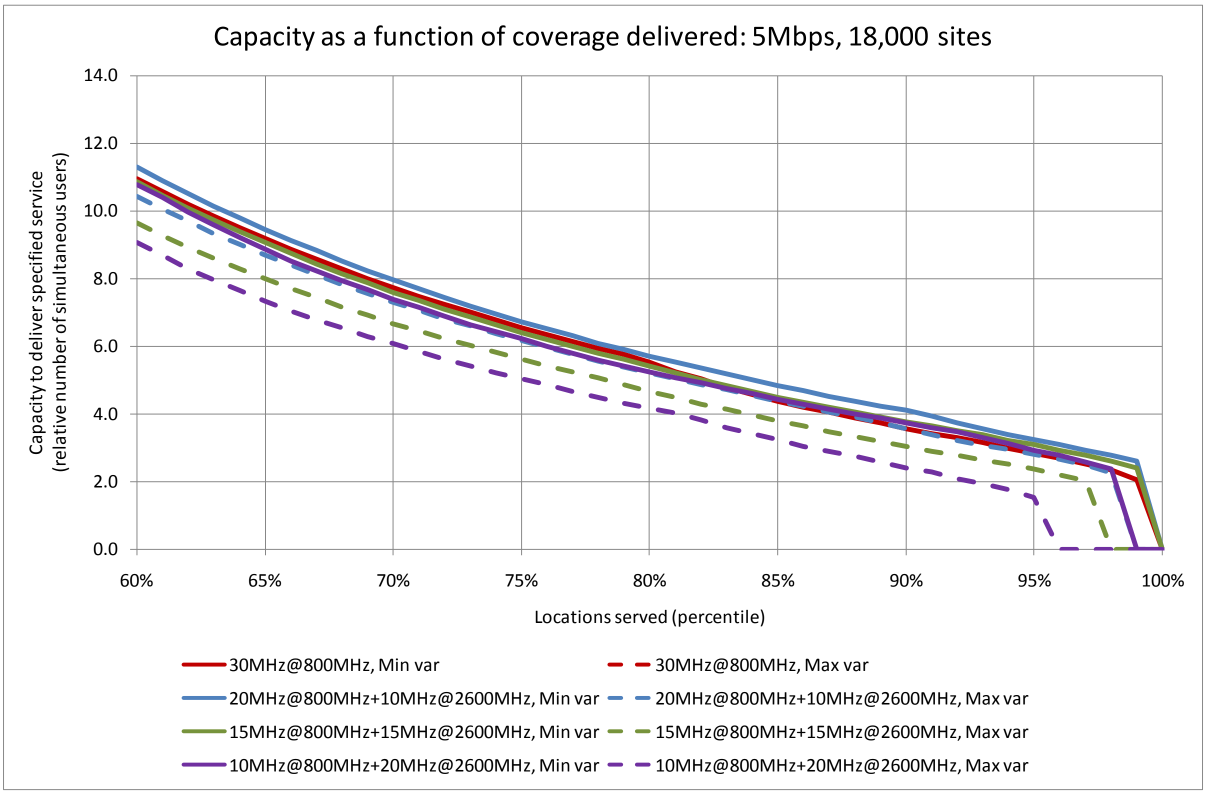
2.6 Figure 43



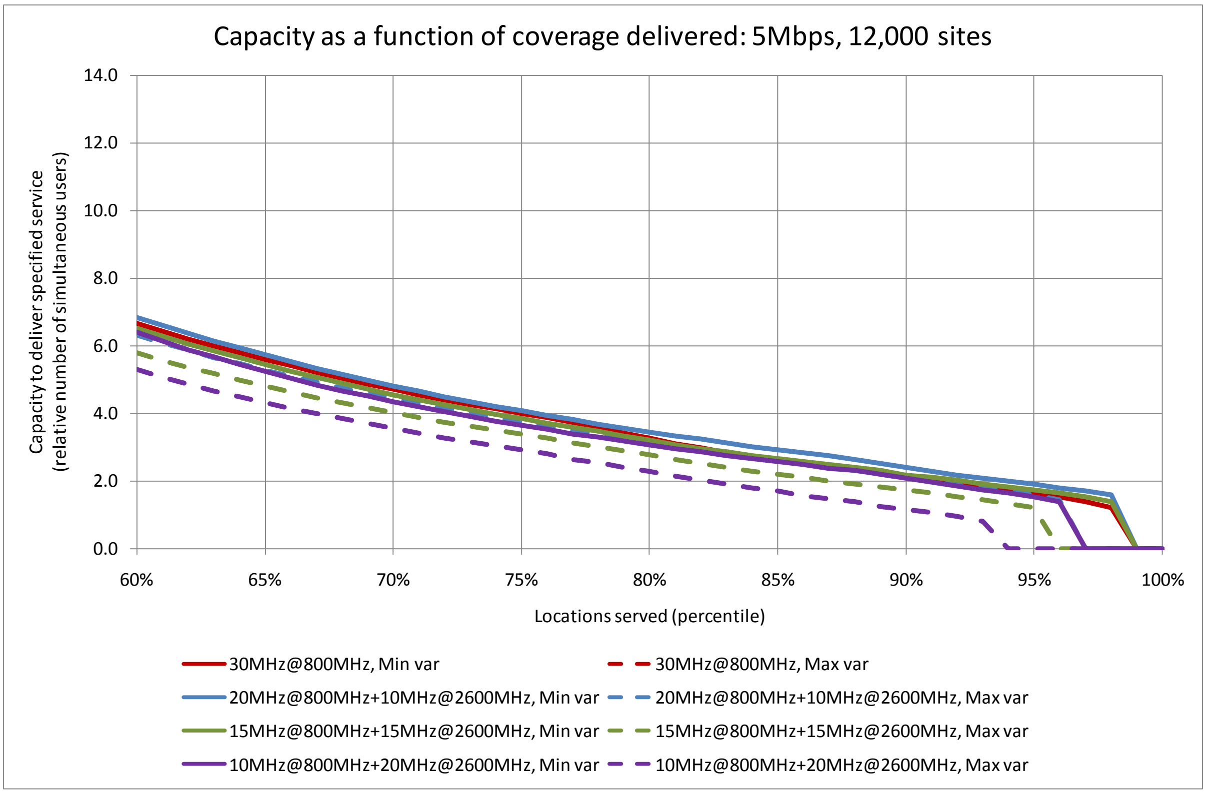
2.7 Figure 44



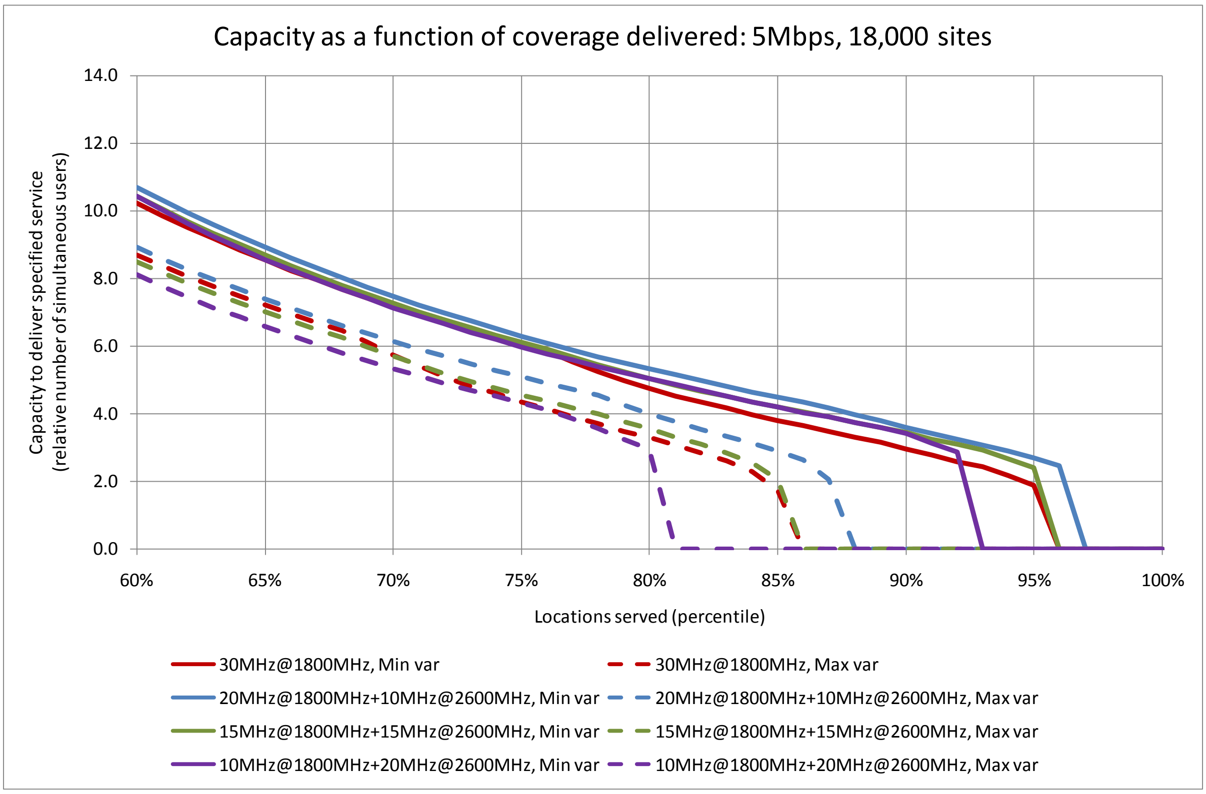
2.8 Figure 47



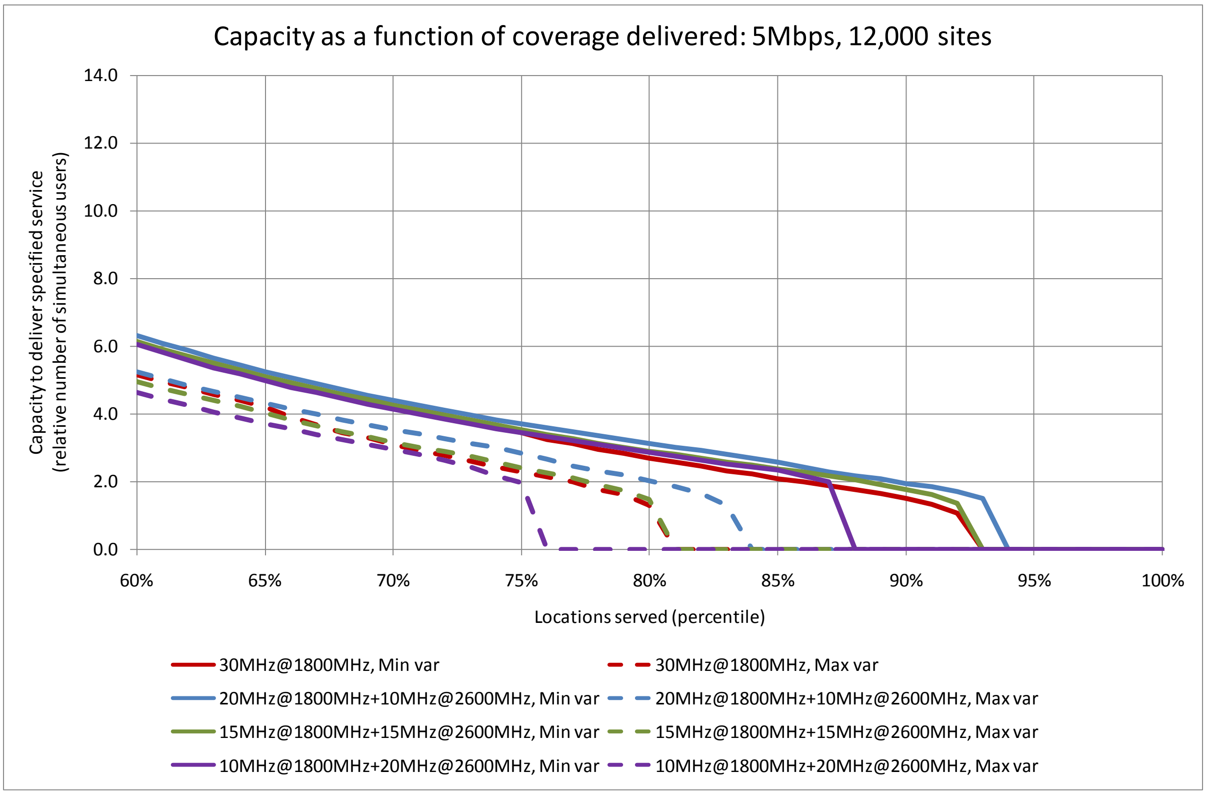
2.9 Figure 48



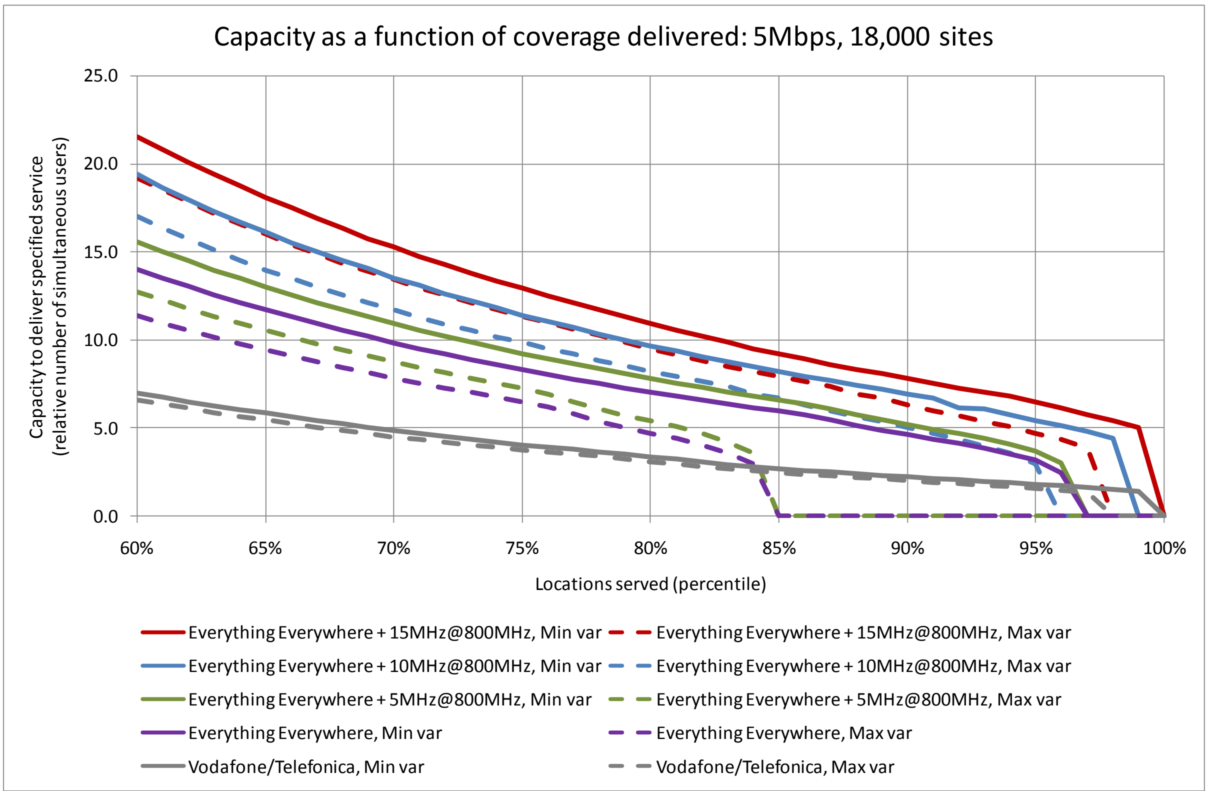
2.10 Figure 49



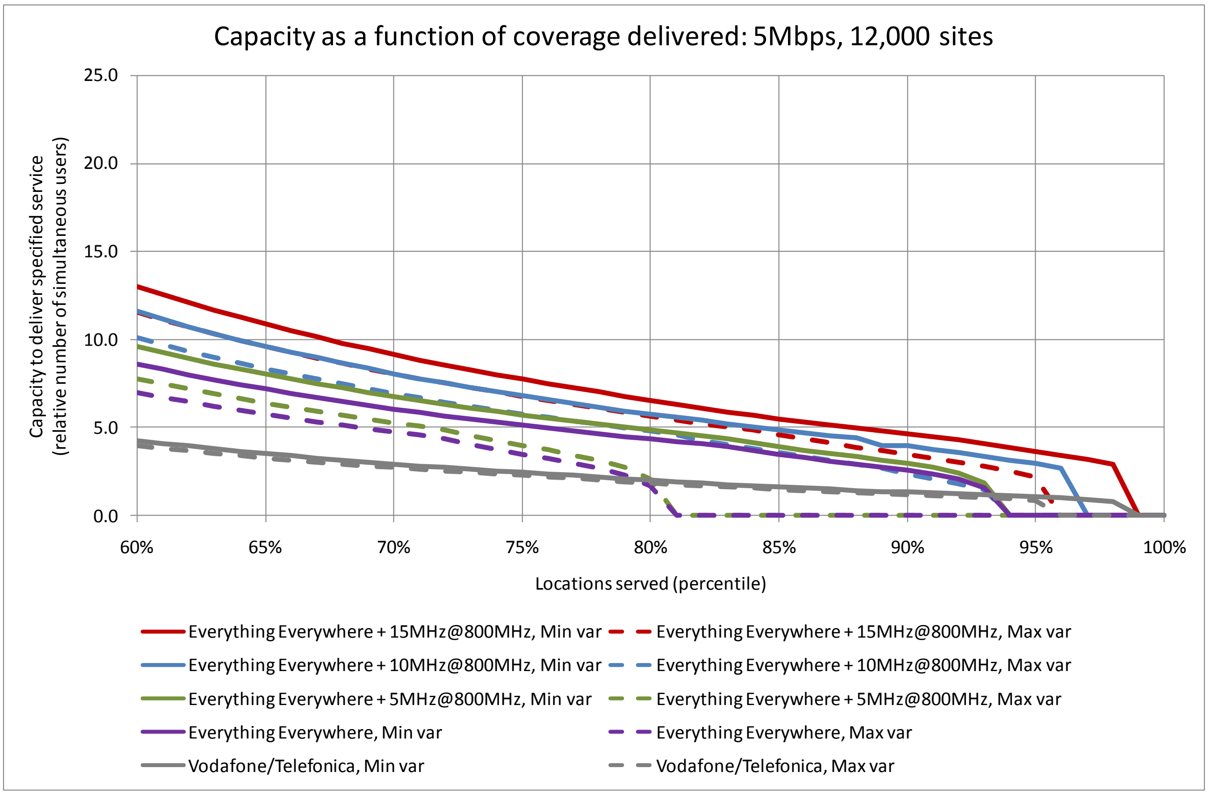
2.11 Figure 50



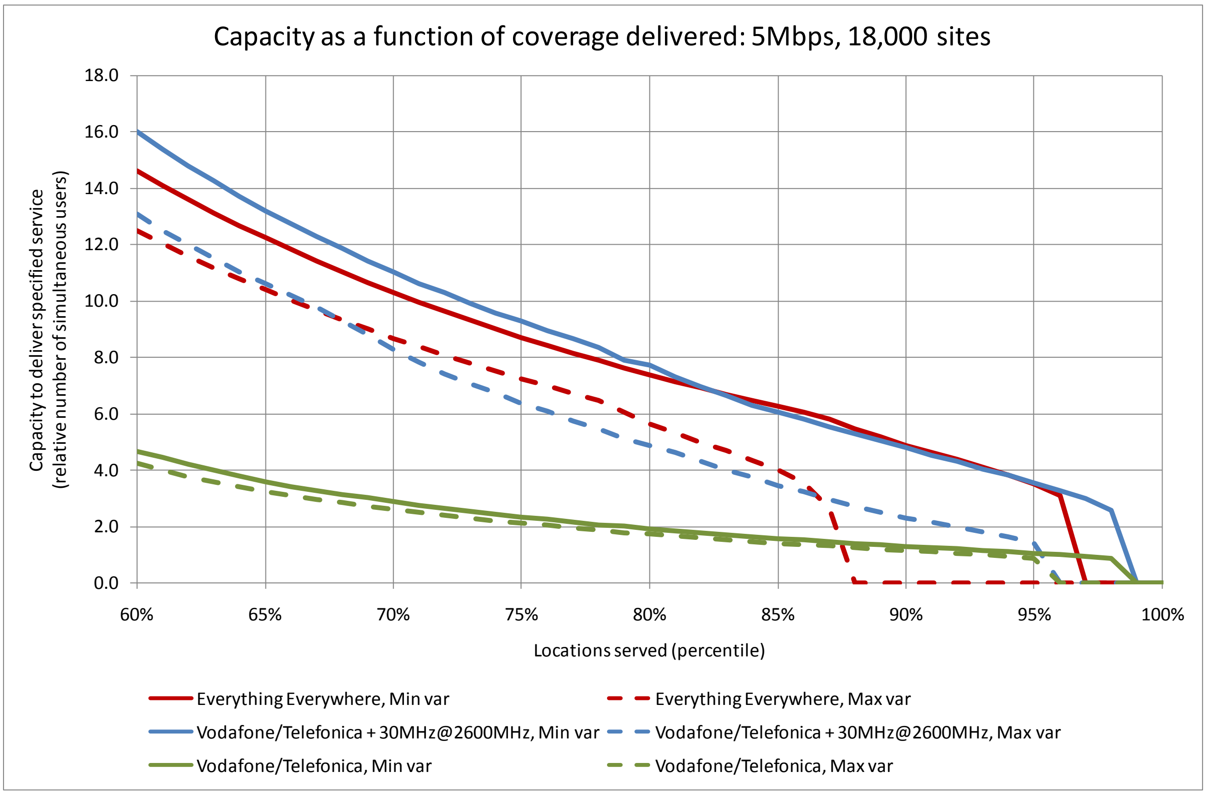
2.12 Figure 67



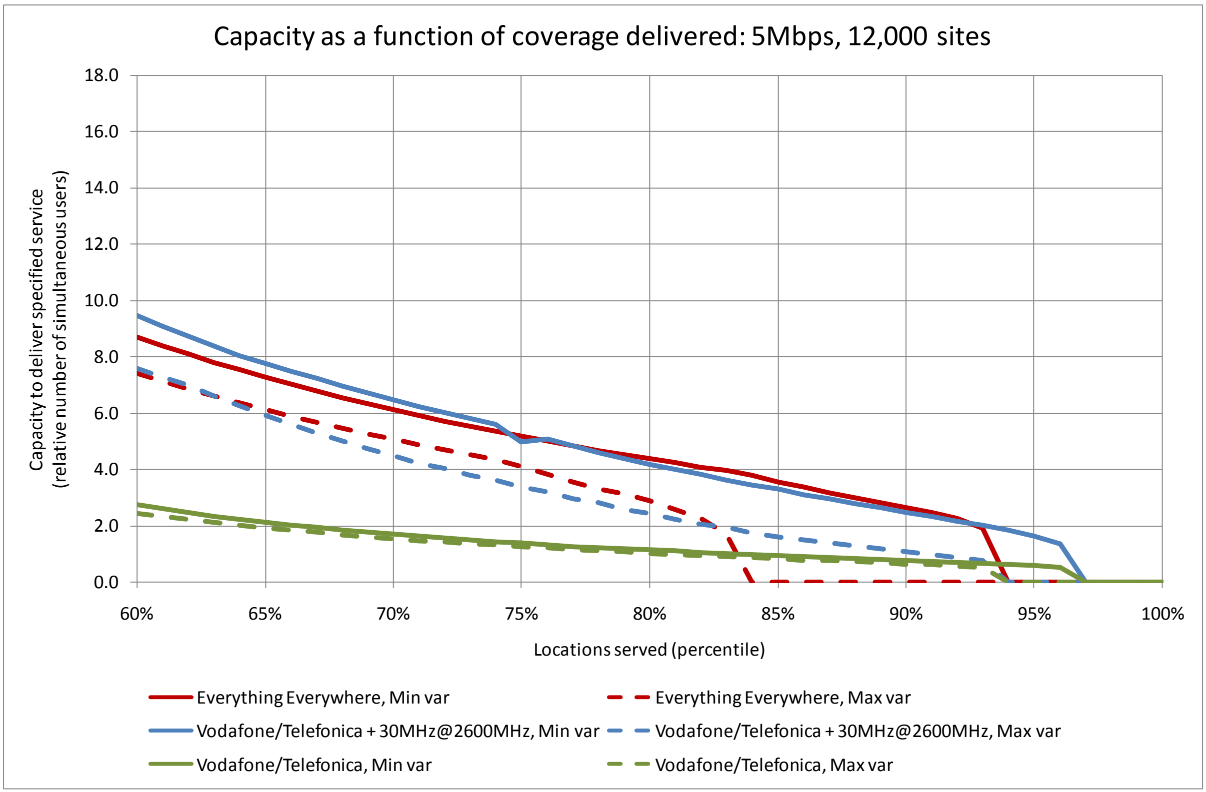
2.13 Figure 68



2.14 Figure 69



2.15 Figure 70



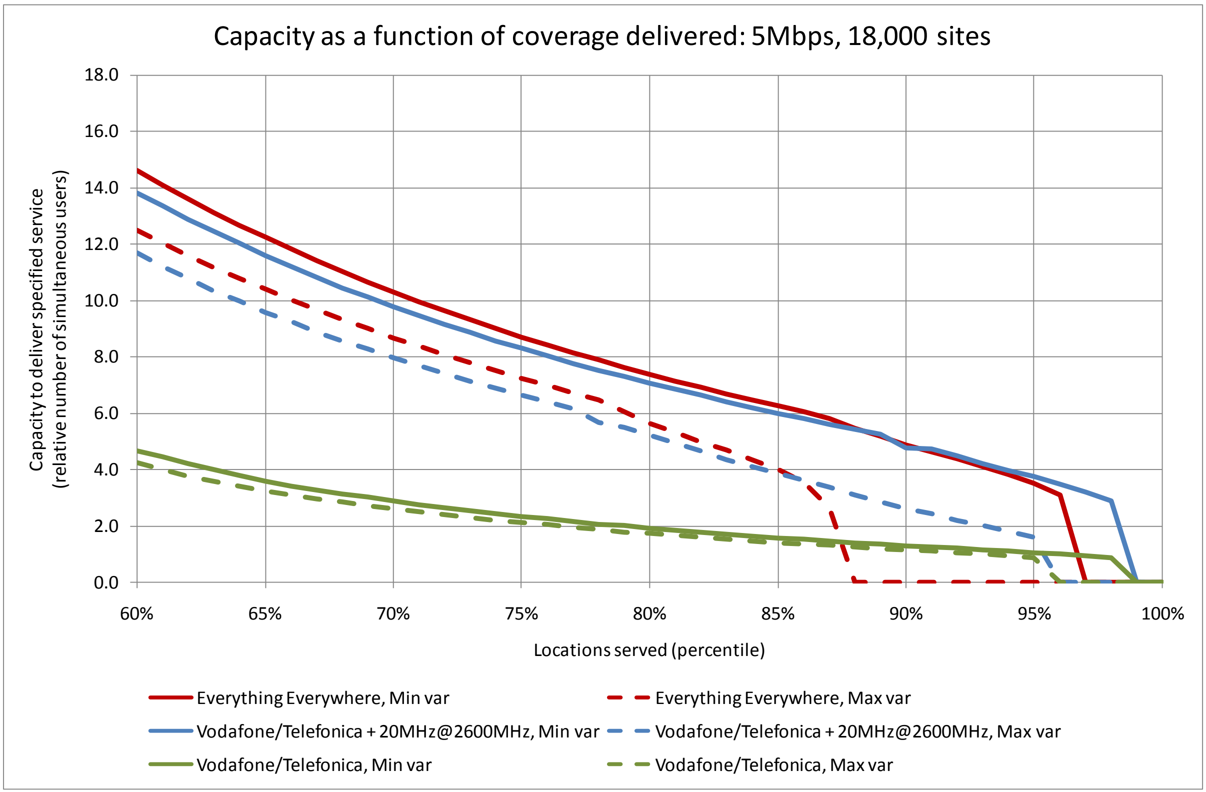
Section 3

Alternative cases

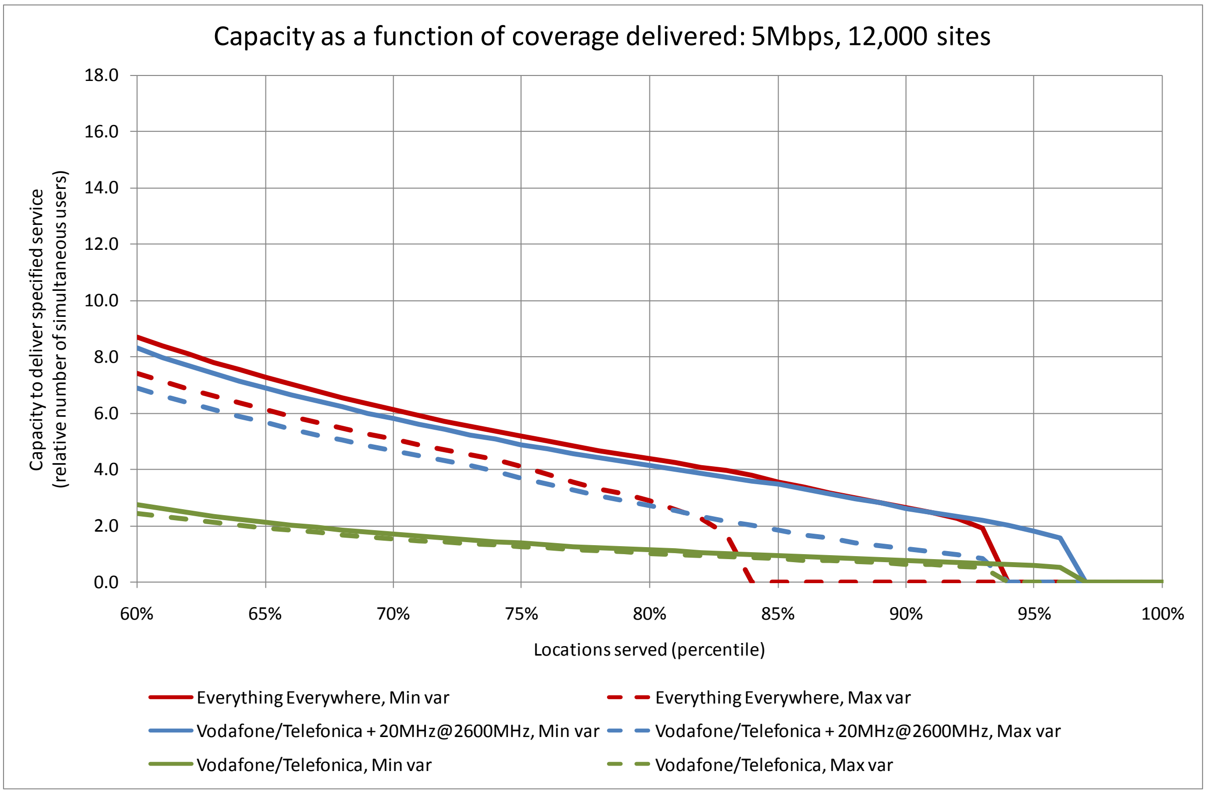
3.1 Introduction

We were asked to reproduce figures 69 and 70 from the January consultation for the case where Vodafone and Telefonica acquire 2x20 MHz of 2600 MHz rather than 2x30 MHz.

3.2 Figure 69 (Telefonica acquiring 2x20 MHz of 2600 MHz)



3.3 Figure 70 (Telefonica acquiring 2x20 MHz of 2600 MHz)



Section 4

Uplink Limitations

4.1 Introduction

We were asked to show our analysis that lead to conclusion in the January 2012 consultation that, *'... for the vast majority of cases presented in this consultation the performance is not impaired by uplink limitations"*.

4.2 Analysis

The technical results presented in our January 2012 consultation are downlink performance results only. In order to confirm that uplink limitations were not likely to be a significant issue, we conducted a worst case link budget analysis using the assumptions given in the table below.

Parameter/ Assumption	**Value or range modelled**	**Units**	**Comment**
Downlink			
Radiated power (EIRP) per 180 kHz LTE resource block	47	dBm	Equivalent to the maximum value permitted by the proposed technical licence conditions for 800 MHz and 2600 MHz[2] i.e. 61 dBm/(5MHz)
UE antenna gain (mean effective gain)	-1.1 dBi @800MHz 0.0 dBi @ 1800 MHz +0.5dBi @ 2600 MHz	dBi	Takes into account antenna efficiency increasing with frequency
UE receiver noise figure	10 (800 MHz) 10 (1800 MHz) 9 (2600 MHz)	dB	Derived from 3GPP TS 36.101[3]
System overheads	20%		The SINR to mapping function used does not include system overheads.

[2] Consultation and information on technical licence conditions for 800 MHz and 2.6 GHz spectrum and related matters, June 2011 http://stakeholders.ofcom.org.uk/consultations/technical-licence-conditions/
[3] http://www.3gpp.org/ftp/Specs/html-info/36101.htm

Parameter/ Assumption	Value or range modelled	Units	Comment
Serving cell loading (% resource blocks available for user and control data)	85%		Consistent with LTE performance results presented in our recent consultation document.
Interference degradation margin	3	dB	Industry standard
SINR to throughput mapping function	'Realistic' mapping function		As defined in our recent consultation Annex 14 LTE Technical Modelling Revised Methodology
Uplink			
Radiated power (EIRP) per 180 kHz LTE resource block	23	dBm	Uplink power assumed to be all across one resource block.
BS antenna gain (mean effective gain)	15.4 dBi @ 800MHz 17.9 dBi @ 1800 MHz 19.0 dBi @ 2600 MHz	dBi	Derived from a typical multi-band antenna from the Kathrein catalogue (742-265) extrapolated to cover the 2600 MHz band.
Interference degradation margin	1	dB	Holma and Toskala[4]
BS receiver noise figure	2	dB	Holma and Toskala[4]
Required SINR	-7	dB	Holma and Toskala[4]

The downlink budget assumes a particular value of target user bit rate, and the purpose of the analysis was to examine the maximum allowable path loss (MAPL) figures for uplink and

[4] H. Holma and A. Toskala, *LTE for UMTS: Evolution to LTE-Advanced*, 2nd ed., John Wiley & Sons, 2011.

downlink. It is the difference between the uplink and downlink MAPL figures, rather than their absolute values, which is of importance. This means that any values in the link budget that change by the same amount in both the uplink and downlink do not affect the difference between the MAPL figures. Even though the location variability, mean building penetration loss and building penetration loss standard deviation are frequency dependent, the difference between the MAPL figures is not dependent on these particular variables. The same argument applies to body loss and location (cell-edge) probability: the selected values do not affect the difference in the MAPL figures.

Note that because the EIRP is fixed in the downlink, the UE antenna gain is used only in the downlink. Similarly, because the EIRP is fixed in the uplink, the BS antenna gain is used only in the uplink.

For the uplink we assume that the maximum power (23 dBm) is transmitted over one resource block to give maximum range, and assume that this gives a high enough data rate for the uplink control and acknowledgement data to sustain the downlink.

To calculate the required SINR in the downlink, the 'Realistic' mapping function[5] is used in reverse. We also applied downlink SINR cut-offs of -5 dB or -10 dB in order to explore a sensible range in line with the values adopted for the 'Max var' and 'Min var' cases in the January 2012 consultation.

The existence of uplink limitations was determined by considering whether the difference between the uplink and downlink MAPL figures is negative, as this would indicate uplink limitations. In terms of our link budget analysis, the relevant scenario where this may happen is widest bandwidth and low user downlink bit rate i.e. those cases where a low bit rate per resource block is required. Once the required SINR is as low as the SINR cut-off, the downlink MAPL will not get any larger, so this is a limiting situation in terms of investigating whether uplink limitations could occur.

The difference between the uplink MAPL and the downlink MAPL is addressed in a number of situations with the aim of seeking the worst cases of uplink limitation. We included in our analysis 800 MHz, 1800 MHz and 2600 MHz, bandwidths of 2 x 5 MHz, 2 x 10 MHz, 2 x 15 MHz and 2 x 20 MHz and target user bit rates of 1 Mbps, 2 Mbps and 5 Mbps.

Considering any particular frequency, the worst case is 2 x 20 MHz bandwidth and low guaranteed bit rate (which may be sufficiently low that the downlink SINR cut-off point is reached). For the range of examples included in our analysis we only found 800 MHz at 2 x 20 MHz bandwidth with a SINR cut-off of 10 dB and a target user bit rate of 1 Mbps to be uplink limited and that was by only 0.5 dB, which is small compared to all the other uncertainties in the modelling.

For target bit rates of 2 Mbps and 5 Mbps we found no case where the downlink MAPL was larger than the uplink MAPL. Of these, the smallest difference between uplink MAPL and downlink MAPL was for 800 MHz with 2 x 20 MHz bandwidth and a -10 dB SINR cut-off where the difference was 2.7 dB.

In conclusion, we consider that for the vast majority of cases presented in the January 2012 consultation the performance is not impaired by uplink limitations, with uplink and downlink at worst being very finely balanced.

[5] 'Realistic' mapping function as defined in our recent consultation Annex 14 LTE Technical Modelling Revised Methodology http://stakeholders.ofcom.org.uk/binaries/consultations/award-800mhz/annexes/annex14.pdf