Techniques for increasing the capacity of wireless broadband networks: UK, 2012-2030

Annex A8: Results for scenarios 22 to 39
Produced by Real Wireless on behalf of Ofcom

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About Real Wireless

Real Wireless is a leading independent wireless consultancy, based in the U.K. and working internationally for enterprises, vendors, operators and regulators – indeed any organization which is serious about getting the best from wireless to the benefit of their business.

We seek to demystify wireless and help our customers get the best from it, by understanding their business needs and using our deep knowledge of wireless to create an effective wireless strategy, implementation plan and management process.

We are experts in radio propagation, international spectrum regulation, wireless infrastructures, and much more besides. We have experience working at senior levels in vendors, operators, regulators and academia.

We have specific experience in LTE, UMTS, HSPA, Wi-Fi, WiMAX, DAB, DTT, GSM, TETRA – and many more.

For details contact us at: info@realwireless.biz

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Contents

A8. Results................................................................................................................................. 1
1.1 Introduction........................................................................................................................... 1
1.2 Results per scenario............................................................................................................. 3
1.3 High and low offload sensitivity ....................................................................................... 4
1.3.1 Scenario 22 - Rural Lincolnshire 2020 mid Spectrum mid Demand low Offload mid Technology ............................................................................................................... 4
1.3.2 Scenario 23 - Rural Lincolnshire Never mid Spectrum mid Demand low Offload mid Technology .................................................................................................................. 8
1.3.3 Scenario 24 - Urban London 2020 mid Spectrum mid Demand low Offload mid Technology .......................................................................................................................... 12
1.3.4 Scenario 25 - Urban London Never mid Spectrum mid Demand low Offload mid Technology .......................................................................................................................... 16
1.3.5 Scenario 26 - Suburban London 2020 mid Spectrum mid Demand low Offload mid Technology ...................................................................................................................... 20
1.3.6 Scenario 27 - Suburban London Never mid Spectrum mid Demand low offload mid Technology ............................................................................................................................ 24
1.3.7 Scenario 28 - Rural Lincolnshire 2020 mid Spectrum mid Demand high Offload mid Technology .......................................................................................................................... 28
1.3.8 Scenario 29 - Rural Lincolnshire Never mid Spectrum mid Demand high Offload mid Technology .......................................................................................................................... 32
1.3.9 Scenario 30 - Urban London 2020 mid Spectrum mid Demand high Offload mid Technology ............................................................................................................................. 36
1.3.10 Scenario 31 - Urban London Never mid Spectrum mid Demand high Offload mid Technology ............................................................................................................................ 40
1.3.11 Scenario 32 - Suburban London 2020 mid Spectrum mid Demand high Offload mid Technology ............................................................................................................................ 44
1.3.12 Scenario 33 - Suburban London Never mid Spectrum mid Demand high offload mid Technology ....................................................................................................................... 48
1.4 Spectrum sensitivity - High case and low (late public sector spectrum) case52
1.4.1 Scenario 34 - Rural Lincolnshire 2020 high Spectrum mid Demand mid Offload mid Technology .............................................................................................................................. 53
1.4.2 Scenario 35 - Rural Lincolnshire 2020 less Spectrum mid Demand mid Offload mid Technology .............................................................................................................................. 57
1.4.3 Scenario 36 - Urban London 2020 high Spectrum mid Demand mid Offload mid Technology .............................................................................................................................. 61
1.4.4 Scenario 37 - Urban London 2020 low Spectrum mid Demand mid Offload mid Technology .............................................................................................................................. 65
1.4.5 Scenario 38 - Suburban London 2020 high Spectrum mid Demand mid Offload mid Technology .............................................................................................................................. 69
1.4.6 Scenario 39 - Suburban London 2020 low Spectrum mid Demand mid Offload mid Technology
A8. Results

1.1 Introduction

This annex forms the second of two results annexes and presents the detailed results for scenarios 22 to 39 (scenarios 1-21 are presented in Annex A7). Table 1 presents a list of the scenarios in order and the associated input parameters for the high and low offload sensitivity, and high and low spectrum quantity all based on mid demand and mid offload.

Also given in the table are the number of sites for both macro and small cells in years 2012 and 2030 that provides the full spread of new sites required over the timeframe. The cumulative total cost in 2030 and 2040 is also given along with the saving in each year respectively. The final two columns provide the total offload costs and the spectrum costs.
<table>
<thead>
<tr>
<th>Area</th>
<th>Inputs</th>
<th>700MHz</th>
<th>Macro sites</th>
<th>Smallcell sites</th>
<th>Site savings of 700MHz</th>
<th>Cumulative Cost, EM</th>
<th>Saving of 700MHz</th>
<th>Offload Cost, EM</th>
<th>Spectrum</th>
<th>Monthly</th>
<th>Total cost</th>
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<tr>
<td></td>
<td></td>
<td>from</td>
<td>in 2012</td>
<td>in 2030</td>
<td>in 2012</td>
<td>in 2030</td>
<td>to 2030</td>
<td>to 2030</td>
<td></td>
<td></td>
<td>from</td>
</tr>
<tr>
<td>High/low offload</td>
<td></td>
<td>22</td>
<td>Rural Lin</td>
<td>Mid demand low offload</td>
<td>2020</td>
<td>157</td>
<td>189</td>
<td>7</td>
<td>48</td>
<td>24%</td>
<td>24%</td>
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<td></td>
<td>23</td>
<td>Rural Lin</td>
<td>Mid demand low offload</td>
<td>Never</td>
<td>157</td>
<td>199</td>
<td>7</td>
<td>40</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td></td>
<td>24</td>
<td>Urban</td>
<td>Mid demand low offload</td>
<td>2020</td>
<td>95</td>
<td>108</td>
<td>360</td>
<td>453</td>
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<td>26%</td>
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<td></td>
<td>25</td>
<td>Urban</td>
<td>Mid demand low offload</td>
<td>Never</td>
<td>95</td>
<td>114</td>
<td>360</td>
<td>485</td>
<td>-</td>
<td>-</td>
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<tr>
<td></td>
<td></td>
<td>26</td>
<td>Suburban</td>
<td>Mid demand low offload</td>
<td>2020</td>
<td>227</td>
<td>237</td>
<td>10</td>
<td>118</td>
<td>60%</td>
<td>36%</td>
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<td></td>
<td></td>
<td>27</td>
<td>Suburban</td>
<td>Mid demand low offload</td>
<td>Never</td>
<td>227</td>
<td>252</td>
<td>10</td>
<td>179</td>
<td>-</td>
<td>-</td>
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<td></td>
<td>28</td>
<td>Rural Lin</td>
<td>Mid demand high offload</td>
<td>2020</td>
<td>157</td>
<td>187</td>
<td>7</td>
<td>26</td>
<td>29%</td>
<td>24%</td>
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<td>29</td>
<td>Rural Lin</td>
<td>Mid demand high offload</td>
<td>Never</td>
<td>157</td>
<td>199</td>
<td>7</td>
<td>24</td>
<td>-</td>
<td>-</td>
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<tr>
<td></td>
<td></td>
<td>30</td>
<td>Urban</td>
<td>Mid demand high offload</td>
<td>2020</td>
<td>95</td>
<td>100</td>
<td>360</td>
<td>433</td>
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<td>31</td>
<td>Urban</td>
<td>Mid demand high offload</td>
<td>Never</td>
<td>95</td>
<td>103</td>
<td>360</td>
<td>485</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td></td>
<td>32</td>
<td>Suburban</td>
<td>Mid demand high offload</td>
<td>2020</td>
<td>227</td>
<td>230</td>
<td>10</td>
<td>45</td>
<td>67%</td>
<td>71%</td>
</tr>
<tr>
<td></td>
<td></td>
<td>33</td>
<td>Suburban</td>
<td>Mid demand high offload</td>
<td>Never</td>
<td>227</td>
<td>236</td>
<td>10</td>
<td>132</td>
<td>-</td>
<td>-</td>
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| Spectrum sensitivity | 24 | Rural Lin | Mid dem, % spectrum m  | 2020 | 157 | 180 | 7 | 25 | 8% | 18% | 27% | 7,128 | 9,678 | 9,678 | 15.6% | 23,013 | 29,971 | 96,256,752 | 0.05% | 31,030 | 40,018 |
| | 25 | Rural Lin | Mid dem, % spectrum m  | 2020 | 157 | 152 | 7 | 37 | 8% | 36% | 2% | 7,615 | 10,036 | 10,036 | 11.7% | 23,013 | 29,971 | 96,256,752 | 0.05% | 31,030 | 44,213 |
| | 26 | Urban | Mid dem, % spectrum m  | 2020 | 95 | 98 | 360 | 400 | 8% | 67% | 6% | 2,240 | 3,223 | 3,223 | 58.9% | 24,442 | 32,320 | 142,320 | 0.04% | 26,674 | 35,468 |
| | | 27 | Urban | Mid dem, % spectrum m  | 2020 | 95 | 132 | 360 | 611 | -10% | -10% | -10% | 14,489 | 21,688 | 21,688 | -108.3% | 24,442 | 32,320 | 118,922 | 0.04% | 38,329 | 53,508 |
| | | 28 | Suburban | Mid dem, % spectrum m  | 2020 | 227 | 231 | 10 | 59 | 81% | 68% | 68% | 5,360 | 6,808 | 6,808 | 46.5% | 43,144 | 54,205 | 111,971 | 0.03% | 46,479 | 61,005 |
| | | 29 | Suburban | Mid dem, % spectrum m  | 2020 | 227 | 292 | 10 | 158 | -25% | 3% | -24% | 14,988 | 22,672 | 22,672 | -50.6% | 43,144 | 54,205 | 93,759 | 0.03% | 56,153 | 76,683 |
1.2 Results per scenario

The following section provides the specific output plots for each of the scenarios listed in Table 1 that represent the key factors for deriving the cost of supplying capacity. In each scenario five plots are presented which include:

- Plot 1: Shows the demand maps and site locations per scenario in years 2012 and 2030.
- Plot 2: Shows the frequency band and site configuration evolution in years 2012 and 2030 (as separate figures). Each frequency band becomes more utilised as demand increases over time and in parallel the site configurations evolve for each of the frequency bands.
- Plot 3: Shows the evolution of sites required in each year which also includes the site types for both macro sites and small cells.
- Plot 4: Shows the average quantity of bandwidth used per macro site in MHz split by frequency band. The evolution of average bandwidth per sites provides an indication of site spectrum utilisation.
- Plot 5: Shows both the cumulative costs (£m) of the network deployment for each cost element such as, site upgrades, configuration upgrades and new site build and also the cost of each element per year.

The scenarios have been divided into three sections in order to build up the story of how the costs of supplying capacity are affected in each study area using the different set of inputs.

1. High and low offload sensitivity:

The plots in this section represent how high and low offload impacts upon the cost, particularly the number of site builds in each of the study areas. The high and low offload cases were set to either 2020 as the baseline or never case. These scenarios can be compared against the ‘mid offload 2020 or never cases.

2. High spectrum case, low (late Public Sector) spectrum case 700 MHz in 2020

This section represents how an increase in spectrum or decrease in the public sector spectrum impacts the utility of 700 MHz against the mid demand and mid technology case. This scenario can be compared against the mid case 2020 timings for 700 MHz.
1.3 High and low offload sensitivity

1.3.1 Scenario 22 - Rural Lincolnshire 2020 mid Spectrum mid
Demand low Offload mid Technology

Figure 1 Demand map and site location evolution in Rural Lincolnshire for years 2012 and 2030
Techniques for increasing the capacity of wireless broadband networks: UK, 2012-2030

Figure 2 Frequency band and site configuration evolution in 2012 for Rural Lincolnshire 2020

Figure 3 Frequency band and site configuration evolution in 2030 for Rural Lincolnshire 2020
Figure 4 Number of sites required for scenario 1 for Rural Lincolnshire 2020

Figure 5 Average bandwidth used per site for scenario 22 for Rural Lincolnshire 2020
Figure 6 Cumulative total cost of ownership for site upgrades and new site builds for scenario 22 for Rural Lincolnshire 2020
1.3.2 Scenario 23 - Rural Lincolnshire Never mid Spectrum mid
Demand low Offload mid Technology

Demand in 2012

Demand in 2030

Site numbers and locations in 2012

Site numbers and locations in 2030

Figure 7 Demand map and site location evolution in Rural Lincolnshire for years 2012 and 2030
Figure 8 Frequency band and site configuration evolution in 2012 for Rural Lincolnshire no 700 MHz

Figure 9 Frequency band and site configuration evolution in 2030 Rural Lincolnshire no 700 MHz
Figure 12 Cumulative total cost of ownership for site upgrades and new site builds for scenario 23
Rural Lincolnshire no 700 MHz
1.3.3 Scenario 24 - Urban London 2020 mid Spectrum mid Demand low Offload mid Technology

Demand in 2012

Demand in 2030

Site numbers and locations in 2012

Site numbers and locations in 2030

Figure 13 Demand map and site location evolution in Urban London for years 2012 and 2030
Figure 14 Frequency band and site configuration evolution in 2012 for Urban London 2020

Figure 15 Frequency band and site configuration evolution in 2030 for Urban London 2020
Techniques for increasing the capacity of wireless broadband networks: UK, 2012-2030

Figure 16 Number of sites required for scenario 24 for Urban London 2020

Figure 17 Average bandwidth used per site for scenario 24 for Urban London 2020
Techniques for increasing the capacity of wireless broadband networks: UK, 2012-2030

Issue date: March 2012
Version: 1.15
1.3.4 Scenario 25 - Urban London Never mid Spectrum mid Demand low Offload mid Technology

Demand in 2012

Demand in 2030

Site numbers and locations in 2012

Site numbers and locations in 2030

Figure 19 Demand map and site location evolution in Urban London for years 2012 and 2030
Techniques for increasing the capacity of wireless broadband networks: UK, 2012-2030

Figure 20 Frequency band and site configuration evolution in 2012 for Urban London no 700 MHz

Figure 21 Frequency band and site configuration evolution in 2030 for Urban London no 700 MHz
Figure 24 Cumulative total cost of ownership for site upgrades and new site builds scenario 25 for Urban London no 700 MHz
1.3.5 Scenario 26 - Suburban London 2020 mid Spectrum mid Demand low Offload mid Technology

Figure 25 Demand map and site location evolution in Urban London for years 2012 and 2030
Figure 26 Frequency band and site configuration evolution in 2012 for Suburban London 2020

Figure 27 Frequency band and site configuration evolution in 2030 for Suburban London 2020
Techniques for increasing the capacity of wireless broadband networks: UK, 2012-2030

Figure 28 Number of sites required for scenario 26 for Suburban London 2020

Figure 29 Average bandwidth used per site for scenario 26 for Suburban London 2020
Figure 30 Cumulative total cost of ownership for site upgrades and new site builds for scenario 26 for Suburban London 2020
1.3.6 Scenario 27 - Suburban London Never mid Spectrum mid Demand low offload mid Technology

Demand in 2012

Demand in 2030

Site numbers and location in 2012

Site numbers and location in 2030

Figure 31 Demand map and site location evolution in Urban London for years 2012 and 2030
Figure 32 Frequency band and site configuration evolution in 2012 for Suburban London no 700 MHz

Figure 33 Frequency band and site configuration evolution in 2030 for Suburban London no 700 MHz
Techniques for increasing the capacity of wireless broadband networks: UK, 2012-2030

Figure 34 Number of sites required for scenario 27 for Suburban London no 700 MHz

Figure 35 Average bandwidth used per site for scenario 27 for Suburban London no 700 MHz
Figure 36 Cumulative total cost of ownership for site upgrades and new site builds for scenario 27 for Suburban London no 700 MHz
1.3.7 Scenario 28 - Rural Lincolnshire 2020 mid Spectrum mid Demand high Offload mid Technology

Figure 37 Demand map and site location evolution in Rural Lincolnshire for years 2012 and 2030
Techniques for increasing the capacity of wireless broadband networks: UK, 2012-2030

Figure 40 Number of sites required for scenario 28 for Rural Lincolnshire 2026

Figure 41 Average bandwidth used per site for scenario 28 for Rural Lincolnshire 2020
Figure 42 Cumulative total cost of ownership for site upgrades and new site builds for scenario 28 for Rural Lincolnshire 2020
1.3.8 Scenario 29 - Rural Lincolnshire Never mid Spectrum mid
Demand high Offload mid Technology

Figure 43 Demand map and site location evolution in Rural Lincolnshire for years 2012 and 2030

Site numbers and locations in 2012
Site numbers and locations in 2030

Figure 43 Demand map and site location evolution in Rural Lincolnshire for years 2012 and 2030
Figure 44 Frequency band and site configuration evolution in 2012 for Rural Lincolnshire no 700 MHz

Figure 45 Frequency band and site configuration evolution in 2030 Rural Lincolnshire no 700 MHz
Figure 48 Cumulative total cost of ownership for site upgrades and new site builds for scenario 29
Rural Lincolnshire no 700 MHz
1.3.9 Scenario 30 - Urban London 2020 mid Spectrum mid Demand high Offload mid Technology

Demand in 2012

Demand in 2030

Site numbers and locations in 2012

Site numbers and locations in 2030

Figure 49 Demand map and site location evolution in Urban London for years 2012 and 2030
Techniques for increasing the capacity of wireless broadband networks: UK, 2012-2030

Figure 50 Frequency band and site configuration evolution in 2012 for Urban London 2026

Figure 51 Frequency band and site configuration evolution in 2030 for Urban London 2020
Techniques for increasing the capacity of wireless broadband networks: UK, 2012-2030

Figure 52 Number of sites required for scenario 30 for Urban London 2020

Figure 53 Average bandwidth used per site for scenario 30 for Urban London 2020
Figure 54 Cumulative total cost of ownership for site upgrades and new site builds for scenario 30 for Urban London 2020
1.3.10 Scenario 31 - Urban London Never mid Spectrum mid Demand high Offload mid Technology

Demand in 2012

Demand in 2030

Site numbers and locations in 2012

Site numbers and locations in 2030

Figure 55 Demand map and site location evolution in Urban London for years 2012 and 2030
Techniques for increasing the capacity of wireless broadband networks: UK, 2012-2030

Figure 56 Frequency band and site configuration evolution in 2012 for Urban London no 700 MHz

Figure 57 Frequency band and site configuration evolution in 2030 for Urban London no 700 MHz
Techniques for increasing the capacity of wireless broadband networks: UK, 2012-2030

Figure 58 Number of sites for scenario 31 for Urban London no 700 MHz

Figure 59 Average bandwidth used per site for scenario 31 for Urban London no 700 MHz
Figure 60 Cumulative total cost of ownership for site upgrades and new site builds scenario 31 for Urban London no 700 MHz
1.3.11 Scenario 32 - Suburban London 2020 mid Spectrum mid Demand high Offload mid Technology

Site numbers and locations in 2012

Site numbers and locations in 2030

Figure 61 Demand map and site location evolution in Urban London for years 2012 and 2030
Figure 62 Frequency band and site configuration evolution in 2012 for Suburban London 2020

Figure 63 Frequency band and site configuration evolution in 2030 for Suburban London 2020
Techniques for increasing the capacity of wireless broadband networks: UK, 2012-2030

Figure 64 Number of sites required for scenario 32 for Suburban London 2020

Figure 65 Average bandwidth used per site for scenario 32 for Suburban London 2020
Figure 66 Cumulative total cost of ownership for site upgrades and new site builds for scenario 32 for Suburban London 2020
1.3.12 Scenario 33 - Suburban London Never mid Spectrum mid Demand high offload mid Technology

Figure 67 Demand map and site location evolution in Urban London for years 2012 and 2030
Techniques for increasing the capacity of wireless broadband networks: UK, 2012-2030

Figure 68 Frequency band and site configuration evolution in 2012 for Suburban London no 700 MHz

Figure 69 Frequency band and site configuration evolution in 2030 for Suburban London no 700 MHz
Techniques for increasing the capacity of wireless broadband networks: UK, 2012-2030

Figure 70 Number of sites required for scenario 33 for Suburban London no 700 MHz

Figure 71 Average bandwidth used per site for scenario 33 for Suburban London no 700 MHz
Figure 72 Cumulative total cost of ownership for site upgrades and new site builds for scenario 33 for Suburban London no 700 MHz
1.4 Spectrum sensitivity - High case and low (late public sector spectrum) case
1.4.1 Scenario 34 - Rural Lincolnshire 2020 high Spectrum mid Demand mid Offload mid Technology

Demand in 2012

Demand in 2030

Site numbers and locations in 2012

Site numbers and locations in 2030

Figure 73 Demand map and site location evolution in Rural Lincolnshire for years 2012 and 2030
Techniques for increasing the capacity of wireless broadband networks: UK, 2012-2030

Figure 74 Frequency band and site configuration evolution in 2012 for rural Lincolnshire 2020

Figure 75 Frequency band and site configuration evolution in 2030 for rural Lincolnshire 2020
Techniques for increasing the capacity of wireless broadband networks: UK, 2012-2030

Figure 76 Number of sites required for scenario 34 for rural Lincolnshire 2020

Figure 77 Average bandwidth used per site for scenario 34 for rural Lincolnshire 2020
Figure 78 Cumulative total cost of ownership for site upgrades and new site builds for scenario 34 for rural Lincolnshire 2020
1.4.2 Scenario 35 - Rural Lincolnshire 2020 less Spectrum mid
Demand mid Offload mid Technology

Demand in 2012

Demand in 2030

Site numbers and locations in 2021

Site numbers and locations in 2030

Figure 79 Demand map and site location evolution in Rural Lincolnshire for years 2012 and 2030
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