Answers to stakeholder questions relating to cost modelling

Relating to the consultation on application of spectrum liberalisation and trading to the mobile sector

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Background

1.1 On 20 September 2007 Ofcom published a consultation on application of spectrum liberalisation and trading to the mobile sector, including implementation of the Radio Spectrum Committee Decision on 900 MHz and 1800MHz.

1.2 The consultation sets out a number of calculations relating the costs and benefits of spectrum release. Ofcom has since received a number of questions from stakeholders which relate to Ofcom's methodology and underlying assumptions for some aspects of our calculations. The calculations relate to some of the quantifications provided in the consultation document and fall into three areas:

- costs of providing 3G services in densely populated ('core') areas
- costs of providing 3G services in less densely populated (non-core) areas
- costs of releasing spectrum

1.3 The questions asked and the answers provided are set out below.

Questions relating to less densely populated areas

Q1. How is the annual capex and opex per site calculated?

1.4 The following information can be used to establish the annual capex and opex used for upgraded and newly built sites. This information is also relevant to calculations for densely populated areas.

1.5 Paragraphs 5.84 and A6.48-51 state that in 2007/08 our mid assumption for capex is £105k for new builds and £45k for upgrades.

1.6 In order to identify the relevant capex figure if expenditure is incurred later it is necessary to trend these figures using the cost trends provided. The £45k upgrade cost is assumed to be predominantly equipment driven, consequently we have applied a equipment cost trend that reduces this by -7.5% in each year

1.7 The £105k new build cost is assumed to include the £45k equipment costs incurred for upgrades, which is again trended at -7.5% per annum. The additional £60k relates to acquisition and construction, which is assumed to be labour and land driven. Consequently we have applied a positive cost trend of 2.5% to this £60k to broadly reflect anticipated real economic growth.

1.8 Annual opex is assumed to be 10% of the relevant capex figure.

1.9 The table below shows how to identify the 2008/9 capex and opex based on this information.

£, 2007/08		**2007/08**	**2008/09**	**Calculation**
New build	Capex	105,000	103,125	45,000*(1-0.075) + 60,000 *(1+0.025)
New build	Opex	10,500	10,313	103,125*0.1

Upgrade	Capex	45,000	41,625	45,000*(1-0.075)
Upgrade	Opex	4,500	4,163	41,625*0.1

Q2. How are the number of new sites and upgrades calculated in less densely populated areas?

1.10 Below we clarify how to replicate our results for the number of sites required in less densely populated areas at different frequencies.

Calculation of total sites

1.11 The total number of sites required in less densely populated areas can be calculated by taking the area (km^2) of the relevant population interval and multiplying it by the appropriate base station density. The example below shows this calculation for UMTS900 and UMST2100 in the 80%-99% population interval.

Areas:				
a	Total area at 80%		31,345	Table 19
b	Total area at 99%		168,430	Table 19
c	Area relevant to 80%-99%	b-a	137,085	
Base station densities:				
d	UMTS 900, less dense		0.017	Table 20
e	UMTS 2100, less dense		0.037	Table 20
Required number of base stations:				
f	UMTS 900	c*d	2,330	Figure 20
g	UMTS 2100	c*e	5,072	Figure 20
h	Difference	g-h	2,742	Table 22

1.12 Note that most of the figures in the table above are un-rounded, whilst those presented in the consultation document are rounded.

Calculation of cost differences

1.13 Having established that covering an equivalent area using spectrum at 2100MHz rather than 900MHz would involve approximately 2,700 extra sites we now demonstrate how to replicate our results for the cost of these additional sites.

1.14 The first step is to split the number of the sites into sites which are upgrades and new builds. In the analysis of less densely populated areas we assume that upgrades form a given proportion of your required site numbers (85% is the central assumption).

1.15 Using this assumption it is possible to identify the number of new builds and upgrades. We then assume that these new builds and upgrades take place over a given period (3 years is the central assumption).

1.16 Having established how many new builds and upgrades occur in each year we multiply this by the relevant per site cost, discounted back to 2007/08.

1.17 The different steps in this calculation are set out in the table below.

i	Upgrade proportion		85%	A7.30
Additional base stations to be costed:				
j	Upgrades	i*h	2,331	
k	New builds	(1-i)*h	411	
Site build out profile:				
l	Year 1 (2009/10)		30%	Table 21
m	Year 2 (2010/11)		50%	Table 21
n	Year 3 (2011/12)		20%	Table 21
NPV of site costs (£k, 2007/08):				
o	Upgrade, year 1 (2009/10)		75	Table 17
p	Upgrade, year 2 (2010/11)		65	Table 17
q	Upgrade, year 3 (2011/12)		60	Table 17
r	New build, year 1 (2009/10)		240	Table 17
s	New build, year 2(2010/11)		230	Table 17
t	New build, year 3(2011/12)		220	Table 17
u	Cost of all upgrades	j*(l*o+m*p+n*q)	156,177	
v	Cost of all new builds	k*(l*r+m*s+n*t)	94,941	
w	**Total cost difference**	v+u	251,118	Table 22

1.18 Again, note that most of the figures in the table above are un-rounded, whilst those presented in the consultation document are rounded.

Q3. What link budgets have been assumed by Ofcom for its 3G coverage analysis? (Table 15 on page 171)

1.19 The Link Budgets used for our analysis of the provision of 3G services in the less densely populated areas are detailed below for each of the following spectrum bands 900MHz, 1800MHz and 2100MHz.

UMTS 900

Universal Parameters		**Value**		**Units**
Environment		Vehicular		
Mobile Velocity		120		km/h
Service		Speech		12.2kbps
Carrier Frequency	F	**900.0**		MHz
Noise Bandwidth	B	**3.84**		MHz

		Downlink	**Uplink**	
Transmitter Parameters	**Parameter**	**Value**		**Units**
		BS_Tx	**MS_Tx**	
Equivalent Isotropic Radiated Power	**EIRP**	**48.01**	**19.47**	**dBm**

Eb/No Calculation		**MS_Rx**	**BS_Rx**	**Units**
Signal To Noise Ratio	**Eb/No**	**9.21**	**7.2**	dB

Receiver Limits		**MS**	**BS**	**Units**
Receiver Noise Figure	NF	**7.0**	**4.0**	dB
SNR	Eb/No	**9.2**	**7.2**	dB
Receiver Thermal Sensitivity	**Srx**	**-116.9**	**-121.9**	dBm

Receiver Parameters				
Body Loss	BL	**1.50**		dB
Minimum Required Isotropic Power	**IPrx**	**-115.4**	**-136.9**	**dBm**

Interference Calculation				
Load Factor	Ioth	**50.00**	**50.00**	%
Total Noise Rise	**NR**	**3.01**	**3.01**	**dB**

Variability Calculation		**STD**		**Units**
Total Variability	**V**	**9.24**		**dB**

Link Loss Calculation				
Soft Handover Gain	SHO	**3.00**	**3.00**	dB
Vehicle Penetration Loss	BPL	**3.00**	**3.00**	dB
Location Variability	V	**9.24**	**9.24**	dB
Coverage Target	Cov	**90.00**	**90.00**	%
Allowed Propagation Loss for Cell Range	**PL**	**148.58**	**141.55**	**dB**
Pilot Planning Level	**PPLev**	**-93.54**		**dB**

UMTS 1800

Universal Parameters		Value		Units
Environment		Vehicular		
Mobile Velocity		120		km/h
Service		Speech		12.2kbps
Carrier Frequency	F	**1800.0**		MHz
Noise Bandwidth	B	**3.84**		MHz

		Downlink	Uplink	
Transmitter Parameters	**Parameter**	**Value**		**Units**
		BS_Tx	**MS_Tx**	
Equivalent Isotropic Radiated Power	**EIRP**	**48.01**	**19.47**	**dBm**

Eb/No Calculation		MS_Rx	BS_Rx	Units
Signal To Noise Ratio	**Eb/No**	**9.21**	**7.2**	dB

Receiver Limits		MS	BS	Units
Receiver Noise Figure	NF	**7.0**	**4.0**	dB
SNR	Eb/No	**9.2**	**7.2**	dB
Receiver Thermal Sensitivity	**Srx**	**-116.9**	**-121.9**	dBm

Receiver Parameters				
Body Loss	BL	**1.50**		dB
Minimum Required Isotropic Power	**IPrx**	**-115.4**	**-136.9**	**dBm**

Interference Calculation				
Load Factor	Ioth	**50.00**	**50.00**	%
Total Noise Rise	**NR**	**3.01**	**3.01**	**dB**

Variability Calculation		STD		Units
Total Variability	**V**	**7.86**		**dB**

Link Loss Calculation				
Soft Handover Gain	SHO	**3.00**	**3.00**	dB
Building Penetration Loss	BPL	**7.00**	**7.00**	dB
Location Variability	V	**7.86**	**7.86**	dB
Coverage Target	Cov	**90.00**	**90.00**	%
Allowed Propagation Loss for Cell Range	**PL**	**146.36**	**139.33**	**dB**
Pilot Planning Level	**PPLev**	**-91.32**		**dB**

UMTS 2100

Universal Parameters		Value		Units
Environment		Vehicular		
Mobile Velocity		120		km/h
Service		Speech		12.2kbps
Carrier Frequency	F	**2100.0**		MHz
Noise Bandwidth	B	**3.84**		MHz

		Downlink	**Uplink**	
Transmitter Parameters	**Parameter**	**Value**		**Units**
		BS_Tx	**MS_Tx**	
Equivalent Isotropic Radiated Power	**EIRP**	**48.01**	**18.97**	**dBm**

Eb/No Calculation		MS_Rx	BS_Rx	Units
Signal To Noise Ratio	**Eb/No**	**9.21**	**7.2**	dB

Receiver Limits		MS	BS	Units
Receiver Noise Figure	NF	**7.0**	**4.0**	dB
SNR	Eb/No	**9.2**	**7.2**	dB
Receiver Thermal Sensitivity	**Srx**	**-116.9**	**-121.9**	dBm

Receiver Parameters				
Body Loss	BL	**2.00**		dB
Minimum Required Isotropic Power	**IPrx**	**-114.9**	**-136.9**	**dBm**

Interference Calculation				
Load Factor	Ioth	**50.00**	**50.00**	%
Total Noise Rise	**NR**	**3.01**	**3.01**	**dB**

Variability Calculation		STD		Units
Total Variability	**V**	**8.06**		**dB**

Link Loss Calculation				
Soft Handover Gain	SHO	**3.00**	**3.00**	dB
Building Penetration Loss	BPL	**8.00**	**8.00**	dB
Location Variability	V	**8.06**	**8.06**	dB
Coverage Target	Cov	**90.00**	**90.00**	%
Allowed Propagation Loss for Cell Range	**PL**	**144.60**	**137.57**	**dB**
Pilot Planning Level	**PPLev**	**-89.56**		**dB**

Q4. What planning assumptions have been made for 3G rural coverage? (A7.20 on p 186)

1.20 The following table (which repeats Table 19 of the consultation document) shows our assumptions for the proportion of the less densely populated area which is already covered in order to achieve 80% population coverage, and hence the additional area over which coverage is required in order to extend coverage from 80 to 99% of the UK population.

		Area km^2 for percentage of UK population				
Population coverage		**80%**	**90%**	**95%**	**99%**	**100%**
Densely populated area		10,203	10,203	10,203	10,203	10,203
Less densely populated area		21,136	56,380	94,270	158,221	158,221
Remote area		-	-	-	-	82,510
Total area		31,345	66,589	104,479	168,430	250,940
Incremental area beyond 80%	Less dense	-	35,244	73,134	137,085	137,085
	Remote	-	-	-	-	82,510

1.21 Networks outside of the 80% population coverage area were planned for coverage according to the link budgets given in answer to Q1 for UMTS 900, UMTS 1800 and UMTS 2100, using the positions of existing GSM 900 sites where appropriate. A traffic model was then used to conduct a static simulation to ensure that these networks could successfully carry the relevant (predominantly voice) traffic. The traffic model was based upon the traffic levels of a GSM 900 network analysed within the Horsham area. This analysis involved drive testing to find the base station footprint and user density levels over the area. This was used to tune a model of traffic density according to clutter type.

1.22 The resulting base station densities were calculated for the re-planned coverage area and were reported in Table 20 of the consultation document (and are repeated below).

Base stations per km^2	UMTS 900	UMTS 1800	UMTS 2100
Less densely population area	0.017	0.027	0.037
Remote area	0.008	0.013	0.018

1.23 The “Less densely populated area” base station densities were used for the whole of the extended coverage area from 80 to 99% of the UK population.

1.24 The number of base stations needed using each frequency band, can then be estimated by using the following equation:

Number of base stations needed = (Coverage Area)*(Base station density)

1.25 This is illustrated by the following example. The table below calculates the number of base stations required to cover the area between 80-99% population coverage with a

UMTS900 network. The base station density is obtained from the table above, whilst the area to be covered is shown in the table previous to that.

Area to be covered (km^2)	137,085
Base station density	0.017
No. of base stations required	2,330

Questions relating to densely populated areas

Q5. What geotype distributions have been assumed by Ofcom?

1.26 In annex 8, the extrapolation from the simulated area to the 80% coverage zone is carried out using the algorithm described in the answer to question 8 below. No direct assumptions are made concerning the distribution of geotypes in this zone except that the characteristics are broadly similar to those in the simulation area.

1.27 The geotype assumptions for the less densely populated 80-99% zone are examined in response to question 4 in the previous section.

Q6. What are the actual geotype distributions for the area studied (A8.9 on p 195)?

1.28 The proportions of the area of the 10km x 10km focus zone in each geotype are as follows:

1 water	3.4%
2 open	6.0%
3 forest	4.8%
4 suburban	53.6%
5 open in urban	14.2%
6 urban	16.6%
7 dense urban	1.5%

Q7. How many concurrent users of voice and data do the simulations attempt to service per sq km, taking the dense urban geotype in the medium adoption scenario as an example? (Tables 26-30 on page 200)

1.29 The simulations use the simulation tool described in section A8.5 to create multiple pseudo-random distributions of users over the simulated 10km x10 km area in proportion to the densities in tables 28-30 for each class of user. For example, from table 299 (p. 200) the mean number of outdoor class 2 users in a 50m x 50m urban pixel in medium adoption will be 0.050 x 0.050 x 270 = 0.65. Users are actually ‘dropped’ into the simulation area with uniform (i.e. Poisson) statistics.

1.30 In medium adoption, each user adopting data services is assumed to use 10 Mbits (downlink) per day. 10% of this is assumed to occur in the ‘busy hour’ so this means that 30% of the simulated users are active with 144 kbps for 10% x 10 x 10^6 / 144 x 10^3 = 6.94 seconds in each busy hour, which is the focus period for the simulation. Each user additionally generates demand for voice services at 20mE in the busy hour or 0.020 x 60 x 60 = 72 seconds. These are the mean durations – the simulator actually generates calls and data demand randomly in each simulation cycle.

1.31 So given that users of classes 2 and 3 generate demand for data services, there are a total of 270 + 1080 = 1350 of these per square km in medium adoption. The average number of concurrent users of medium-rate data services will thus be 1350 x 6.94 / (60 x 60) = 2.6 per square km.

1.32 Additionally voice services are demanded by all user classes, resulting in a total of 945 + 270 + 2205 + 1080 = 4500 per square km (urban). The mean number of concurrent users is thus: 4500 x 72 / (60 x 60) = 90 per sq km.

1.33 Note however that as well as serving this traffic with 95% success rate, the requirement to provide 80% coverage at Ec and Ec/Io levels commensurate with 144 kbps service (for medium adoption) places an additional significant performance requirement on the network.

Q8. How are the site requirements for the 100sq km simulation area (table 34 on p 203) extrapolated to 80% population coverage (table 35 on p 205)?

1.34 The algorithm is described in sections A8.27 – A8.31 and figure 27 (pp. 203-205). The algorithm is:

Sites required = Ns = (1 + (Nss/Nss9L – 1) x planning_efficiency) x Ns9

Where:

- *Nss* = total sites required for the specified scenario based on the simulation (as given in table 34, p 203)
- *Nss9L* = sites required from simulation for 900 MHz low adoption = 37.
- *planning_efficiency* = proportion of sites in excess of 900 MHz indicated by the simulations which are actually needed when providing service in the 80% population zone.
- *Ns9* = sites required at 900 MHz for service to 80% of population at low adoption = 6600 (table 35, p 205)
- *Nsup* = sites available for upgrade = Pup x 6500
- *Pup* = proportion of existing sites to be upgraded = 85% (or 100% at zero cost for 2100 MHz)

1.35 For example, take the case of 2100 MHz medium adoption.

- From table 34, Nss = 64 + 130 = 194 sites and Nss9L = 37 sites.
- So Ns = (1 + (Nss/Nss9L – 1) x planning_efficiency) x Ns9 = (1 + (194 / 49 – 1) x 0.40) x 6600 = 17,802 sites. Note that there is a typographical error in table 35, which gives the rounded value as 17,900 rather than 17,800. The correct values are used in the subsequent figures and tables.

Q9. What data usage is assumed by the simulation? 5.84ii on page 48 states that medium data users consume 10Mbits per day downlink, but Table 26 on page 200 says 20Mbits per day.

1.36 Page 48 refers to the central estimate, corresponding to the medium adoption scenario. There are two classes of user which make use of medium-rate data services: class 2 and class 3, demanding 10 and 20 Mbits of downlink service daily respectively. However in the medium adoption scenario there are no users of class 3 as stated in Table 29 (p. 200), so all medium-rate data is at 10 Mbits per user as stated on page 48.

Q10. What 3G handset penetration has been assumed for the core scenario? Table 7 on page 100 states that the low demand scenario has 15% of users with 3G handsets by 2010, and the high demand 35%, so does the medium scenario assume 25%?

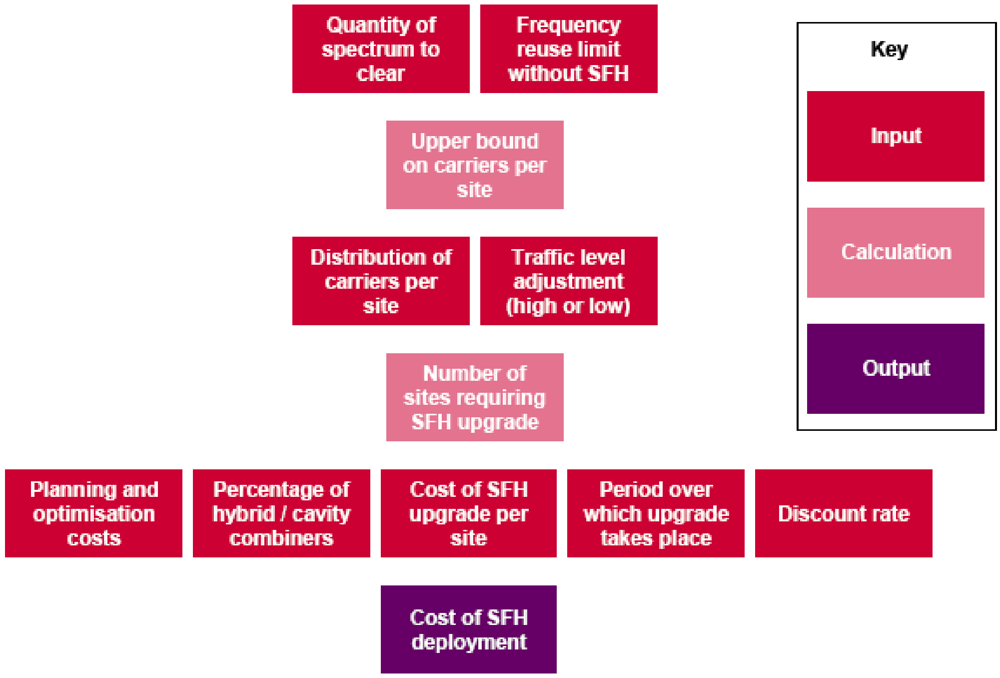
1.37 The high and low demand for mobile broadband scenarios have been defined to aid our analysis of the costs and benefits for different policy options, the consultation document does not formally define, or rely upon, a core scenario for these purposes. The low and high demand scenarios have been defined such that they simplify the quantification task.

1.38 We have not sought to quantify the costs and benefits associated with the medium demand scenario as this would be more complex and so difficult to do in a reliable way. We do not consider it necessary in order to make the policy choices required. Consequently we have not needed to specify a particular level of 3G handset penetration associated with the medium demand scenario.

Questions relating to estimating the costs of spectrum release

Q11. Please provide further details of the calculation of the Synthesised Frequency Hopping costs (Tables 44 & 45 on page 243)?

1.39 Below we clarify how to replicate our results for the cost of implementing Synthesised Frequency Hopping (SFH). We split the relevant calculations into three main stages as shown in Figure 43, reproduced below.



Calculation of upper bound on carriers per site

1.40 We can estimate what the theoretical maximum number of carriers per sector is based on reasonable assumptions about the frequency reuse factors for BCCH and TCH carriers (the reuse pattern for BCCH must be more relaxed than TCH as these channels cannot take advantage of baseband hopping), for any given amount of spectrum.

1.41 Put another way, for any reduction in the current amount of spectrum we can estimate how many sites are likely to become capacity constrained (a constraint that can't be alleviated by simply adding extra carriers without reducing the frequency reuse factors below a level that is likely to impact on the quality of service).

1.42 These calculations are performed in the table below. The table takes the spectrum available for the GSM network and calculates the upper bound on carriers per sector.

GSM 900 spectrum released/refarmed per operator[1]	Remaining GSM spectrum[1]	Number of carriers[2]	BCCH carrier reuse factor[3]	TCH carrier reuse factor[3]	TCH carriers per sector	Maximum carriers per sector
(2 x MHz)	(2 x MHz)	(200 kHz channels)				
	a	b 5*a	c	d	e (b-c)/d	f e+1
0	23.2	116	21	12	7	8
2.5	20.7	103	21	12	6	7
5.0	18.2	91	21	12	5	6
7.5	15.7	78	21	12	4	5
10.0	13.2	66	21	12	3	4
12.5	10.7	53	21	12	2	3
15.0	8.2	41	21	12	1	2

Notes:

1 – As shown in Table 41 & 42.

2 – As stated in paragraph A9.82.

3 – As stated in paragraph A.9.97.

1.43 The table is constructed as follows: the available spectrum (a) is divided into the number of available 200 kHz spaced carriers (b). It is assumed that each sector requires a single BCCH carrier with a reuse factor of 21 (c). TCH carriers are assumed to permit tighter reuse of 12 (d). The available TCH carriers in each sector (e) is then the total number of carriers available (b), less the required number of BCCH carriers (c), divided by the TCH reuse factor (d). The total number of carriers per sector is then the TCH carrier numbers plus 1 to account for the BCCH carrier.

Calculation of number of sites requiring SFH upgrade

1.44 The second stage is to translate this maximum number of carriers into a number of sites on which to implement SFH (or any other solution to combat the capacity constraint).

1.45 The first step is to recognise that although, for any given spectrum reduction, the previous table states that “f” shall be the maximum number of carriers available per sector, this is an approximation. In reality it is reasonable to expect that some sectors with less than f carriers per sector will require upgrading to SFH. Whilst, on the other hand, some sectors with more than f carriers will not require upgrading to SFH.

1.46 Consequently, rather than applying an upgrade to only those sites exceeding the maximum carriers available per sector, f, we smooth the profile. The form of this smoothing is shown in the table below, and explained in paragraph A.9.126.

Sites with no. of carriers per sector	Proportion to upgrade
F + 2	100%
F + 1	75%
F	50%
F - 1	25%
F - 2	0%

1.47 When this profile is applied for different amounts of spectrum reduction you obtain the following table which gives you the proportion of sites a network will need to upgrade, based on the number of carriers per sector at that site.

GSM 900 spectrum released/refarmed per operator (2 x MHz)	Maximum carriers per sector	Carriers per sector							
		1	2	3	4	5	6	7	8
2.5	7	0%	0%	0%	0%	0%	25%	50%	75%
5.0	6	0%	0%	0%	0%	25%	50%	75%	100%
7.5	5	0%	0%	0%	25%	50%	75%	100%	100%
10.0	4	0%	0%	25%	50%	75%	100%	100%	100%
12.5	3	0%	25%	50%	75%	100%	100%	100%	100%
15.0	2	25%	50%	75%	100%	100%	100%	100%	100%
		g1	g2	g3	g4	g5	g6	g7	g8

1.48 We now know, for a given reduction in spectrum, what proportion of sites (at a given number of carriers per sector) will need upgrading. Combining this information with the distribution of sites by carriers per sector will tell us how many sites need to be upgraded.

1.49 Two such distributions are provided in Table 43, reproduced below. Both networks are assumed to have 8,000 sites. Network A is assumed to have an average of 2 sectors per site, whereas network B is assumed to have an average of 3 sectors per site.

	Total network		
Carriers per sector	Stylised network A	Stylised network B	
1	2%	6%	h1
2	23%	51%	h2
3	27%	22%	h3
4	22%	17%	h4
5	15%	3%	h5
6	8%	1%	h6
7	3%	0%	h7
8	0%	0%	h8

1.50 From this point onwards, for the purposes of illustration, we will demonstrate the calculations with network A and a reduction in spectrum of 7.5 MHz in the high demand for mobile broadband scenario.

1.51 If we expected traffic levels to change over time, the distributions shown above would also change. Consequently, there is an adjustment that can be made to allow the distribution of carriers per sector to reflect a higher traffic level on the GSM network. This adjustment is made in the low demand for mobile broadband scenario. The adjustment is to add two carriers per sector to each site in the distributions above.[1]

1.52 Having selected the appropriate stylised distribution and spectrum reduction level (network A and 7.5MHz in our example) we can now multiply that distribution by the proportion of sites to be upgraded, calculated earlier. Summing this result for each carrier per sector gives you the total number of sites to be upgraded.

1.53 The table below shows this result for a reduction of 2 x 7MHz on network A in the high demand for mobile broadband scenario.

GSM 900 spectrum released/refarmed per operator (2 x MHz)	Carriers per sector								Total sites
	1	2	3	4	5	6	7	8	
7.5	0	0	0	440	600	480	240	0	1,760
	g1*h1	g2*h2	g3*h3	g4*h4	g5*h5	g6*h6	g7*h7	g8*h8	

1.54 We then make two adjustments to this total value of 1,760 sites.[2] Firstly it is multiplied by 2 to reflect the fact that SFH needs to be applied to areas, rather than individual sites. Secondly, if the resulting value is less than 5% of the network's

[1] With the exception of sites with 7 carriers per sector, where 1 is added, and sites with 8 carriers per sector, where no adjustment is made.

[2] See paragraph A9.128.

sites, it is increased to 5% of total sites. This is to reflect the minimum likely deployment of SFH in a network.

Number of sites	1,760
Factor reflecting clustering	2
Total sites to upgrade	**3,520**
Sectors per site	2
Sectors to upgrade	**7,040**

1.55 This figure can be expressed as sites or sectors requiring upgrade (the number of sectors is obtained by multiplying sites by the assumed average number of sectors per site).

Cost of SFH deployment

1.56 Implementing SFH involves a number of fixed costs, which do not vary with the number of sites or sectors to be upgraded. Our assumptions in relation to these costs are as follows. We have assumed that the frequency planning and optimisation costs of implementing SFH are £2m, and the required network management system upgrade costs, is £1m, in 2007/08.[3] These costs are then assumed to increase at 3% a year thereafter (real increase).

1.57 Implementing SFH also involves costs which vary on a per site basis. There are two items that are costed on a per site basis. Software upgrades are assumed to cost £1,000 per site in 2007/08, and are then assumed to fall by 5% a year. Whilst labour costs are also assumed to cost £1,000 per site in 2007/08, but are forecasted to rise at 3% a year.[4]

1.58 We have also identified one cost item which varies on a per sector basis. This is the cost of upgrading to a hybrid combiner. It is assumed that 15% of network A's combiners require such an upgrade. That proportion is assumed to be 33% for network B. A hybrid combiner is estimated to cost £11,000 per sector in 2007/08, and is then assumed to fall by 5% a year thereafter.[5]

1.59 It is assumed that these costs are incurred in the two years prior to spectrum release. Further, it is assumed that these expenditures will need to be repeated every 8 years as the equipment is replaced (with the exception of the frequency planning and optimisation cost which is not incurred again, i.e. has 20+ year life).

[3] See paragraph A9.132.

[4] See paragraph A9.131, price changes are in real terms

[5] See paragraph A9.131, price changes are in real terms

1.60 The tables overleaf show the calculations for our example, a reduction in spectrum of 7.5 MHz for network A in the high demand for mobile broadband scenario. They omit years in which there are no expenditures.[6]

Costing of initial two year rollout of SFH

	2008/09			2009/10		
	Price	Unit	Cashflow	Price	Unit	Cashflow
Frequency planning and optimisation	2,060,000	0.5	1,030,000	2,122,000	0.5	1,061,000
Network management system upgrades	1,030,000	0.5	515,000	1,061,000	0.5	530,500
Software upgrage (per site)	950	1,760	1,672,000	900	1,760	1,584,000
Labour (per site)	1,030	1,760	1,812,800	1,060	1,760	1,865,600
Hybrid combiner (per sector)	10,500	528	5,544,000	9,900	528	5,227,200
Total undiscounted cashflow			10,573,800			10,268,300
Discount factor			0.934			0.902
Discounted cashflow			9,875,929			9,262,007
Total NPV **37,062,087**						

Costing of equipment replacement after 8 years

	2016/17			2017/18		
	Price	Unit	Cashflow	Price	Unit	Cashflow
Frequency planning and optimisation	2,610,000	0	0	2,688,000	0	0
Network management system upgrades	1,305,000	0.5	652,500	1,344,000	0.5	672,000
Software upgrage (per site)	630	1,760	1,108,800	600	1,760	1,056,000
Labour (per site)	1,300	1,760	2,288,000	1,340	1,760	2,358,400
Hybrid combiner (per sector)	6,900	528	3,643,200	6,600	528	3,484,800
Total undiscounted cashflow			7,692,500			7,571,200
Discount factor			0.709			0.685
Discounted cashflow			5,453,983			5,186,272

Costing of equipment replacement after 16 years

	2024/25			2025/26		
	Price	Unit	Cashflow	Price	Unit	Cashflow
Frequency planning and optimisation	3,306,000	0	0	3,405,000	0	0
Network management system upgrades	1,653,000	0.5	826,500	1,702,000	0.5	851,000
Software upgrage (per site)	420	1,760	739,200	400	1,760	704,000
Labour (per site)	1,650	1,760	2,904,000	1,700	1,760	2,992,000
Hybrid combiner (per sector)	4,600	528	2,428,800	4,400	528	2,323,200
Total undiscounted cashflow			6,898,500			6,870,200
Discount factor			0.538			0.520

[6] Please note that the figures overleaf have been rounded at each stage for the purposes of presentation. The calculation displayed works off these rounded figures. Consequently the results may vary slightly to those shown in the consultation document due to rounding.

Discounted cashflow	3,711,393	3,572,504

1.61 In the course of preparing this response we uncovered a minor mechanical error in the synthesised frequency hopping model. This has resulted in the outside 3G coverage area distribution of sites being used where the total network distribution should have been used. As a consequence following the steps set out above will not produce precisely the same cost estimates for all the SFH costing set out in Tables 44 and 45 in the consultation document. The resulting differences in the results of the SFH modelling are relatively minor, given the purpose of these calculations; hence, Ofcom does not consider that this mechanical error in the spreadsheet changes any of the policy analysis and views set out in the consultation document.

1.62 The impact of the error is shown by comparison of the tables presented below. The top table (purple shaded) under each heading is that shown in the consultation. The bottom (pink shaded) tables contain the updated figures in italics. The value of £37m calculated above rounds to £35m and is shown in the right hand column of Table 44, 2 x 7.5MHz cleared per operator.

Table 44: SFH upgrade costs – high mobile broadband demand scenario

Spectrum cleared per operator	Synthesised Frequency Hopping cost per operator	
	Lower (£m)	Upper (£m)
2 x 2.5 MHz	10	15
2 x 5.0 MHz	10	15
2 x 7.5 MHz	20	25
2 x 10.0 MHz	40	45
2 x 12.5 MHz	75	100
2 x 15.0 MHz	75	175

Spectrum cleared per operator	Synthesised Frequency Hopping cost per operator	
	Lower (£m)	Upper (£m)
2 x 2.5 MHz	*10*	*15*
2 x 5.0 MHz	*10*	*20*
2 x 7.5 MHz	*25*	*35*
2 x 10.0 MHz	*60*	*65*
2 x 12.5 MHz	*75*	*125*
2 x 15.0 MHz	*75*	*175*

Table 45: SFH upgrade costs – low mobile broadband demand scenario

Spectrum cleared per operator	Synthesised Frequency Hopping cost per operator	
	Lower (£m)	Upper (£m)
2 x 2.5 MHz	20	25
2 x 5.0 MHz	40	45
2 x 7.5 MHz	75	100
2 x 10.0 MHz	75	175

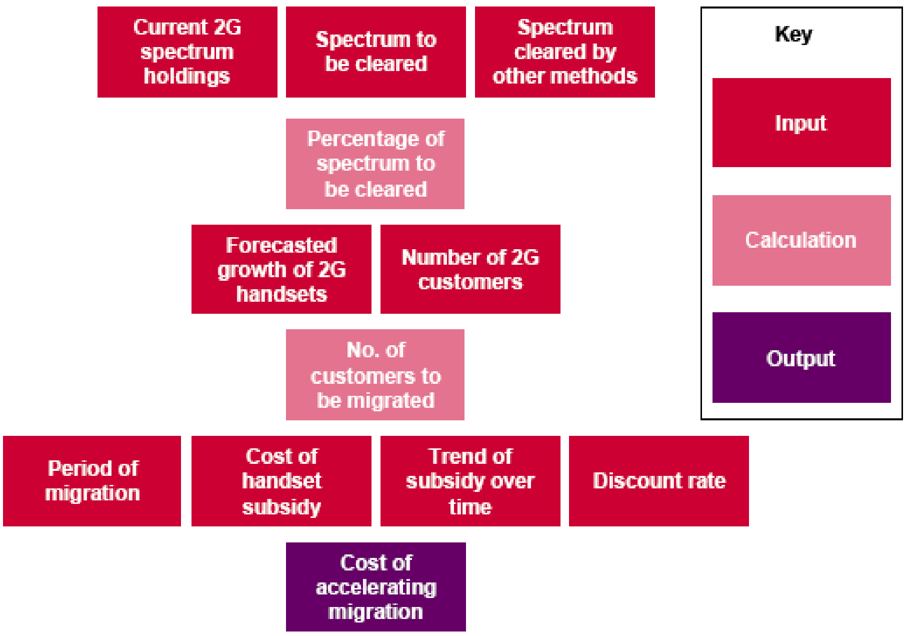
Spectrum cleared per operator	Synthesised Frequency Hopping cost per operator	
	Lower (£m)	Upper (£m)
2 x 2.5 MHz	*25*	*35*
2 x 5.0 MHz	*60*	*65*
2 x 7.5 MHz	*75*	*125*
2 x 10.0 MHz	*75*	*175*

Q12. How do the accelerated handset migration calculations (pages 250 onwards) work, in terms of number of customers on 2G and on 3G before and after the accelerated migration?

1.63 Below we clarify how to replicate our results for the cost of accelerating handset migration. We split the relevant calculations into three sections, as shown in Figure 45, reproduced below.

1.64 The calculations show the algebraic form of the model, and also contain the input data necessary to reproduce the 'high' estimate for clearance of 2 x 12.5 MHz in Table 51.

1.65 Note that all the figures below are un-rounded, whilst those presented in the consultation document are rounded to the nearest £25m.



1.66 The first stage of this model establishes what percentage of an operator's 2G spectrum holdings is to be cleared by accelerating migration to 3G handsets. This calculation is shown in the table below.

Spectrum:			
A	Total 2G spectrum holdings (2 x 5MHz blocks)		4.5
B	Total spectrum to be cleared per operator		2.5
C	Spectrum to be cleared by other methods		2
D	Amount of spectrum to be cleared by accelerated migration	b-c	0.5

E	Percentage of remaining spectrum to be cleared by accelerated migration	d/(a-c)	20%

1.67 Having established the percentage of spectrum to be cleared by accelerated migration, we now seek to determine how many customers this represents.

1.68 To do this we construct a very simple forecast of the number of 2G subscribers on a typical operator's network. The forecast is the number of 2G subscribers at the time of release, absent any accelerated migration.[7] This is constructed by taking the current number of 2G-only subscribers on a typical network (15m) and adjusting by a factor to reflect net additions increasing the subscriber number, and migration to 3G reducing the number of 2G-only subscribers.

1.69 Finally we apply the value obtained at "e" to this subscriber forecast to obtain the number of customers that will need to be migrated. These steps are shown below.

Customers:			
f	Current no. of 2G only customers		15,000,000
g	Change in no. of 2G customers between now and spectrum release		-20%
h	No. of 2G customers at date of release, absent accelerated migration	f*(1+g)	12,000,000
i	No. customers to be migrated by accelerated migration	e*h	2,400,000

1.70 Having established how many people need to be given an extra subsidy to migrate across from 2G to 3G, we now seek to put a cost on that subsidy. This is depicted by the bottom third of the flow diagram.

1.71 We specify the date of release, the period prior to release in which the acceleration will occur, the size of the extra subsidy, and its trend over time. The table below shows the detail of the calculations.

Cost:			
j	Year of spectrum release		2010/11
k	Period over which 3G migration is accelerated (years)		2
l	Additional subsidy for 3G handset in 2007/08 (£)		100.00
m	Annual trend in real subsidy		0%
n	Handset subsidy in year 2008/09 (£, 2007/08)	l*(1+m)	100.00
o	Handset subsidy in year 2009/10 (£, 2007/08)	l*(1+m)^2	100.00
p	Undiscounted cost in year 2008/09	n*(i/k)	120,000,000
q	Undiscounted cost in year 2009/10	o*(i/k)	120,000,000
r	Real social discount rate		3.50%
	Total cost discounted to beginning 2007/08	p*(1/(1+r)^2)+q*(1/(1+r)^3)	220,254,409

1.72 Note that all of the figures in the tables above are un-rounded, whilst those presented in the consultation document are rounded.

[7] This is the counterfactual; the number of 2G subscribers that would have been present on the network hand it not been for 3G migration being accelerated by this extra subsidy.