Annex 11

Market scenarios

Introduction

A11.1 This annex sets out a range of scenarios for the future provision of mobile broadband services within more densely populated areas of the UK. These scenarios are used in our analysis of the differences between bands for providing mobile broadband services. They are an important input to that analysis because the extent of differences between bands for the provision of mobile broadband is likely to depend on the quality of mobile broadband service provided.

A11.2 There was a range of views expressed in response to our initial consultation as to the appropriate assumptions to make about the future deployment and use of mobile broadband services when assessing differences between bands. In addition there have also been significant developments in the mobile broadband market since our last consultation. To inform our analysis in this consultation, we have reviewed mobile broadband developments and market expectations about how it is likely to develop in the future, as well as commissioning focus group research.

A11.3 We have developed a range of scenarios because it is not possible to precisely forecast the future provision of mobile broadband. In particular the mobile broadband services provided are likely to depend on demand for such services, including consumers' sensitivity to different aspects of the service and the costs and feasibility of supplying different types of service, which may in turn depend on the spectrum that is available to operators (we review feasibility of deployment in annex 13). They may also depend on the level of competition and operator strategies, for example if competition led to greater marketing of the capabilities of different mobile broadband services or innovations that made mobile broadband more attractive to use.

A11.4 This annex is structured as follows

- Summary of responses to our previous consultation
- Further research undertaken
- Identification of relevant variables for the analysis
- Relevant time period for the analysis
- Discussion of values for each variable:
  - Quantity of data traffic
  - Speed of mobile broadband services
  - Coverage of mobile broadband services
- Summary of values and scenarios

Responses to our previous consultation

A11.5 The responses to our previous consultation in relation to the scenarios we used for future mobile broadband market developments varied between those that have 900 MHz spectrum (who took a more sceptical view) and those that do not (who took a more optimistic view). In summary:

- Vodafone and O2 argued that we had not provided evidence or analysis to support the high demand scenario used in that consultation. They believed the evidence presented was at best inconclusive or only supported a low demand scenario.

- T-Mobile believed that our medium and high scenarios were conservative. Both T-Mobile and H3G pointed to evidence that there is likely to be higher 3G take-up than we assumed.

A11.6 We note however that market expectations and actual take up of mobile broadband services have moved on significantly since these comments were submitted (December 2007).

Further research undertaken

A11.7 In the light of stakeholder responses to the September 2007 consultation and market developments since then, we have carried out additional research and analysis on both the growth of demand for mobile broadband services and on the importance of quality for these services. This included reviewing external research and evidence[1] drawing on existing Ofcom research and commissioning new research. Specific types of evidence reviewed include:

- evidence on the recent growth in data traffic in mobile data networks and take-up of mobile broadband services;

- mobile network operators' investment strategies;

- trends in industries that work with network operators in enabling data growth (handset manufacturers, application developers etc.);

- financial market analysis and expectation on mobile data revenues;

- consumer surveys undertaken by Ofcom and external organisations;

- focus group research commissioned by Ofcom (discussed below)

- Queries and complaints received by Ofcom from consumers about their mobile broadband services

Market research on consumer attitudes towards mobile broadband

A11.8 Consumers' attitudes towards the quality of mobile broadband services were investigated in market research commissioned by Ofcom[2]. The main objective of

[1] Ofcom, Communications Market Report 2008 and, Ofcom, Mobile Citizens Mobile Consumers, 28 August 2008

[2] The full research report commissioned for this consultation can be found at http://www.ofcom.org.uk/consult/condocs/spectrumlib/mobilebb.pdf

the market research was to assess the importance of service quality, including coverage and speed, for consumers of mobile broadband services and the impact this might have on their supplier choice and supplier switching behaviour. The research involved 8 focus groups held in London and Cardiff and included non users, light and heavy users, and business users.

A11.9 The research demonstrated that the mobile broadband market is at an early stage of development as users were generally impressed that mobile broadband exists at all. Within this context, the findings of the research included:

- People primarily use mobile broadband when fixed line broadband is not available. It is mainly used as a back up or as a complement to fixed line broadband.
- At present the ability to connect rather than speed is more important for mobile internet use.
- Consumers have expectations that mobile operators will improve the speed and coverage of networks over time.
- The idea of differences in quality of mobile broadband between operators is not yet well formed for many consumers. This means they are not ready to begin comparing different operators in great detail and having strong ideas about whether they should switch operators. However, users perceived there was less risk to switching their provider of mobile broadband via a USB dongle, compared to switching their provider of services (voice, text and mobile internet) delivered via a handset.

Relevant variables for the market scenarios

A11.10 The relevant variables for the market scenarios are identified by considering whether there was a high impact on the results of the analysis and where they was a high uncertainty surround the variable. On this basis we use the following variables:

- **Quantity of data traffic.** This variable measures the average volume (in megabytes) of data that is downloaded per mobile user per day. The measure used is an average across all mobile users, not just those who subscribe to mobile broadband services, to enable this variable to capture uncertainty over the level of mobile broadband take-up as well as level of use. Clearly some mobile users would use much more or some much less than these average levels. For example those using mobile broadband on their laptop would use much more, whilst non-users of mobile broadband would use none at all. This variable was chosen because differences between bands can reduce if volumes are sufficiently high to cause capacity constraints rather than coverage to drive network deployment, and because there are significant uncertainties over future data volumes.
- **Indoor coverage depth**. This variable measures how good indoor coverage is for mobile broadband services. This variable was chosen because although there is clearly a need to provide some indoor coverage, the degree of indoor coverage that consumers will value and operators will seek to provide is more uncertain. This is particularly relevant when assessing the differences between bands, because lower frequencies are typically better at providing indoor coverage.

- **Data rates.** This variable measures the minimum data rate (specifically the throughput) that users can consistently get whilst within coverage. In any mobile network, data rates vary a lot from location to location and for this reason, we focus on the minimum data rates that can be expected consistently (the cell edge rate), rather than on the maximum rates achievable. The maximum achievable data rate is limited by the technology deployed – for example approximately 10Mbps using HSPA. This variable was chosen because the number of sites required is typically sensitive to the cell edge rate sought. In addition, it is currently uncertain what speeds will be provided for mobile broadband in the future.

A11.11 For each parameter we have identified a range of plausible values for the relevant time period (around 2015 – see below), i.e. from the lowest plausible value to the highest plausible value. Although outcomes outside these ranges are not impossible, the range is intended to capture the most likely outcomes. The range for each variable is discussed below. Our market scenarios are then defined by different combinations of values for these variables.

Relevant time period

A11.12 The relevant time period for these scenarios is the point at which mobile broadband networks using 900 MHz spectrum could have been deployed and be in widespread use by consumers, but before networks using 800 MHz spectrum are likely to be in widespread use. Any growth in mobile broadband services beyond this point is less relevant for our analysis because there may be opportunities for operators without liberalised 900 MHz to provide comparable services at a similar cost using 800 MHz spectrum. If this is the case, additional demand will not translate into additional advantage for operators with liberalised 900 MHz spectrum. We use 2015 as an approximate reference to this point for the purposes of calibrating the market scenarios. This is consistent with the timing analysis set out in Annex 12 (Gantt charts G and H).

Quantity of data traffic

A11.13 In our previous consultation, we considered three adoption levels for mobile broadband. The data volumes for these were equivalent to non existent as network is designed for voice only, *medium adoption* 0.4 MB/user per day ; and *high adoption* 1MB/user per day. However, given major developments in the take-up of mobile broadband services since then we have significantly revised the volumes for our updated analysis. In doing this we have reviewed evidence on the actual growth of mobile broadband, and considered whether this growth seems likely to continue in the future.

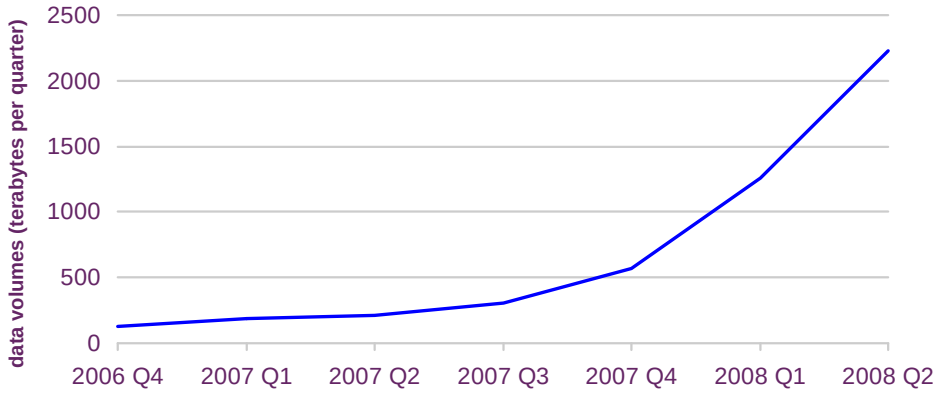
A11.14 The relevant data traffic for these scenarios is the traffic delivered using traditional ‘macrocell’ networks. Our quantitative analysis focuses on the use of macrocells to deliver mobile broadband services because these are the primary means of delivering mobile broadband services using 3G technologies, and we expect that this will continue to be the case in future. In addition, although additional data quantities may be carried through smaller cells, for example microcells and picocells, as well as the potential deployment of femtocells, the effects of frequency in these cases is less pronounced or non-existent. For example, the extent that the fixed broadband traffic of some subscribers is in the future delivered in the home via femtocells or Wi-Fi, is largely irrelevant to our analysis of differences between bands.

Growth in data traffic volumes

A11.15 At the time of the previous consultation (September 2007), mobile data traffic was beginning to grow but levels were still relatively low. Since then mobile data traffic has grown rapidly from this low base.

A11.16 Figure 1 shows that data volumes were around 300 terabytes per quarter (equivalent of 0.1MB/user/day when averaged across all mobile users), at the time of the previous consultation (Q3 2007). This grew to 2200 terabytes per quarter by the middle of 2008 (equivalent of 0.4MB/user/day). If growth in the most recent quarter for which data is available continued, this would give an annualised growth rate of 3,900 terabytes per annum, equivalent to growth in average usage of 0.7MB/user/day.

Figure 1: UK Mobile data volumes



Source: Ofcom
Source: Aggregated data from five mobile operators. Includes estimates where Ofcom does not receive data from operators

A11.17 This growth seems likely to have been driven by a number of factors including the introduction of USB dongles, improved handsets, simpler and cheaper pricing plans (i.e. flat rate data tariffs), upgrades in network speeds through rollout of HSPA technologies, and heavy marketing by operators. There appears to be a general consensus that growth will continue, although there are varying views on how sustainable the current rate of growth is. Continued growth is likely to be supported by improvements in mobile broadband capable devices and mobile data services:

- **Device improvements.** Whilst initial growth has been driven by USB dongles, the range and accessibility of devices that support mobile broadband is likely to continue to improve. The user experience for browsing the internet from a mobile handset continues to improve with more processing power, better screens and user interfaces. The number of handsets available with these design features seems set to grow. The range and number of devices using mobile broadband is also growing. For example, there has been significant growth in use of netbooks (which are optimised for mobile use) and the bundling of mobile broadband with laptops / netbooks on contract monthly plans. Operators and laptop manufacturers are also beginning to offer embedded mobile broadband modems in laptops and netbooks.

- **Increased range of mobile data services.** Recent examples of services that could drive mobile data volumes include social networking sites, some of which

are now built in functions on handsets, and the BBC iPlayer for mobiles. Whilst it is uncertain which of the many new mobile data applications being developed will be successful, the success of at least some of the applications seems likely to increase mobile data usage.

A11.18 The rate of continued growth will however to some extent depend on the continued network investments by mobile operators. Whilst it is currently unclear to what extent the credit crunch will affect the immediate level of operators network investment, many have signalled the strategic importance of growth from mobile broadband and therefore future investment seems plausible. Investments to improve the coverage, speed and capacity of networks will tend to encourage as well as enabling continued growth.

How much future growth?

A11.19 Whilst there has been significant growth in data volumes over the last year, and further growth seems likely, it is currently very uncertain how fast this growth will be in the future, particularly when looking out to around 2015. The growth of new services is particularly hard to predict and historically there have been technologies that have had over inflated expectations, only to disappoint, and those that have come from nowhere and taken everyone by surprise. Therefore, we have deliberately used a particularly wide range in our analysis:

- **Low end: 1MB per user per day**, averaged across all mobile users. This is approximately 2.5x the average level of usage in mid 2008 (0.4MB) and represents the most pessimistic scenario where growth slows down rapidly, perhaps because mobile broadband turns out to be a niche service and many people become disillusioned with the service.

- **High end: 30MB per user per day**, averaged across all mobile users. This is approximately 80x the average level of usage in mid 2008.It represents a yearly growth in volumes of approximately of approximately 4 MB /user/day, significantly higher than the fastest growth seen so far (equivalent to yearly growth in average usage of 0.7 MB/user/day.

A11.20 Clearly some mobile users would use much more and some users much less than these average levels. For example those using mobile broadband on their laptop would be likely to use much more, whilst users who only ever use voice and text would not use mobile broadband at all.

A11.21 Setting a high end estimate is particularly difficult. The history of fixed internet suggests that applications will become more data intensive and consumers will consume more data if given the opportunity to (e.g. flat rate tariffs with no usage constraints). In practice consumer usage is limited by choice of tariff and network capability. Therefore, although we believe the above is a sensible core range, given the potential for the differences between bands to be sensitive to capacity constraints, it is also important to consider how sensitive results are to higher volumes (this is considered further in annexes 13 and 15) whilst taking into account what would be feasible for operators to deploy.

Other forecasts

A11.22 We have a reviewed a number of other sources which present forecasts of future mobile data traffic levels. Although these provide useful comparisons, relying

entirely on third party forecasts may have limitations. For example, there could be publication bias - analysts who do not think that mobile data will grow may pay less attention to the sector and therefore not publish forecasts, or forecasts may be selected to support certain interests.

A11.23 Relatively recent forecasts include:

- Spectrum Value Partners have published forecasts of data take up for representative countries within Europe[3]. The work was commissioned by, and informed by input from, a consortium of mobile operators (Orange, Telefonica and Vodafone) and manufacturers. For Italy and the Netherlands (arguably the closest in usage to the UK), their median forecast is equivalent to around 900 MB/user/month around 2015[4], or around 30 MB/user/ day.

- Informa recently published a report forecasting that European data volumes will increase at rate over 50% year on year between 2007 and 2012 or 7.3 times increase in data traffic during this time period[5]. This projected growth, from the base of end of 2007, would lead to around 1 MB/ subscriber / day at the end of 2012. If we extrapolate the same trends to 2015, this would be equivalent to 2.5 MB / subscriber /day at the end of 2015.

- A report by Analysys Mason predicts traffic volumes to grow in developed countries to between 10 to 30 times between 2008 and 2015[6]. They expect this rise to be driven by take-up of dongles and smartphones, improvements in 3G technologies, affordable pricing, and increase in indoor usage of cellular devices. For the UK market, this growth rate would give rise to volumes of 4-12 MB/user/day.

Data rates (speed)

A11.24 In our previous consultation we considered the provision of services with data rates of 144kbps and 384kbps. However, since then there has been widespread deployment of HSDPA, which makes possible the provision of services with speeds of several megabits per second, and there has been significant growth in the use of mobile broadband on laptops (using a dongle), for which higher speeds are likely to be more important than for services provided to a handset. Therefore, our refined analysis has considered the impact of higher speeds, specifically higher data rates actually experienced by the customer (rather than increases in headline speed.)

A11.25 As discussed above, focus group research commissioned by Ofcom suggests that some users are generally impressed that mobile broadband exists at all at present and are currently content with relatively low speeds as long as they are able to connect. Although they may prefer higher speeds, it is currently the ability to connect that is most important for these users. Nonetheless, the current marketing of mobile broadband does suggest that the speed of service is viewed as an important factor in consumer choice and that operators place some weight on

[3] Spectrum Value Partners, Getting the most out of the digital dividend, March 2008 http://www.spectrumstrategy.com/Pages/GB/perspectives/Spectrum-Getting-the-most-out-of-the-digita-dividend-2008.pdf
[4] Ibid, precise figures are not available in the report. These numbers were extracted from Exhibit 9.
[5] Informa, Mobile Network Forecasts: Future Mobile Traffic, Base stations and Revenues, 2008
[6] Analysys Mason, *Mobile network operators: prepare for a ten-fold increase in wireless traffic*, 13 November 2008, in http://www.analysysmason.com/About-Us/News/Insight/Mobile-network-operators-prepare-for-a-ten-fold-increase-in-wireless-traffic/

ensuring they provide competitive speeds and communicating this to consumers[7]. In addition, operators continue to make improvements to their HSDPA networks to improve the maximum speeds available.

A11.26 The experience of fixed broadband services has been that broadband speeds, specifically accurate information about the actual data rates achievable, are very important to consumers. Ofcom has been seeking to promote better information in this area for consumers so that they can make an informed choice of provider[8]. For example, where operators are able to offer faster service than their competitors, this is often marketed as a key factor differentiating their service. In addition, consumers' expectations of broadband speeds have increased over time as network capabilities improve and as the demands of typical web sites and applications increase.

A11.27 Our expectation therefore is that speed could also come to have a similar importance for mobile broadband services, and that operators will seek to provide as fast a service as practical and profitable. In addition, now that mobile broadband is starting to be used for fixed broadband applications, i.e. internet access from a laptop (potentially including video applications such as BBC iPlayer and YouTube), the speeds of fixed broadband may increasingly become a relevant comparator. However, the practicality and profitability of a providing a particular speed is uncertain and therefore we have considered a wide range:

- **High end: 2.4 Mbps** minimum that can be expected consistently (in technical terms the cell edge rate) whilst within coverage. This is likely to be materially better than existing mobile broadband services (around 1Mbps on *average* according to Vodafone research[7]) comparable with the speeds actually being achieved on fixed broadband at present (currently an *average* of 3.6 Mbps based on recent Ofcom research[9]).

- **Low end: 384kbps** minimum that can be expected consistently whilst within coverage. This is more likely to be consistent with a more pessimistic outcome for mobile broadband services.

Coverage

A11.28 In our previous consultation we assessed the provision of a consistent level of indoor coverage across more densely populated areas inhabited by 80% of the population, as well as extending coverage to less densely populated areas (see Annex 14 for our further work on less densely populated areas). Outdoor coverage is already provided to areas inhabited by at least 80% of the population by all five of the 3G mobile network operators[10].

A11.29 In response to feedback from stakeholders, we have reviewed whether the provision of a consistent level of indoor coverage across more densely populated areas is an appropriate scenario to assess. Our view remains that this is an appropriate assumption to make about the level of mobile broadband service that operators will seek to provide in the future (although of course the practicality of

[7] For example Vodafone, "Independent Trials Show Vodafone UK to be Most Reliable and Fastest Network for Mobile Broadband", Press release 13 June 2008
[8] Ofcom, Advice for Consumers: Broadband Speeds
[9] Ofcom, UK Broadband speeds 2008: Research Report, pg 2
[10] http://www.ofcom.org.uk/media/news/2008/05/nr_20080502a

providing this may depend on what frequency spectrum they hold). Our reasoning is set out below.

A11.30 Provision of good coverage is well established as an important requirement for consumers of traditional mobile voice and text services. For example mobile operators provide coverage maps on their websites, and consumers complain if coverage is not satisfactory. Research Ofcom conducted for the Consumer rights review, found that poor coverage was the number one complaint in regards to mobile networks[11]. A Point Topic survey conducted on mobile internet use in May 2008, found that uncertainty of coverage and usage areas was the number one disadvantage to business users of using mobile internet, and the number two disadvantage to a personal user (after cost of sending or receiving data)[12].

A11.31 It seems reasonable to believe that the provision of good coverage for mobile broadband services will also be important. Operator coverage maps now include mobile broadband services and their marketing highlights any advantage they have in mobile broadband coverage, or, related to this, in the reliability of their service (consistency of coverage being a critical requirement for ensuring a reliable service)[13]. Our focus group research also highlights the importance of coverage to consumers.

A11.32 The majority of current mobile use occurs indoors. Research for the Communications Market Report 2008 found that 70% of people with a mobile and a fixed-line phone say they use their mobile to make some calls when they are in the home[14]. Other sources such as NEC and Analysys estimate that around 60% of mobile usage originates from indoor areas[15]. It seems plausible that mobile broadband will be used at least as much, if not more, whilst indoors. For example, walking outside whilst talking on a mobile seems relatively common and practical, whereas common sense suggests that laptops (currently the largest driver of mobile broadband growth) are predominantly used whilst seated indoors.

A11.33 Recent research tends to support this intuition, for example:

- Work focused on whether mobile broadband could be a viable substitute for fixed broadband identified that indoor coverage is one area that would need to be improved if mobile broadband were to be a substitute for fixed broadband. It was seen that current indoor coverage is poor and this may be a limiting factor for the growth of mobile broadband[16].

[11] Futuresight, Consumer complaints review, Qualitative and quantitative research findings, published 10 July 2008, Figure 3.
[12] Point Topic, BB BBUS Consumer Survey 6, May/June 2008
[13] For example 02 in response to their own customer research introduced a mobile broadband coverage checker and customer happiness guarantee for their customers. Please see O2 looks to change perceptions on in the mobile industry with the refresh of its customer proposition, Press release 31 October 2008
[14] Ofcom, Communications Market report, pg 294
[15] "Optimisation and Evolution of 3G", in 3G Optimisation Forum, Berlin 12 March 2008.
16 Citigroup, Telecommunications Services Cannibal or Companion, Citigroup Global Markets, Equity Research 1 September 2008
and Analysys Mason, Mobile broadband: another substitution threat for fixed operators?

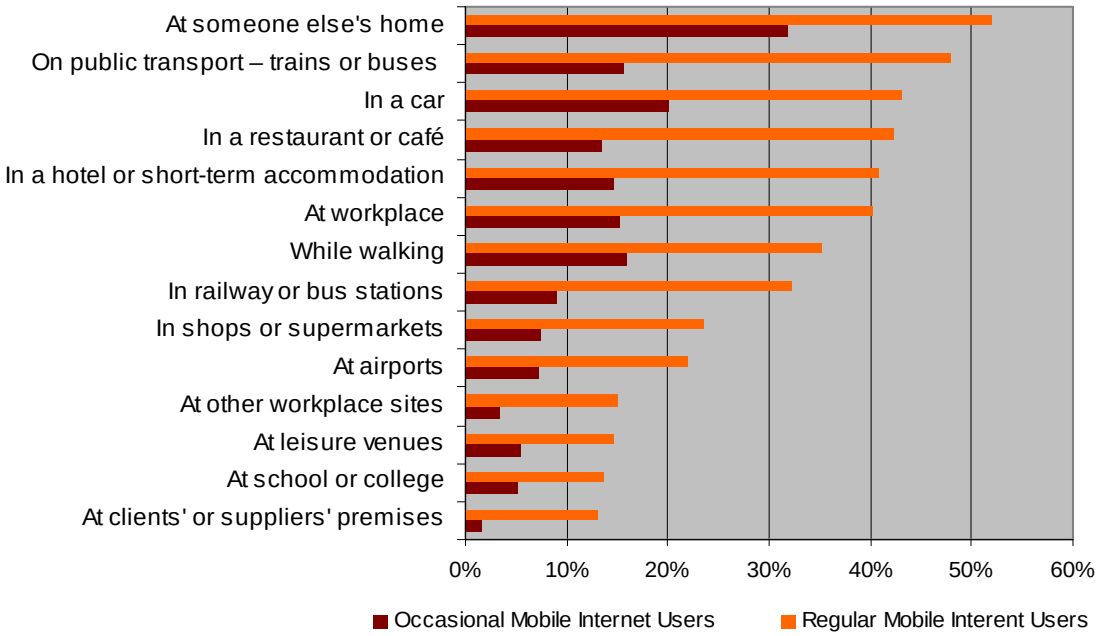
- Ip.access. quote a Nokia smartphone survey from December 2007. The survey involved installing applications in users' smartphones to monitor usage. This indicated 44% of usage is at home[17].

- Due to longer internet sessions which require more data such as streaming or downloading video content, uploading pictures mobile traffic from the home is expected to increase from 35% of all mobile data traffic in 2008 to 60% of the total by 2013[18].

- Analysys Mason sees that for mobile broadband services to be successful, one of the things mobile operators will need to improve indoor coverage because much of the demand for wireless broadband services will be generated in the home[19].

- The Point Topic survey mentioned above also included data on where people are using mobile internet outside their homes. Figure 2 shows consumers are using mobile internet in indoor locations, such as someone else's home, in a cafes and hotels or other short term accommodation.

Figure 2: Locations where consumers are using mobile internet



Source: Point Topic, BB BBUS Consumer Survey 6, May/June 2008

A11.34 In summary, we believe that operators are likely to seek to provide good indoor coverage for their mobile broadband services because coverage, and related to this, reliability, are important factors for consumers and because a large part of mobile broadband use is expected to be indoors. However, the differences observed between using higher and lower frequencies are sensitive to the depth of indoor coverage provided, for example how much a building is covered and with

[17] Tiller,A of Ip.access. "Are Femtocells the Answer to Optimising Indoor Coverage?", 11 March 2008
[18] Informa, Mobile Broadband Access at home: The business case for femtocells, UMA and IMS/VCC dual mode solutions, pg 12
[19] Analysys Mason, Cost minimisation strategies are a key as MNOs invest in mobile broadband, 7 August 2008

what confidence. Therefore we have sought to consider a range of plausible scenarios for the depth of indoor coverage provided.

- **Low end:** 'Depth 1' provides a measure of in-building service but with a relatively shallow service level.
- **High end:** 'Depth 2' provides a more consistent service level across the area of a building.

A11.35 The technical specification of 'depth 1' and 'depth 2' is considered in annex 13 based on parameters that reflect technical research and industry practice.

Summary of variables and scenarios

A11.36 Table 1 below summarises the range of values for the variables identified above.

Table 1: Summary of values used in market scenarios

Variable	Description	Low value	High value
Data quantity	Average volume of data downloaded per mobile user per day (averaged across all mobile users)	1 megabyte	30 megabytes
Speed	Minimum throughput consistently provided whilst within coverage (cell edge rate)	384kbps	2.4Mbps
Coverage	Depth of indoor coverage provided	Depth 1 (shallower)	Depth 2 (deeper)

A11.37 Our market scenarios are then defined by different combinations of low and high values for the three variables discussed above. Table 2 below sets out the scenarios on this basis. However, not all combinations of variables will be as likely as others. In particular we believe that there is likely to be a positive correlation between data rates and data quantities, so that the highest volumes of usage seem unlikely if the lowest speeds are provided and similarly the lowest level of usage seems unlikely if the highest levels of speeds are provided. In much of our subsequent analysis we focus on the highest and lowest scenarios (labelled 'higher demand' and 'lower demand') in terms of their impact on the differences between bands.

Table 2: Market scenarios used for area covering 80% of population

Scenario	**Speed** (minimum consistently provided whilst in coverage)	**Depth of indoor Coverage**	**Data quantity** (average downloaded per user per day)
Lower demand	384 kbps	Depth 1 (shallower)	1 megabyte
As "lower demand" but high volume	384 kbps	Depth 1 (shallower)	30 megabytes
As "lower demand" but	384 kbps	Depth 2	1 megabyte

deeper indoor coverage		(deeper)	
Higher demand	2.4 Mbps	Depth 2 (deeper)	30 megabytes
As 'higher demand' but low data rates	384 kbps	Depth 2 (deeper)	30 megabytes
As 'higher demand' but shallower indoor depth	2.4 Mbps	Depth 1 (shallower)	30 megabytes