FUTURE DEMAND FOR MOBILE BROADBAND

EE RESPONSE TO OFCOM CALL FOR INPUT

Version 1.0

29 April 2013

[redacted]

NON-CONFIDENTIAL version

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Introduction

The following document has been written in response to Ofcom's Call for Input regarding 'Future demand for mobile broadband spectrum and consideration of potential candidate bands'.

The EE view on UK mobile data demand for 2015-2030 is outlined below, with key assumptions highlighted. Particular attention is paid to a few key elements that are considered to have the most impact on data demand going forward. The demand model is based on the assumption that the mobile networks will have the physical capacity to support customer demand, with no economic constraints on growth.

This demand forecast is then overlaid on the view of available capacity in the UK based on the existing spectrum portfolio. This provides a conclusion as to when EE feels that new spectrum will need to be made available in order to meet the demands of the UK mobile subscriber base. With this requirement understood, recommendations are made as to which candidate bands would be most suitable and reasoning provided.

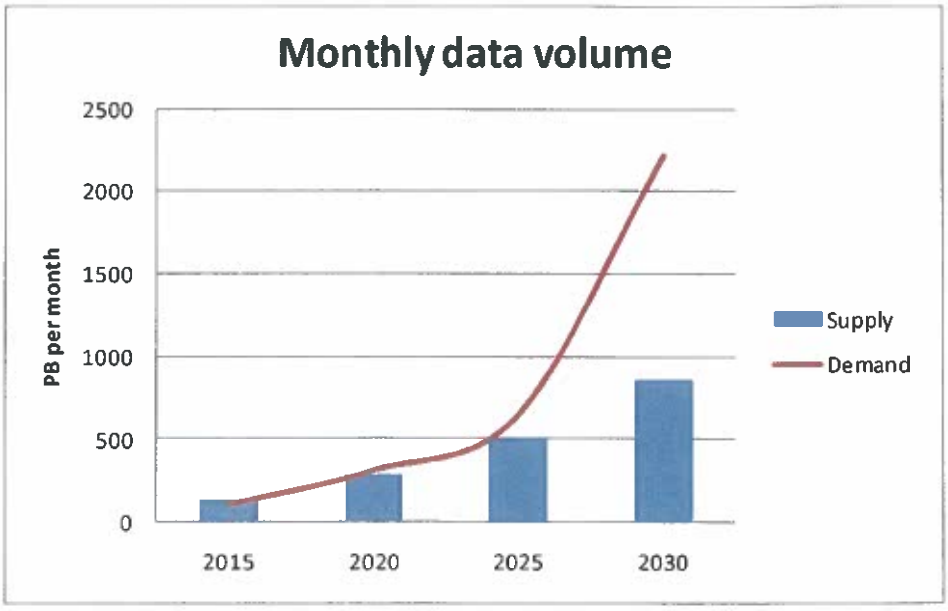
Executive Summary

Mobile data in the UK will see significant growth over the next 20 years and EE have invested in spectrum to meet that demand and deliver a great experience to our customers.

There is a natural balance between supply and demand. For example, the use of variable bit-rate video codecs allow an application to consume more or less network resources depending on what is available at a given location and time.

However, looking at the mobile operator's ability to serve demand, and expected future demand from consumers, EE believes that new spectrum will be required in the 2020-2025 timeframe. This assumes there are no economic constraints on demand and the average revenue per user (ARPU) generated is sufficient to cover the cost of the network upgrades required to meet the demand. If the ARPU requirement is not met, then the demand cannot be realised so this is a risk to the model and could lead to considerable variance in the modelling.

Figure 1 - UK Data Demand Forecast vs. Spectral Capacity



Forecast Summary

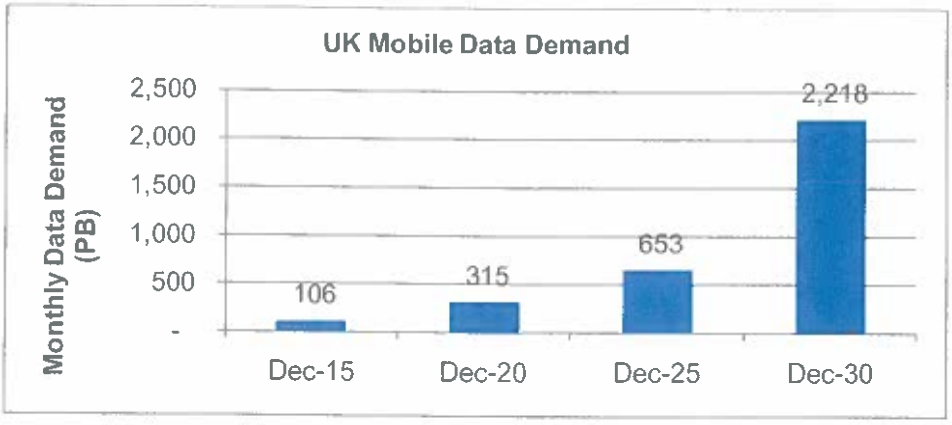
- UK monthly data demand CAGR of 23% over the period 2015-2030
- Video comprises 76% of monthly data volume by EoY 2030 (24% CAGR)
- Growth in non-video demand (19% CAGR) driven by a number of factors:
  - online gaming
  - augmented reality
  - larger file download
  - data-centric applications
  - device capability
  - wider adoption of data services
- M2M comprises [redacted] of total traffic in 2030
- In 2030, [redacted] of total mobile data demand is expected to be offloaded to WiFi

UK Mobile Data Demand Forecast (2015-2030)

The following section outlines the key trends in the EE demand model, with key assumptions and rationale included where relevant.

Total Demand Summary

Figure 2 - UK Mobile Data Demand



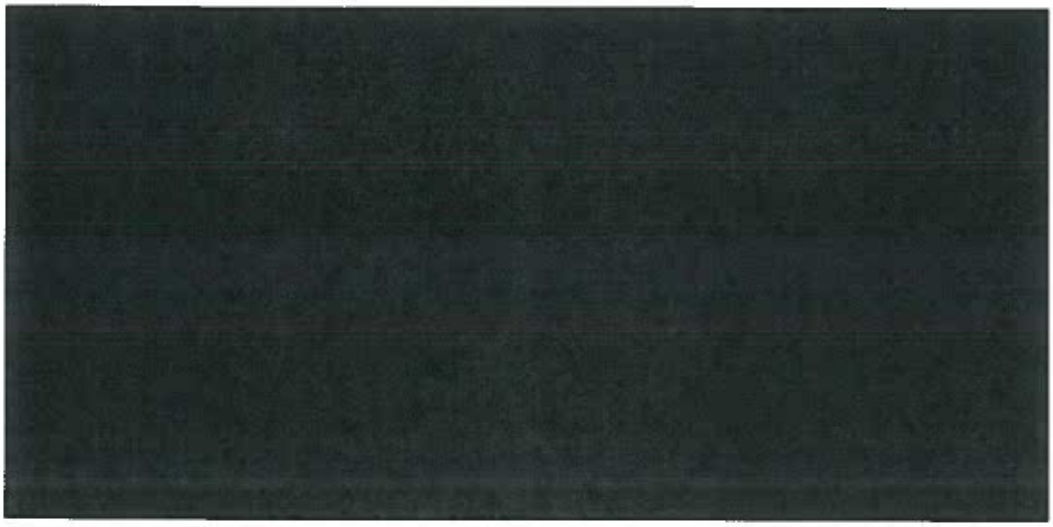
Total Mobile Data Demand will increase 22-fold in the period 2015-2030 (23% CAGR)

Annual Growth Rate

Over the last 5 years, the UK market has seen a huge amount of growth in data demand. On this basis, EE are expecting to see a significant growth in data demand by 2015 (70% CAGR). This is driven by the roll-out of LTE, the continued adoption of high-capability devices and the increasing availability of data-centric applications and services such as video. For the forecast period 2015-2030, the growth rate in UK data demand is expected to be 23% CAGR. This change in growth rate is explained by a number of factors: the saturation in penetration of high-end smartphones and LTE devices, along with the stabilisation of growth in average usage.

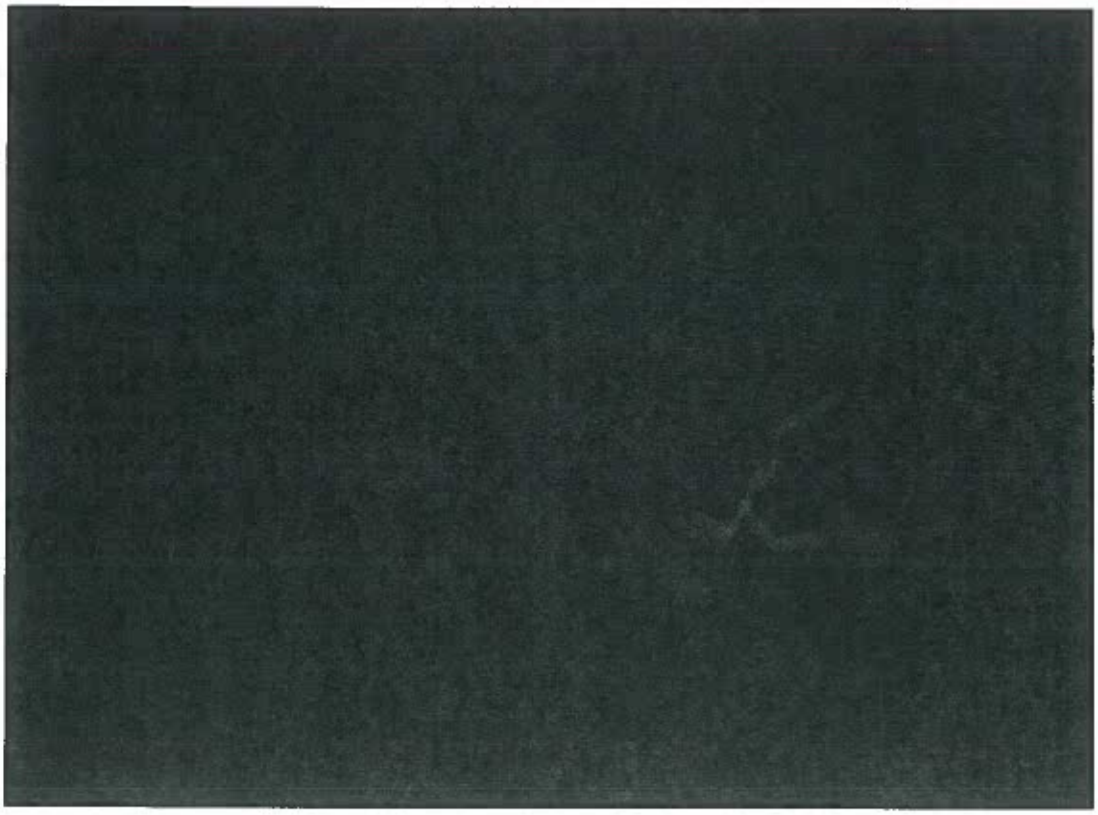
Contribution of Device Type

Historically, average usage has had a close correlation to screen size. Therefore, we can expect the growth in the tablet market to continue having an impact on customer behaviour and adoption of data-intensive services such as video and gaming. This leads to an increasing percentage of total data demand being attributable to larger screen devices such as tablets, laptops and dongles, which results in the average usage per user (AUPU) increasing over time.



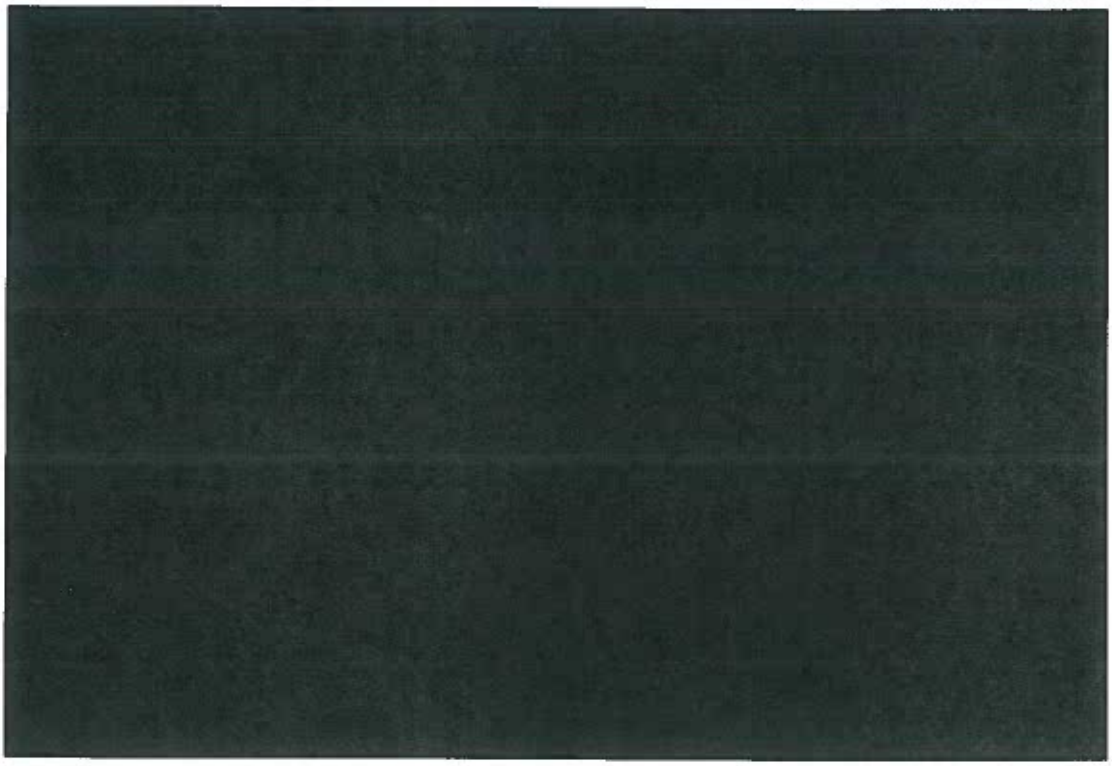
M2M

The number of M2M devices is set to explode as more and more applications are deployed across the UK. Similarly, as the deployment of 4G networks continues, higher-bandwidth applications for M2M will evolve, such as video surveillance and automotive applications. This results in M2M growth accelerating over the forecasting period. However, its contribution to total demand will remain very small



WiFi Offload

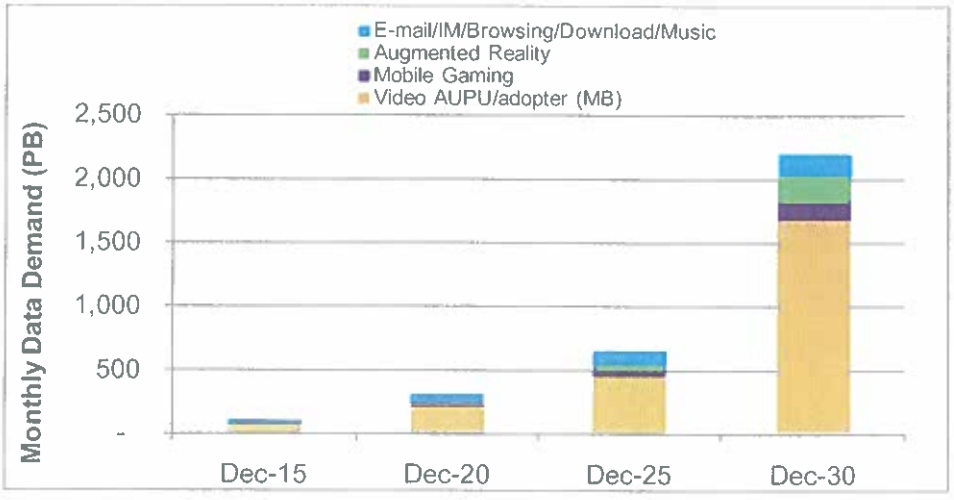
As total data demand increases, so too does the amount of traffic offloaded to public and corporate WiFi [redacted] However, the percentage of total demand offloaded to WiFi will decrease over time as coverage improves and LTE provides a more favourable experience to WiFi. The figures below do not include traffic carried on residential WiFi.



Key Growth Drivers

The following section highlights a number of areas that are seen as key drivers of growth.

Figure 6 - Monthly Data Demand split by Service-type



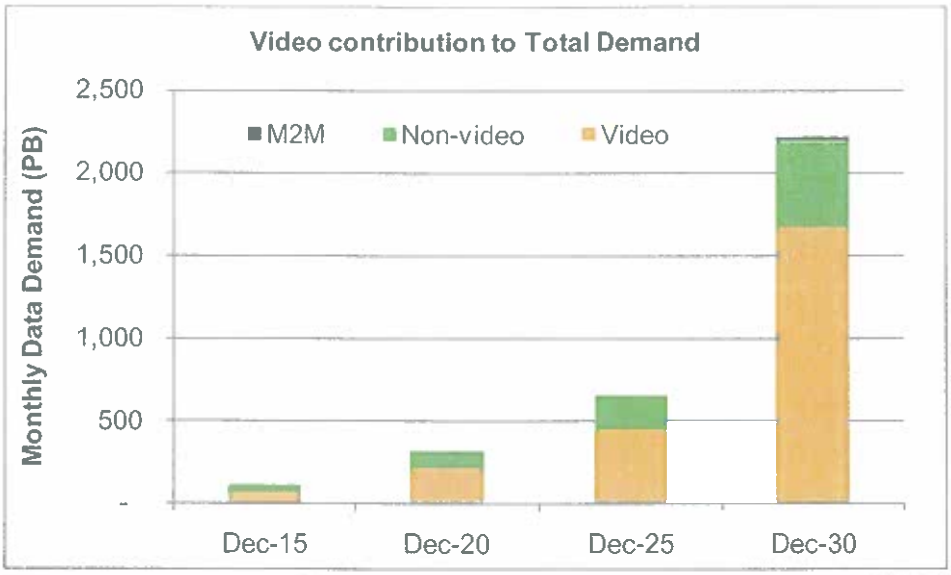
Video Data Demand

EE predicts that 76% of mobile data will be video by 2030. This is driven by the increased penetration of video services and the growth in data consumption brought about by device capability and the requirement for higher-resolution services.

As mentioned above, the increased penetration of tablets in the UK will be a key driver for growth in video based on the notion that screen size is proportional to average usage. Considering this, user behaviour will evolve in line with device capability, resulting in the time spent consuming video increasing significantly over the period as a function of the number of sessions per month and minutes per session.

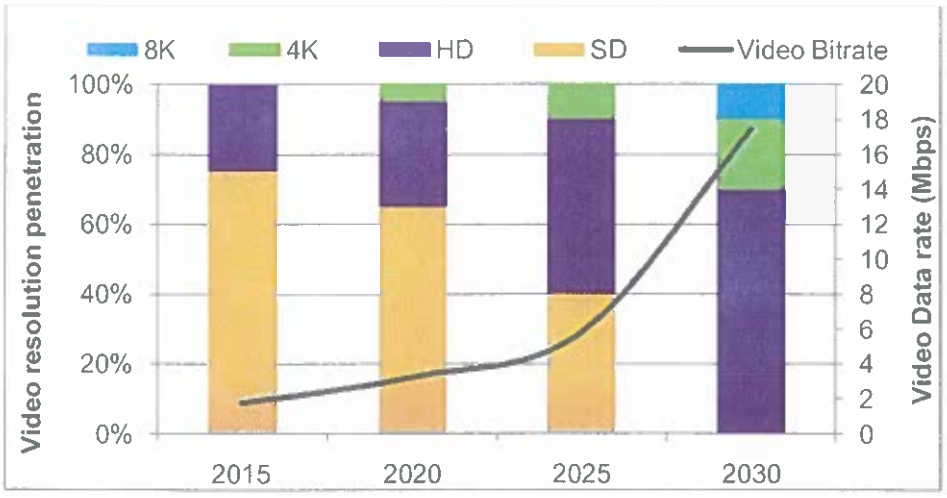
In addition to this, the demand for high-resolution services will increase, which drives a considerable uplift in demand. The graphs below show the contribution of video to total mobile data demand, and the impact of HD, 4K and 8K on data rates:

Figure 7 - Mobile Video contribution



[redacted]

Figure 8 - Impact of resolution on Video data rates

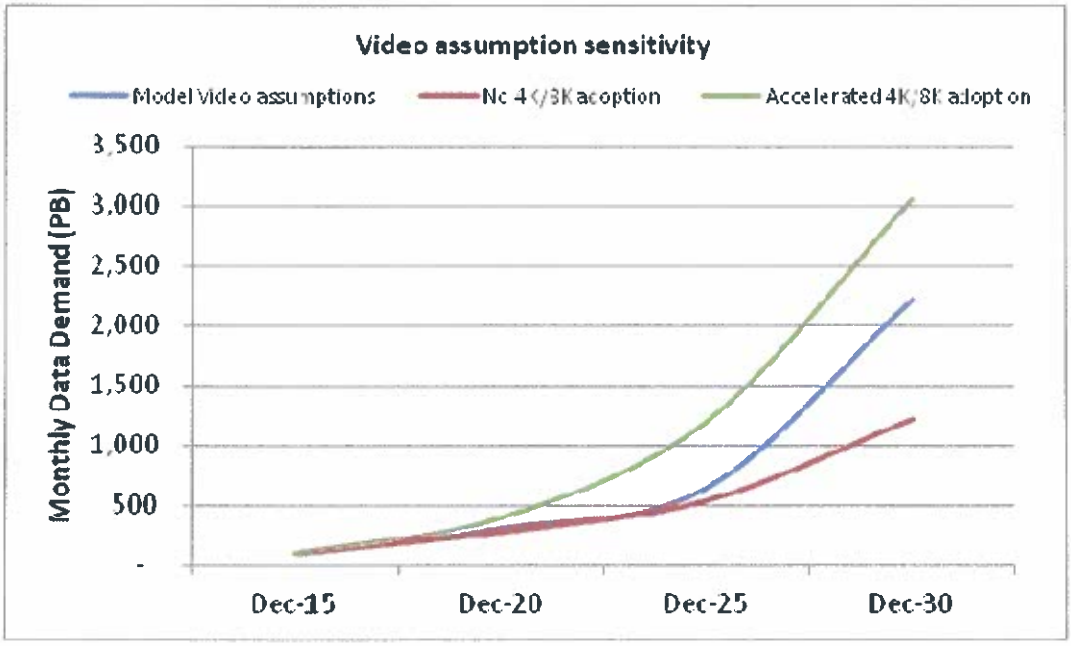


The data rate required to support the emergence of 4K and 8K resolution for video increases substantially, with file size growing at a similar rate. This graph serves to illustrate the sensitivity of the video assumptions to resolution.

Video Forecast Sensitivity

As shown in the graph above, the video assumptions included in the model are sensitive to resolution and its adoption across devices. The graph below serves to demonstrate how this sensitivity could impact the requirement for spectrum in the UK.

Figure 9 - Video assumption sensitivity



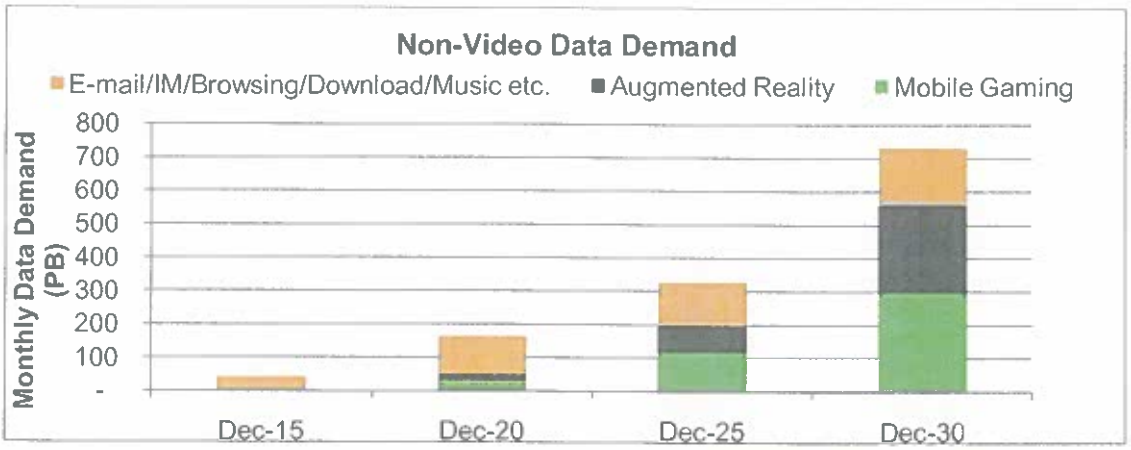
The model assumes that 4K and 8K technology will be both available to and, most importantly, adopted by the UK public. The extent of this availability and adoption influences the outcome of the model considerably. The graph above highlights the impact of video resolution on total demand. The low forecast assumes that no video technology beyond HD is available on devices. The high scenario assumes that the 4K and 8K adoption assumptions included in the model are accelerated by 10%. We believe in the assumptions included in the model because competition in video services

will drive adoption of higher quality content. At the same time, this demand will be tempered by the cost to serve this content to the customer.

Non-Video Data Demand

Whilst video is set to drive the majority of demand, growth in non-video data will still be very strong (19% CAGR), based on the penetration and adoption of data-centric applications and the subsequent evolution of behaviour as a result of increasing device capability. For example, as with video, online gaming will continue to grow and will be subject to the same demands with regards to high-resolution. Similarly, the emergence of augmented reality will drive considerable growth in data demand from customers, either conscious or otherwise. As with video, the growth in non-video services is primarily a function of sessions per month and data per session.

Figure 10 - Non-Video Data Demand



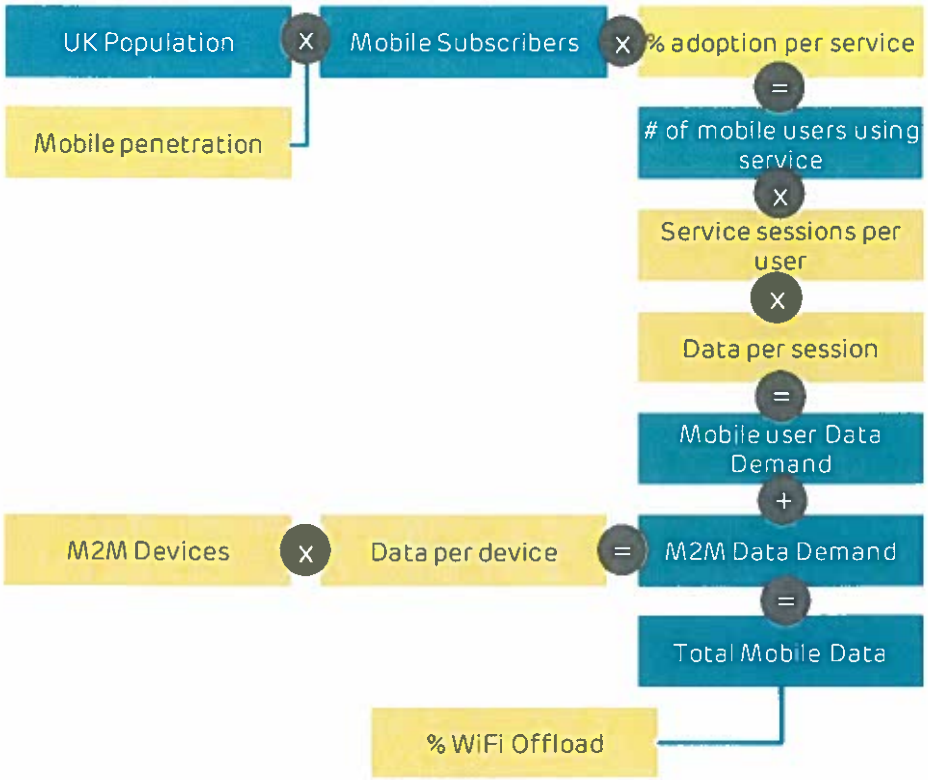
	Dec-15	Dec-20	Dec-25	Dec-30
Mobile Gaming	4	29	117	297
Augmented Reality	2	20	82	265
E-mail/IM/Browsing/Download/Music etc.	34	115	128	167
% Total Demand	39%	26%	15%	14%

Other emerging technologies included within the browsing assumptions include the likes of Smart TVs and companion devices. However, growth in mobile data demand driven by these is not expected to grow at the same rate as it is assumed the majority of use cases involve the use of fixed WiFi.

Forecast Methodology

This section serves to highlight the forecasting methodology adopted and demonstrates where assumptions have been made. The flow chart below outlines the methodology (assumptions are show in yellow):

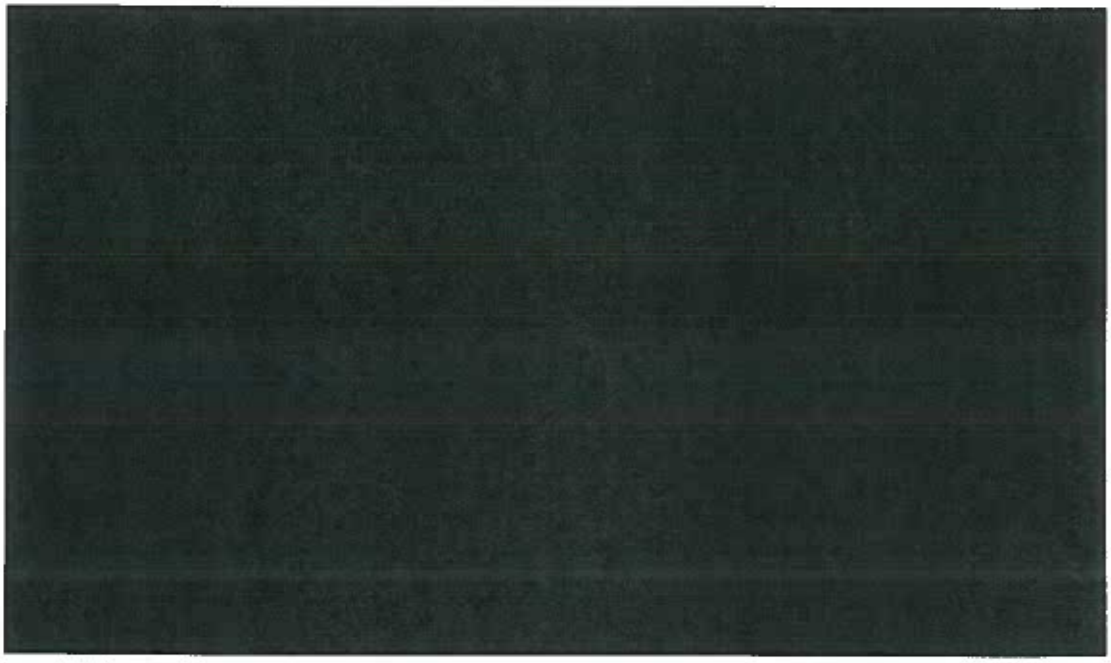
Figure 11 - Forecasting Methodology

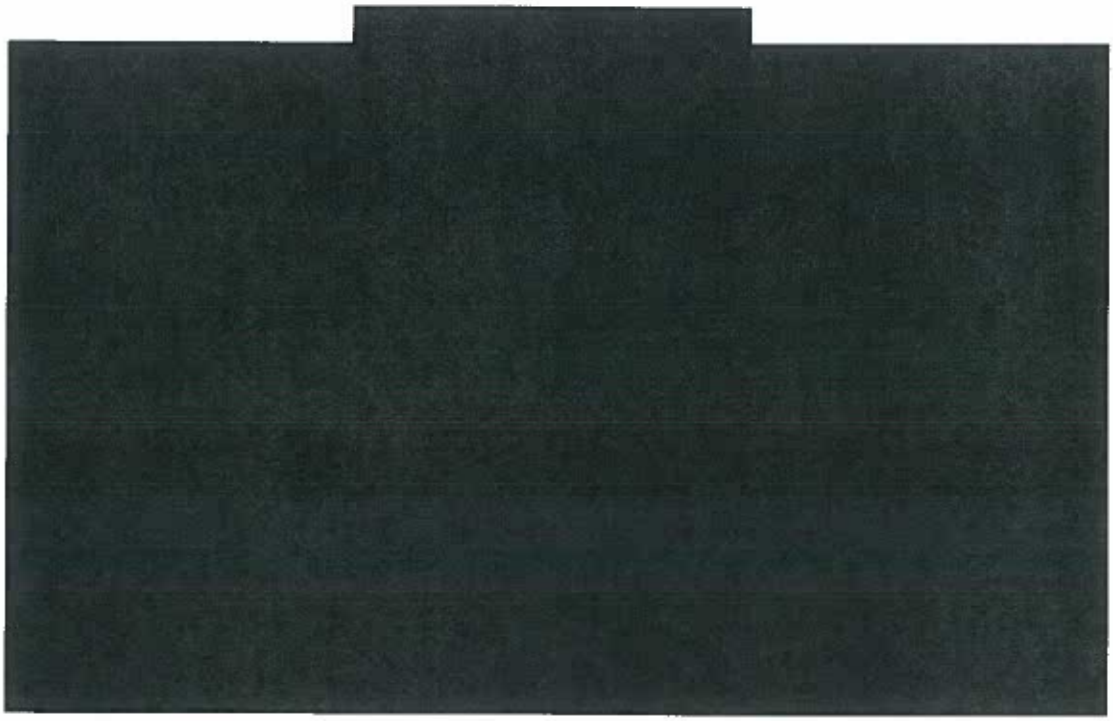


There are some elements within the forecast model that are very sensitive to change. This sensitivity is magnified by the time frame the forecast addresses. The main sensitivity within the EE model revolves around video, as this element comprises the majority of demand by 2030. The forecast is particularly sensitive to the penetration and adoption of 4K and 8K technology as demonstrated above.

Assumptions around sessions per month and data per session are also open to significant variance based on device capability and service adoption rates. However, historical information and analysis have been used to inform the assumptions to minimise the likelihood of any variance from the forecast.

Supply





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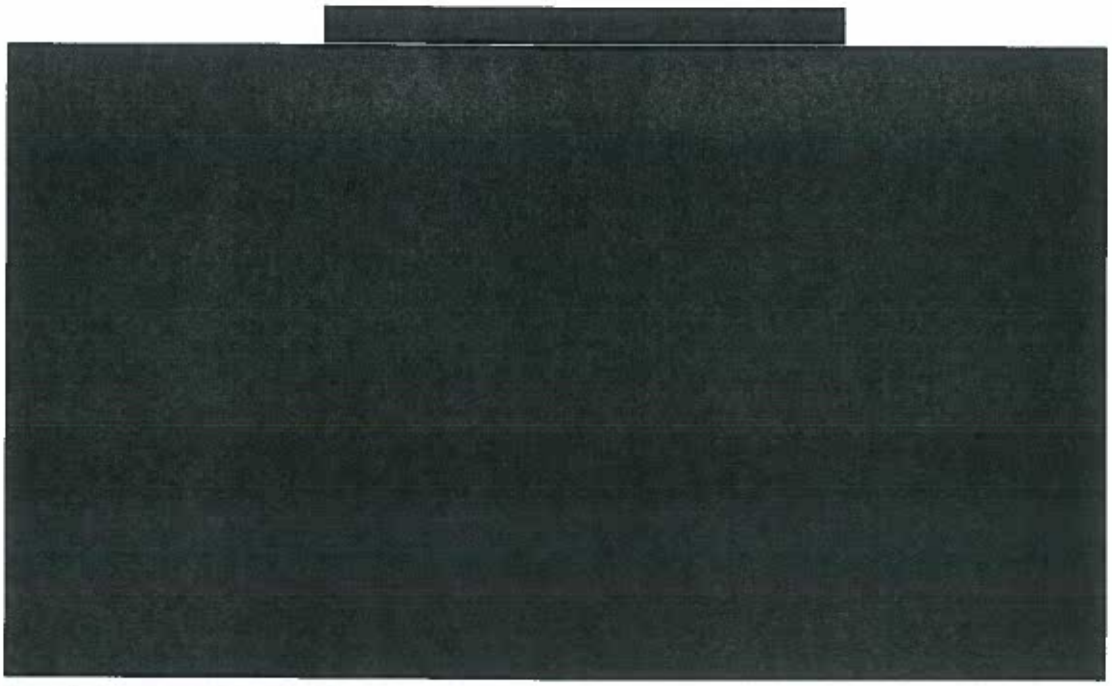

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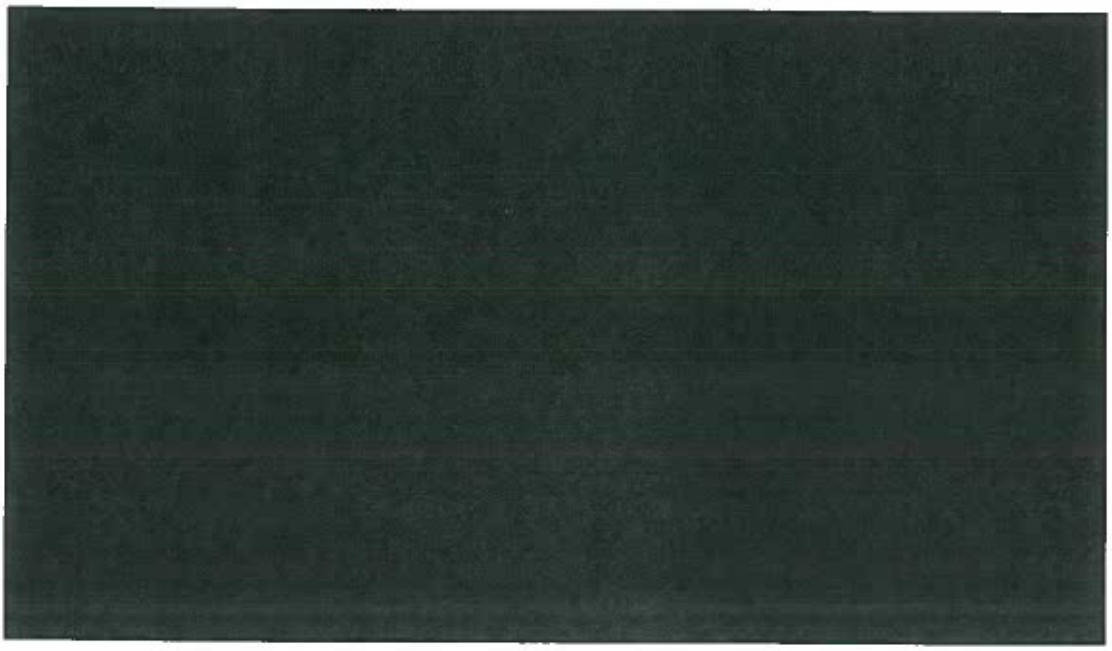

Candidate Band Recommendation

Question 8: What are your views about the pros and cons of the frequency ranges in Table A6.1 in Annex 6 for mobile broadband and for existing applications using this spectrum? Do you have views on other bands that are not in Table A6.1?

Question 9: Are there any other bands that are not in Table A6.1 for which you think we should be considering their pros and cons for mobile broadband and for existing applications using this spectrum?

Question 10: What are your views on bands which should be a priority for consideration for mobile broadband?

EE believes the overwhelming emphasis on candidate bands for mobile access spectrum should be on sub-1 GHz spectrum, i.e. 470-694 MHz.

This is because sub-1 GHz spectrum has superior propagation characteristics, meaning it is well suited to deliver ubiquitous mobile broadband coverage for smartphones and tablets. Sub-1 GHz spectrum is enormously value for mobile, because it delivers coverage in those hard to reach deep indoor locations. Lack of deep indoor coverage is hard to mitigate because such locations are dotted all over urban and suburban areas and from a network planning perspective, it is difficult to detect where these 'holes'. Sub-1 GHz spectrum allocated to mobile is relatively scarce and its relative value has been demonstrated in all recent European auctions of 800 MHz and 2.6 GHz.

As a second priority in terms of candidate bands for mobile access, EE supports spectrum in the range 1300-1527 MHz. These frequencies also have good propagation characteristics and there is scope for developing band plans to accommodate the asymmetric nature of mobile data traffic, for example supplementary down link.

The range 3.4-3.8 GHz is also interesting for deployment in small cells. We do not expect this spectrum to be suitable for deployment in the macro-cellular network. Hence it will not prevent MNOs from having to deploy small cells but it could help add capacity in the small cells once they are deployed. Therefore this band will help address spectrum shortage only in the very long term, i.e. when MNOs have deployed small cells to overcome the first spectrum shortages and run out of bandwidth in each cell.

Although 2.7-2.9 GHz would also be useful for mobile (and part of the band was identified for potential release by the MoD), we believe this will be more challenging to release for mobile in the UK. The radar co-existence issues that are being addressed in relation to deployment of 2.6 GHz for mobile show that co- band sharing between radar and mobile is unlikely to be feasible and re-planning/re-location of radar systems to alternate spectrum would potentially be required.

In addition to mobile access, it is of utmost importance to acknowledge that the increase in demand for mobile capacity cannot be met with more access spectrum alone. We will need to deploy small cells which require efficient wireless backhaul solutions. Finding harmonised spectrum for non-line of sight wireless backhaul must be given the same priority as finding spectrum for mobile access. We believe that a suitable block of spectrum below 6 GHz must be assigned for non-line of sight wireless backhaul. To achieve the required capacity each network needs at least 40 MHz of unpaired spectrum, suggesting that 120-160 MHz is needed as a total allocation.

The range from 3.8-4.2 GHz could be suitable for non-line of sight backhaul but as it may be difficult to clear this across Europe on a harmonised basis, we need some alternative candidate bands at this stage of the WRS-15 preparations.[1]

EE opposes the inclusion of 18.1GHz-18.6GHz, 27GHz-29.5GHz and 38GHz-39.5GHz in bands to study for mobile broadband spectrum as these bands include heavily used non line of sight fixed service spectrum. Mobile operators rely on these bands for wireless backhaul.

It would also be very useful to identify some of the higher frequency bands on the basis that they were harmonised for high bandwidth/high capacity line of sight links for the macro cellular network.

[1] Response to RSPG Consultation – "Strategic challenges facing Europe in addressing the growing spectrum demand for wireless broadband" – see Annex A

Annex A

RSPG Consultation response – "Strategic challenges facing Europe in addressing the growing spectrum demand for wireless broadband"

Radio Spectrum Policy Group
By email to: CNECT-RSPG@ec.europa.eu.

29 May 2013
Draft RSPG opinion on strategic challenges facing Europe in addressing the growing spectrum demand for wireless broadband.

EE welcomes the opportunity to comment on the RSPG's draft opinion on the strategic challenges facing Europe in addressing the growing spectrum demand for wireless broadband.

EE is one of the largest mobile network operators in the UK. We have 27 million customers and an annual turnover of £6.7 billion. We employ 15,000 people in the UK.

EE launched 4G services in 1800 MHz at the end of October 2012. We were the first operator in the UK to launch 4G and we currently remain the only mobile network operator in the UK that offers 4G services. We continue to invest £1.4m a day in our network and the upgrade to 4G. As of the end of March 2013, we have 318,000 4G customers, equivalent to 2.3% of our Pay Monthly customer base.

We believe that the recent trends in increasing mobile data usage will continue and more spectrum will be needed for mobile in the long term. However, meeting the future demand for mobile data is not only about identifying more spectrum for wireless broadband. As Ofcom in the UK has noted, there are three pillars that will jointly help to increase the capacity available on mobile networks:

- deployment of the most efficient radio access technologies, e.g. transitioning from 2G and 3G to 4G;
- the allocation and award of more spectrum to mobile; as well as
- deployment of more network sites in a way that is optimised to deliver more capacity where there is localised congestion, e.g. rolling out small cells in 'heterogeneous network' designs.

Over the past few years, policy initiatives such as the RSPP have been concerned with ensuring that licence restrictions that prevent the deployment of the latest access technology are lifted and that enough spectrum is allocated and assigned for radio access networks. This has been achieved through:

- setting deadlines for NRAs to award spectrum that has already been allocated to mobile broadband (800 MHz and 2.6 GHz); and
- pushing the liberalisation of existing spectrum licences in 900 MHz, 1800 MHz and 2.1 GHz for 4G.

In our view this means that those operators who are willing to invest are now well positioned to upgrade the capacity of their radio access networks in the short and medium term according to customer demand.[2] We do not see a requirement for more spectrum by 2015 and with additional bands such as 1.5 GHz, 2.3 GHz and likely 700 MHz in the pipeline for mobile, the requirements for more access spectrum are being addressed in the intermediate term beyond 2015 as well.

Against this background, there is now a unique opportunity, and an urgent requirement, to address the third pillar, namely how to improve the conditions for deployment of more network sites and in particular small cells. From a spectrum point of view this means addressing the lack of commonality in spectrum bands used for wireless backhaul for these sites (also referred to as fixed links or microwave links). Currently, mobile operators in different Member States use a plethora of bands for wireless backhaul. A key reason for this is that different NRAs have made available and promoted different spectrum bands for backhaul through various different licensing methods. Whilst there are a number of ECC Decisions on harmonisation of spectrum for backhaul none of these are the result of an EC mandate and none have a 100% adoption rate in the CEPT countries. The lack of commonality in bands used for wireless backhaul may not previously have been perceived as a significant issue that warranted European co-ordination. This was probably because vendors could adapt their network equipment to different bands at a reasonable costs and there was not the same overwhelming case for achieving economies of scale in equipment as there was for end user terminals (handsets) for the radio access network.

However that is changing. With the forecast increase in demand for capacity, mobile network operators will increasingly need to deploy access spectrum in small cells. These cells will need a backhaul solution. EE is considering several options for small cell backhaul, both fixed and wireless, but one issue is clear: By definition there are going to be many such small cells and hence their deployment needs to be cost effective. For wireless backhaul to be a viable solution for small cells we need equipment that is manufactured to achieve economies of scale. For such an eco-system to develop, we need common spectrum bands used for wireless backhaul across Europe, and preferably globally, in the same way that we have common bands used for the radio access network. There is a clear relationship between the cost of deploying small cells and the demand for more spectrum for mobile access networks. Whilst they are complements, they are also substitutes: The more expensive it is to deploy small cells and 'reuse' access spectrum across our network, the more additional access spectrum would be needed to be deployed in our macro cellular network as an alternative.

EE would therefore like to suggest that a recommendation is added to the nine recommendations in the draft RSPG Opinion. This should recommend that the European Commission works to promote the use of common bands for wireless backhaul across the Member States. Spectrum for backhaul should also be considered as part of the actions under the other recommendations. Importantly, the strategic plan referred to in recommendation 1 and 2 to make the necessary spectrum available to meet the future demand for wireless broadband services, should also consider how commonality of use for wireless backhaul can be promoted and how the necessary spectrum for backhaul can be made available on a harmonised basis.

In terms of specific frequencies and candidate bands, EE would like to suggest that a sizeable spectrum allocation below 6 GHz is considered as a harmonised allocation for non-line of sight wireless backhaul, suitable for small cells. The frequencies around 4 GHz have particular good

[2] For example, in the recent auction of 800 MHz and 2.6 GHz in the UK, EE acquired 2x5 MHz of 800 MHz and 2x35 MHz of 2.6 GHz to support future growth. We believe that we are well positioned to meet our customers' future demand through our investments in network rollout and our spectrum portfolio.

characteristics. To achieve the required capacity each network needs at least 40 MHz of unpaired spectrum, suggesting that 120-160 MHz is needed as a total allocation.

We are of course happy to discuss our suggestions further and provide detailed information about our current use of backhaul spectrum if this would be useful to the RSPG.

Yours Sincerely,

Inge Hansen
Head of Spectrum