Future demand for mobile broadband spectrum and consideration of potential candidate bands

Submission from Alcatel-Lucent UK

1. AIM

Alcatel-Lucent welcomes the opportunity to respond to the UK Government Future demand for mobile broadband spectrum and consideration of potential candidate bands.

Mobile has become one of the largest and most significant platforms in history. Supporting over six billion connections worldwide, it is entirely transforming the way we communicate, experience entertainment and make use of the Internet.

Moreover, the spread of smart mobile devices – smartphones and tablets – is growing at a very fast pace, putting more emphasis on the mobile broadband. In the conversation on the broadband development and take up, the spectrum is of increasing importance and relevance, as identification, allocation and availability of the right spectrum for mobile communication is a lasting process.

The mobile data traffic is increasing exponentially and the ability of mobile broadband technologies such as Long Term Evolution (LTE) and LTE-Advanced (LTE-A) to meet this demand depends on the availability of spectrum beyond that which is currently available to cellular mobile systems. Additional spectrum will be required in the future even considering the gains that will be delivered by LTE and LTE-A's higher spectral efficiency and the use of cell densification.

Allocating and making spectrum available on a global basis is a complex process that is managed by the International Telecommunication Union (ITU) on a worldwide scale. Alcatel-Lucent (ALU) and the wider mobile industry are working to harmonize this spectrum as much as possible to improve economies of scale for mobile broadband technologies and products.

This paper reflects the view of Alcatel-Lucent on the future needs of spectrum in general and in particular in the context of the UK market.

2. ALCATEL –LUCENT'S OPINION

Question 1: How much do you expect UK mobile data demand to change in the period 2015-2030? Please provide evidence for the trend and, where possible, please indicate how demand might vary across the device categories listed in paragraph 4.7. How should we account for factors (including pricing) that would constrain demand?

The fast spread and adoption of smart devices is seen as a key enabler for the mobile data demand worldwide. The traffic predictions are taking into account five key dimensions, namely: the device type, the user behaviour, the applications used, the network capabilities, and the availability of cloud-based applications. While mobile traffic usage is increasing on yearly basis, we need point out that the pricing strategies are heavily influencing the consumption patterns.

Current studies performed by our Bell Labs team for the advanced US mobile market indicates that the key evolution trend setter is the device, pointing out that the tablet is a 'platform' that is profoundly influencing device usage. While mobile data per device is continuously growing there is also a natural trend for people to use simultaneously two or three connected devices that lead to additional traffic growth (eg. internet browsing while downloading content and video streaming).

According to the five year analysis (2011-2016) on the adoption of devices, technologies, and consumption of data and application, the findings per region are as follows:

- Number of subscribers, adoption of device types and technologies varies across regions, but some similar trends are observed
- **Usage per device grows 14 to 20 fold** over the period (weighted average across all devices)
- **Traffic growth for 2011-2016: ~25x** times worldwide with variations across the regions depending on the mix of technologies, devices, and consumption patterns

Unconstrained traffic (PB/month)	2011	2012	2013	2014	2015	2016	Growth (x times)
NAR	150	422	864	1 516	2 403	3 520	23,5
APAC	264	648	1 397	2 752	4 906	7 486	28,3
EU	195	499	981	1 728	2 792	4 198	21,6
NAR, APAC, EU	**609**	**1 569**	**3 242**	**5 996**	**10 102**	**15 204**	**25,0**

Table 1 – Unconstrained Traffic Forecast 2011-2016, Bell Labs Traffic Index

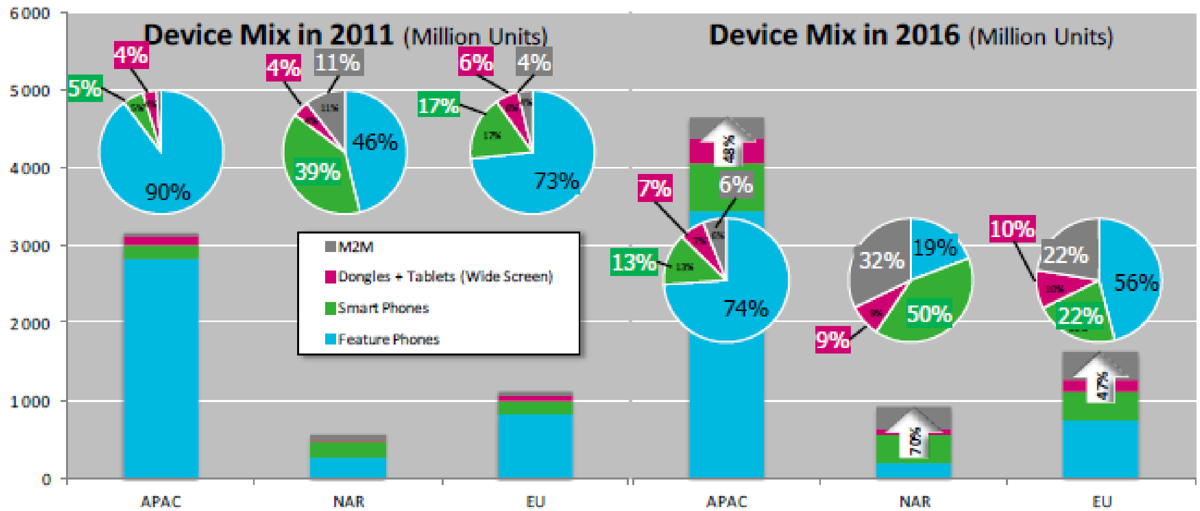


Figure 1 – Bell Labs Traffic Index: Traffic Forecast per Region 2011-2016

Wide screen devices will generate most of the traffic in the networks; although counting for a small percent of the installed devices (less than 10%) they generate the majority of the traffic (60% - 70% of the traffic) worldwide, in all regions.

- 4G penetration is the catalyst for growth and the main reason for the differences in usage per widescreen, but 3G remains the dominant technology by 2016 (except Asia Pacific region where 2G remains dominant)
- Widescreens and feature phones account for more than 90% of the traffic
- Feature phones still make for a large share of the device mix, driving down the average traffic per device
- M2M is a small component of the traffic, insignificant quantity of total, but driving down per device averages.

Question 2: What evidence do you think is relevant to assessing the extent of consumer benefits associated with meeting the increase in demand for mobile data?

There are many efforts to correlate the increase in mobile data demand and the consumer benefits. The Deloitte study for GSMA[1] of November 2012 "What is the impact of mobile telephony on economic growth?" is the latest one investigating the impact of mobile broadband on GDP growth.

According to the study, the impact of 3G penetration on GDP growth:

- A doubling of mobile data use leads to a growth in the GDP per capita growth rate of 0.5 percentage points
- Countries characterised by a higher level of data usage per 3G connection have seen an increase in their GDP per capita growth of up to 1.4 percentage points.
- A 10% rise in 3G penetration increases GDP per capita growth by 0.15 percentage points. In developing markets, a 10% expansion in mobile penetration increases productivity in the long run by 4.2 percentage points.

[1] http://www.gsma.com/publicpolicy/wp-content/uploads/2012/11/gsma-deloitte-impact-mobile-telephony-economic-growth.pdf

The report measures the impact on GDP growth of consumers moving from basic 2G connections to 3G connections, analyzing 96 developed and developing markets. The report shows the positive effect of consumers substituting a 2G connection with a 3G connection. A 10 per cent rise in 3G penetration increases GDP per capita growth by 0.15 percentage points.

According to the findings of the study, UK is in the falling into the category of countries for which the doubling of mobile data use leads to a 1.4 percentage point increase in GDP.

Additionally, in the Annex, we provide the methodology and findings of the ITU-R

Question 3: What proportion of mobile data traffic do you expect to be carried over (a) Wi-Fi and similar systems in licence-exempt spectrum and (b) mobile networks in licensed spectrum? How do you expect this to change over the period 2015-2030 and how do you expect total data demand for Wi-Fi and similar systems in licence-exempt spectrum to change over the same period? How might this vary by location, environment etc.?

Mobile data traffic carried over the license-exempt spectrum is considered in our view as a traffic optimization option. We consider two main options considered for optimizing traffic in the network: WiFi offloading and smart loading. Also a greater penetration of fixed broadband leads to a higher proportion of traffic carried by Wi-Fi.

The Bell Labs Traffic Index report indicates a strong correlation between the regional penetration of fixed broadband and Wi-Fi offload, showing that Wi-Fi offload is less impactful in Asia-Pacific due to lower fixed BB penetration than Europe and North America Region (NAR – US and Canada).

To this extent, we should keep in mind that Wi-Fi offloading is a voluntary action of the user and the service provider can use additional actions to offload / secure specific traffic on the mobile network.

Modern networks have the ability to carry traffic from multiple applications and device types with different network requirements, traffic loads on the network, and levels of profitability.

Depending on the strategy a service provider can selectively offload traffic to Wi-Fi, maintaining more profitable traffic on the mobile network while offloading less profitable, offloading at various locations, over either free or secure Wi-Fi access points.

It is thought to mention that in our view the Wi-Fi and mobile network can be used in a complementary fashion with one supplementing the other, with the Wi-Fi providing non-guaranteed bandwidth suitable for tasks such as web browsing or ftp download, and the cellular connections providing higher quality suitable for quality sensitive applications such as real-time communications. The cellular network will also continue to allow user mobility by virtue of superior wide-area coverage and hand-off capabilities.

Actual analysis[2] indicates that an UK average ratio of 4/1 of Wi-Fi / mobile data traffic, with 97% of the smartphone users actively using Wi-Fi data. Also, the typical average monthly data consumption ranges between 100 and 500MB depending on the country and operator in question (Wi-Fi excluded).

The Annex at the end of this document provides the details of the ITU-R methodology for the distribution of the forecasted traffic that is used by the ITU-R WP5D Sub-Working Group "Traffic" that is chaired by Alcatel-Lucent.

Question 4: What factors will act to change the spectral efficiency of mobile technologies in the future? What spectral efficiency values are appropriate for consideration in our study for the period 2015-2030?

[2] Informa Telecom & Media's White Paper: 3Understanding today's smartphone user: Demystifying data usage trends on cellular & Wi-Fi networks", 2012

Operators are constantly seeking spectral efficiency improvements in order to maximize the return on their investment in telecommunications infrastructure. The graphic below shows the steady increase in spectral efficiency in 3GPP technologies (from GRPS to LTE) over time, as measured in bits per second of aggregate throughput per Hz of occupied spectrum. The original graph (see footnote 3) was completed with Alcatel-Lucent's addition (in agreement with actual, simulated 3GPP figure) of the downlink spectral efficiency of LTE-A as being 2.4 Bps/Hz.

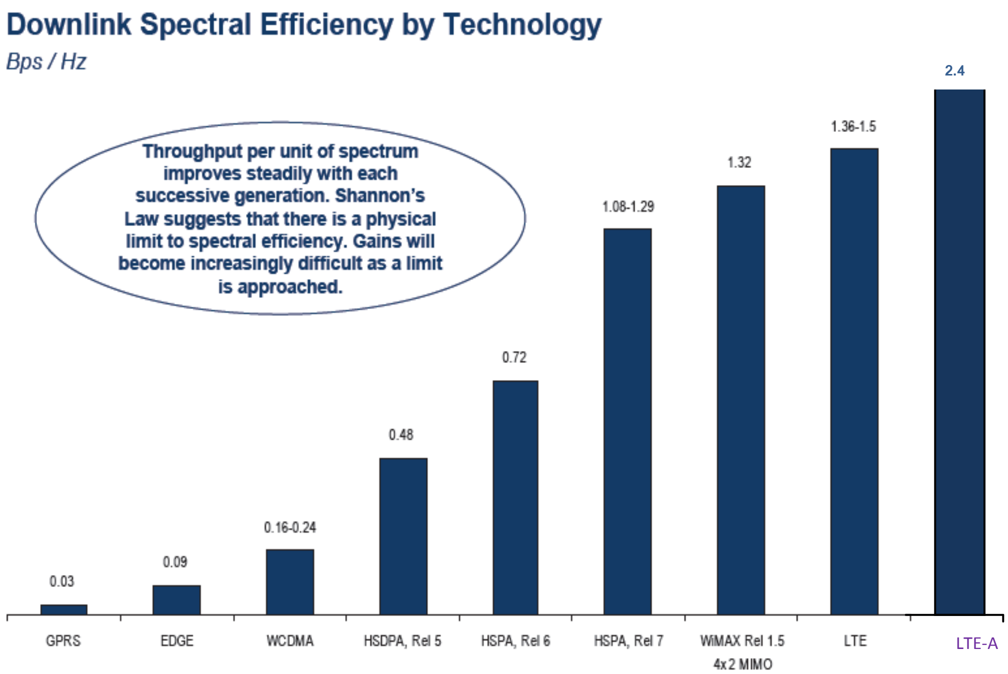


Figure 2 – Downlink Spectral Efficiency by Technology[3]

As the circled text in the graph indicates, technology innovation is subject to diminishing returns in the form of the Shannon Bound. "The Shannon bound is a theoretical limit to the information transfer rate [per unit bandwidth] that can be supported by a communications link with a given noise or interference level. The bound is a function of the Signal to Noise Ratio [SNR] of the communications link. As shown in the figure below, current mobile broadband technologies are all within 2 to 3 decibels (dB) of the Shannon bound, indicating that there is little room for improvement in spectral efficiency, speaking strictly from the perspective of innovations in the radio access technology."[4]

Nevertheless, vendors are working closely with operators to push the boundaries of these limitations. Recent innovations, such as an all IP-Open Internet network architecture, beam forming, adaptive antennas, carrier aggregation, power control, etc., have resulted in more efficient spectrum usage. Adopting more efficient mobile broadband technologies, such as IMT-Advanced will certainly allow operators to handle some of the increase in mobile data traffic. Among the features of IMT-Advanced that will facilitate greater efficiency are Multiple Input Multiple Output (MIMO), Coordinated Multi Point (CoMP) transmission, and Enhanced Inter Cell Interference Coordination (eICIC).

[3] Source: 4GAmerica's White Paper: "Sustaining the Mobile Miracle: A 4G Americas Blueprint for Securing Mobile Broadband Spectrum in this Decade", March 2011"
[4] Source: idem

Modern wireless systems are able to operate within a few dB of the Shannon bound. It is doubtful that this gap between the theoretical bound and practical implementations will be closed by more than one or two dB in the foreseeable future, suggesting that we should expect that spectral efficiency will increase no more than a factor of 1.5x by 2020, or 2x by 2030 to t.5 b/s/Hz.

Much of this optimization aims to improve the SINR domain of operation in Figure 3, by reducing the interference levels by cancellation or scheduling approaches.

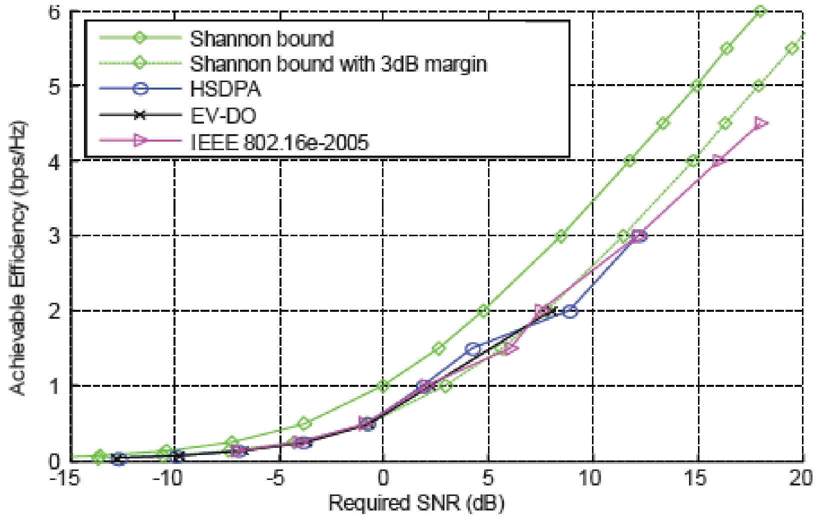
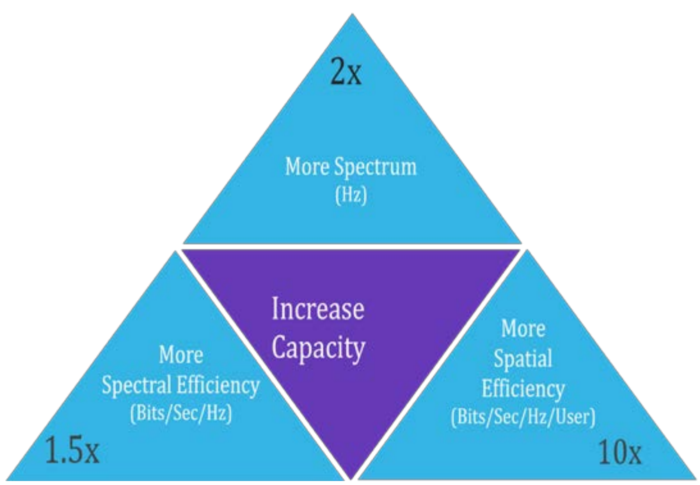


Figure 3 – The Shannon Bound per Technology Type

Industry consensus is increasingly looking for small cell deployments to address the growing demands on capacity, essentially improving spatial efficiency, measured in Mbps/km2 by locating capacity where the demands are greatest.

The remainder of the capacity growth needs to come from additional spectrum. However, historically, spectrum allocations to commercial mobile services have only been growing about 10% year over year even as traffic has been growing at more than 100% year over year[5].

The figure below illustrates the expected impact of these three factors:



[5] 2011 Ofcom report, "Communications Market Report" indicated that the volume of mobile data transferred over UK's mobile network increased 40-fold between 2007 and 2010, corresponding to a CAGR of nearly 242% Year over Year

Figure 4 – Factors that Influence the Increase of Capacity

Question 5: What service bit rate values are appropriate for consideration in our study for the period 2015-2030? What evidence do you have of changing needs for service bit rates?

Alcatel-Lucent recently reported network traffic statistics gathered from the 9900 Wireless Network Guardian network analytics tool providing insights into 3G and 4G usage[6]. This confirms other reports findings that LTE users are consuming about 1.4 GByte per month, a 168% increase over that of 3G subscribers. Notably, the study found that while LTE is observed to be 7 times faster than 3G service and traffic volume increased 168%, the signalling increased only 13% and airtime by the relatively modest 26%, confirming the relative signalling efficiency of 4G over 3G.

The general wireless traffic is continuing to grow at prodigious rates, though somewhat less on a percentage basis, than in the early days of smart phones. As seen in the figure below, reports from 2008 through 2010 were seeing a tripling of wireless data traffic year over year (>200%), but since 2010 the growth has reduced to the still-whopping 100% year over year rates, corresponding to double the traffic year over year.

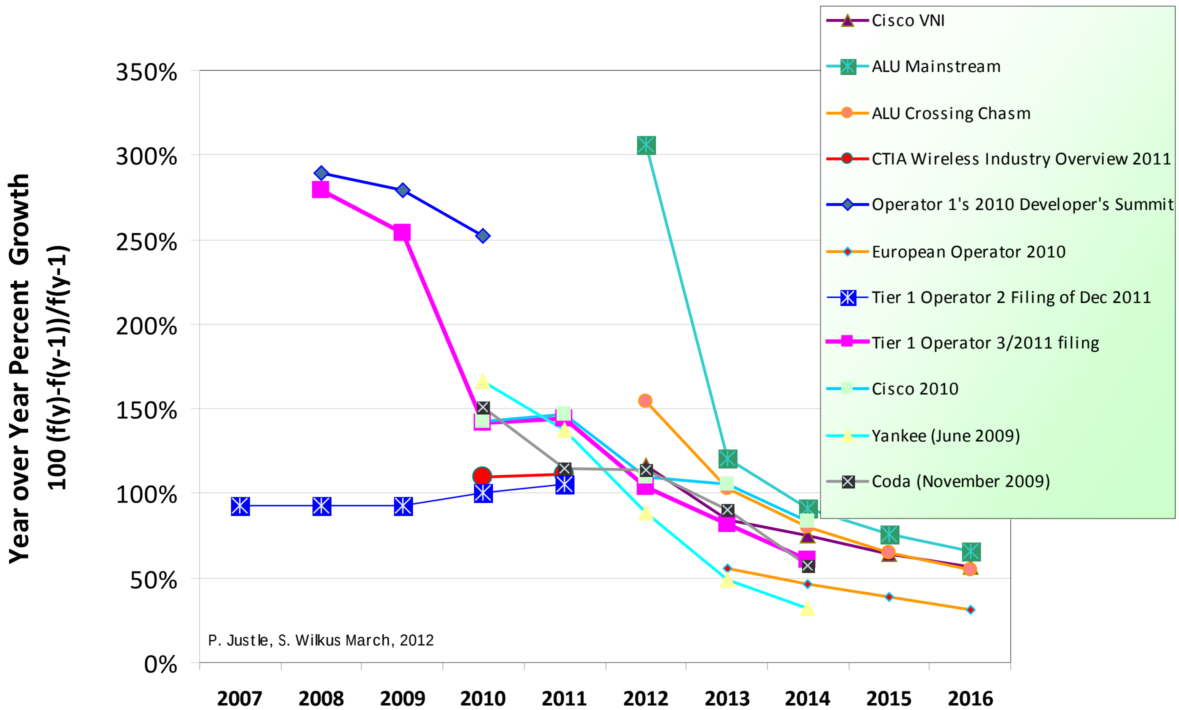


Figure 5 – Trends in Wireless Growth Rates

The current LTE networks commonly provide users with downlink speeds well in excess of 10 Mbps and often 15 Mbps[7]. With more years of doubling demand year over year we might expect a growth of 1000x in aggregate wireless data usage over 10 year time. But as we see in figure 5 below, growth is slowing somewhat to slightly less than 100% year over year (doubling). Some have pointed out the limited neural

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[6] "LTE networks: the gateway for application addiction," April 22, 2013 by Patrick Tan. http://www2.alcatel-lucent.com/blogs/corporate/2013/04/lte-networks-the-gateway-for-application-addiction/

[7] http://gadgetwise.blogs.nytimes.com/2013/03/20/who-has-the-fastest-lte-service/?smid=pl-share April 26, 2013

capacity for the human body to accept data, suggesting that about 10 Mbps per eye is all that can be 'consumed'[8].

Past performance, however, does not guarantee future results, of course, and new appliances such as Google glass and machine-to-machine communications equipment may disrupt the historical trends as much as the iPhone did in 2007. Peak rates, too, may buffer busts of content for later viewing/consideration.

Question 6: What proportion of traffic do you consider should be assumed to be carried on each cell types for the period 2015-2030? How will this vary with service environment i.e. between home, office, public areas, rural, suburban and urban? What evidence do you have of the factors affecting the uptake of small cells in licensed spectrum in the future?

In response to this question on the distribution of traffic to be carried by each cell type, Alcatel-Lucent believes the best data on this come from ITU-R Recommendation ITU-R M.1768-1 (Methodology for calculation of spectrum requirements for the terrestrial component of IMT), April 2013. Annex B depicts some extracts from this report.

As a compliment to the observations in this key ITU-R Recommendation, Alcatel-Lucent observes that the mixed of cell types carrying traffic will depend upon the environment type. For example, while cellular services in rural areas would be expected to remain largely based macro cells this will not be the case in urban areas especially after the onset of macro "spectrum exhaustion" after which point the total traffic carried on the macro cell layer would remain constant with all subsequent traffic growth carried by an increasing denser network of small cells. In parallel to this capacity driven view for small cell usage there will also be an increasing role of small cell devices to provide indoor coverage and capacity in both public and private environments.

Table 2 below presents an initial view of Alcatel-Lucent on how the proportion of traffic carried on each cell type will vary with service environment for coming years.

Service Environment	Key Cell Type	Observations
Home	2010 – Macro only From 2020 – largely femto based complemented by private WLAN	Currently largely macro based for cellular services complemented by private WLAN using residential broadband backhaul. Expect to see increasing adoption of residential femto cell for 3G and later on 4G services reaching very high penetration rates by 2020. When coupled with WLAN this would results in almost 100% offload from macro layer.
Office	2010 – Macro and DAS systems From 2020 – largely femto based complemented by enterprise WLAN	Currently based on mixture of outdoor macro coverage and indoor DAS (Distributed Antenna System) systems connected to modified macro or micro cell site equipment complemented by enterprise WLAN systems. Expect to see increasing adoption of enterprise femto cell systems for 3G and later on 4G services reaching high penetration rates by 2018 including replacement and/or conversion of existing DAS systems
Public area (indoor)	2010 – Macro and DAS systems From 2020 – largely metro based complemented by	Currently based on mixture of outdoor macro coverage and indoor multi-operator DAS systems connected to modified macro or micro cell site equipment complemented by public access WLAN systems.

[8] R.R. Miller, "A Glass of Water without the Glass: Next-Generation Terahertz Wireless Networks," IWPC meeting of Dec, 2011

Service Environment	Key Cell Type	Observations
	enterprise WLAN	Expect to see increasing adoption of indoor metro systems for 3G and 4G services reaching high coverage rates by 2018 including replacement and/or conversion of existing DAS systems
Rural	2010 – Macro 2020 – Macro complemented by selected usage of femto and metro	High tower macro cell solutions expected to remain mainstream solution for the foreseeable future. Rural homes and small villages likely to see increasing adoption of small cell (femto and metro) in areas where wireline broadband are available for backhaul
Suburban	2010 – Macro 2020 – Macro complemented by wide spread usage of femto and metro	Macro capacity based designed are expected to remain the dominant solution provided that sufficient spectrum resources are available and that most indoor traffic is carried by a parallel femto layer.
Urban	2010 – Macro 2020 – Metro providing majority of capacity complemented by macro layer for coverage	Macro capacity based designs are already under pressure with operators holding limited spectrum resources actively deploying outdoor metro cells and making extensive use of indoor DAS system to offload the macro layer. Expect to see increasing density of metro nodes as more and more operators encounter macro layer capacity exhaustion for 3G and/or 4G services despite the rollout of advanced radio features, new and re-farmed spectrum resources and indoor coverage based macro offload solutions. It is likely that the required very high densities of outdoor metro systems will be only practical using dedicated carriers, leading operators to assign a part of their spectrum holdings for this layer. Once the networks have been re-configured to use dedicated small cell spectrum for outdoor metro then it is likely that other small cell solutions such as residential and enterprise femto would re-use the same carriers.

Table 2 - Initial Alcatel-Lucent Views on the Traffic Distribution per Cell Type and its Evolution with the Service Environment

Question 7: Given the current mix of services on cellular networks what is the ratio of downlink to uplink capacity currently dimensioned for and how would you expect this to change over time by 2015, 2020, 2025 and 2030? How do you expect the ratio of downlink to uplink demand to vary for the service categories given in Table A5.4 of Annex 5, and what factors might affect this? How does this ratio of downlink to uplink capacity change (if at all) with network radio access technology and offload to licence-exempt systems?

We believe that this question would be most appropriately addressed by operators, who can share their experience and traffic projections. As previously states we consider that traffic evolution is highly influenced by the commercial strategies and the pricing of the services.

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?

Alcatel-Lucent is an equipment producer and therefore we are not experts in the existing applications. We believe it is not appropriate for us to provide views on the pros and cons of the frequency ranges for existing applications.

Frequency Band	Pros for Mobile Broadband	Cons for Mobile Broadband
470-694 MHz	• These frequencies have favourable propagation characteristics that allow broadband wireless coverage to be provided over large areas with fewer cells compared to higher frequency band which reduces network infrastructure costs. • When used for the macro network, these frequencies allow for reliable outdoor and indoor coverage as these frequency ranges also offer favourable building penetration of radio signals. • The lower and upper edges of the 470-694 MHz frequency range are adjacent to bands in which IMT systems are currently deployed (i.e. 450-470 MHz and 698-960 MHz). The use of bands currently used by IMT terminals, or in close proximity to bands currently implemented in IMT terminals, could result in greater availability of RF components and reduce equipment complexity	Sharing with existing services could be problematic. Therefore, relocation of existing services may be required, delaying access to this spectrum.
1300-1400 MHz	• These frequencies have favourable propagation characteristics that are suitable for mobile broadband systems that provide reliable wide area coverage over urban and rural areas. • These frequencies can be used for macrocell and microcell network to provide capacity. • Parts of the spectrum around 1.5 GHz are currently used, or planned for use, for IMT systems in some countries. Equipment based on international standards, is already available in relatively close proximity to this band. • There is already an existing Mobile allocation in Region 1 in 1350-1400 MHz.	The use of some of these frequencies by passive services makes sharing particularly problematic. Sharing with other existing services, such as radars and aeronautical radionavigation could be problematic.

1400-1427 MHz	• These frequencies have favourable propagation characteristics that are suitable for mobile broadband systems that provide reliable wide area coverage over urban and rural areas. • These frequencies can be used for macrocell and microcell network to provide capacity. • Parts of the spectrum around 1.5 GHz are currently used, or planned for use, for IMT systems in some countries. Equipment based on international standards, is already available in relatively close proximity to this band.	The use of these frequencies by passive services makes sharing particularly problematic.
1427-1527 MHz	• These frequencies combine the attractive propagation characteristics of the lower frequencies with the ability to offer larger bandwidths. • These frequencies are already allocated to the Mobile Service on a primary basis in all three Regions.	In Region 2, the use of the band 1 435-1 535 MHz by the aeronautical mobile service for telemetry has priority over other uses by the mobile service; so, it may be difficult to get a global identification.
1452-1492 MHz	• These frequencies combine the attractive propagation characteristics of the lower frequencies with the ability to offer larger bandwidths. • These frequencies are already allocated to the Mobile Service on a primary basis in all three Regions.	In Region 2, the use of the band 1 435-1 535 MHz by the aeronautical mobile service for telemetry has priority over other uses by the mobile service; so, it may be difficult to get a global identification.
1518-1559 MHz	• These frequencies combine the attractive propagation characteristics of the lower frequencies with the ability to offer larger bandwidths. • Up to 1525 MHz is already allocated to the Mobile Service on a primary basis in all three Regions.	Sharing with existing services could be difficult. In Region 2, the use of the band 1 435-1 535 MHz by the aeronautical mobile service for telemetry has priority over other uses by the mobile service; so, it may be difficult to get a global identification.
1626.5-1660.5 MHz	• These frequencies combine the attractive propagation characteristics of the lower frequencies with the ability to offer larger bandwidths	Sharing with existing services could be difficult
1668-1675 MHz	• 1668.4-1675 MHz already has a global allocation to the Mobile service. • Could be combined with adjacent bands, such as 1675-1710 MHz to offer larger bandwidths.	Unless combined with adjacent bands, this only offers 9 MHz of spectrum, which is not particularly useful for today's intensive services.

1695-1700 MHz	• 1675 – 1690 MHz already has a global allocation to the Mobile service. • Could be combined with adjacent bands, such as 1668-1675 MHz to offer larger bandwidths.	Unless combined with adjacent bands, this only offers 9 MHz of spectrum, which is not particularly useful for today's intensive services.
2025-2110 MHz **2200-2290 MHz**	• These frequencies have propagation characteristics that are suitable for use in urban areas where the deployment of mobile networks is typically capacity limited. • These frequencies have some potential to provide large contiguous bandwidths that can be used for macrocell and microcell network to provide increased capacity. • Parts of the spectrum around 2 GHz are widely used for IMT systems, which makes RF components readily available. Frequency bands within this range could support mobile broadband applications with minimal hardware modifications allowing for economies of scale to be met in deployment of new systems and networks. • The use of certain additional frequencies around 2 GHz would allow for simple extension of existing bands used for IMT deployments.	Footnote 5.391, says: "In making assignments to the mobile service in the bands 2 025-2 110 MHz and 2 200-2 290 MHz, administrations shall not introduce high-density mobile systems, as described in Recommendation ITU R SA.1154, and shall take that Recommendation into account for the introduction of any other type of mobile system." this is intended to protect the space research services using the bands. Additionally these frequencies are used in some countries to backhaul mobile broadband traffic.
2700-2900 MHz	• These frequencies could be used to handle 'capacity' requirements of mobile broadband. • These frequencies offer sufficiently large bandwidth to realize the benefits of 20 MHz channels in IMT-Advanced. • There is the possibility of a globally harmonized band, with some country exceptions	Sharing with existing services could be problematic. Therefore, relocation of existing services may be required, delaying access to this spectrum. Due to the use of the band by radars, unlikely that this spectrum will be available in all countries.

3400-3600 MHz	• These frequencies have propagation characteristics that are suitable for use in dense urban areas where the deployment of mobile networks is typically capacity limited since it provides an opportunity for increased frequency reuse. • These frequencies have potential to provide large contiguous bandwidths that can be used for microcell and picocell network to provide increased capacity and performance. • Parts of the spectrum between 3-6 GHz are also used for IMT systems and are covered by relevant international standards, • Some frequency ranges between 3-6 GHz could support mobile broadband applications with minimal hardware modifications allowing for economies of scale to be met in deployment of new systems and networks. • 3.5-4.2 GHz is allocated to the Mobile Service on a primary basis in Regions 2 and 3. 3.4-3.6 GHz is already identified for IMT by footnote in dozens of Region 1 and 3 countries, which means RF components may be readily available. • There is the possibility of a globally harmonized band, with some country exceptions.	The propagation characteristics in 3.4-3.6 GHz make it relatively unattractive for macrocell deployment. Small cells might be a more appropriate use of the spectrum Sharing with existing services could be problematic. Therefore, relocation of existing services may be required. Additionally portions of these frequencies are used in some countries to backhaul mobile broadband traffic.
3600-3800 MHz	• These frequencies have propagation characteristics that are suitable for use in dense urban areas where the deployment of mobile networks is typically capacity limited since it provides an opportunity for increased frequency reuse. • These frequencies have potential to provide large contiguous bandwidths that can be used for microcell and picocell network to provide increased capacity and performance. • These frequencies are adjacent to spectrum already identified for IMT, which may mean that equipment for mobile broadband applications could be available with minimal hardware modifications allowing for economies of scale. • 3.5-4.2 GHz is allocated to the Mobile Service on a primary basis in Regions 2 and 3.	The propagation characteristics in 3.6-3.8 GHz make it relatively unattractive for macrocell deployment. Small cells might be a more appropriate use of the spectrum. Sharing with existing services could be problematic. Additionally portions of these frequencies are used in some countries to backhaul mobile broadband traffic.

3800-4200 MHz	• These frequencies have propagation characteristics that are suitable for use in dense urban areas where the deployment of mobile networks is typically capacity limited since it provides an opportunity for increased frequency reuse. • These frequencies have potential to provide large contiguous bandwidths that can be used for microcell and picocell network to provide increased capacity and performance. • 3.5-4.2 GHz is allocated to the Mobile Service on a primary basis in Regions 2 and 3.	The propagation characteristics in 3.8-4.2 GHz make it relatively unattractive for macrocell deployment. Small cells might be a more appropriate use of the spectrum. Sharing with existing services could be problematic. Additionally portions of these frequencies are used in some countries to backhaul mobile broadband traffic.
4400-4900 MHz	• These frequencies could be used to handle 'capacity' requirements of mobile broadband. • These frequencies offer sufficiently large bandwidth to realize the benefits of 20 MHz channels in IMT-Advanced • There is a global allocation to the mobile service in 4.4-5.0 GHz.	The propagation characteristics in 4.4-4.9 GHz make it relatively unattractive for macrocell deployment. Small cells might be a more appropriate use of the spectrum. As the frequency increases, the ability to support mobility becomes an issue.
4500-4800 MHz	• These frequencies could be used to handle 'capacity' requirements of mobile broadband. • These frequencies offer sufficiently large bandwidth to realize the benefits of 20 MHz channels in IMT-Advanced.	The propagation characteristics in 4.4-4.9 GHz make it relatively unattractive for macrocell deployment. Small cells might be a more appropriate use of the spectrum. As the frequency increases, the ability to support mobility becomes an issue.
5350-5470 MHz	• These frequencies have propagation characteristics that are suitable for use in small coverage areas, both indoors and outdoors, within dense urban areas since it provides an opportunity for increased frequency reuse. • These frequencies are particularly suitable for massive multiple antenna techniques, e.g., higher order multiple antenna techniques, which increases system capacity and coverage because a large number of antenna elements can be implemented in smaller size in higher frequencies.	While there may be some specialized applications (e.g. RLANs and WiFi) for these higher frequencies, Alcatel-Lucent does not believe the propagation characteristics lend themselves to IMT use.

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5850-5925 MHz	• These frequencies have propagation characteristics that are suitable for use in small coverage areas, both indoors and outdoors, within dense urban areas since it provides an opportunity for increased frequency reuse. • These frequencies are particularly suitable for massive multiple antenna techniques, e.g., higher order multiple antenna techniques, which increases system capacity and coverage because a large number of antenna elements can be implemented in smaller size in higher frequencies.	While there may be some specialized applications (e.g. RLANs and WiFi) for these higher frequencies, Alcatel-Lucent does not believe the propagation characteristics lend themselves to IMT use.
5850-6425 MHz	• These frequencies have propagation characteristics that are suitable for use in small coverage areas, both indoors and outdoors, within dense urban areas since it provides an opportunity for increased frequency reuse. • These frequencies are particularly suitable for massive multiple antenna techniques, e.g., higher order multiple antenna techniques, which increases system capacity and coverage because a large number of antenna elements can be implemented in smaller size in higher frequencies.	While there may be some specialized applications (e.g. RLANs and Wi-Fi) for these higher frequencies, Alcatel-Lucent does not believe the propagation characteristics lend themselves to IMT use. Report ITU-R M.2119

5925-6425 MHz	• These frequencies have propagation characteristics that are suitable for use in small coverage areas, both indoors and outdoors, within dense urban areas since it provides an opportunity for increased frequency reuse. • These frequencies are particularly suitable for massive multiple antenna techniques, e.g., higher order multiple antenna techniques, which increases system capacity and coverage because a large number of antenna elements can be implemented in smaller size in higher frequencies.	While there may be some specialized applications (e.g. RLANs and WiFi) for these higher frequencies, Alcatel-Lucent does not believe the propagation characteristics lend themselves to IMT use.
13.4-14 GHz	• While there may be some specialized applications for these higher frequencies, Alcatel-Lucent does not believe the propagation characteristics lend themselves to IMT use.	While there may be some specialized applications for these higher frequencies, Alcatel-Lucent does not believe the propagation characteristics lend themselves to IMT use.
18.1-18.6 GHz	• While there may be some specialized applications for these higher frequencies, Alcatel-Lucent does not believe the propagation characteristics lend themselves to IMT used.	While there may be some specialized applications (e.g. RLANs and Wi-Fi) for these higher frequencies, Alcatel-Lucent does not believe the propagation characteristics lend themselves to IMT use. These frequencies are used for microwave backhaul, essential to the operation of mobile broadband networks.
27-29.5 GHz	• While there may be some specialized applications for these higher frequencies, Alcatel-Lucent does not believe the propagation characteristics lend themselves to IMT use.	While there may be some specialized applications for these higher frequencies, Alcatel-Lucent does not believe the propagation characteristics lend themselves to IMT use.
38-39.5 GHz	• While there may be some specialized applications for these higher frequencies, Alcatel-Lucent does not believe the propagation characteristics lend themselves to IMT use.	While there may be some specialized applications for these higher frequencies, Alcatel-Lucent does not believe the propagation characteristics lend themselves to IMT use. Portions of these frequencies are used for microwave backhaul, essential to the operation of mobile broadband networks.

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?

Considering that 21 countries of the Region 1 already allocated the spectrum in the band 3.3-3.4 GHz to mobile service at WRC-12, it may be advisable to consider and develop a position on this band.

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

In our opinion, the following bands should be a priority:

- 470-694 MHz
- 1300-1527 MHz (excluding 1400-1427 MHz)
- 2.7-2.9 GHz
- 3.4-4.2 GHz

3. BACKGROUND

Alcatel-Lucent (Euronext Paris and NYSE: ALU) is the long-trusted partner of service providers, enterprises and governments around the world. Alcatel-Lucent is a leading innovator in the field of networking and communications technology, products and services. The company is home to Bell Labs, one of the world's foremost research centres, responsible for breakthroughs that have shaped the networking and communications industry.

Alcatel-Lucent innovations are regularly recognized by international institutions for their positive impact on society. In 2012 and for the second year running, Alcatel-Lucent was named one of the Thomson Reuters Top 100 Global Innovators, recognition for the company's continued addition to its world-class patent portfolio, one of the largest in the telecom industry. Alcatel-Lucent has also been recognized for its sustainability performance. In 2012 the company was ranked Technology Supersector Leader by the Dow Jones Sustainability Index. Through its innovations, Alcatel-Lucent is making communications more sustainable, more affordable and more accessible as we pursue our mission of Realizing the Potential of a Connected World.

With operations throughout the world, Alcatel-Lucent is a local partner with global reach. The Company achieved revenues of Euro 14.4 billion in 2012 and is incorporated in France and headquartered in Paris.

For more information, visit Alcatel-Lucent on: http://www.alcatel-lucent.com, read the latest posts on the Alcatel-Lucent blog: http://www.alcatel-lucent.com/blog and follow the Company on Twitter: http://twitter.com/Alcatel_Lucent.

4. CONTACT DETAILS

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ANNEX A

Detailed ITU-R methodology for the distribution of the forecasted traffic

The ITU-R methodology described in ITU-R M.1768-1 takes into account four RATGs (Radio Access Technique Groups):

> *The methodology takes into account the total terrestrial communication market that will be provided by various communication means in terms of services and networks according to Recommendations ITU-R M.1645, ITU-R M.1457 and ITU-R M.2012. There are a number of RATGs which can be identified. The present methodology distributes the total traffic forecasted for the total terrestrial communication market to the identified RATGs, which are:*
> *Group 1: Pre-IMT systems, IMT-2000 and its enhancements.*
> *This group covers the digital cellular mobile systems, IMT-2000 systems and their enhancements. Group 2: IMT-Advanced Systems as described in ITU-R M.2012.*
> *Group 3: Existing radio LANs and their enhancements.*
> *Group 4: Digital mobile broadcasting systems and their enhancements.*

"Wi-Fi and similar systems in licence-exempt spectrum" are grouped in RATG 3.

Based on this methodology, ALCATEL-LUCENT chaired the ITU-R WP5D Sub-Working Group "Traffic" which produced the Table A1 which provides the distribution ratios between RATGs according to their (concurrent) availability. For instance, where Group 2 (IMT-A) and Group 3 (Wi-Fi and similar systems) are both available, it is estimated that they share the traffic on a 50-50 basis. And if Group 1 systems are also available, IMT-A still take 50% of the traffic but Group 1 systems take 10% and Group 3 the remaining 40%.

Table A1 - Distribution ratios among available RAT groups in 2020[1]

Available RAT groups	Distribution ratio (%)		
	RATG 1	RATG 2	RATG 3
1	100	–	–
2		100	
3	–	–	100
1, 2	10	90	-
1, 3	10	–	90
2,3	-	50	50
1,2,3	10	50	40

[1] The Recommendation ITU-R M.1768-1 methodology did not include a specific parameter or model that would easily allow considerations of the influence of the offloading effect. The Table 24c corresponds to cases where several RATGs are supported in the same radio environment for a given service category and indicates how the traffic is split in those circumstances.
In the case that RATGs 1, 2 and 3 are all available and if distribution ratio to RATG3 decreases (while distribution ratio to RATG2 increases), then traffic demands of RATG2 in the Picocell and Hot spot would increase significantly. For example, when distribution ratio to RATG3 decreases from 40% to 10% (less mobile offloading to RLAN) and RATG2 distribution ratio would be 80% then traffic in Pico cell and Hot spot would increase by about 40-60 %. As a single input parameter, a change in the traffic distribution ratios when RATG 1, 2 and 3 are available will not necessarily have an impact on overall spectrum requirements.

ANNEX B

Concerning the distribution across service environment, this report identifies services into 3 different categories in terms of teledensity, see Table B1:

Table B1 - The Identification of Service Environments

Teledensity / Service usage pattern	Dense urban	Suburban	Rural
Home	SE1	SE4	SE6
Office	SE2	SE5	
Public area	SE3		

Where each Service Environment (SE) are defined by Table B2.

Table B2 - Examples of User Groups and Applications of Service Environments

	User groups	Applications
SE1	Private user, business user	Voice, Internet access, games, e- commerce, remote education, multimedia applications
SE2	Business user, small and medium size enterprise	Voice, Internet access, video conferencing, e-commerce, mobile business applications
SE3	Private user, business user, public service user (e.g. bus driver, emergency service), tourist, sales people	Voice, Internet access, video conferencing, mobile business applications, tourist information, e- commerce
SE4	Private user, business user	Voice, Internet access, games, e- commerce, multimedia applications, remote education
SE5	Business user, enterprise	Voice, Internet access, e- commerce, video conferencing, mobile business applications
SE6	Private user, farm, public service user	Voice, information application

According to this report, Radio Environment (RE) is defined by the cell-layers in the network consisting of macro, micro, pico and hot-spot cells. The cell area will have a direct impact on the traffic volume dependent on spectrum requirement. The deployment of these cell types do not significantly vary between different teledensity areas. Table B3 depicts cell area values for considered teledensities with new parameters updated for estimate group of WP5D.

Table B3 - Assumed Cell Area per Radio Environment (km^2) (with Penetration Loss)

Radio Environment	Teledensity		
	Dense urban	Sub-urban	Rural
Macro cell	0.10	0.15	0.87
Micro cell	0.07	0.10	0.15
Pico cell	0.0016	0.0016	0.0016
Hot spot	0.000065	0.000065	0.000065

Note: Hot spots are geographically isolated from each other.

Resulting from the ITU-R WP5D SWG “Traffic” work, the Table B4 provides the population coverage by macro/micro/pico-cells and hot spots according to the Service Environment defined as above.

Table B4 – Example: Population Coverage Percentage of the Radio Deployment Environments in each SE

SE	RE			
	Macro cell	**Micro cell**	**Pico cell**	**Hot spot**
SE1	100	0	0	80
SE2	100	0	20	80
SE3	100	80	20	10
SE4	100	0	0	80
SE5	100	20	20	20
SE6	100	0	10	50