Tuesday, April 29, 2014

To: Shri Sanjeev Banzal, Advisor (NSL II),
Telecom Regulatory Authority of India (TRAI)
New Delhi

Subject: Siklu's comments to TRAI consultation paper

Dear Sir

Thanks for publication of this important consultation paper "Recommendation for allocation and pricing of Microwave Access (MWA) and Microwave Backbone (MWB) RF carriers" dated 28th March 2014 by TRAI.

The opening of the E-band in the 2011NFAP, generated an excitement among operators about the use of E-Band in their spectrum hungry networks, coupled with a concern about the cost such spectrum would bare.

Following the new developments in the world regarding network densification, whether 3G/4G small cells or WiFi offload, there is also a growing interest in using 60GHz unlicensed (in many parts of the world) spectrum for street level backhaul. The main concern is about the cost tag that would be associated with the new, wide channel bandwidth (250MHz vs. 28MHz in traditional microwave), while they still have the technical uncertainty of the true performance such equipment could provide in the rainy conditions of India.

Siklu, as the pioneer and leader of low cost, small form factor, high volume E-band systems is committed to continue making the smallest, lowest cost systems in V-Band as well. Siklu sees markets as the one in India as one of its main markets and is looking to establish a local presence in India when the market will open up. We are proud to say that two of our main trials were carried out in Mumbai, during the monsoon seasons of 2011 and 2012. We have also been committed to contribute to the regulatory process, and wish to also offer our humble contribution to the appropriate pricing for this virgin band.

The initial data gathered from the monsoon operation in Mumbai shows viability of the equipment at ranges of up to 1000 meters, depending on operator's capacity/ availability requirements. These numbers represent a big share in the dense urban deployments, but would still drive cautious deployment from the operator's side.

The attached document refers mainly to E-Band and V-Band related issues covered in questions 15 through 17. We have taken the liberty to also answer a few other questions, where we felt we can humbly contribute from our global experience. We do hope to see a pricing policy that will encourage TSPs to use this new virgin spectrum. The wide use of this spectrum will definitely help in relieving the spectrum congestion issues in lower frequency bands and improve network capacity for mobile broadband, which will also generate higher royalties to the Indian government from both the new spectrum and increased operators' revenues.

With sincere thanks for your kind consideration of our suggestion, I would also request for a meeting to be able to better present our proposal, address some possible questions.

Thank you very much for this opportunity,

Izik Kirshenbaum
Chairman & President
Siklu Communication Ltd.
Email: izik@siklu.com

Siklu Comments on

TRAI Consultation Paper dated 28th March 2014 - Allocation and Pricing of Microwave RF Carriers

Table of Contents

1. Siklu Response to consultation issues

Q1. How many total Microwave Access and Backbone (MWA/MWB) carriers should be assigned to a TSP deploying:

a. 2G technology only.
b. 3G technology only.
c. BWA technology only.
d. Both 2G and 3G technologies.
e. 2G and BWA technologies.
f. 2G, 3G and BWA technologies.

Please give rationale & justification for your answer.

Siklu: According to table 2.6 of the consultation paper, it was determined in 2010 that a BWA TSP in Metro and A Circles would need 4-6 carriers. Since some operators, in these circles use today 6-8 carriers, it can be argued that with the exponential growth expected in mobile traffic (see Annex 1 – Cisco VNI 2014), a number of 8-10 carriers or more could be needed if other frequency bands (i.e E-Band and V-Band) will not be utilized to cover the dense short range part of the last mile and small cell backhaul. The factors that would contribute to that would be:

- The traffic growth
- The expected densification of cells that will increase the interference between carriers and require spectral diversification
- The higher peak to average ratio dictated by the dominance of video transport
- The need for backhaul of WiFi offload, which will definitely be needed in India where carriers have lower access frequency allocation compared to other countries.

The same would probably also apply to 3G TSP's that will just need to rely on more extensive WiFi offload to carry the capacity.

Q2. How many MWA/MWB carriers need to be assigned to TSPs in case of 2G, 3G and BWA at the start of their services[i.e. at beginning of rolling of services]
Please justify your answer.

Siklu: No comments

Q3. Should excess spectrum be withdrawn from existing TSPs?

Siklu: No comments

Q4. If yes, what should be the criteria for withdrawal of excess allocation of MWA and MWB carriers, if any, allocated to the existing service providers?

Siklu: No comments

Q5. What should be the preferred basis of assignment of MWA/MWB carriers to the TSPs i.e. 'exclusive basis assignment' or 'link-to-link based assignment'?

Siklu: No comments

Q6. In case 'exclusive basis' assignment is preferred, whether MWA and MWB, carriers should be assigned administratively or through auction. Please comment with full justifications.

Siklu: We believe that microwave carriers should not be auctioned, and this is the case in most of the world (except for a minority of cases which are usually in the PTMP bands). Administrative assignment allows a good control on market requirement development and the ability to change allocations much faster than the auction processes. As we can expect rapid changes in the following years, faster processes are favored.

Q7. In case 'link-to-link basis' assignment is preferred, how the carrier assignment for different links should be carried out, particularly in nearby locations?

Siklu: In the traditional microwave (up to 42GHz), once the carriers are assigned on an exclusive basis per circle (as it is done today), it is the TSP responsibility to manage frequency planning and interference.

In the mm wave frequencies, the narrow beams (called by FCC "pencil beams"), the high attenuation and the vast available spectrum (2 X 5GHz), enable a light licensing scheme such as is used in the USA and most of Europe, where (with the appropriate channel bandwidth limitations) licenses are available on an first come first served basis.

Q8. Considering the fact that different TSPs may require additional carriers at different point of time, what should be the assignment criteria for allocation of additional carriers for MWA and MWB?

Siklu: Amount of available carriers, Network density, Average capacity, (deployment of rural parts may add points), and the willingness of the TSP to pay more for the additional carriers (progressive charging)

Q9. How can it be ensured that spectrum carriers assigned are used optimally and the TSPs are encouraged to move towards the OFC?

Siklu: No comments.

Q10. Should an upfront charge be levied on the assignment of MWA or MWB carriers, apart from the annual spectrum charges?

Siklu: The entire network (access and backhaul) is an infrastructure, and its well-being promotes the economy. Therefore the regulator interest is to allow this infrastructure to function the best it could. Since one of the main bottlenecks of this infrastructure happens to be the backhaul, then the regulator should give the TSPs the motivation to optimize the backhaul of their network and use his charging policy for that. This includes both the annual spectrum charge and any additional charge if it exists. By doing that the regulator should note that the TSPs have to invest considerable amounts of money while deploying the equipment utilizing these carriers.

There is a view on Spectrum management that claims that the main asset in great need is the Access Spectrum (2G/3G/4G), so this is where regulators need to focus on one hand by allocating more and more spectrum (white space, reverse auction), and on the other hand this should be the main tool to charge the operator the royalties for the revenues generated from its use. All other spectrum needs, to build a good and efficient infrastructure for that access spectrum, should be supplied by the regulator at minimum charges (just cover the cost) so that infrastructure will help the TSPs generate more revenues that will yield more royalties to the government.

Q11. What should be the pricing mechanism for MWA and MWB carriers? Should the annual spectrum charges be levied as a percentage of AGR or on link-by-link basis or a combination of the two?

Siklu: No comments.

Q12. In case of percentage AGR based pricing, is there any need to change the existing slabs prescribed by the DoT in 2006 and 2008?
Please justify your answer.

Siklu: No comments

Q13. In case link-by-link based charging mechanism is adopted then:

(a) Should the spectrum be priced differently for different MW spectrum bands (6GHz/7GHz/13GHz/15GHz/18GHz/21 GHz/26 GHz/28GHz/32GHz/42 GHz etc)? If yes, by what formula should these be charged?
(b) What are the factors (viz as mentioned in para 3.22), that should appear in the formula? Please elaborate each and every factor suggested.

Siklu: In most cases, it is custom to have a multiplier that reflects the availability and usability of the spectrum. Multiplier is higher for lower frequencies since re-use of frequency is limited (wide beams and longer propagation distance). Multiplier is also lower where more spectrum is available and propagation distance/ coverage is smaller (which is usually in the higher frequency bands).

Q14. Should the option of assignment of MWA carriers in all the spectrum bands in 6-42 GHz range be explored in line with other countries? What are the likely issues in its assignment MWA carriers in these additional spectrum bands?

Siklu: No comments

Q15. In your opinion, what is the appropriate time for considering assignment of MWA carriers in higher frequency bands viz. E-band and V-band?

Siklu: E-Band and V-Band are used in growing numbers by TSPs, WISPs and enterprise customers all over the world, including fiber rich countries like Korea and Japan. LTE networks and high speed WiFi standards have increased the use of E-Band and V-Band.

Having one of the most dense telecom deployments in the world, there is every reason to start using these frequencies in India immediately. More than that, given the shortage of access spectrum in India, and the absence of residential access, WiFi offload can have a key role in India, and these higher frequencies can play an important role in backhauling these offload networks. If by using E-Band, TSPs may be able to free up RF carriers in lower frequencies that can be used in rural places for longer hops, use of E-Band can also help rural areas.

With increase in 3G and now with new rollouts on 4G (LTE) and with rapid increase in data traffic , operators now require between 20-100 mbps per cell site . The common architecture is ring based to bring the networks to high availability. Moreover, the nature of the traffic where video and large packets are used more commonly, reduce the efficiency of header compression techniques. The WiFi/3G/4G traffic requires high capacity rings which can be met by V band and E band frequencies.

The traditional legacy MWA carriers in the 6-42 GHz band are incapable of carrying such large capacities. Hence, MWA carriers in E-band and V-band are required to be allocated IMMEDIATELY to ensure good quality of service, high throughput, high network availability for new bandwidth hungry applications and excellent " Customer experience " and customer satisfaction.

Q16. Should E-band be fully regulated or there should be light touch regulations?

Siklu: E-Band should be **lightly licensed**, as in many places in the world. That would enable to take advantage of the re-usability nature of this spectrum, and still operate in wide channels, that do not enable exclusive allocation per TSP.

Light Licensing:
The deployment under a license exempt basis could result in unacceptable interference and would be unlikely to lead to optimal use of the spectrum, particularly considering the high availability applications proposed to be used in the bands.

On the other hand, the potential for interference is likely to be small in these bands due to the 'pencil beam' signal characteristics (narrow beams and lower Tx power) of E-Band. Therefore, a simple mechanism which enables individual 70/80 GHz links to gain protection from interference can be accomplished by the implementation of a centralized database with a registration system with a first come first served data and time record essentially forming the basis for protection.

In the US for example, three database managers, FFI, Micronet and Comsearch use distinct but centralized databases, offering the choice to the user community while ensuring a centralized format for available link information. The same is implemented in The UK and some other European countries.

V-Band should be un-licensed and free to use in the very short distances that can be used due to the combination of Oxygen absorption and rain attenuation.

Q17. What charging/pricing mechanism would be appropriate for these bands?

Siklu:

E-Band

Link-by-link (**with light licensing**) charges for E-Band (See Annex 2)

- **Per link policy ("light License") where each 2 X 250MHz channels ("spot") will be around 1,500 Rupees annually.**
- **During 5 year transition period:**
  - **First 2 years during which frequency will be charged at 80% discount.**
  - **Further 3 years during which the operators will receive 50% discount.**

V-Band

We recommend allocation of the whole 57-64GHz band (beyond what was proposed in IND-80) in order to offer a wide band as existing in other countries (see Annex 3), with free of charge pricing, as appropriate for unlicensed bands with a low probability of interference.

The Frequencies of 64 to 66GHz can be allocated as lightly licensed frequencies, with the same pricing as E-Band.

Q18. Apart from Q1-Q17, stakeholders are requested to bring out any other issue, which needs to be examined, with justification.

Siklu: Appropriate spectrum pricing and licensing processes are essential to encourage the TSPs to use these higher frequency bands. Use of these frequency bands would also benefit the users as well as bring additional revenues for the Government through spectrum charges for these bands as well as larger licence fee and access spectrum charges (on revenue share) for enhanced operator revenues. Otherwise, use of these bands may remain very low, depriving the users and the government of the benefits.

2. Annex 1 – Exerts from Cisco VNI 2014

Bharti Airtel reported mobile data traffic growth of 112% between 3Q 2012 and 3Q 2013.

Reliance Communications reported mobile data traffic growth of 116% between 3Q 2012 and 3Q 2013.

Overall mobile data traffic is expected to grow to 15.9 Exabyte's per month by 2018, nearly an 11-fold increase over 2013. Mobile data traffic will grow at a CAGR of 61% percent from 2013 to 2018 (Figure 10). Because mobile video content has much higher bit rates than other mobile content types, mobile video will generate much of the mobile traffic growth through 2018. Mobile video will grow at a CAGR of 69 percent between 2013 and 2018, the highest growth rate of any mobile application category that we forecast, other than machine-to-machine traffic. Of the 15.9 Exabyte's per month crossing the mobile network by 2018, 11 Exabyte's will be due to video. Mobile video represented more than half of global mobile data traffic beginning in 2012, indicating that it is having an immediate impact on traffic today, not just in the future.

The Asia Pacific and North America regions will account for almost two-thirds of global mobile traffic by 2018, as shown in Figure 2. Asia Pacific will have a CAGR of 67 percent.

The increasing number of wireless devices that are accessing mobile networks worldwide is one of the primary contributors to global mobile traffic growth. Figure 5 shows the impact of mobile smart devices and connections growth on global traffic. Globally, smart traffic is going to grow from 88 percent of the total global mobile traffic to 96 percent by 2018. This is significantly higher than the ratio of smart devices and connections (54% by 2018), because on average a smart device generates much higher traffic than a non-smart device.

While 3G and 3.5G account for the majority (60 percent) of mobile data traffic today, 4G will grow to represent over half of all mobile data traffic by 2018, despite a connection share of only 15 percent (Figure 13).

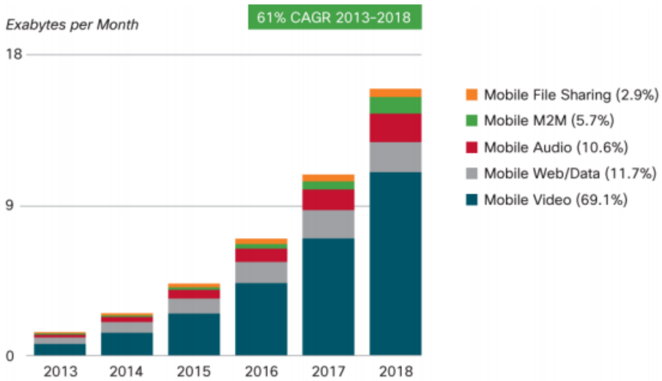
Much mobile data activity takes place within users' homes. For users with fixed broadband and Wi-Fi access points at home, or for users served by operator-owned femtocells and picocells, a sizable proportion of traffic generated by mobile and portable devices is offloaded from the mobile network onto the fixed network. For the purposes of this study, offload pertains to traffic from dual mode devices (i.e., supports cellular and Wi-Fi connectivity; excluding laptops) over Wi-Fi and small cell networks. Offloading occurs at the user/device level when one switches from a cellular connection to Wi-Fi/small cell access. Our mobile offload projections include traffic from both public hotspots as well as residential Wi-Fi networks.

As a percentage of total mobile data traffic from all mobile-connected devices, mobile offload increases from 45percent (1.2 Exabyte's/month) in 2013 to 52 percent (17.3 Exabyte's/month) by 2018 (Figure 14). Without offload, Global mobile data traffic would grow at a CAGR of 65 percent instead of 61 percent. Offload volume is determined by smartphone penetration, dual-mode share of handsets, percentage of home-based mobile Internet use, and percentage of dual-mode smartphone owners with Wi-Fi fixed Internet access at home.

The Cisco VNI Global Mobile Data Traffic Forecast model now quantifies the effect of dual-mode devices and femtocells on handset traffic.

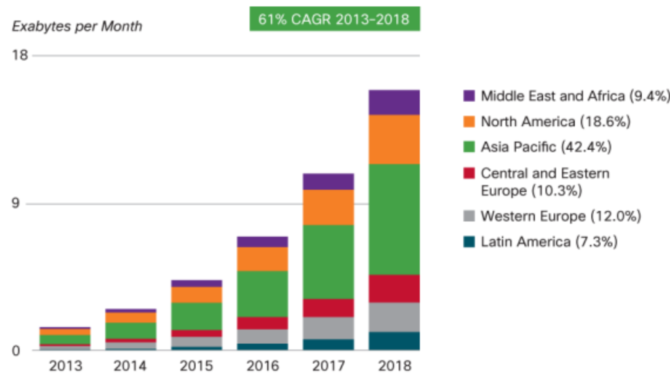
Mobile video applications have a "prime time" in that they are predominantly used during certain times of day. Web and general data usage tends to occur throughout the day, but video consumption is highest in the evening. Video therefore has a higher peak-to-average ratio than web and data. Live video and video communications have higher peak-to-average ratios than video-on-demand. As the mobile network application mix shifts towards video, and as the video mix increasingly includes live video and video communication, the overall mobile data peak-to-average ratio increases. Busy hour mobile traffic is growing at a slightly higher pace than average hour traffic, and by 2018 mobile busy hour traffic will be 83 percent higher than average hour traffic by 2018, compared to 66 percent in 2013 (Figure 30).

Figure 10. Mobile Video Will Generate Over 69 Percent of Mobile Data Traffic by 2018



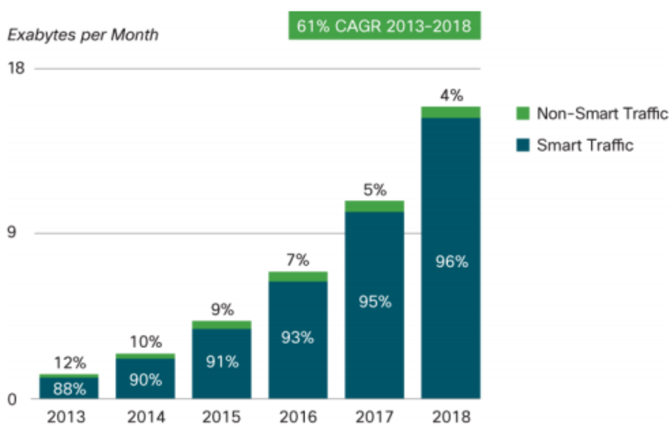
Figures in parentheses refer to traffic share in 2018.
Source: Cisco VNI Mobile, 2014

Figure 2. Global Mobile Data Traffic Forecast by Region



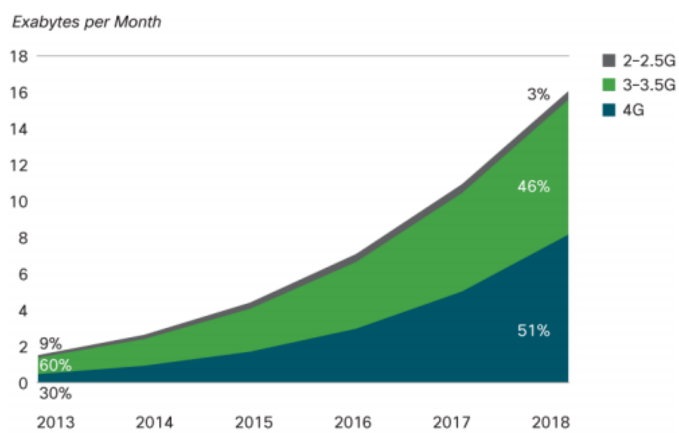
Figures in parentheses refer to regional share in 2018.
Source: Cisco VNI Mobile, 2014

Figure 5. Effect of Smart Mobile Devices and Connections Growth on Traffic



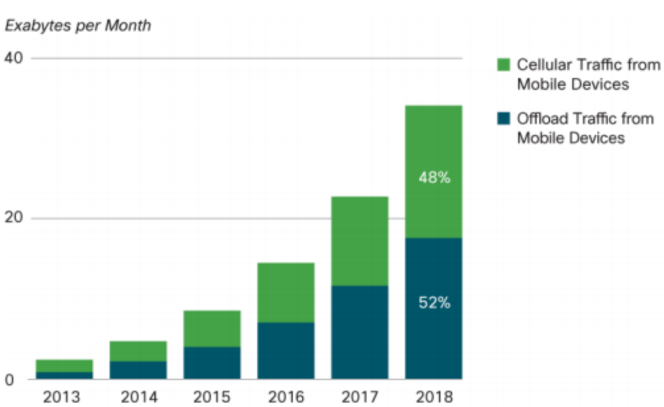
Percentages refer to device or connections share.
Source: Cisco VNI Mobile, 2014

Figure 13. 51 Percent of Total Mobile Data Traffic Will Be 4G by 2018



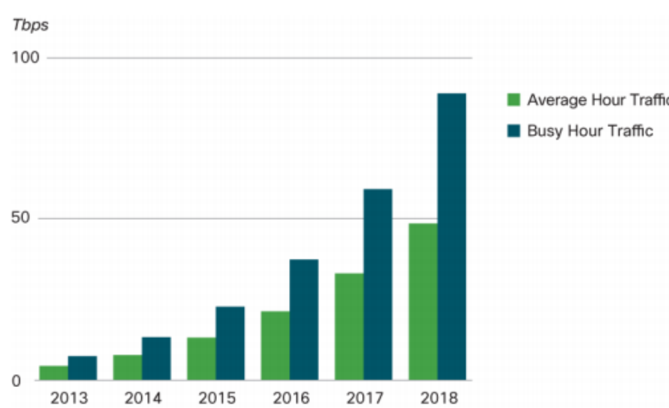
Source: Cisco VNI Mobile, 2014

Figure 14. 52 Percent of Total Mobile Data Traffic Will Be Offloaded by 2018



Source: Cisco VNI Mobile, 2014

Figure 30. Mobile Busy Hour Is 66% Higher Than Average Hour in 2013, 83% by 2018



Source: Cisco VNI Mobile, 2014

3. Annex 2: E-band Regulation and Pricing

3.1 Executive Summary

The motivation to use E-band in India seems stronger than in the rest of the world due to the special conditions of the Indian Telecom market, that include: very high density in the urban areas, urgent need to increase the capacity of data services (mobile broadband), the general shortage of microwave spectrum for backhaul and the need to allocate such spectrum to new operators and rural deployments.

The unique characteristics of the Eband spectrum: The short range (up to 1Km, in the high intensity rain zones of India while in most of the western world it is up to 2.5Km), the high spectral reuse in dense urban areas, and the ability to achieve small form factor, coupled with low cost equipment make it ideal for last mile urban deployments, subject to the existence of an appealing business case to encourage usage of new equipment in this band.

The aggressive price reduction of microwave equipment, mainly driven by the large Indian Telecom market, has made the charges for the wireless spectrum/ licenses as a major burden. Most of the countries that have opened the E-band spectrum, have done so with a pricing policy in which the cost per MHz is 200 to 400 times less than in the 8-38GHz band!

The major financial benefit to the government from encouraging the use of E-band lies in the large potential of increasing the overall operator revenues, and hence the revenue share on account of license fee, spectrum charges (from other spectrum allotments) and other levies that are derived from them, and not from direct revenue from this unused/ virgin spectrum, which presently is bringing no revenue.

What is expected?

An E-Band Spectrum Policy that will encourage the use of this technology by opening it up at a minimal charge (if not completely free!) with a technology neutrality specification that will enable a multi-vendor market that will drive high competition, low prices, and high deployment rates that will accelerate the mobile broadband usage in India.

- **Per link policy where each 2 X 250MHz channel ("spot") will be around 1,500 Rupees annually.**
- **During 5 year transition period:**
  - **First 2 years during which frequency will be charged at 80% discount.**
  - **Further 3 years during which the operators will receive 50% discount.**

3.2 E-Band Spectrum

Mobile operators worldwide are turning to the E-band spectrum specifically the 71-76 GHz, 81-86 GHz bands to enhance and streamline their backhaul networks. Due to the large allocated spectrum and propagation characteristics at these frequencies, wireless backhaul systems operating at these frequencies, also referred to as millimeter-wave wireless systems, can provide up to multi-gigabit capacities for relatively short distances of a few kilometers. The antennas used in E-band frequencies are highly directional and together with the propagation limitations, wireless systems operating at the E-band frequencies are highly focused, point-to-point “pencil beam” links allowing a much higher reuse of the same frequency in a given area.

Utilizing the E-band spectrum, mobile operators can better design their backhaul, allowing a more efficient frequency plan. Mobile operators are building a layered backhaul network where the 6-38 GHz spectrum will be used for relatively long-haul transmission and the E-band spectrum for high-capacity, short-haul links particularly in urban and sub urban deployments. Doing so, mobile operators are able to increase their backhaul capacity according to their increasing needs without causing frequency congestion. This allows the mobile operators to introduce new and advanced mobile broadband services to the consumers. The consumers on the other hand are enjoying the true experience of mobile broadband at their fingertips.

The mm-wave (E-Band) band, with two 5GHz blocks of spectrum allocated at 71-76GHz and 81-86GHz, benefits from the large channel bandwidth available in this frequency, with typical channel bandwidth of 250MHz, and channel aggregation that is allowed up to the entire 5GHz of available spectrum. As the operating frequency increases, the propagation of a radio wave transmitted from a given antenna becomes more directional. In a dense environment where many links are expected to operate in close proximity, this translates to better spatial isolation between links, and practically zero interference. Recognizing the minimal risk of interference when operating in this band, regulators worldwide adopted a new, 'light licensing' paradigm. Under this 'light licensing' paradigm link licensing is based on quick (mostly online) registration, extremely low spectrum license fees, and technology neutrality to duplexing (TDD/FDD), channel aggregation and modulation beam. The main limitation imposed on this band is the requirement for a minimum antenna gain (38/43dBi in EU/US) in order to maintain a directivity level that will ensure the spatial diversity.

The high sensitivity of this band to rain attenuation, limits the practical ranges of equipment operating in this technology to 2 – 2.5 Km (and even less than 1 Km in monsoon areas), making it ideal for high density broadband deployments. Channel aggregation and advanced modulation techniques can scale this technology to 5Gbps and more, while maintaining small form factor and low power consumption.

Commercial equipment working in this band has been available in the last decade, providing GigE wireless links, mainly for enterprise and vertical applications, but at costs ranging from above $50K just a few years ago, to $20K recently. It is only the high volume silicon integration of Siklu that has enabled introductions of modern systems at a price point suitable for mobile operators.

3.3 The Motivation for E-band in India

Allocating the E-band spectrum for use in India will generate additional revenues to the Government of India:

- **Revenues from new mobile broadband data services:** Allocating and utilizing the E-band spectrum will enable mobile operators to offer and provide to their customers a wide variety of mobile broadband services, especially in dense urban areas. These services will generate new and significant additional revenues to the mobile operators which in turn will pay the Government of India a percentage of these revenues as agreed in the terms of the license fee and other levies, including enhanced charges for access and other microwave spectrum. The table below shows the numbers (rupees in crores) for the first quarter of 2011. It is evident that any increase in revenues contributes more than 10% (close to 15% in the Metro and A circles) in license fees.

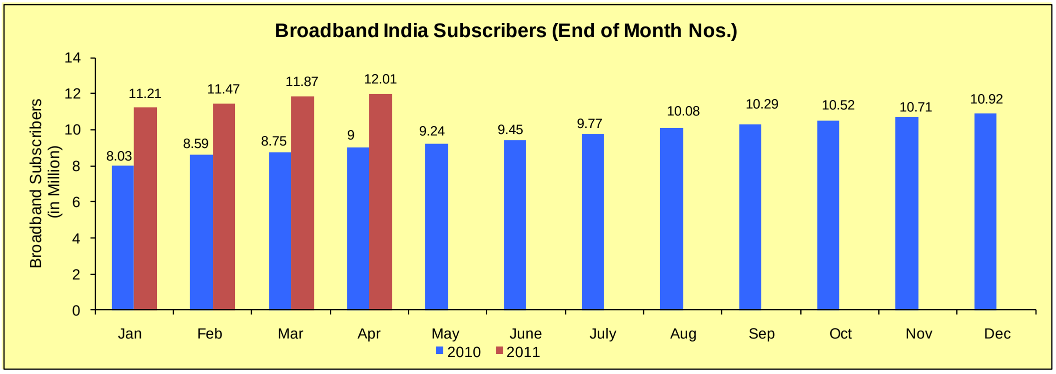
Circle type	GR - Gross Revenue	AGR - Adjusted GR	License Fees		Spectrum Charges	
Metro	5,900	3,682	371	10.1%	181	4.9%
A	11,489	8,391	839	10.0%	445	5.3%
B	10,614	7,734	621	8.0%	366	4.7%
C	3,672	2,728	164	6.0%	126	4.6%
Total (crores)	**31,674**	**22,535**	**1,994**	**8.8%**	**1,118**	**5.0%**
($M value)	**6,694**	**4,762**	**421**		**236**	

Charges in Crores of rupees for the Quarter ended in March 2011

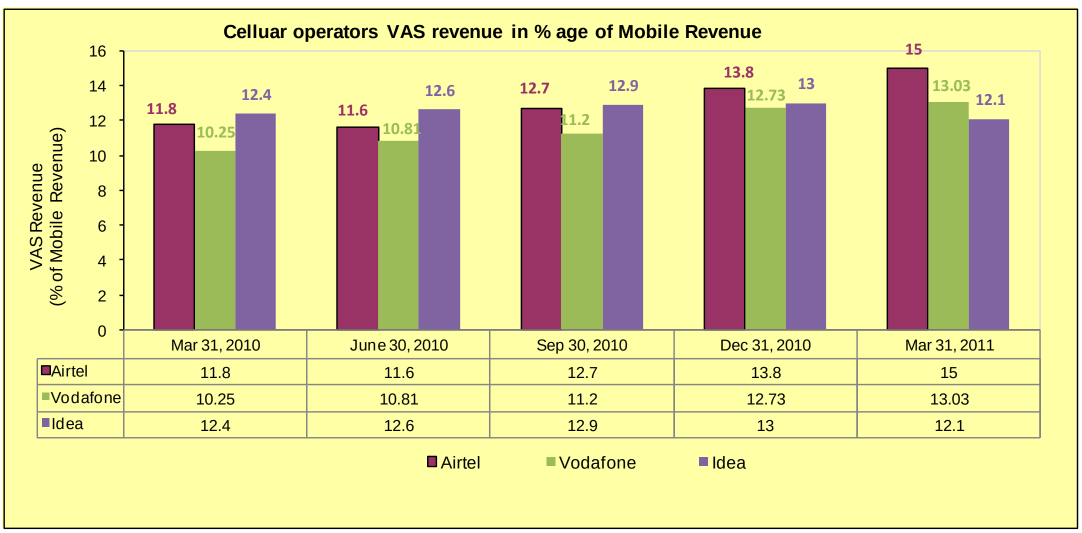
- **Revenues from an unused spectrum:** Allocating the E-band would lead to the utilization of a band which is presently unused / virgin and thus brings “zero” revenues to the Government of India. Its utilization would bring reasonable revenues for its usage (even at nominal spectrum charges).

Allocating the E-band spectrum in India will facilitate data hungry mobile broadband services while contributing to release some spectrum in conventional lower microwave bands, which in turn would enable additional advanced telecommunications and data services to rural areas in India as well.

- **Enabling mobile broadband data services:** With the dramatically increased capacity requirements by modern data services and increase of the density of the cell-sites deployed in 3G and 4G networks mobile operators are turning to the 71-76 / 81-86 GHz E-band spectrum to increase their backhaul capacity while introducing new and advanced mobile broadband services to the consumers. With the astonishing large numbers of mobile subscribers that are added each month, it is important that mobile operators will have the entire necessary spectrum to plan their backhaul network to provide adequate solutions to the near and long term challenges. As we can see below, the number of broadband subscribers is still very low, and is expected to dramatically increase and surge network backhaul capacity requirements because of subscriber numbers and various new applications.



- **Improving the strength to the Telecom Operators:** In an era of falling ARPU's, data and VAS are the main source of increasing operator revenues. This kind of services is, and will be highly dependent on adequate capacity of networks, including backhaul capacity.



	Mar 31, 2010	June 30, 2010	Sep 30, 2010	Dec 31, 2010	Mar 31, 2011
Airtel	11.8	11.6	12.7	13.8	15
Vodafone	10.25	10.81	11.2	12.73	13.03
Idea	12.4	12.6	12.9	13	12.1

- **Coping with the spectrum congestion:** The increasing number of wireless backhaul links together with the scarcity of available spectrum is eventually leading to a congestion of the microwave spectrum even to a point where it will no longer be available for new operators, new links or allocations. Due to the large allocated spectrum and propagation characteristics of the 71-76 / 81-86 GHz E-band, wireless backhaul systems operating at these frequencies can provide up to multi-gigabit capacities for relatively short distances of a few kilometers with a much higher reuse of the same frequency in a given area.

- **Contribution for telecommunication and data services in rural India:** New mobile operators which are making an effort to bring broadband services to the rural areas in India have limited 15-18 GHz spots as these are taken by the established operators. Designing and implementing a backhaul network which uses the E-band spectrum will allow a more efficient distribution of the 15-18 GHz spots amongst the established and new operators which is vital for rural deployments.

3.4 Frequency Coordination – Light Licensing

The FCC has adopted a flexible and innovative regulatory framework for the 71-76 GHz and 81-86 GHz bands. Rights with regard to specific links are established based upon the date and time of link registration. Therefore, a first-in-time criterion is adopted in order to protect the first-in-time registered or incumbent links.

Furthermore, all licensees are required to obtain and submit an interference analysis to a third party manager as a part of link registration. The aim is to minimize the adverse economic impact on licensees, including those that are small entities. In adopting the interference-analysis requirements, the cost and benefits of imposing an interference analysis requirement are considered, especially for small entities. In an FCC survey, it was found that the cost of performing such analyses would be relatively small, particularly when compared with the benefits of preventing harmful interference to existing operations for all licensees. Three database managers, FFI, Micronet and Comsearch use distinct but centralized databases, offering the choice to the user community while ensuring a centralized format for available link information.

Light Licensing Approach (UK and some other European countries)

The deployment under a license exempt basis could result in unacceptable interference and would be unlikely to lead to optimal use of the spectrum, particularly considering the high availability applications proposed to be used in the bands.

On the other hand, the potential for interference is likely to be small in the bands due to the 'pencil beam' signal characteristics of the fixed wireless systems. Therefore, a simple mechanism which enables individual 70/80 GHz links to gain protection from interference can be accomplished by the implementation of a centralized database with a registration system with a first come first served data and time record essentially forming the basis for protection.

3.5 Pricing

Since E-Band links are going to be implemented in urban short overlays over the existing microwave structure, initial deployments will contribute only to part of the operator revenues, therefore royalty based pricing cannot be practically implemented, as it will result with a too high cost per link when one calculates the circle AGR versus the number of links to be deployed. **The bottom line is that E-Band links cannot be priced on royalty basis, even at very low percentage**.

The current per-link pricing scheme enforced in India is calculated according to the following formula such that a 28 MHz channel, short range (up to 5 km) link would cost 288,000 Rupees (~US$ 5,760):

R = M x W x C

Where:

- **M** – Constant multiplier depending on the distance of the link. The shorter the link the small M is (for example: M=1200 for links up to 5 Km and M=2400 for links up to 25 Km). **We suggest M value of 600 for links of up to 2Km**.
- **W** – Weighting factor decided by the adjacent channel separation of the channeling plan (for example: W=30 for adjacent channel separation above 2 MHz and W=120 for adjacent channel separation greater than 7 MHz but less than or equal to 28 MHz (since from 2MHz to 28MHz W was increased by a factor of 4, a similar proportionate factor when going from 28MHz to 250MHz would be 2.55). **We suggest W=360 for a 250MHz Channel**
- **C** – Number of RF channels used. **C= 2 for 500MHz TDD or 250MHz FDD systems and 8 for 1000MHz FDD systems**
- **E** – We propose a new correction factor, based on the re-use and spectral efficiency (as detailed in Annex 8a - Method 1) and **suggest setting it at 1/300**.

Taking these factors together the per-link pricing scheme suggested for the E-band spectrum is as follows:

- **500MHz TDD: R = M x W x C x E = 600 x 360 x 2 / 300 = 1,440 (say 1,500) Rupees (~US$30)**
- **1000MHz FDD: R = M x W x C x E = 600 x 360 x 8 / 300 = 5,760 (say 6,000) Rupees (~US$120)**

If we perform a "sanity check" according to method 2 in the previous section, we conclude that the same 2*250MHz channel should cost 1,350 Rupees which is along the same numbers as suggested here.

3.6 Trials in India

- Mobile Operator A (August 2011 – November 2011) – outdoor trial of 3 links during the last 6 weeks of the monsoon season, followed by 2 "dry" months. Results matched expectations
- Mobile Operator B (2012) – outdoor trial of 3 links .

3.7 What do we want

India has the potential to be the biggest user of E-Band technology while it is shaping up. This will both drive the mobile broadband infrastructure in India, and also create an opportunity to the Indian market to influence this industry. In order for that to happen we need to have the following:

- Spectrum Allocation for broadband use
- Technology Neutrality specifications that will enable the competition of many vendor in the Indian market
- Minimal charge (if not completely free!) of this band.
- Quick and friendly way to register and install the equipment in this frequency

3.8 Annexes

3.8.1 Pricing Models and Methodologies

Method 1 – Carrier Value Perspective [bits/Hz/area]

Basically we pay for the number of bits we provide in a certain area (modeled by distance and angle). The following factors should then affect the licensing fees / spectrum charges of the E-band spectrum:

- **Typical spectral efficiency:** In the E-band spectrum there are two bands of 4.75 GHz of continuous spectrum in each of the 71-76 GHz and 81-86 GHz frequency bands which are divided into large 250 MHz channels which can even be aggregated. The available spectrum together with the large channels allows achieving high data rates while using low modulation states as limited by the high frequency. As such, typical E-band wireless systems that are available in the market today have a spectral efficiency of upto 2 bits/sec/Hz. In comparison, traditional microwave bands where typical channel size is 28 MHz, high data rates are achieved by using high modulation techniques and XPIC antenna technologies. As such, wireless microwave has a spectral efficiency of 7 bits/sec/Hz (2X7 bits/sec/Hz including the XPIC).
- **Typical Link Distance:** The propagation characteristics and rain fading of the E-band spectrum result in an effective, link range of about 1 Km. For comparison, the typical link distances of lower frequencies (15 GHz or 18 GHz) are 10 to15 Km on average as the free-space-loss and rain attenuation are less significant in these frequencies.
- **Re-Use Factor:** The highly directional, “pencil beam” propagation characteristics of E-band wireless systems mean that operators can plan and deploy networks with an extremely high degree of frequency reuse, minimal frequency coordination and deploy links very close to one another with minimal interference concerns. Due to antenna transmission patterns (beam width 2-5 times lower) we can assume a re-use factor that is around 3 times higher in E-band compared to traditional microwave bands (this is without taking propagation into account since it is factored into the link distance).

The above mentioned factors are summarized in the table below:

Band	Frequency [GHz]	”contamination” Factor[1] [Deg]	Spectral Efficiency [Bits/second/Hertz]	Link Distance [Km]
Microwave	**15, 18, 23**	3	7 x 2 (XPIC)	15
E-band	**71-76, 81-86**	1	2	1

$$\boldsymbol{Cost\ Multiplier} = \frac{\mathbf{3\ X\ 7\ X\ 2\ X\ 15\ (15, 18\ GHz)}}{\mathbf{1\ X\ 2\ X\ 1\ (E - band)}} = \frac{\mathbf{630}}{\mathbf{2}} = \mathbf{315}$$

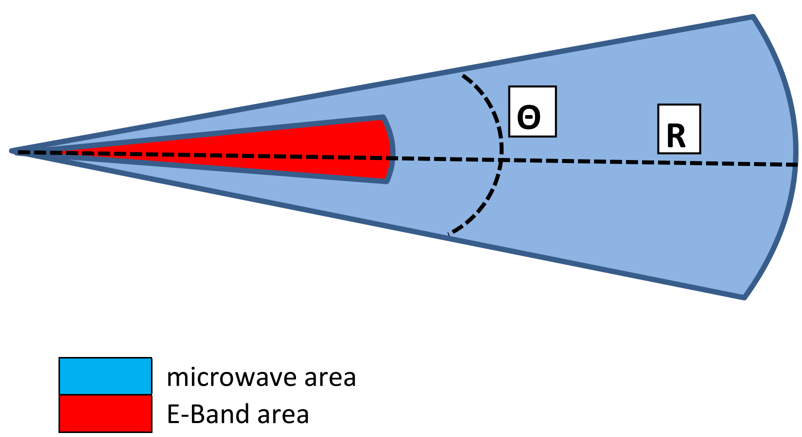
Taking into account channel sizes we get to the conclusion that **a 2 X 250 MHz E-band channel should be 33 times lower than a 2 X 28MHz microwave channel**, which is very much in line with the 20-40 range we find in other countries.

Method 2 – Fees as per Area covered/ affected by link

Another way to consider the license fee per link, is to see what is the typical area one link (and therefore one annual fee) can cover, and then estimate how many E-Band links can coexist in the area covered by a link in conventional microwave bands, and therefore generate multiple license fees.

Number of E-Band links in one microwav area (in conventional bands)

Fmin	Fmax	Fave	Θ	R	S		Per link price	
71	76	73.5	1	1.5	0.0196	Sq-Km	288000	WPC formula for 28MHz Channel
15	23	19	3.9	15	7.5956	Sq-Km	744	Target 250MHz Channel according to area ratio
Θ	Antenna 3 db angle					386.84		
R	Link effective range							
S (area)	Π*R^2 * Θ/360							



According to the calculation above, the per-link annual cost of an E-Band link (2*250MHz) should be around 750 Rupees

3.8.2 Annual Frequency Costs in foreign countries

Frequency (GHz)	15		23		38		71-76/81-86			38 (56MHZ) to E-band (500MHZ) ratio
Bandwidth (MHz)	28	56	28	56	28	56	250	500	1000	
India[1]	$6,300		$6,300				$30	$60	$120	215
USA	$230	$230	$230	$230	$230	$230	$7.5	$7.5	$7.5	30
UK	$1650 (£1,060)	$3290 (£2,120)	$1150 (£740)	$2300 (£1480)	$1000 (£640)	$2000 (£1,280)	$80 (£50)	$80 (£50)	$80 (£50)	25
Australia[2]	$2690 (A$2,630)	$5380 (A$5,260)	$2690 (A$2,630)	$5380 (A$5,260)	$1470 (A$1,435)	$2940 (A$2,870)	$190 (A$184)	$190 (A$184)	$190 (A$184)	15
Japan							$70	$70	$70	
Switzerland	$5730 (SFr 5,376)	$11550 (SFr 10,752)	$4770 (SFr 4,480)	$9540 (SFr 8,960)	$3820 (SFr 3,584)	$7635 (SFr 7,168)	$850 (SFr 800)	$1700 (SFr 1,600)	$3410 (SFr 3,200)	4.5
Ireland[3]	$1865 (€1,440)	$2330 (€1,800)	$1400 (€1,080)	$1750 (€1,350)	$1025 (€792)	$1285 (€990)	$235 (€180)	$235 (€180)	$235 (€180)	5.5

Russia, Mexico, Serbia – free!

(1) Eband numbers are still proposed.

(2) Links in a High Usage Path or in Congested Frequency Band Area

(3) High density geographic location

(*) Note that many countries have the same price in E-Band to any bandwidth

3.8.3 Other metrics to compare to India

When coming to compare the spectrum cost with other countries, we can also look at two more metrics

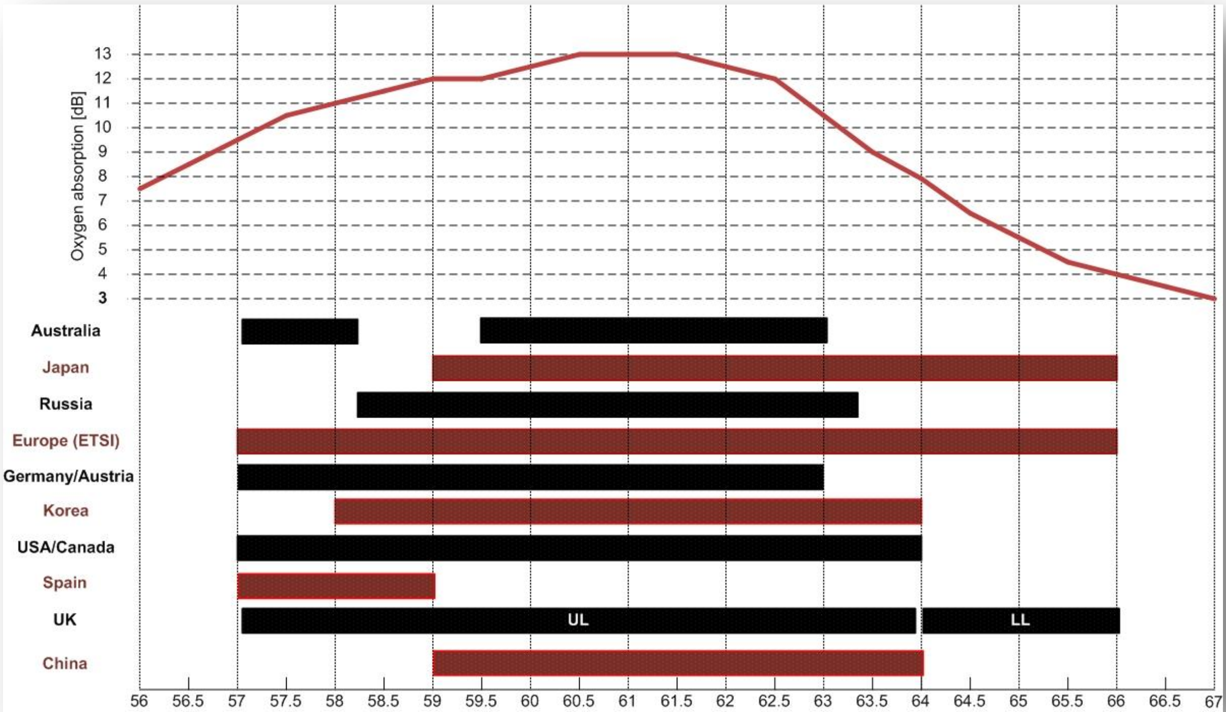
- **The relative cost of the spectrum compared to the cost of the equipment**
  Cost of a 100Mbps link in the UK is $4,500 while in India it is $2,800 (from the same vendor). This difference is coming from the highly competitive nature of the Indian Telecom market, and its high buying power. This means that even at same cost per link, the relative overhead of the spectrum fees on the equipment are higher than in the UK. If we also consider the fact that in the UK this payment is for any channel bandwidth used, that would imply that get to a common ground with the UK, **the annual cost of a 1GHz FDD license should be around 2,500 Rupees**

- **The revenues generated by use of the spectrum**
  Talking about high capacity links, we discuss mainly the data plans. The cost in the UK is around £10 per 1Gbyte, which is around 750 Rupees. The cost of 1Gbyte in India is around 600 Rupees in GSM and already 100 Rupees in CDMA. Since data tariffs in India are at infancy, we can expect an aggressive price erosion that will bring data tariffs in India to be much lower than in the UK, which again support our argument that **per link prices in India should be lower than UK since they generate lower revenues**.

4. Annex 3: V-Band regulation

4.1 Channels Arrangement - Worldwide Summary

Below is an overview snapshot of the worldwide channel arrangement (partial snapshot).



4.2 Countries where 60GHz is currently forbidden outdoor

France, Serbia, Malta, Slovakia, Mexico, Ukraine

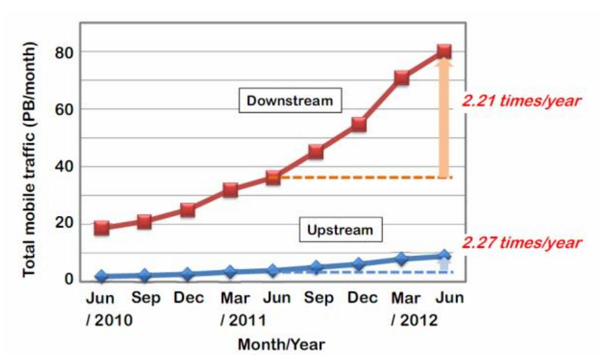
4.3 Brief Overview of V band

The introduction of mobile broadband is changing consumer habits with mobile web surfing, emailing and other advanced data services becoming routine. But this Mobile broadband is leading to a dramatic, exponential increase in the traffic/ data capacity transported over the cellular network affecting the cellular network planning and particularly the backhaul network. While the 3G/ 4G air-interface and the core network may support this capacity explosion it is necessary that the backhaul network will be designed to cope with this new phenomenon as well.

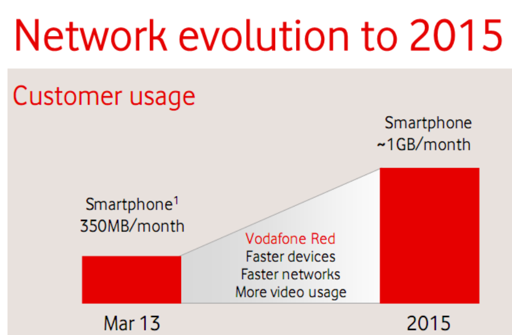
With the dramatically increased capacity requirements and increase of the density of the cell-sites deployed in 3G and 4G networks, the backhaul network needs to be carefully planned taking into account the advantages and limitations of the various backhaul alternatives. This is particularly important in urban and sub urban parts of the network that contain the majority of cell sites and the high capacity is extremely important. While fiber optics can provide all the necessary capacity and beyond, fiber reach is frequently limited, and deploying new fiber links to base stations takes long design, authorization and deployment time and is often prohibitively expensive and sometimes impossible. As the emphasis of the cellular market has shifts from coverage enhancement to capacity enhancement, small cells solution is expected to augment the ability of urban networks to handle dense mobile data traffic. Small cells are miniature cellular base stations planned for installation closer to the end user on street level walls and lighting polls. The small cells are add-on elements to the current macro cellular network. The combined macro and small cell network going to be managed and built as heterogeneous networks (HetNet) and self-organizing networks (SON). The leading standards bodies, regulation authorities, and manufacturers all over the world, realizing that network evolution trend, found line-of-sight mm-wave radios operating at 60 GHz, its form factor, perfectly suitable to serve as future proof capacity enabler backhaul solution. The 60 GHz band is also referred as V-band.

Some expected data consumption figures as presented by leading operators, forums and vendors:

NTT (Japan):

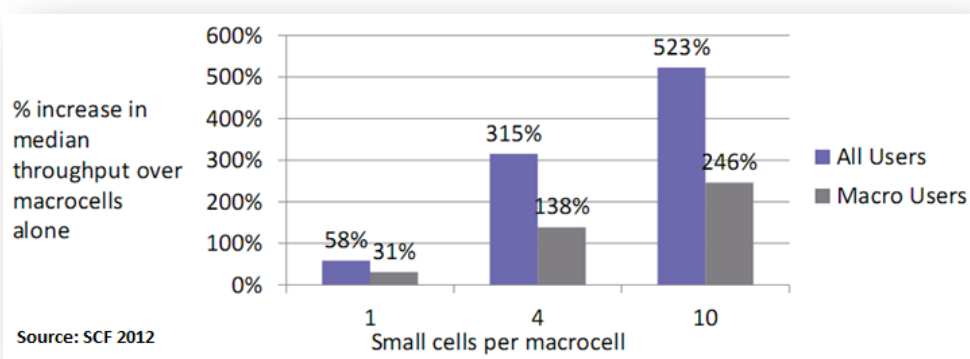


Vodafone:



Cisco: "*the average mobile connection will generate 716 MB of mobile data traffic per month in 2016, up from 30 MB in 2011*" (world average)

Small Cells Forum – The effect of adding small cells to macro network:



Utilizing the V-band spectrum, mobile operators can better design their backhaul, allowing a more efficient frequency plan. The main characteristics of the 60GHz band:

- ~9 GHz of spectrum (57-66 GHz)

- Spatial variation in shadowing is greater than lower frequencies: great potential for re-use
- Because oxygen molecules absorb electromagnetic energy in the 60 GHz frequency, the band allows for more 60 GHz links to operate in the same geographic area than links with longer ranges at other frequencies:
    - Additional path loss at 60 GHz due to Atmospheric Oxygen : Atmosphere attenuates~15 dB/Km
    - Perfectly suitable for high density usage as small cell topologies require

Doing so, mobile operators are able to increase their backhaul capacity according to their increasing needs without causing frequency congestion. This allows the mobile operators to introduce new and advanced mobile broadband services to the consumers. The consumers on the other hand are enjoying the true experience of mobile broadband at their fingertips.

V-band is designed for TDD (primary indoor), thus makes FDD challenging:

- Only one continues band of 7GHz (less in some countries)
- The minimum feasible diplexer will take 1-1.5GHz, and overlap the usable band.
- Locating the diplexer in the middle of the band (in order to maximize usable spectrum), will create, In some countries, asymmetry in UL/DL performance due to Oxygen absorption
- The licensed 64-66MHZ sub-band spectrum (in some countries) which is preferred by operators cannot be used for FDD

Understanding those facts and researches, mobile operators worldwide are turning to the V-band spectrum to enhance and streamline their expanded backhaul networks. Due to the large allocated spectrum and propagation characteristics at these frequencies, wireless backhaul systems operating at these frequencies, also referred to as millimeter-wave wireless systems, can provide up gigabit capacity for relatively short distances of a few hundred meters. The antennas used in V-band frequencies are highly directional and together with the propagation limitations, wireless systems operating at the V-band frequencies are highly focused, point-to-point “pencil beam” links allowing a much higher reuse of the same frequency in a given area.

4.4 World Technical Recommendation

The 60 GHz V-band spectrums was established for fixed link services:

- In the 1990s, the **FCC** adopted rules for unlicensed operations over a 7GHz wide bandwidth, in the 57GHz to 64GHz band. Because of the wide bandwidth, this spectrum is very desirable for high-capacity uses, especially in point-to-point fixed operations outdoors (extending the reach of fiber optic networks by providing broadband access to adjacent structures in commercial facilities. In 2001 the FCC set aside a continuous block of 7 GHz of spectrum (57-64 GHz) for wireless communications. All uses are permitted except for radar. The major commercial benefit is that users don’t need an FCC license to operate equipment in this spectrum. In addition to the high-data rates the spectrum allows, energy propagation in the 60 GHz band has unique characteristics that add other benefits, such as excellent immunity to interference, high security, and the reuse of frequency. **Recently (Aug 2013)** The FCC decided to modify its Part 15 rules governing unlicensed communication equipment in the 57GHz to 64GHz band to ease its use for wireless services. 2 main updated were published:
    1. The FCC increased the power permitted for outdoor operations between fixed points using highly directional antennas and tied the maximum power permitted to the precision of the antenna beam, which determines its potential for causing interference to other users, including to indoor low-power networks. This rule change would permit outdoor devices to deliver high-capacity communication links over longer distances, enhancing the utility of the unlicensed 57GHz to 64GHz band as a vehicle for broadband. It will also facilitate the use of this unlicensed spectrum as a backhaul alternative in densely populated areas where 4G and other wireless

services are experiencing an ever-increasing need for additional spectrum. Figure 1 illustrates the ratios between allowed EIRP and antenna gain, adding also the resulted maximum output power.

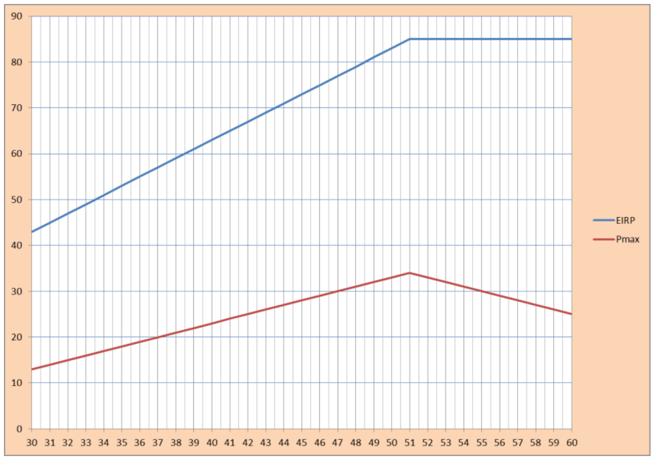


Figure 1: ratios between allowed Max. EIRP and antenna gain and the resulted maximum output power

2. Only for outdoors links, the FCC also took additional actions to reduce the regulatory burden on these operations by eliminating a station identification rule that has become unnecessary.

- **ITU**-R F.1497-1 (2002) Radio-frequency channel arrangements for fixed wireless systems operating in the band 55.78-59 GHz
- Europe was soon to follow:
  1. **CEPT** REC 12-09 (1998) RADIO FREQUENCY CHANNEL ARRANGEMENT FOR FIXED SERVICE SYSTEMS OPERATING IN THE BAND 57.0 – 59.0 GHz WHICH DO NOT REQUIRE FREQUENCY PLANNING
  2. **CEPT**/ERC/Recommendation 05-02 (2005): "Use of the 64,0 - 66,0 GHz frequency band for Fixed Service
  3. **CEPT** REC 09/01(2009) "USE OF THE 57 - 64 GHz FREQUENCY BAND FOR POINT-TO-POINT FIXED WIRELESS SYSTEMS" – First band expansion
  4. The following ETSI Technical Harmonized Standards defining the rules for these bands has been published:

     a. ***ETSI EN 302 217-3 V1.3.1 (2009-07)***

     Fixed Radio Systems; Characteristics and requirements for point-to-point equipment and antennas; Part 3: Equipment operating in frequency bands where both frequency coordinated or uncoordinated deployment might be applied; Harmonized EN covering the essential requirements of article 3.2 of the R&TTE Directive.

     Annex UA (normative): Frequency band around 58 GHz

     Annex UB (normative): Frequency band 64 GHz to 66 GHz

     Annex UBa (normative): Frequency band 57 GHz to 66 GHz for point-to-point fixed wireless systems

     b. ETSI EN 302 217-4-1 V1.4.1 (2010-01)

     Fixed Radio Systems; Characteristics and requirements for point-to-point equipment and antennas; Part 4-1: System-dependent requirements for antennas.

     c. ***ETSI EN 302 217-4-2 V1.5.1 (2010-01)***

     Fixed Radio Systems; Characteristics and requirements for point-to-point equipment and antennas; Part 4-2: Antennas; Harmonized EN covering the essential requirements of article 3.2 of R&TTE Directive.

     Chapter 4.2: Radiation Pattern Envelope (RPE)

     4.2.7 Frequency range 6: 47 GHz to 66 GHz

4.2.8 Frequency range 7: 66 GHz to 86 GHz

Chapter 4.3 Cross-Polar Discrimination (XPD)

4.3.2 Frequency range 3 GHz to 86 GHz

- **UK - OFCOM.** Followed the European technical standards defined by CEPT and ETSI. As for the type of regulation, it is based on a consultation work that adopted an approach to divided V-band into two ranges with 2 types of regulations**:**
    a. 57.1–63.9 GHz License exempt
    b. 64–66 GHz Light licensed
- **MPHPT – Japan**. In 2000, the Ministry of Public Management, Home Affairs, Posts, and Telecommunications of Japan issued 60 GHz radio regulations for unlicensed utilization in the 59–66 GHz band. The 54.25–59 GHz band is, however, allocated for licensed use.

It is strongly suggested to follow the European recommendations and standards adopting them as mandatory requirements. As the vast majority of the equipment vendors manufacture equipment that conforms to the European recommendations, this will lead to a greater variety of equipment to be offered to potential customers. In addition, conforming to the European recommendations will ease the selection process of the equipment made by relevant customers.

4.5 V-band Spectrum pricing

The following factors need to be taken into consideration when coming to determine the licensing fees / spectrum charges of the V-band spectrum:

1. The highly directional, "pencil beam" propagation characteristics and the signals' short-range propagation and inability to penetrate walls allows for heavy reuse of the spectrum in dense urban areas without causing interference of other V-band wireless systems, mean that operators can plan and deploy networks with an extremely high degree of frequency reuse, minimal frequency coordination and deploy links close to one another with minimal interference concerns.
2. There are 7 GHz and more of continuous spectrum in each of the 60 GHz band which can be divided into large 250 MHz channels which can even be aggregated. The available spectrum together with the large channels allows implementation of simpler modems with lower spectral efficiency such as QPSK and QAM64.
3. The propagation characteristics and rain fading of the V-band spectrum result in an effective, average link range of 0.2-1 km.

4.6 "License exempt" and "Light Licensing" Schemes

License Exempt

V-band is very often regarded as a natural development of the well-known Wi-Fi spectrum (2.4 / 5 GHz based) or its successor for enabling future broadband. As such, it benefits from being promoted as part of governments objectives of furthering the availability of broadband connectivity to all citizens. The various technical characteristics of the systems to be deployed, along with the high gaseous absorption propagation attenuation around 60 GHz, implies that sharing should be possible between the various applications with a very low probability of interference. Therefore, most regulators were content that a license exempt approach remains appropriate for the 60 GHz band and consistent with our duty to secure optimal use of the spectrum. A minimum antenna gain (most of the times 30dBi) was adopted in the technical conditions to the license exemption. This was decided in order to increase confidence regarding the intra- and inter- service sharing issues and in order to avoid systems being deployed with wide beam antennas which could increase the probability of interference between assignments.

Light Licensing

Some regulators, (like Ofcom in UK) have added more spectrum adjacent to the license exempt existing spectrum (of 57 to 64 GHz). Those regulators added that spectrum as a light licensing spectrum, as in E-Band (see Annex 2).