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| **SOUTH ASIAN TELECOMMUNICATIONS REGULATOR’S COUNCIL** **(SATRC)** |  |
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**SATRC report on**

**WIRELESS BACKHAUL-SPECTRUM, TECHNOLOGY AND POLICY CONSIDERATIONS**

**Prepared by**

**SATRC Working Group on Spectrum**

**Adopted by**

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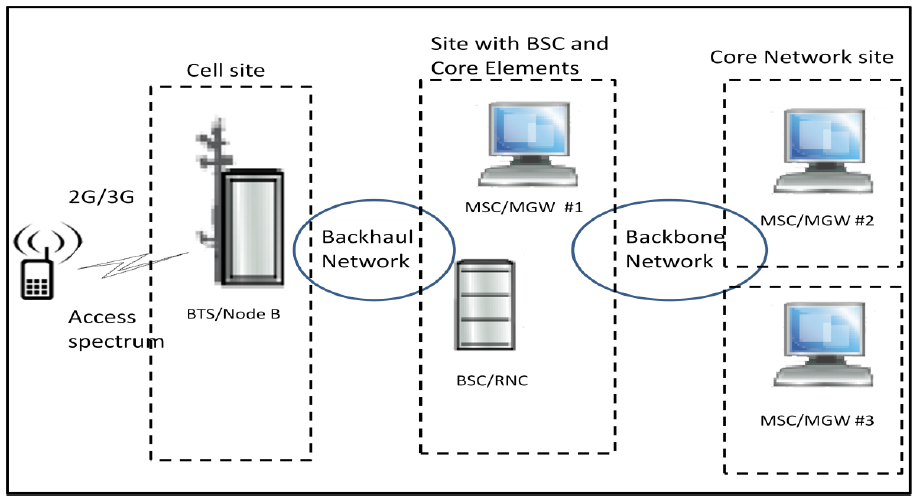
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# CHAPTER-1: INTRODUCTION

## 1.1 General

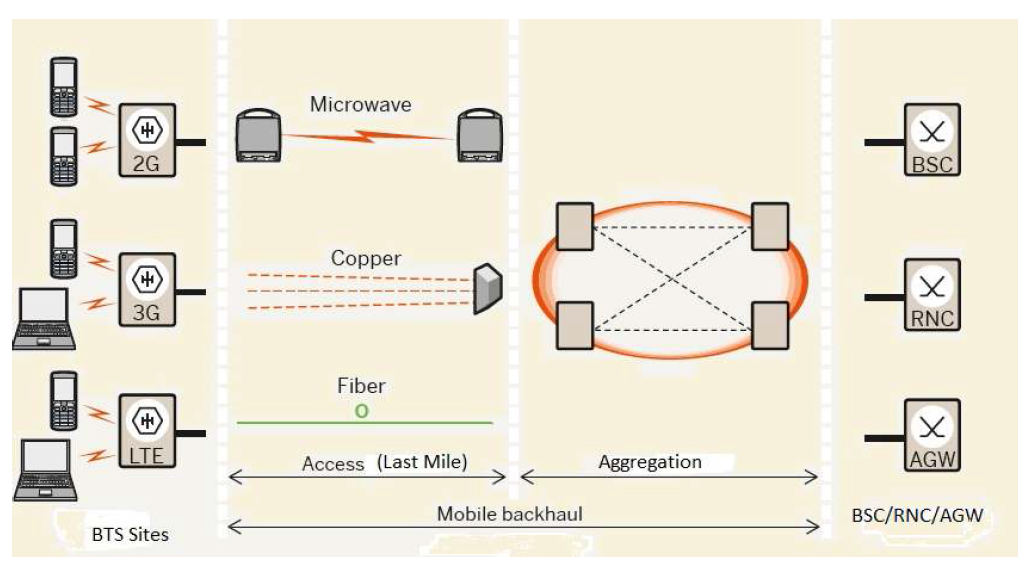
The mobile network can be visualized as connectivity from mobile handsets to cell site (BTSs/Node Bs) through access spectrum, cell site to BSCs/RNCs through backhaul network and the interconnection of MSCs/MGWs and other core elements through backbone network (Fig 1.1).



*Figure 1.1: Mobile Network*

The **mobile backhaul** is an integral part of the network which connects cell site BTSs with BSCs. From an implementation point of view, the backhaul architecture can be further divided into two parts (Fig. 1.2):

* + Last Mile (Access) part of backhaul - It provides last mile backhaul connectivity to BTS from the aggregation point. It aggregates traffic from a number of BTSs sites and feeds it into the aggregating network. It can also be called pre-aggregation segment.
  + Aggregation part of backhaul: It aggregates traffic from different access parts and backhauls it to BSC/RNC.



*Figure 1.2: Mobile Backhaul*

Depending on operator’s strategy and availability at the site, one or a combination of various available physical link technologies (microwave, copper and fibre) can be used in this part. Each type of backhaul link has got certain advantages and disadvantages.

**Mobile backbone** network refers to the interconnection of core elements situated at separate geographic locations. As the requirement of bandwidth is large, typically, OFC is used in the backbone network. However, microwave is also sometimes used in the backbone network, particularly in those areas where laying fibre is not a feasible option due to difficult terrain, time constraints or economic viability.

## 1.2 Requirement of high capacity backhaul

All voice and data signals - conversations, SMSs, video downloads - travel through the backhaul network. It is an essential component of mobile networks. The mobile world is rapidly evolving with the proliferation of new mobile devices and applications. Increasing penetration of web-enabled devices such as smart-phones, tablets etc, coupled with bandwidth intensive applications which generate significantly higher traffic across the mobile networks, are driving the adoption of new access technologies. Increase in the mobile data usage in the past few years has resulted in the need for greater capacity in the mobile backhaul networks.

## 1.3 Background

Mobile operators have a challenging time backhauling the mobile voice and data traffic from varied urban, sub-urban, rural, office, residential home, high-rise buildings, public buildings, tunnels, etc. Today, wireless or microwave connections currently account for over 50% of mobile backhaul access connections for macro cell sites worldwide. As per one estimate, nearly 80% of cell sites in India have a microwave-based backhaul link. Moving forward, it is expected that Microwave will continue to play an important role in providing backhaul connectivity.

Microwave networks are a vital ingredient for operators even with rising capacity needs. Capacity needs will continue to increase on the road to 5G. Keeping pace with the access technology evolution, microwave requires a continued technology evolution and is likely to evolve to support multi-gigabit capacities in traditional frequency bands as well as in the millimeter wave. In supporting microwave to meet the capacity increase for backhaul as well as front haul, E-band (70/80 GHz) and V-Band (60 GHz) spectrum is the key.

## 1.4 Objective & Purpose of the report

The objective of this report is to give information to member regulators regarding Wireless Backhaul that will help them in making policy and relevant regulations on the aspect.

The report addresses the following issues regarding the Microwave Links-

* Capacity requirements of Backhaul links
* Suitability of Microwave backhaul vis-à-vis Optical Fibre, and Copper backhaul links
* Spectrum bands and capacity
* The Millimeter waves potential
* ITU Standards
* Policy Consideration such as licensing procedures and charges.

In order to carry out the study, a questionnaire was prepared and circulated to all expert members of the SATRC countries for their inputs. The questionnaire is placed as Annexure-I to this report. An analysis of various regulations and provisions in the above mentioned areas has been carried based on the inputs received from the experts of the following SATRC countries:

1. Bhutan
2. Maldives
3. Nepal
4. Iran
5. India

# CHAPTER-2: MICROWAVE BACKHAUL FOR SATRC COUNTRIES

## 2.1 Capacity requirements of Backhaul links

1. **Increase in mobile data usage**

The Internet plays an important role in every aspect of human life. Its usage is extended to numerous fields, including education, healthcare, business, and much more. The number of individuals accessing the Internet through their smartphones is increasing rapidly and will continue to increase in near future due to digitalization and affordable smartphones. Trend of Data usage in various SATRC countries is shown in table 2.1 below. Increase in the mobile data usage in the past few years is pretty evident from the table. This has resulted in the need for greater capacity in the mobile backhaul networks.

***Table 2.1: Data Usage Trend in various SATRC countries***

|  |  |  |  |
| --- | --- | --- | --- |
| **Country** | **Total data usage in May 2013 (in TB)** | **Total data usage in May 2017**  **(in TB)** | **Change in total data usage** |
| India | 52,351 | 1,169,568 | 21.00% |
| Bhutan | 25.51 | 176.30 | 591.10% |
| Maldives | 28,575 | 92,250 | 70.00% |
| Iran | 387 | 642 | 65.89% |
| Nepal | 81.89 TB (Ncell)  2 TB (Smart) | 2222.3 TB (Ncell)  205 TB (Smart) | 2700 % (Ncell)  10250 % (Smart) |

Although mobile data traffic has grown dramatically in the past few years, there are plenty of reasons to believe there is far more growth still to come.[[1]](#footnote-1) In the next ten years, with the advent of Internet of Things (IoT), billions more people and machines will use mobile networks to access online services and connect with each other. At the same time, smartphones will become increasingly ubiquitous and each new smartphone user will send and receive far more data than they did with their previous handset. Moreover, usage of video-on-demand services will continue to rise and the resolution of these videos will continue to improve. The anticipated increase in mobile data usage in various SATRC countries by 2020 is shown in table 2.2.

***Table 2.2: Anticipated increase in mobile data usage in various***

***SATRC countries by 2020***

|  |  |
| --- | --- |
| **Country** | **Anticipated increase in mobile data usage (In %)** |
| India[[2]](#footnote-2) | 500%[[3]](#footnote-3) |
| Bhutan | 300% |
| Maldives | >40% |
| Iran | 500% |
| Nepal | 700 % (Ncell) |

1. **Evolution of mobile access technologies**

With the changing requirements and increasing users’ data demand, the access technology has evolved over a period of time. It has resulted in better use of spectrum in terms of improved spectral efficiencies and more capacity as shown in the Table 2.3. Telecom Service Providers (TSPs) are forced to deploy IMT/IMT-A access technologies in order to adapt to the changing customer expectations. However, this shift to higher technologies is not possible without complementary support in the form of higher capacity of mobile backhaul. The higher data carrying capacity of access technologies can be effective in providing mobile broadband services to the customers only if these are complemented by an equally supportive and capable backhauls.

***Table 2.3: Evolution of Mobile Access Technologies***

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
|  | **WCDMA** | **HSPA** | **HSPA+** | **LTE** | **LTE Advanced** |
| Max downlink  Speed | 384 kbps | 14 Mbps | 28 Mbps | 300Mbps | 1Gbps |
| Max uplink  Speed | 128 kbps | 5.7 Mbps | 11 Mbps | 75 Mbps | 500 Mbps |
| 3GPP releases | Rel 99/4 | Rel 5/6 | Rel 7 | Rel 8 | Rel 10 |
| Approx years of  initial roll out | 2003/4 | 2005/6 HSDPA  2007/8 HSUPA | 2008/9 | 2009/ 10 | In  development  stage |
| Access  Methodology | CDMA | CDMA | CDMA | OFDMA  /SC-FDMA | OFDMA / SCFDMA |

Most industry estimates suggest that for LTE deployments, operators will require peak capacities of 50-100Mbit/s per cell site. The transition to all-IP technologies such as LTE means that the backhaul network will need to cater to an increasing volume of packet data over time, whilst at the same time being able to handle legacy circuit switched traffic. Therefore, choice of access technology has direct bearing on the backhaul requirement. Tentative requirement of backhaul capacity for different technologies is given in Table 2.4.

**Table 2.4: Backhaul requirements for different Access Technologies[[4]](#footnote-4)**

|  |  |
| --- | --- |
| **Access Technology** | **Backhaul Capacity per BTS** |
| 2G | Typically 2 Mbps to 4 Mbps required. Very large urban BTSs could require up to 12 Mbps. |
| 3G | HSPA will require 12 Mbps – 30 Mbps for typical macro-base station deployments. |
| LTE | LTE macro-base stations will require between 30 Mbps – 120 Mbps, with very large urban base stations potentially requiring up to 240 Mbps backhaul capacity. |

For 2G and 3G technologies, average base station capacity is 2-30 Mbps, but the capacity required for deployment of 4G technologies is comparatively high. According to the ITU, IMT mobile networks are defined as providing at least 100 Mbps peak capacity for high mobility applications, and 1 Gbps for stationary applications. This massive jump in performance definitions from 3G to 4G is one of the key drivers for enhanced backhaul capacity needs, and is the main reason for the transition to fibre or higher-capacity wireless backhaul solutions. It is expected that cell site backhaul will inevitably grow to hundreds of Mbps per cell site, and multiple Gbps in the aggregation networks.

5G standardization process is going on in 3GPP and commercial deployment is expected in 2020. 5G is expected to provide “4A- anytime, anywhere, anyone, anything” connectivity, which will take mobile data speeds to new limits and will support an immense increase in connections. With the advent of 5G technologies, mass scale of deployment is expected in the areas of Internet of Things (IoT) and Machine-to-Machine (M2M) communication. However, a good 5G network cannot be expected unless we have a reliable and strong backhaul. While current wireless backhaul links serve requirements of hundreds of Mbps, future links will be required to support tens of Gbps.

## 2.2 Suitability of Microwave backhaul vis-à-vis Optical Fibre and Copper backhaul links

Today’s backhaul relies mostly on three physical mediums: copper, optical fibre and microwave radio links. Copper cables are the traditional backhaul medium between Base Transceiver Stations (BTSs) and Base Station Controller (BSC). Copper cables can be used by deploying xDSL2 technologies to provide backhaul connectivity in pre-aggregation segment. However, links provided on copper suffer from its limited capacity support and inability to scale in a cost efficient manner. The use of copper is limited to support few Mbps of data upto few kilometers using xDSL technologies and hence it is not useful for technologies like 3G or LTE which require higher data capacity.

Over a period of time, optical fibre has evolved as the most practical wired solution for backhaul as well as backbone network. OFC provides practically unlimited capacity. Owing to its almost limitless capacity, it is the right choice for high-capacity routes where logistics are manageable, capacity need is high, and the potential revenue gain offsets the expense. Its share in the mobile backhaul network is likely to go up owing to the expected growth in the data traffic and the increasing requirement of backhaul for the new technologies such as LTE, LTE-Advanced etc. However, the flip side of fibre deployment that decreases its usage is that it is costly and requires time for deployment. Pulling fibre to every cell site is practically not feasible due to cost and logistical challenges.

Though Microwave does not have the matching capacity of fibre, it is cheaper, scalable and a highly reliable option and can be deployed quickly. Therefore, it is the dominating backhaul technology in the majority of cell sites in the pre-aggregation segment of backhaul. In certain rural and remote locations, Microwave is the only practical high-capacity backhaul solution available. Reducing inter-site distances have also helped in Microwave links becoming so popular. However, aggregation part of the backhaul network mainly relies on OFC considering its higher bandwidth requirement. However, Microwave can also be used in places of lesser bandwidth requirements.

Table 2.5 shows comparison between various physical link technologies used in mobile backhaul.

***Table 2.5: Physical link technologies***

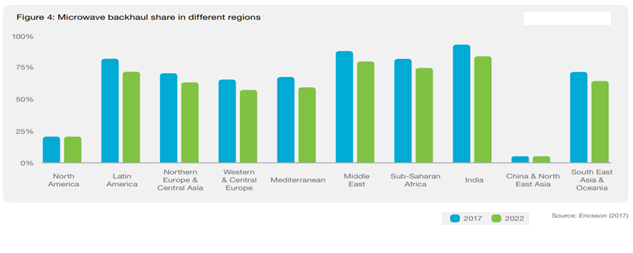
|  |  |  |  |
| --- | --- | --- | --- |
|  | **MICROWAVE** | **OPTICAL FIBRE CABLE (OFC)** | **COPPER CABLES** |
| **Wireless**  **/Wired** | Wireless | Wired | Wired |
| **Mobile Backhaul** | Microwave is widely being used in pre-aggregating stage of mobile backhaul. It can also be used in aggregation part of the backhaul network in places of lesser bandwidth requirements | Optical fibre has evolved as the most practical wired solution for backhaul as well as backbone network. Aggregation part of the backhaul network mainly relies on OFC considering its higher bandwidth requirement | For backhaul connectivity in pre-aggregating stage, copper can be used by deploying xDSL2 technologies |
| **Cost** | Cheaper -It is the cheapest option when none of the option is pre-existing at a cell site | High cost | Reasonable |
| **Capacity** | It depends upon frequency, modulation technologies, type of antenna array, polarization techniques | Extra-ordinary capacity | Limited capacity support |
| **Scalability** | Scalable | Limitless scalability | Inability to scale in a cost efficient manner |
| **Speed Of Roll Out** | Fast | Poor-requires time for deployment |  |
| **Other Challenges** | Line-of-sight (LOS) requirement | Logistical challenges |  |

Globally, mobile network backhaul continues to evolve with a mix of fiber and microwave. As for global scenario, the schematic[[5]](#footnote-5) in Figure 2.1 below provides the trends for various backhaul technologies used in networks. For 2015, approximately it was 8% copper, 18% fibre and 74% microwave.



*Figure 2.1: Backhaul media distribution –Global Trends[[6]](#footnote-6)*

Figure 2.2 gives the share of microwave backhaul in various regions of world.



*Figure 2.2: Microwave backhaul share in different regions*

Table 2.6 shows the percentage wise breakdown of technologies being used for Mobile Backhaul in various SATRC countries.

***Table 2.6: Percentage wise breakdown of technologies being used for Mobile Backhaul in various SATRC countries***

|  |  |  |
| --- | --- | --- |
| **Country** | **Backhaul Technology** | **% over total mobile backhaul access connections** |
| **Bhutan** | Copper | 10 % |
| Optical Fibre | 45 % |
| Microwave | 45 % |
| **Maldives** | Copper | - |
| Optical Fibre | 28 % |
| Microwave | 72 % |
| **Iran** | Copper | 5 % |
| Optical Fibre | 25 % |
| Microwave | 70 % |
| **India** | Copper | 10% |
| Optical Fibre |
| Microwave | 90% |
| **Nepal** | Copper | Nil. (Ncell) |
| Optical Fibre | 21 % (Ncell) |
| Microwave | 79 % (Ncell) |

In Maldives, at present for 72% of the total mobile backhaul connections, microwave backhaul technology is used since based on the nature of geography and customer density in Maldives, it was the only viable option available to them till now. However, for the future backhaul installation, Maldives is looking forward to Optical Fibre due to the need to carry huge volume of data to the node sites. Because of this the microwave backhaul deployment in Maldives could be less than submarine optic fibre cable in years ahead.

In Bhutan, at present for 45% of the total mobile backhaul connections, optical fibre cables are used since the national fibre cable network is available to the operators that provides high bandwidth and is highly reliable. The microwave backhaul technology is also used for other 45% of the total mobile backhaul connections as redundant backhaul connectivity services. In rugged geographical terrain, the microwave backhaul serves better purposes than laying the optic fibre lines. Bhutan is planning to convert all its copper wire based backhaul to optical fibre cable. In order to provide better quality of services, more microwave links will also be established in Bhutan the near future.

In Iran the backhaul between cities and major centers inside cities are all fibre optics based. Optical fibre based backhaul covers 5% of the total mobile backhaul access connections. For the other regions in the city, 70% of the total mobile backhaul access connections, microwave technology is used. Microwave backhaul technology is used majorly in Iran as it provides speed of radio link deployment and can be deployed in difficult terrains. Most of the ongoing backhaul expansion programs in Iran deals with fiber line. However, for rural area and small cities, microwave will be used as backhaul technology.

Nepal’s geography is composed of a mixture of plain regions (17%), hilly regions (68%) and mountain regions (15%). Plain regions have the highest population whereas mountainous regions have the lowest population. Due to this uneven distribution in occupancy, the choice of backhaul depends upon geography and population density. Nepal is planning to create additional 486 links and 521 stations to connect the un-served and unconnected regions in the country.

According to Ericsson’s report titled “Microwave towards 2020” released in 2014, microwave transmission dominates mobile backhaul, where it connects some 60 percent of all macro base stations. Even as the total number of connections grows, microwave’s share of the market will remain fairly constant. By 2019, it will still account for around 50 percent of all base stations (macro and outdoor small cells). It will play a key role in last mile access and a complementary role in the aggregation part of the network. At the same time, fibre transmission will continue to increase its share of the mobile backhaul market, and by 2019 will connect around 40 percent of all sites. Fibre will be widely used in the aggregation/metro parts of the networks and increasingly for last-mile access.

## 2.3 Spectrum bands and capacity

Spectrum in different frequency ranges is used by backhaul solutions to support communication in many types of locations, from sparsely populated rural areas to ultra-dense urban environments.

1. **Spectrum Bands in 6-42 GHz Range:**

Conventionally licensed frequency bands from 6 GHz to 42 GHz are used for the licenced operations of the microwave point-to-point communications. The details of allotment of carriers for microwave point-to-point links in various SATRC countries are highlighted in table 2.7 below.

***Table 2.7: Details of the existing spectrum allocation for Mobile Backhaul in various SATRC countries***

|  |  |
| --- | --- |
| **Country** | **Band** |
| **India** | 6 GHz, 7 GHz ,13 GHz, 15 GHz, 18 GHz and 21 GHz |
| **Bhutan** | 7 GHz, 8 GHz, 13 GHz, 15 GHz, 18 GHz |
| **Maldives** | 4.4 GHz, 6 GHz, 7 GHz, 8 GHz, 13 GHz |
| **Iran** | 4 GHz, 6 GHz, 7 GHz, 8 GHz, 10 GHz, 11 GHz, 13 GHz, 15 GHz, 18 GHz, 23 GHz, 24 GHz 26 GHz, 28 GHz, 38 GHz |
| **Nepal** | 6 GHz, 7 GHz, 8 GHz, 13 GHz, 15 GHz, 18 GHz, 23 GHz, 38 GHz |

The sub-42 GHz bands are expected to become increasingly saturated in future, as mobile broadband traffic rises over the next three to five years. In particular, it will become increasingly difficult to accommodate high bandwidths required for LTE backhaul in the existing PTP fixed link bands. Mobile operators are constantly searching new backhaul alternatives (like more backhaul spectrum bands and optical fibre solutions) to increase their backhaul capacity which is expected to increase upto 100 Mbps (approx.) per site.

Over a period of time, with the requirement arising due to congestions in these bands and demand for more capacity, wireless technology has expanded the frequency range at which commercially viable communication systems can be built and deployed. Millimeter wave is a new generation of point-to-point radio communication operating at very high frequencies, typically including 71–76 GHz, 81–86 GHz, and 92–95 GHz. Frequencies up to 300 GHz are also the subject of wireless communications research. To meet future demand for high-capacity fixed links, regulators are opening up higher frequency bands, such as 60 and 70 GHz.

1. **E-Band (71-76 GHz/ 81-86 GHz):**

Operators in many countries are looking for new wireless spectrum bands that are scalable and flexible in providing necessary bandwidth as well as also allow them to reduce wireless backhaul expenditures. One such spectrum band is E-Band spectrum (71-76 GHz, 81-86 GHz) which has the potential to deliver high throughput in urban areas/ geography. It is sufficiently capable for ultra-high capacity point-to-point communications (fixed links) and may act as a suitable replacement for optical fibres particularly in dense urban areas where lying of optical fibre is particularly difficult.

The Federal Communications Commission (FCC) was first to regulate and allocate the E-Band spectrum in 2003, followed by Ofcom in the UK in early 2007. Regulators worldwide are also following the FCC and Ofcom’s lead, by allocating this spectrum in a steady manner. Following are the key drivers of E-Band microwave as a mobile backhaul solution:

* Higher capacities per site
* Dense network as the 3G and LTE sites will be higher than traditional 2G sites demanding pencil beam microwave ensuring less or minimal inter link interference
* Increased data rate at lower cost per bit
* Secure network and investment

E-Band gives a total spectrum bandwidth of 10 GHz which is sufficient to deliver very high capacity data along a single radio path relative to conventional microwave spectrum. ITU in its recommendation ITUR F.2006 and CEPT in its recommendation ECC/ REC / (05/07) have provided a detailed channel plan for this band. In FDD case there are 19\*250 MHz channels with a duplex separation of 10 GHz or less between them along with a guard band of 5 GHz. The channel sizes in E-band are sufficiently greater than conventional microwave spectrum for fixed links which creates the capability to transfer very high data rates of 1 Gbps and above.

Systems of E-band cast very narrow beams which allow deployment of multiple independent links in close proximity. A key benefit of the highly narrow beam millimeter wave links is the scalability of their deployments. Millimeter wave is well suited for network topologies such as point-to-point mesh, a dense hub-and-spoke or even a ring. Despite being affected by rain attenuation, the robust system design and higher antenna gains allows E-Band wireless systems to provide the necessary high capacities with 99.999% carrier grade service availability at link distances of up to three kilometers.

Presently, almost 40 countries have released license plan for E-Band. In some countries like USA and UK, there is light licensing approach while in some countries like Germany, Italy, and Belgium, it is fully licensed. In light licensed category, individual link licenses are issued by the licensor, but the licensees take their own responsibility for coordinating these links. Links are registered on Licensor’s wireless telegraphy register and are given priority in the band on a ‘date of registration’ basis, which can be referred if an interference case arises.

1. **V- Band (60 GHz Band (57-64 GHz)):**

Another band for wireless backhaul is 60 GHz. Availability of large 7 GHz bandwidth in 60 GHz band, also known as V-Band, makes it suitable for very high capacity (e.g. 100Mbps ~ 1Gbps Ethernet systems) and short hop (1–2 Kms) fixed wireless systems. The 60 GHz band has unique propagation characteristics with high oxygen gas absorption of 15dB/km – i.e. the radiation from a particular radio transmitter is quickly reduced. Though, this limits the distances that 60 GHz links can cover, it makes these links highly immune to interference from other 60 GHz radios. Another link in the immediate vicinity will not interfere if its path is just slightly different from that of the first link, while oxygen absorption ensures that the signal does not extend far beyond the intended target, even with radios along the exact same trajectory.

At 60 GHz, systems are quite susceptible to rain attenuation as raindrops are roughly the same size as the wavelength of the electromagnetic wave and they make the radio signal scatter. During heavy rain the specific attenuation can exceed 40dB/km. Hence 60 GHz Band is license exempt spectrum band in countries like USA, UK, Australia and Japan. Although, a little ecosystem is developed for this band and equipments available for this band are expensive but if planned efficiently this band has the capability of solving bandwidth crunch.

In Iran, currently E-Band is partially assigned for common use of MNOs with self-coordination mechanism. The rest of the band has been reserved for future to have less difficulty in dealing with WRC-19 results under agenda item 1.13. The V-band has been separated into two parts: 55.78-57 GHz paired with 64-66 GHz and 57-64 GHz. The first part is usable by applications for individual Radio license while the second part is open for the use of TSP with a simplified licensing method. However, no request has been received for V-band yet. Iran's preference is to keep V-band for applications similar to WiGig.

Bhutan will use E-band and V-band for backhaul installations only after they are ready to develop IoT and 5G technology in their country. However, at present they are planning to look into the cost implication of using E-band and V-band for Microwave Backhaul purpose on their TSPs. Bhutan is of the opinion that the year 2020 and beyond would be appropriate time for considering assignment of Microwave carriers in E- band and V- band.

In India, the allotment of E- band and V-band for microwave backhaul purpose is under active consideration of the government.

In Nepal, E-Band and V-Band have been allocated for microwave backhaul purpose. The usage of these bands is left to be decided by market demand.

## 2.4 Standards

ITU-R deals with propagation modeling, path loss, scattering etc. which are used to do link engineering.

Some ITU-R reports related to backhaul are-

* Report[[7]](#footnote-7) ITU-R F.2393-0 (11/2016): Use of fixed service for transport of traffic, including backhaul, for IMT and other terrestrial mobile broadband systems
* Report ITU-R F.2323-0 (11/2014): Fixed service use and future trends

ITU-R has also issued certain recommendations related to radio-frequency channel and block arrangements for Fixed wireless systems.

ETSI has worked in certain areas such as fixed P2P links[[8]](#footnote-8), millimetric wave transmission[[9]](#footnote-9), etc. The Working Group TM 4 of ETSI technical committee Access, Terminals, Transmission and Multiplexing (ATTM) is responsible for working on specifications for point-to-point and multipoint radio systems. This work includes not only Harmonised Standards but also Technical Reports and Technical Specifications.  Furthermore, TM 4 is in close liaison with the CEPT/ECC, ITU and European Commission in order to synchronize the activities.

ETSI has established a millimetre Wave Transmission (mWT) Industry Specification Group (ISG) to provide a platform and opportunity for companies and organizations involved in the microwave and millimetre-wave industry chain to address the challenges involved in using this spectrum.

The mWT ISG aims to facilitate the use of:

* V-band (57 to 66 GHz)
* E-band (71 to 76 & 81 to 86 GHz) and
* in the future higher frequency bands (up to 300 GHz)

for large volume applications in back-hauling and front-hauling to support mobile network implementation, wireless local loop and any other service benefitting from high speed wireless transmission.

mWT is intended to address the whole industry value chain with particular emphasis on:

* current and future regulations and licensing schemes for the use of suitable spectrum in different countries
* putting in communication the whole industry chain to share and circulate public information regarding the applications in field in order to favor faster and more effective decisions on investments needed to provide new technologies, features and equipment
* influencing standards for the deployment of the products
* enhancing the confidence of all stakeholders and the general public in the use of millimetre-wave technologies

Some recent ETSI white papers related to mWT are-

* Microwave and Millimetre wave for 5G Transport
* E-Band and V-Band - Survey on status of worldwide regulation
* Maturity and field proven experience of millimetre wave transmission
* mmWave Semiconductor Industry Technologies

## 2.5 Policy Consideration such as licensing procedures and charges.

* 1. **Assignment of microwave access/backbone carriers**

Unlike access spectrum which is assigned mostly by auction in a number of countries, backhaul spectrum is generally assigned administratively on a link-by-link or case-by-case basis while taking care of various technical (spectrum bands, interference, antenna characteristics and path length) factors.

Presently in India, Bhutan, Nepal and Maldives, the assignment of Microwave Access & Backbone (MWA/MWB) carriers to the TSPs is done administratively based on the demand and justification given by them and subject to the availability of spectrum spots.

* 1. **Pricing of microwave access/backbone carriers**

***India***

Initially, in India, the methodology adopted for spectrum charging was based on a mathematical formula accounting for number of R.F. channels used, adjacent channel separation etc, which was affected by WPC’s order dated 20th July 1995. It inter-alia prescribed the annual royalty charges for Microwave Links for GSM based Cellular Mobile Telephone Service as given below:

Annual Royalty (R) = M x W x C, where;

1. M (Constant Multiplier) = 4800 for GSM Standard CMTS Microwave Networks within a city/town/service area and point-to-multipoint network; M= 4800 for point to point microwave link(s) with end-to-end distance less than or equal to 60 Km.

M= 9000 for point to point microwave link(s) with end-to-end distance greater than 60 Km but less than or equal to 120 Km.

M= 15000 for point to point microwave link(s) with end-to-end distance greater than 120Km but less than or equal to 500 Km.

M= 20000 for point to point microwave link(s) with end-to-end distance greater than or equal to 500 Km.

1. Weighing Factor ‘W’ which is decided by the adjacent channel separation of the R.F channelling plan deployed where:

W = 30 for adjacent channel separation up to 2 MHz.

W = 60 for adjacent channel separation greater than 2 MHz but less than or equal to 7 MHz.

W = 120 for adjacent separation greater than 7 MHz but less than or equal to 28 MHz.

W = 0.15 X Number of equivalent voice channels that can be accommodated within the adjacent channel separation greater than 28 MHz.

1. Number of R.F. Channels used (equal to twice the number of duplex R.F. channel pairs) represented by ‘C’;

In April 2002, WPC modified the calculation methodology for spectrum charges for MW access links[[10]](#footnote-10) and MW backbone networks[[11]](#footnote-11) of GSM based cellular networks from link-to-link basis to an AGR based regime as given below:

For MW access networks

* + For spectrum bandwidth up to 112 MHz in any of the circles, or 224 MHz in any of the 4 metros, spectrum charges shall be levied @ 0.25% of AGR per annum; and
* For every additional 28 MHz or part thereof (if justified and assigned) in circles or 56 MHz or part thereof in any of 4 metro areas, additional spectrum charges shall be levied @ 0.05% of AGR per annum.
  + These would also include the royalty charges for spectrum usages and license fee for the fixed stations in the Microwave access links.

For MW backbone networks

* + - For spectrum bandwidth upto 56 MHz, spectrum charges shall be levied @ 0.10% of AGR per annum; and
    - For every additional 28 MHz or part thereof (if justified and assigned), additional spectrum charges shall be laid read @ 0.05% of AGR per annum.
    - These would also include the royalty charges for spectrum usages and license fee for the fixed stations in the Microwave backbone links.

Through its order of 03.11.2006 followed by and its amendments dated 10.11.2008 and 19.02.2009, WPC amended the AGR based royalty charges for MW Access and MW Backbone networks of GSM based cellular networks and also made them applicable for CDMA based telecom service providers, which hitherto were determined on link-by-link basis. The revised share percentage(s) for assignment of Microwave networks of GSM and CDMA based Telecom Service Providers (TSPs) were prescribed as given in Table 2.8.

***Table 2.8: Revised Spectrum charges***

|  |  |  |
| --- | --- | --- |
| **Spectrum Bandwidth** | **Spectrum charges as percentage of AGR** | **Cumulative spectrum charges as percentage of AGR** |
| First carrier | 0.15 % | 0.15% |
| Second carrier | 0.20% | 0.35% |
| Third carrier | 0.20 % | 0.55 % |
| Fourth carrier | 0.25 % | 0.80 % |
| Fifth carrier | 0.30 % | 1.10 % |
| Sixth carrier | 0.35 % | 1.45 % |
| Seventh carrier | 0.40% | 1.85% |
| Eight carrier | 0.45% | 2.30% |
| Ninth carrier | 0.50% | 2.80% |
| Tenth carrier | 0.55% | 3.35% |
| Eleventh carrier | 0.60% | 3.95% |

The revenue share is based on the AGR for complete service area for simplicity of calculations. These charges include the royalty charges for spectrum usages and license fee for the fixed stations in the MW access and MW backbone links. As mentioned earlier, the above spectrum charging orders were set aside by the Hon'ble TDSAT judgment dated 22.04.2010 and the matter is now sub-judice and is before the Hon'ble Supreme Court.

**Nepal**

The pricing mechanism for microwave backhaul is given below:

Exchange Rate: 1 USD = Rs. 110

*Annual Price per Link or Hop (AP) = [Basic Price (B) x Band Factor (Bf) x Bandwidth Factor (BwF) x Ecosystem Factor (EF)]*

Where, B =Rs. 10,000 and

|  |  |
| --- | --- |
| **Frequency Range (GHz)** | **Ecosystem Factor (EF)** |
| 5GHz<EF<=45 GHz | 1 |
| 45<EF<=70GHz e.g. (V - Band (60 GHz) | 0.1 |
| EF>70 GHz eg. [E - Band (80 GHz)] | 0.4 |

|  |  |
| --- | --- |
| **Band Factor (BF)** | **Frequency Range (GHz)** |
| 1 | 0<BF<=10GHz |
| 0.5 | 10<BF <= 20GHz |
| 0.3 | 20 <BF <= 30GHz |
| 0.2 | 30< BF <= 45 GHz |
| 0.1 | 45 <BF <= 70GHz |
| 0.1 | 70 <BF <= 100GHz |
| 0.05 | > 100GHz |

|  |  |
| --- | --- |
| **BwF** | **Bandwidth (BW) in MHz** |
| **1** | 0<BW<=10MHz |
| **2** | 10<BW<= 20 MHz |
| **3** | 20<BW<= 30 MHz |
| **4** | 30<BW<= 40 MHz |
| **5** | 40<BW<= 50 MHz |
| **6** | 50<BW<= 60 MHz |
| **8** | 60<BW<= 80 MHz |
| **9** | 80 <BW<= 100 MHz |
| **10** | BW>100 MHz |

# CHAPTER 3: SUGGESTIONS/CONCLUSION

Technology evolution, increased mobility, and massive digitalization continue to place more demanding performance requirements on the networks. The performance of the network not only depends on the access technology that can provide high data rates, but also on the backhaul network technology that can support large data carrying capacity. Hence SATRC countries should plan for such performance requirements and accordingly for the need of mobile backhaul installations.

As the dominant backhaul technology in today’s networks, microwave plays a significant role in meeting the growing demand of the subscribers. The performance of microwave backhaul has evolved continuously with new and enhanced technologies and features that make ever better use of available spectrum.

Capacity-wise microwave backhaul will compete with the fibre backhaul. However, the choice between fibre and microwave in backhaul networks will not be about capacity, it will be about fibre presence and total cost of ownership (TCO). Microwave technology can provide high capacity backhaul for the broadband networks in a cost-efficient way. It appears to be more suitable for operations in the cities and difficult terrains where laying fibre is not possible. Considering these advantages, SATRC countries are encouraged to use microwave backhaul.

Due to the increasing use of newer multimedia and other data centric applications, the capacity demands are rising rapidly. The constant pressure to increase the capacity that the network can support translates into the need for more spectrum. More spectrum is required not just for radio access, but for microwave backhaul as well.

As capacity needs have grown, the use of spectrum for microwave backhaul has shifted. The newer E-band (70/80GHz) & V-band (60 GHz) are today gaining popularity, as it offers wide spectrum and enabling capacities in the 10Gbps range. In line with the international trend, SATRC countries should consider these bands for assignment to their TSPs for roll-out of high capacity backhaul networks to cater high throughput needs that will be generated by roll-out of future technologies.

Since E-band and V-band utilization for Microwave Backhaul is a new concept in most of SATRC countries, regional harmonization is very essential. It will make the implementation easier and will provide the economy of scale in terms of equipment manufacturing.

ITU-R deals with propagation modeling, path loss, scattering etc. which are used to do link engineering. ETSI has worked in certain areas such as fixed p2p links, millimetric wave transmission, etc. The SATRC countries can leverage the information/standards available in ITU-R and ETSI for planning their future microwave backhaul implementations.

With the limited inputs, it was difficult to justify the effective license conditions for Microwave Backhaul License. Hence it is opined that the SATRC countries could drive their own framework.

# ANNEXURE – 1

**Questionnaire**

1. **Provide technology wise breakdown of the number of mobile users in your country.**

Example:

|  |  |
| --- | --- |
| **Technology** | **No. of users** |
| 2G |  |
| 3G |  |
| 4G |  |

1. **What is the percentage change in mobile data usage in your country in the last 3-5 years? (till May 2017)**

Example:

|  |  |  |
| --- | --- | --- |
| **Total data usage in May 2013 (in TB)** | **Total data usage in May 2017**  **(in TB)** | **Change in total data usage** |
| 52,351 | 1,169,568 | 21% |

1. **What is the anticipated increase in mobile data usage in your country by 2020?**

**(Provide data in percentage)**

1. **How many TSPs are there in your country?**
2. **Which technologies are being used for Mobile Backhaul in your country? Provide percentage wise breakdown.**

Example:

|  |  |
| --- | --- |
| **Backhaul Technology** | **% over total mobile Backhaul access connections** |
| Copper | 20 % |
| Optical Fibre | 30% |
| Microwave | 50% |

1. **What are the reasons for the choice of Backhaul technologies which are presently deployed in your country?**

Example: Geography, customer density etc.

1. **What is the plan for Backhaul installations (in terms of technology and its projected percentage of usage) in your country in the next 3 years?**
2. **What is the anticipated Microwave Backhaul deployment in your country in next 3 years? Provide details.**
3. **Provide the details of the existing spectrum allocation for Microwave Backhaul in your country.**
4. **Band**
5. **Carrier bandwidth**
6. **Number of carriers**
7. **Existing assignments**
8. **Provide the details of frequency allocation for Microwave Backhaul, if any, in the National Frequency Allocation Plan/Table of your country.**

1. **Which frequency bands are under consideration for future use for Microwave Backhaul in your country?**
2. **What is the National outlook of your country towards E band and V band for utilizing in Microwave Backhaul? Kindly provide detailed deliberations.**
3. **Do you consider it beneficial to have regional harmonization on E band and V band for Microwave Backhaul in SATRC countries?**
4. **In your opinion, what is the appropriate time for considering assignment of Microwave carriers in higher frequency bands viz. E-band and V-band?**
5. **What is the present licensing procedure for Microwave Backhaul in your country? Kindly provide a brief on the methodology followed.**
6. **Is the spectrum assigned through administrative allocation? (Yes/No)**
7. **Is the spectrum assigned through auction? (Yes/No)**
8. **What is the proposed administrative procedure for future in respect of licensing?**
9. **How many total Microwave carriers should be assigned to a TSP deploying:**
10. **2G technology only**
11. **3G technology only**
12. **4G technology only**
13. **BWA technology only**
14. **2G and 3G**
15. **2G and BWA**
16. **3G and BWA**
17. **Any other combinations**

**Please give rationale & justification for your answer.**

1. **What should be the preferred basis of assignment of Microwave carriers to the TSPs i.e. ‘exclusive basis assignment’ or ‘link-to-link based assignment’?**
2. **In case ‘exclusive basis’ assignment is preferred, whether Microwave carriers should be assigned administratively or through auction. Please comment with full justifications.**
3. **In case ‘link-to-link basis’ assignment is preferred, how the carrier assignment for different links should be carried out, particularly in nearby locations?**

1. <https://www.gsma.com/spectrum/wp-content/uploads/2015/06/GSMA-Data-Demand-Explained-June-2015.pdf> [↑](#footnote-ref-1)
2. According to Ericsson Mobility Report 2018, the total monthly mobile data traffic in India is expected to increase by 5 times and reach 10 EB by 2023. [↑](#footnote-ref-2)
3. <https://www.ericsson.com/assets/local/mobility-report/documents/2018/ericsson-mobility-report-june-2018.pdf> [↑](#footnote-ref-3)
4. OFCOM: Future Options for Efficient Backhaul, 23rd January 2007 [↑](#footnote-ref-4)
5. <https://www.ericsson.com/en/microwave-outlook/reports/2017> [↑](#footnote-ref-5)
6. Excluding China, Japan, Korea and Taiwan [↑](#footnote-ref-6)
7. <https://www.itu.int/dms_pub/itu-r/opb/rep/R-REP-F.2393-2017-PDF-E.pdf> [↑](#footnote-ref-7)
8. <http://www.etsi.org/technologies-clusters/technologies/fixed-radio-links> [↑](#footnote-ref-8)
9. <http://www.etsi.org/technologies-clusters/technologies/millimetre-wave-transmission> [↑](#footnote-ref-9)
10. Normally in the frequency band 10 GHz and beyond. [↑](#footnote-ref-10)
11. Generally below 10 GHz frequency band and used to provide connectivity in the circle including spur routes. [↑](#footnote-ref-11)