Reliance Jio
Infocomm Limited

RJIL/TRAI/2014-15/156
5th May 2014

To

Shri Sanjeev Banzal,
Advisor (Networks, Spectrum and Licensing),
Mahanagar Doorsanchar Bhawan (next to Zakir Hussain College),
Jawaharlal Nehru Marg (Old Minto Road),
New Delhi: 110 002

Subject: **TRAI's Consultation Paper on Allocation and Pricing of Microwave Access (MWA) and Microwave Backbone (MWB) RF carriers.**

Sir,

Pl find attached comments of Reliance Jio Infocomm Limted (RJIL) on the issues raised in consultation paper No. 02/2014 on "Allocation and Pricing of Microwave Access (MWA) and Microwave Backbone (MWB) RF carriers".

Thanking You,

Yours Sincerely,

For Reliance Jio Infocomm Ltd.,

Kapoor Singh Guliani
(Authorised Signatory)

Encl.: As above.

Operating Office: D-7, Dhawandeep Building, 6, Jantar Mantar Road, New Delhi - 110001, India. Tel: 011-43523795; Fax: 011-23340453
Registered Office: 3rd Floor, Maker Chambers IV, 222, Nariman Point, Mumbai - 400021, India. Tel: 022-22785500; Fax: 022-22785560

RJIL's comments on TRAI consultation paper on Allocation and Pricing of Microwave Access (MWA) and Microwave Backbone (MWB) RF carriers

Modern high capacity networks require equally efficient backhaul networks to enable the customers to have an always connected experience. Due to proliferation of high data rate radio network the need for high-density and high-capacity backhaul networks will keep on increasing every year. These Microwave Access & Microwave Backbone networks are also essential to deliver high performance in a cost effective way as we migrate to high speed data-rate modern communication system and services. With proliferations of the high capacity all IP Access networks & ever improving technologies the operators are always looking at various ways to make efficient use of the available resources including MWA & MWB. The demand for wider channels for backhaul will continue to grow as operators roll out next generation technologies or migrate their systems to new efficient networks. The new data rich services will place additional demands on the access network and the backhaul spectrum which may become the constraining factor in high speed data-rate modern communications systems, if its allocation and pricing issues are not addressed at this stage.
We, therefore, welcome the timely step taken by TRAI by issuing the detailed consultation paper on the critical issue of allocation and pricing of Microwave Access (MWA) and Microwave Backbone (MWB) RF Carriers. Our comments on the various issues raised in this consultation paper are submitted as below:

ISSUES FOR CONSULTATION

Q 1. 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.

Q 2. 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.

Comments on Q1 & Q2:

We agree with the report submitted by the committee constituted by DOT in December 2010 to determine the requirement of microwave access carriers (MWA) for different

RELIANCE JIO INFOCOMM LIMITED

services, only for 2G & 3G services. However, for standalone BWA and BWA with access spectrum in 900/1800 MHz band it is submitted that number of microwave carriers (MWA) suggested by DOT committee are not adequate. Based on the technical analysis of LTE TD networks using only BWA spectrum (2300 MHz band), it is submitted that the number of MWA carriers required in spectrum band below 26 GHz on exclusive basis per Licensee per service area, for networks having only BWA spectrum in 2300 MHz band and those having BWA spectrum in 2300 MHz band along with access spectrum in 900/1800 MHz band may be done as suggested below:

Spectrum	Metro & A Circle	B Circle	C Circle
BWA spectrum in 2300 MHz band	6 to 8	4 to 6	
BWA spectrum in 2300 MHz band along with access spectrum in 900/1800 MHz band	8 to 10	6 to 8	

For standalone BWA networks, minimum **six** MWA carriers in Metro & A circles and minimum **four** MWA carriers in B & C circle need to be allotted initially with the provision to increase them to eight and six respectively depending on network architecture deployed and network capacity enhancements.

However, for BWA networks with 900/1800 MHz spectrum, minimum **eight** MWA carriers in Metro & A circles and minimum **six** MWA carriers in B & C circle need to be allotted initially with the provision to increase them to ten and eight respectively depending on network architecture deployed and network capacity enhancements to cater to the increased data traffic capacity requirements of LTE networks operating in both 2300 MHz and 900 / 1800 MHz spectrum bands

In addition, MWA carriers with spectrum band above 26 GHz should also be issued based on requirement and justification for its utilization from the concerned Licensee based on feasibility & as per provisions in National Frequency Allocation Plan.

Further, at least two MWB carriers need to be allocated for each Licensee per service area on exclusive basis irrespective of type of access spectrum deployed. Beyond the initial two MWB carriers, additional MWB carriers can be allocated on link by link basis, based on network architecture deployed and network capacity enhancements.

Technical Analysis for MWA requirement for LTE TD Networks using BWA spectrum

Detailed technical analysis of LTE TD networks using standalone BWA spectrum, as mentioned below, has been carried out to ascertain the requirement of the number of

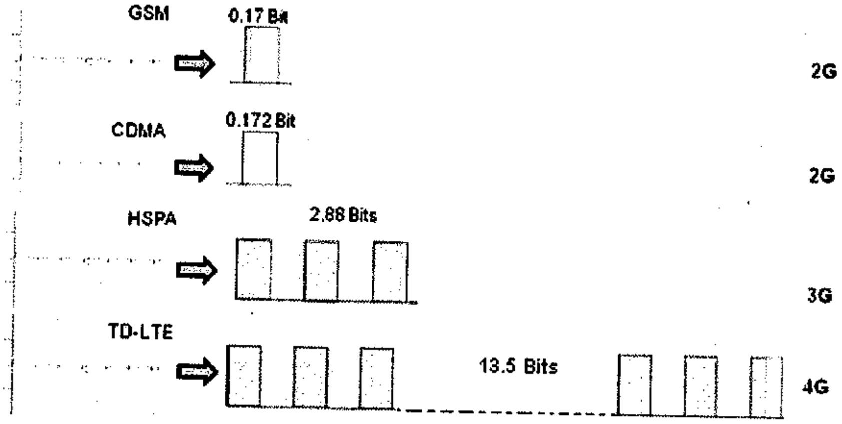
RELIANCE JIO INFOCOMM LIMITED

MWA carriers. This analysis is also supported by a sample network simulation of Mumbai using state of the art tools available in the industry and is placed at **Annexure.**

1 Main Differentiators for TD-LTE Networks

1.1 Massive Data Packing Per Hz in LTE Network

Figure below shows the bits carried per Hz for various technologies.



LTE provides massive packing of bits per Hz of spectrum

It may be seen that there is a massive difference (more than 4.5 times) in the number of bits per Hz that BWA network will provide when compared to existing 3G operators. The difference is much more when compared to 2G operators.

1.2 Quantity of BWA spectrum is twice that of 3G spectrum

BWA network has 20 MHz of contiguous spectrum against 5x2 MHz spectrum in 3G network. The combination of high spectral efficiency and double quantity of the spectrum permits BWA network to provide data capacity per sector which is 9 times or more than a typical 3G data capacity. Compared to the existing 2G networks, the increase in data rates will be even higher.

1.3 Deploying Multi-input Multi-output (MIMO) Technology:

LTE network deploy MIMO technology for antenna systems, a technique that is virtually non-existent in most of the current networks.

LTE has a family of multi antenna solutions that allow the exploitation of spatial-domain as a new dimension in the quest for higher spectral efficiencies. With the use of multiple antennas (4 Transmit and 4 Receive configuration, for example) the achievable spectral efficiency scales linearly with the number of transmit and receive antennas employed in suitable radio propagation environments. This enables a peak throughput of 270 Mbps per sector for 20 MHz spectrum.

RELIANCE JIO INFOCOMM LIMITED

1.4 Rapid maturation of LTE Advanced Standards

Considering the scarcity of the spectrum it is in our national interest that operators exploit the latest technology so as to most efficiently utilize the limited spectrum available to them and meet the growing demand of fast internet access and multi-media services.

LTE still falls short of the 'International Mobile Telecommunications (IMT) Advanced' requirements enumerated by the International Telecommunication Union (ITU). This advanced system will provide peak data rates up to 1 Gbps. LTE networks will focus both on high data use enterprise and retail customers.

1.5 Customer Push

The devices that the customers use for Fast Internet services have undergone a sea change from the current scenario which is based mainly on Desktops/Laptops. The customers are increasingly using Smart phones, i-Pad and Kindle like devices in addition to the Slim Notebooks that have recently emerged in the Market Place. New services like TV everywhere, online gaming and similar services being developed are putting pressure on service providers to offer these services & upgrade their networks constantly.

The huge amounts of data being guzzled by the i-Phone and its smart phone brethren already demonstrates the explosion in capacity demand that we are going to witness sooner than later. In the Indian context where the Broadband capacity and connectivity have been severely limited so far, the growth in demand will be exponential.

Significantly, the customers requiring high data rate services are typically located in dense central business districts necessitating the need of a large number of Base stations in a small geographical area.

1.6 BWA spectrum band requires greater number of base stations

The BWA spectrum of 2.3-2.4 GHz being higher than the existing 800/900/1800 MHz spectrum bands provides lesser cell size and hence requires higher number of base stations for covering the same area.

Typically, to cover the same geographic area, the number of base station required in the BWA spectrum will be three times those required at 850/900 MHz and 1.60 times at 1800 MHz.

Therefore the base stations are typically 230 to 350 meters apart leading to high density and greater interference is caused while forming the microwave backhaul rings.

1.7 Need to avoid Choking of Backhaul

The massive data rate increase in the 'Broadband Wireless Access (BWA)' will require matching capacity in the backhaul. Unless the backhaul is properly tailored and

RELIANCE JIO INFOCOMM LIMITED

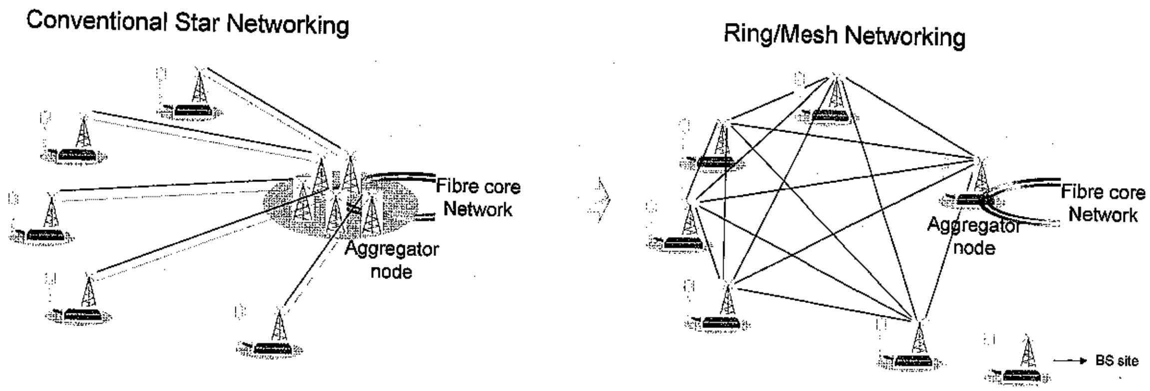
dimensioned to carry this data to the network, the purpose of LTE networks will be lost resulting in poor data rates and inferior customer experience. Thus it is critical that backhaul does not become the 'choke point' of the network.

1.8 Need for Partial Mesh Networking in Backhaul

Existing networks in India have a typical hub and spoke arrangement where each Base Station is connected only to the aggregation point and there is no connectivity between base stations. However, in LTE systems, there is need for partial meshing of base stations to each other.

The X2 interface in LTE has been standardized for creating interconnections between the base stations. This interconnection requirement adds to major complexity and capacity increase for BWA backhaul – requirement which is non-existent in backhaul systems of existing networks.

In the 3GPP LTE architecture wherein the base stations are connected to each other over a standardized X2 interface, during handovers the bearer traffic (which is considerable in LTE) will flow directly between the neighbouring base stations without the need for travelling to the core network node. This fundamental difference requires Ring/Mesh connections in the backhaul for which typically ring architecture is implemented in which the base stations have one-to-one logical connections using the physical ring topology. This has multiplier effect on the data capacity of the rings – even though a single LTE base station generates 100 Mbps traffic, a ring of 4 – 5 base station requires that the ring carries a data rate of 400 to 500 Mbps.



Backhaul Network Topologies

Thus the backhaul in BWA not only requires fat data pipes for connection of base stations to the aggregation point but also data pipes between base stations.

2 Microwave Backhaul Planning Considerations

2.1 High Capacity Ring Architecture

- As submitted above, a BWA network based on LTE is to be designed to deliver high throughputs in its serving cells, typically, 100 Mbps per base station site. Further enhancements with LTE-Advanced, will drive the throughput to still higher values.
- In microwave backhaul, possible network topologies can be ring, hub and spoke or a combination of these two. There are two reasons for creating ring architecture. a.) Compliance to Telco grade network availability by creating a one-cut-not-out ring architecture b.) Need to implement the X2 interface as mandated by 3GPP standards. Therefore, the simple hub-and-spoke architecture cannot be applied to 4G / LTE systems.
- Backhaul equipment available today offers link throughputs of the order of 200 Mbps in a single 28 MHz channel. This can be increased to 400 Mbps using special techniques like XPIC or Dual Channel using two 28 MHz channels. Just 4 Base stations in a MW ring will exhaust the capacity of 400 Mbps available on the ring whereas many more 2G base stations can be served by this capacity of MW ring.
- It can be seen that for the same number of base stations, the number of rings required in the MW backhaul for LTE networks will be several times more than the rings in backhaul for 2G/3G networks, thus increasing the requirement of MWA carriers manifold for LTE networks.

2.2 Ring Aggregation at Fiber PoPs

- A set of rings must terminate at an aggregation hub, typically a point of presence (PoP). In central business districts the demand for data would be the highest whereas the number of Fiber PoPs will be limited.
- Therefore a large number of rings must terminate on a limited number of fiber PoPs. For example, if there are 40 base stations in a densely populated business district, there will be at least 10 rings in a LTE network and these will terminate on a single fiber PoP. Moreover the inter-site distance between the base stations will be very small due to high propagation losses in 2.3 GHz band.
- Therefore, multiple MW frequency spots are essential to limit the interference between the various rings terminating on a single aggregator hub which is due to spill-over of a beam emanating from a node in the ring and directed towards a node on the aggregator hub into another beam emanating from another node and directed towards yet another node on the same aggregator hub.

3 Microwave Backhaul Network planning

Microwave Backhaul Network planning for start-up standalone BWA operations done by sample network simulation of Mumbai using state of the art tools available in the industry is placed at **Annexure** to these comments. The conclusion is as below:

i. Standalone BWA operators will require 6 Microwave frequency spots for start-up in Metros and A-circles. We find that the cell radius is very small (230 m to 350 m) in the dense urban areas of several major cities and therefore they will need identical number of microwave spots.

ii. In cities of B and C circles, the typical cell radius is between 360 m to 420 metres. For standalone BWA operators 4 Frequency spots may be sufficient for start-up in B-circles and C-circles considering the lower density of cell sites in these circles.

iii. Contiguous frequency spots are preferable to optimize link capacity.

4 FREQUENCY SPOT SELECTION

Specific requirements for backhaul frequency spots for BWA roll out are as below:

- New microwave transport advances have delivered bandwidth saving techniques which deliver compression capabilities that can deliver 10-30% gain increase which increases the effective microwave spectral efficiency. Even with such microwave link bandwidth minimization techniques, there is still a requirement to provide 56 MHz to 84 MHz of microwave spectrum per link. This necessitates requirement of at least 6 x 28 MHz frequency spots in order to minimize the intra-system interference that occurs with a lesser number of channels.
- Availability of contiguous frequency spots provides significant advantage in terms of requirements of the number of Microwave equipment. Contiguous frequency spots of 28 MHz allow a single Radio to be used for two 28 MHz channels instead of two separate Radios for each 28 MHz channel.
- This will also result in de-cluttering of microwave antenna sites as lesser number of Radios are required to be mounted atop the site if frequency spots are allocated in a contiguous manner.

Q 3. Should excess spectrum be withdrawn from existing TSPs?

Q 4. 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?

Comments for Q3 & Q4:

RELIANCE JIO INFOCOMM LIMITED

The existing allocations of MWA and MWB carriers need to be examined with respect to MWA / MWB allocation as well merger & acquisition guidelines and the microwave carriers beyond the number prescribed in set MWA / MWB allocation guidelines, should be withdrawn immediately.

Q 5. 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'?

Comments:

Exclusive basis assignment is better, since it is easier to do the microwave network planning from both Link engineering/RF planning perspective with complete set of microwave carriers known in advance and to implement MWA / MWB equipment network at the sites. This will also take care of the design of microwave links to the appropriate capacity and ensure optimal loading of all microwave carriers in the network. Since the availability of MWA & MWB is ensured along with Access spectrum Operators can define time to market and deployment time is much faster this way. This will also ensure the faster roll-out and minimum network outages in case of major and critical outage scenarios due to properly designed microwave network having ring architecture.

This will help operators to protect their investment in procuring the right microwave material at initial stage as the microwave radio is frequency band dependent. So, by choosing the right material and implementing the right topology and plan will help operators to avoid the frequent re-engineering and access backhaul resulting in less wastage of hardware, site material, services and cost effective operations. This will in turn enhance the customer satisfaction level.

Q 6. In case 'exclusive basis' assignment is preferred, whether MWA and MWB carriers should be assigned administratively or through auction. Please comment with full justifications.

Comments:

For such 'exclusive basis' assignment, MWA and MWB carriers should be assigned administratively and not through auction. Auction can be a preferred method for access spectrum allocation but it will not be appropriate for MWA and MWB carriers. The requirement of backhaul carriers will keep on changing with increase in number of customers and associated traffic. It will also be dependent upon the fibre rollout of the operators which requires considerable time and costs. It will be very difficult for any operator to ascertain its backhaul carrier requirement in advance for the long term.

Further, the new operators will be hesitant in participating in the access spectrum auction if there is no certainty about availability of the backhaul which will lead to reduced participation in the access spectrum auctions thereby impacting government's revenue due to lack of competition. As pointed out in the consultation paper, even internationally very few countries have attempted auction of backhaul spectrum with mixed results and most of the countries continue to assign backhaul spectrum administratively. The auction of MWA & MWB spectrum separately will also bring uncertainty to access spectrum auction. Therefore there is no reason for the Government to change the prevalent regime of allocating backhaul spectrum on administrative basis which has enabled greater competition, enhanced revenues through access spectrum auctions and overall growth in the telecom sector.

Q 7. In case 'link-to-link basis' assignment is preferred, how the carrier assignment for different links should be carried out, particularly in nearby locations?

Comments:

As submitted earlier, the preferred basis of assignment of MWA / MWB carriers to the TSPs is 'Exclusive basis assignment'. In the event 'link-to-link basis' is adopted for MWA / MWB carriers, Licensees should get different channel bandwidth options of 28 MHz, 56 MHz, 112 MHz as per guidelines.

Q 8. 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?

Comments:

As stated above a minimum set of MWA & MWB carriers should be allocated along with the allocation of access spectrum for the technology being deployed by the operators. Only if minimum allocated microwave carriers are fully utilized then based on network architecture deployed and planned network capacity enhancements the additional carriers can be assigned. This may also be allocated to mitigate interference or any other technical issue if any. However, the additional carriers may be allocated only to the extent permitted as per set allocation guidelines.

Q 9. How can it be ensured that spectrum carriers assigned are used optimally and the TSPs are encouraged to move towards the OFC?

Comments:

This can be done through periodic MW frequency Utilization audit. Following, suggested, criteria can be used to ascertain the optimal utilization of Microwave carriers are:

- Link by Link basis analysis of utilization in a service area based on topology & technical requirements like interference etc.
- Actual throughput of the link v/s throughput capacity of the link.
- Connection to network it is meant for and its utilization, and
- End customer experience

The main impediments for laying OFC primarily within urban areas are obtaining requisite permissions from local authorities and unreasonable conditions imposed in for laying fibre and associated reinstatement costs. If the Ministry simplifies sectorial policy for Right of Way for laying OFC in coordination with the State Governments / local bodies, as envisaged in NTP-2012 objectives, TSPs will be encouraged to move towards the OFC.

Q 10. Should an upfront charge be levied on the assignment of MWA or MWB carriers, apart from the annual spectrum charges?

Comments:

Access spectrum for Mobile communication is already available through auction route only and to quickly deploy the BTS's there is a need for MWA & MWB spectrum hence we feel that there is no reasons for levy of an upfront charge over and above the annual spectrum charges for the assignment of MWA or MWB carriers and we believe it shouldn't be applied. We feel that as per set guidelines MWA & MWB spectrum should be allocated to access providers at the time of allocating access spectrum won through auction.

Q 11. 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?

Comments:

The annual spectrum charges for MWA and MWB carrier as a percentage of AGR should be charged on the basis of number of MWA carriers and MWB carriers as is being done presently but separately for MWA and for MWB carriers.

Q 12. 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.

RELIANCE JIO INFOCOMM LIMITED

Comments:

We suggest that the existing slabs in case of percentage AGR based pricing are optimal and there is no need for any change. However, the MWA (meant for enabling access spectrum reuse) and MWB (meant for network nodes connectivity for rolling out the network) carriers should be counted separately for charging of AGR based slab rates. Also it should be ensured that these slabs are made applicable to all operators uniformly, irrespective of access technology used, so as to ensure level playing field.

Q 13. 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/21GHz/26GHz/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.

Comments:

As replied above we prefer allocation of spectrum on exclusive basis however if Link by Link methodology is used then spectrum for charging may be charged in two slabs of sub 26 GHz & above 26 GHz. It is submitted that for higher spectrum band the cost should be lower, as there are more available channels and more possibility for reuse to promote efficient utilization of spectrum.

The following factors can be considered for deciding the link-by-link charging mechanism for sub 26GHz band.

- Frequency bands increasing in frequency (6 / 7 / 8 / ... / 13 / 15 GHz) should have inverse co-relation to pricing due to better coverage in these bands.
- Spectral utilization [bits/Hz] – As the efficiency goes higher, the price should be lower and therefore should have inverse co-relation to pricing since it will promote operators to go in for employing spectrum efficient systems.
- Channel BW: For higher bandwidth the price should be higher and therefore should have direct co-relation to pricing.

It may be noted that the above pricing method is not recommended for MW Spectrum bands in 28, 42, 60, 80 GHz. These bands are severely underutilized and should be promoted with light touch regulations.

Q 14. 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?

RELIANCE JIO INFOCOMM LIMITED

Comments:

Yes, higher channel bandwidth shall be allowed, as is done in other countries and the spectrum allocation should be re-worked for this purpose. Higher frequency (>26GHz) should be promoted. It can be seen that 80MHz (NA, Europe) and 112MHz (Europe) channels are being approved by respective regulators as a response to the increase in MW link capacity. Such additional spectrum bands can also be offered in India, especially in new bands (28, 42GHz) with lower pricing to act as incentive to utilize them.

Q 15. In your opinion, what is the appropriate time for considering assignment of MWA carriers in higher frequency bands viz. E-band and V-band?

Comments:

Considering growing need for it, primarily in urban environment, the assignment of MWA carriers in higher frequency bands (E-band and V-band) should be taken up at the earliest.

Q 16. Should E-band be fully regulated or there should be light touch regulations?

Comments:

The E-band allows for relatively short links, high reusability and high Bandwidth. Due to a very high reuse factor and limitation of usage, it is recommended to have a light licensing scheme for E-band. This is commonly followed all over the world.

Q 17. What charging/pricing mechanism would be appropriate for these bands?

Comments:

It is suggested to have simple approach of Light licensing scheme, as followed internationally.

Q 18. Apart from Q1-Q17, stakeholders are requested to bring out any other issue, which needs to be examined, with justification.

Comments:

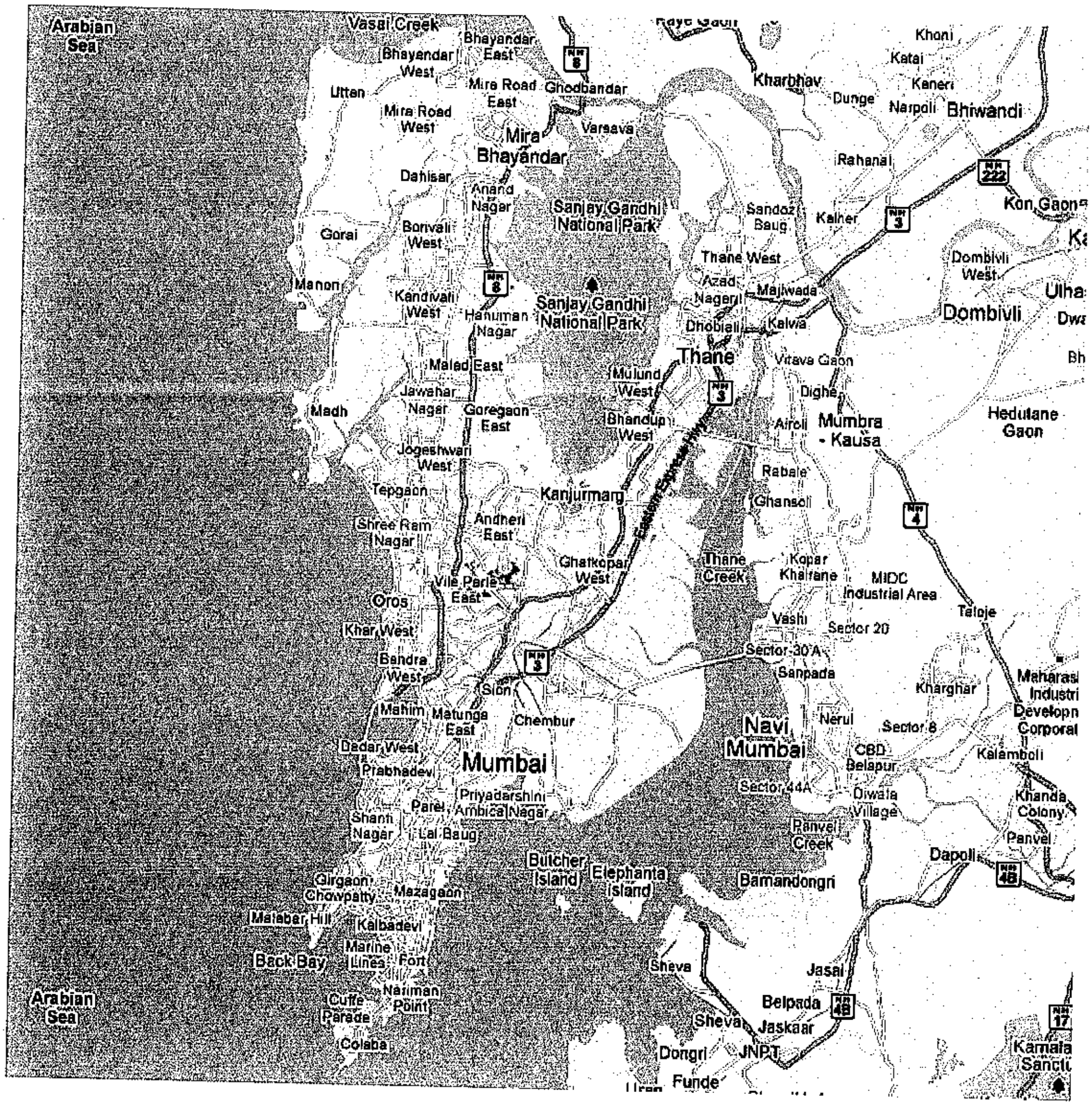
Nil.

RELIANCE JIO INFOCOMM LIMITED

ANNEXURE

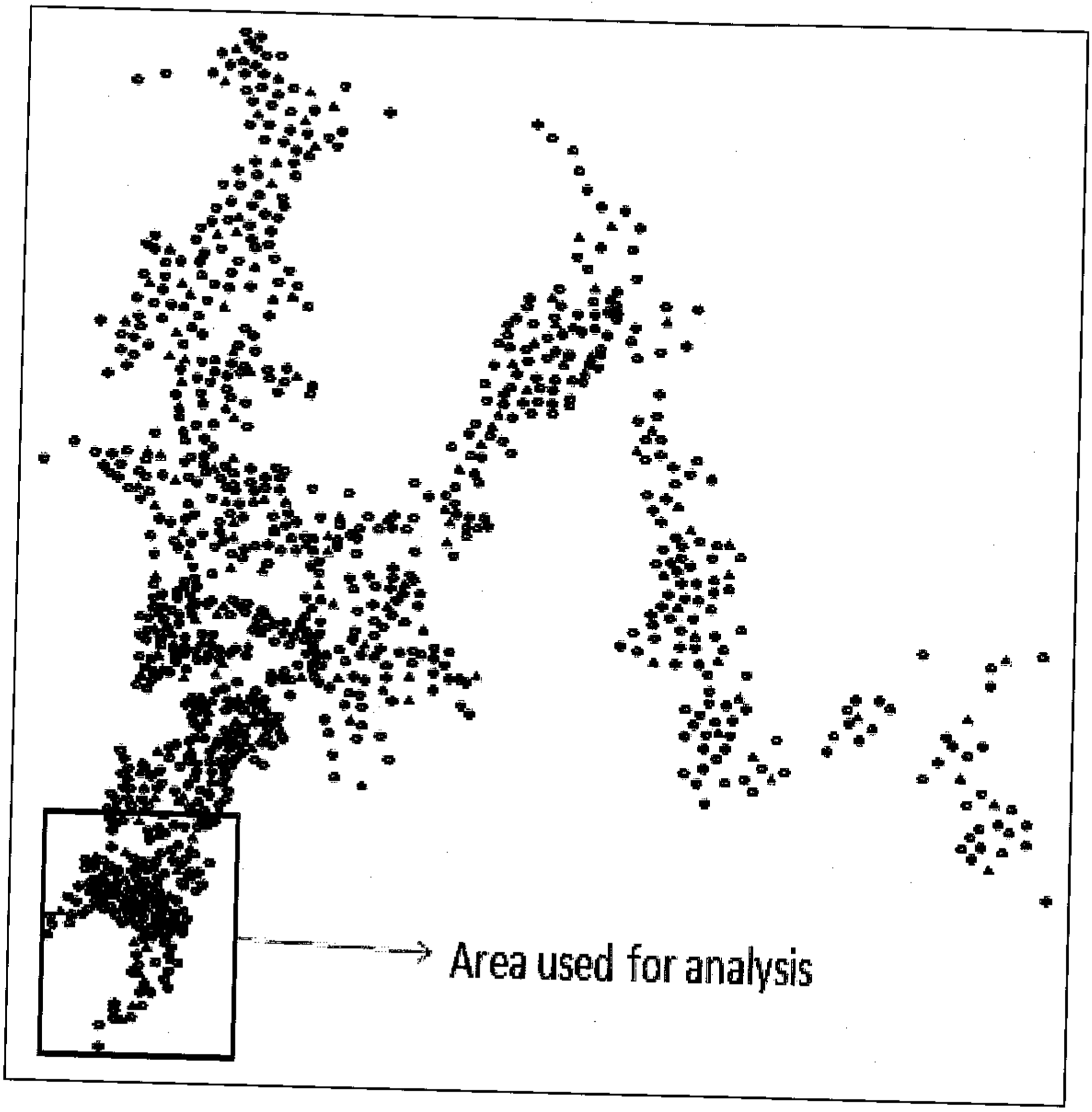
Microwave Backhaul Network planning – Mumbai

Sample network planning for start-up of a part of Mumbai network is presented here. The figures below presents map of Mumbai and the backhaul network designed for Mumbai with each dot representing a microwave backhaul site.



Mumbai Map

RELIANCE JIO INFOCOMM LIMITED



Backhaul Network Design for Mumbai

RELIANCE JIO INFOCOMM LIMITED

A Microwave Backhaul Planning - Mumbai Circle

- Mumbai circle area is divided into three parts based on subscriber density.
- Three parts of the Mumbai Circle area are as follows:
    - Dense Urban (South Mumbai)
    - Urban (North and Central Mumbai)
    - Suburban (Navi-Mumbai)
- To cover all three areas, about 3400 eNodeB sites would be required initially for start up
- For aggregation eNodeB sites (AG1), about 680 fiber PoPs (20% of total 3400) are used.
- Two, four and six frequency spots in 13 GHz are assumed to determine the optimum number of microwave frequency spots.

Frequency Spots used for Mumbai Microwave Backhaul Planning

[illegible]	[illegible]	[illegible]
1	13031	12765
2	13059	12793
3	13087	12821
4	13115	12849
5	13143	12877
6	13171	12905

B Network Design Parameters

Network design of Mumbai is based on the following parameters:

1. Dense Urban region is used for simulation.
2. Total no. of sites used in simulation – 374
3. Total no. of fiber pops used – 75
4. Total no. of rings – 61
5. Total no. of spurs – 55
6. Max no. of rings terminating on single fiber Pop – 03

RELIANCE JIO INFOCOMM LIMITED

7. Capacity per link – 400 Mbps
8. Capacity per site – 100 Mbps
9. Total number of microwave links – 360
10. Total no. of frequency spots used in 13GHz/28MHz – 2, 4 and 6.
11. Threshold Degradation Objective – 3 dB. If interference level increases above 3 dB then link switches to lower modulation scheme resulting in throughput degradation. Table below shows a mapping of Modulation Scheme and supported throughput.

Mapping of Threshold Degradation to Modulation and Throughput

[redacted]	[redacted]	[redacted]	[redacted]
Above 10 dB	QPSK	74	400
5-10 dB	32 QAM	200	400
3-5 dB	64 QAM/128QAM	220/288	400
0-3 dB	256 QAM	400	400

C Summary of interference cases with 2 Frequency Spots

When 2 frequency spots of 28 MHz in 13GHz frequency band are used for planning, a total of 753 interference cases are found in the network.

Summary of the interference cases with 2 Frequency Spots

[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
354	Above 10dB	QPSK	74	400
250	5-10dB	32 QAM	200	400
149	3-5dB	64 QAM/128QAM	220/288	400

From the table above, it is clear that ring architecture is not possible with Dual Channel. As almost every ring is having at least one interference case, which results in decrease of total throughput of the ring.

RELIANCE JIO INFOCOMM LIMITED

D Summary of interference cases with 4 Frequency Spots

Mumbai Dense Urban

When 4 frequency spots of 28 MHz in 13GHz frequency band are used with Dual Channel configuration, a total of 150 interference cases are found in the network.

These were reduced to 65 after following interference mitigation techniques were used:

- ATPC (Automatic transmit power control)
- Load sharing
- Polarization change
- Proper transmitter high low planning
- Lowering the transmit power
- Proper use of suitable antennas to achieve the proper Beam-width
- Maximum frequency reuse separation

Summary of the interference cases with 4 Frequency Spots: Mumbai Dense Urban

[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
18	Above 10dB	QPSK	74	400
10	5-10dB	32 QAM	200	400
37	3-5dB	64 QAM/128QAM	220/288	400

From the table, it is clear that ring architecture is not possible with Dual Channel. As almost every ring is having at least one interference case resulting in decrease of total throughput of the ring.

E Summary of interference cases with 6 Frequency Spots

When 6 frequency spots of 28 MHz in 13 GHz frequency band are used with Dual Channel configuration, no interference cases are found above a threshold degradation point of 3 dB. Table below provides a break-up of interference cases from 0 to 3 dB.

RELIANCE JIO INFOCOMM LIMITED

Summary of the interference cases with 6 Frequency Spots

[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
0	Above 10dB	QPSK	74	400
0	5-10dB	32 QAM	200	400
0	3-5dB	64 QAM/128QAM	220/288	400
181	2-3dB	256QAM	400	400
374	1-2dB	256QAM	400	400
559	0-1dB	256QAM	400	400

F Summary of interference cases with 4 Frequency Spots: Entire Mumbai

When the same exercise was repeated for entire Mumbai (2720 sites) using 4 frequency spots, a total of 1298 interference cases were found. A break-up of the interference cases is shown in Table below.

Summary of the interference cases with 4 Frequency Spots: Entire Mumbai

[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
282	Above 10dB	QPSK	74	400
579	5-10dB	32 QAM	200	400
437	3-5dB	64 QAM/128QAM	220/288	400

G Summary of Observations from Mumbai Case Study

1. The case study only covers a small part of entire microwave backhaul network for Mumbai. The number of interference cases is likely to be much higher when a complete city-wide network is considered. (e.g. 65 cases with 4 spots for Dense Urban area of Mumbai and 1298 cases with 4 spots for Entire Mumbai).
2. It is evident from this case study that four frequency spots are not sufficient for 4G network deployment in metro cities like Mumbai.
3. The interference in microwave backhaul networks for start-up in Metro and major cities can be eliminated by only on using 6 frequency spots for microwave planning.

RELIANCE JIO INFOCOMM LIMITED