Capacity Increasing in a Cellular Network Using Multibeam Antenna

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Abstract

Today's mobile subscribers have a voracious appetite for data. As smartphones flood the wireless market, the demand for higher data throughput continues to skyrocket. As a result, operators are searching for simple, cost-effective ways to add capacity. Timely rollout of new 3G and 4G services is key to addressing subscriber needs and protecting their reputation for efficiency and reliability.

When operators need to add capacity, they typically build new cell sites or split sectors by adding more antennas to existing sites. However, both options are time-consuming and expensive.

To build new cell sites, the expense, time and effort required to deploy a new site is significant. Deployment costs and regulatory approvals can easily delay the installation of new sites for up to 2 years. Given these challenges, operators understand that this option is no longer realistic.

Add more equipment to existing sites is also expensive and complex. The conversion process overlays new technology onto older infrastructure, requiring a complete radio frequency path to the base station for each new sector. You may also need filters, tower-mounted amplifiers or multi-band combiners, which can cause compatibility issues and pile on the expenses. Zoning challenges, leasing fees and extra wind load can add even more complexity to the process.

Multi-beam antennas can give double, triple even nine times more capacity compare to existing without adding more antennas on site.

Approval Sheet

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Candidate Declaration

It is hereby declared that this project or any part of it has not been submitted elsewhere for the award of any degree or diploma.

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Acknowledgement

I’m grateful to the almighty for directing me toward the right path in order to pursue the full requirement of project and thesis work.

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Chapter 1: Introduction

1.1 Overview of Bangladesh Telecom Market:

Bangladesh is densely populated country. Present population is around 160.411 Million. Population growth rate is 1.22. By considering number of connections, presently 75% of total population are using mobile phone and among them only 6% is using smart phone.

Presently there are 6 mobile phone operators and 3wimax operators in Bangladesh. As Bangladesh is a very densely populated country so the telecom market is not so small here. Grameen phone is the leader in this market. Presently the subscribers of the mobile operators as below.

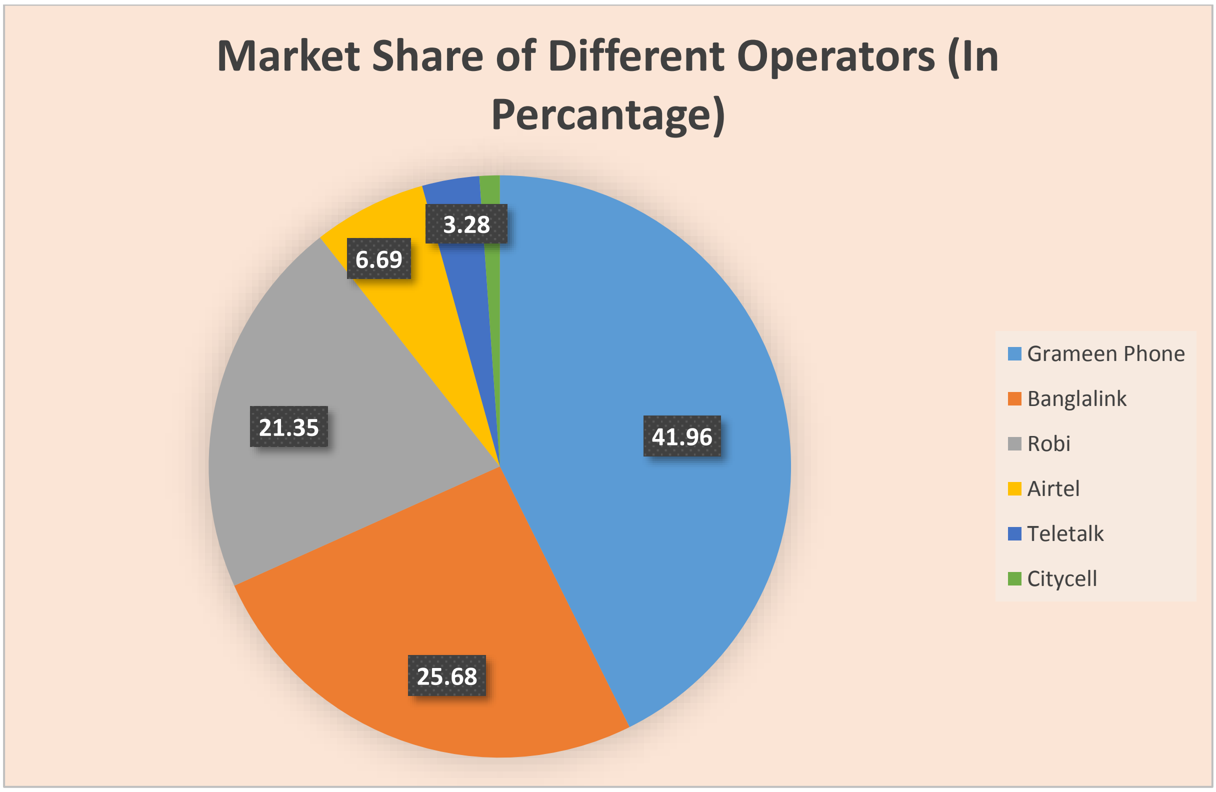


Fig 1: Bangladesh Telecom Market

Table 1: Number of Subscribers

Sl	Name	Number of Subscriber (Million)
1	Grameen Phone (GP)	56.679
2	Banglalink	32.865
3	Robi	28.317
4	Airtel	10.710
5	Teletalk	4.143
6	Citycell	1.007

Note: Data source BTRC, End of December 2015 report.

Now the total number of mobile phone users in Bangladesh is133.720million (Dec, 2015) beyond this there are Wimax operators also. Except Citycell, all other operators already has deployed 3G network.

Beside this there are a good number of mobile and wimax Internet users. Mobile internet users' number is increasing though wimax internet users are decreasing. Overall Internet users' growth rate is very promising. As per capital income of the country is increasing in a good rate, so there are a big number of new internet users who will join to the data transfer world within few years.

Table 2: Number of Mobile and Wimax Internet Users

Sl	Types of Users	Number (Million)
1	Mobile Internet	51.453
2	Wimax	0.148

Note: Data source BTRC, December 2015 report.

Grameen phone has a target to boost up their internet users number at 50milion milestone within next few years.

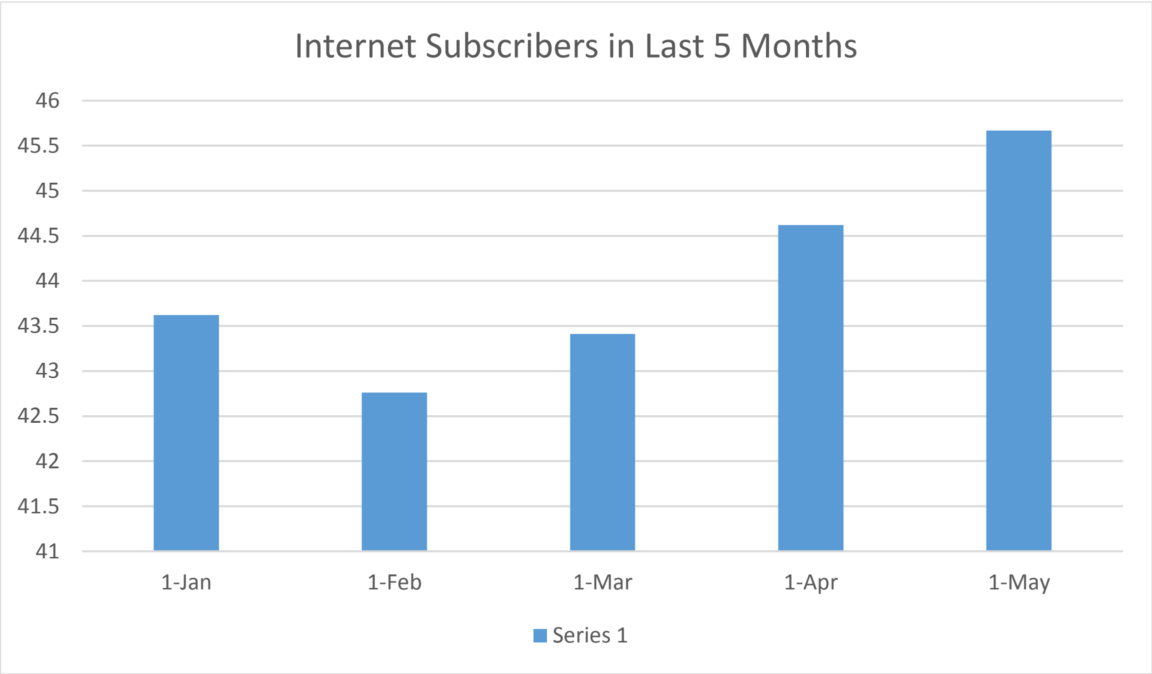


Fig 2: Internet Subscribers Chart

Note: Data source BTRC*(BTRC makesthis statistic by considering the people who are using internet at least one time in last three months)*

1.3 Challenges of the Operators and Solution

Now a day's key challenge for a mobile phone operator is to meet the capacity demand. Providing quality network in high traffic and high data demand area. As well as operators has to keep in mind about the future readiness of the network.

Chapter 2: Back Ground Knowledge and Existing Solution to Meet Data Demand

2.1 Present Technology

Third Generation (3G) radio networks are based on the code division multiple access technology (CDMA) and are currently being installed in countries such as Japan and South Korea. The aim of the technology is to fulfil the user requirement for innovative services such as enhanced and multimedia messaging through high-speed data channels. CDMA is a digital cellular technology that uses spread-spectrum techniques. It does not assign a specific frequency to each user. Rather, every channel uses the full available spectrum. Individual conversations are encoded with a pseudo-random digital sequence. Third Generation networks may also be referred to as Universal Mobile Communication Telecommunication System (UMTS), for example. There are three standards accepted by International Telecommunication Union (ITU). They are Wide-band CDMA (WCDMA), CDMA2000 and time-division synchronous CDMA (TDSCDMA).

2.2Planning Process and Objectives in 3G

2.2.1 Planning Process

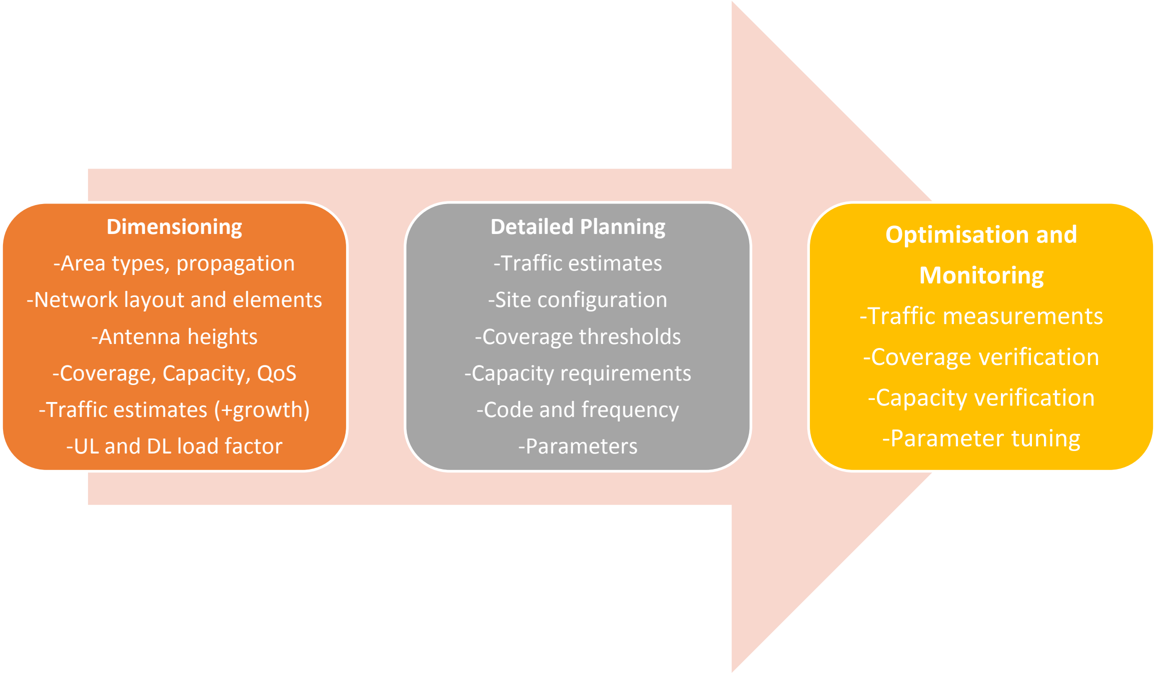


Fig 3: Network Planning Procedure

In the 3G planning, since all carriers in the network use the same frequency range, frequency planning is not required. Furthermore, coverage and capacity planning should be performed in tandem since capacity requirement and traffic distribution influence the coverage. Although there are three distinct standards in 3G networks (each used in different parts of the world), WCDMA, CDMA2000 and TD-SCDMA, the general planning process and overall objectives are the same.

2.2.2 Planning Objectives

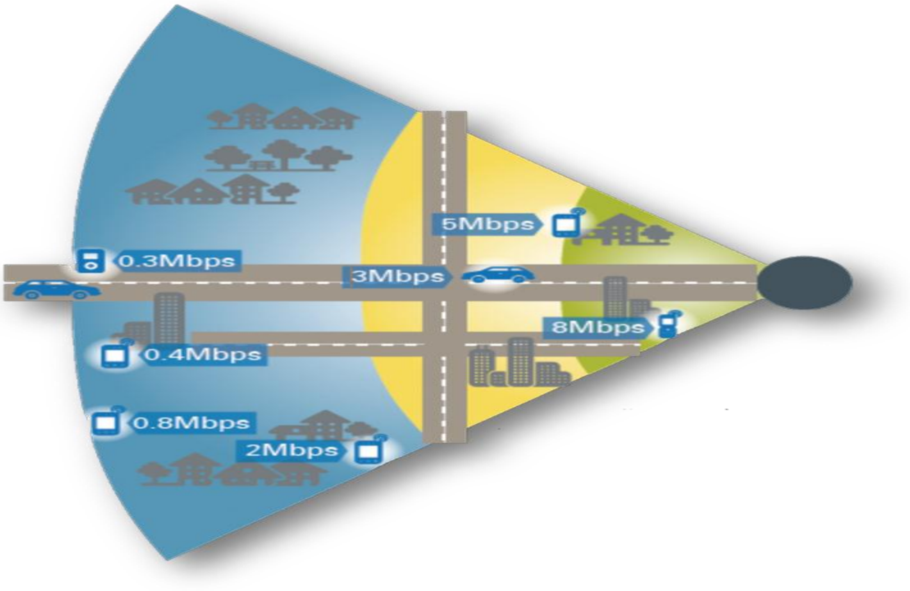


Fig 4: Data speed at the Edge of the Sector

From the above picture it is clear that at the edge of the sector network quality is a big challenge. The overall radio network planning goal is to maximizethe coverage and capacity while meeting the key performance indicators (KPIs) and quality of service (QoS). So the main objectives are

1. Maximize WCDMA Network Capacity
2. Maximize WCDMA Network Coverage

2.3Probable Solutions:

As the goal is to improve capacity and coverage so how these objectives can be achieved those are summarized as follows.

Maximize WCDMA Network Capacity:

• DL capacity is considered more important than UL, asymmetric traffic

• Due to the less multipath microcell capacity better than macro cell

• Adding frequency layers for WCDMA brings more capacity

• Power splitting between frequencies

• Adding cells and sites is expensive and more possible interference

• Power splitting between sectors

• Sectorization

• Transmit diversity

• Lower bit rate codecs for speech (AMR 5,95 – 12.2 kbps supported)

• Multi-beam antennas

• Indoor cells with better interference isolation -> more capacity

• Network evolution with features like HSDPA, HSUPA, MIMO

Maximizing Network Coverage in WCDMA:

• Coverage is limited by UL due to the lower TX power of mobile and BTS RX-sensitivity

• Mast head amplifiers reduce the composite noise figure of the base station receiver

– Uplink link budget is improved and the service coverage improved

– Problems if cell is already DL limited -> DL capacity decreases more

• Active antennas include the low noise amplifier as an integrated part of the antenna itself

• Antenna bearing and tilting can reduce the interference leakage further

• Higher-order receive diversity not generally feasible to deploy with more than 4 branches

• Sectorization improves both system capacity and service coverage at the same time

– Antenna selection and placing is a critical part of planning

• Repeaters provide a solution for extending the coverage of an existing base station

– Problems if repeated cell is already DL limited -> DL capacity decreases more

• Adding more sites is expensive

• Enhance RX –sensitivity leads usually to higher equipment cost

• Multi-user detection and interference cancellation in the future

So from network planning point of view antenna is a very important part to increase coverage and capacity. By considering the existing challenges and demand of the operators, multi-beam antenna can be a very good and optimum solution to enhance coverage and capacity. How it can add value from technical and commercial point of view that is described in next chapters

2.4 Base Station Antenna:

An antenna is a device to transmit and/or receive electromagnetic waves. Electromagnetic waves are often referredto as radio waves. Indeed, the antenna is one of the key points of wireless network since it represents the last link in the chain that allows emission, transmission and reception of the signal and therefore the information contained in it most antennas are resonant devices, which operate efficiently over a relatively narrow frequency band. An antenna must be tuned (matched) to the same frequency band as the radio system to which it is connected, otherwise reception and/or transmission will be impaired.

2.4.1 Antenna Selection Criteria

To select antenna following issues are very important

- Cost of increased capacity:

• Justifiable

- Size/weight:

• Zoning issues

• Mounting requirements

- Form Factor:

• Zoning issues

• Wind loading

- System performance requirements:

• Horizontal & vertical pattern shape, gain, polarization, interference & isolation issues, bandwidth and ports

2.4.2 Some Important Parameter of Antenna

Antenna is very important part of a network to meet data demand of a network. Some parameters of an antenna have direct effect on key performance indicator (KPI) of a network. Which are as follows.

2.4.2.1 Antenna Gain

Antenna gain is a comparison of the power/field characteristics of a device under test (DUT) to a specified gain standard.Gain can be associated with coverage distance and/or obstacle penetration (buildings, foliage, etc.).It is measured using data collected from antenna range testing. The reference gain standard must always be specified.

• An isotropic antenna is a single point in space radiating in a perfect sphere (not physically possible).

• A dipole antenna is one radiating element (physically possible).

• A gain antenna is two or more radiating elements phased together.

• Gain (dBi) = Directivity (dBi) – Losses (dB)

• Losses: Conductor, Dielectric, Impedance, Polarization

2.4.2.2 Main Lobe

The main lobe is the radiation pattern lobe that contains the majority portion of radiated energy. Shaping of the pattern allows the contained coverage necessary for interference-limited system designs.The main lobe is characterized using a number of the measurements which will follow.

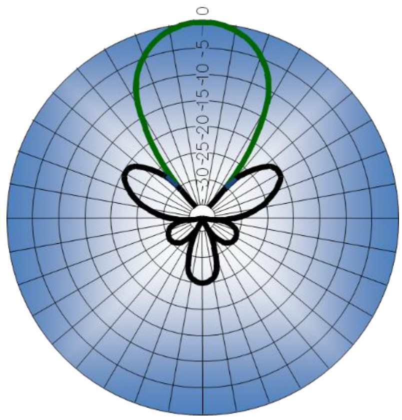


Fig 5: Antenna Patern

2.4.2.3 Half Power Beamwidth

The angular span between the half-power (-3 dB) points measured on the cut of the antenna's main lobe radiation pattern. It allows system designers to choose the optimum characteristics for coverage vs. interference requirements. It is measured using data collected from antenna.

2.4.2.4 Font to Back Ratio

The ratio in dB of the maximum directivity of an antenna to its directivity in a specified rearward direction. Note that on a dual-polarized antenna, it is the sum of co-pol and cross-pol patterns. It characterizes unwanted interference on the backside of the main lobe. The larger the number, the better. It is measured using data collected from antenna range testing.

2.4.2.5 Sidelobe Level

Sidelobe level is a measure of a particular sidelobe or angular group of sidelobes with respect to the main lobe.

Sidelobe level or pattern shaping allows the minor lobe energy to be tailored to the antenna's intended use. See Null Fill and Upper Sidelobe Suppression.It is always measured with respect to the main lobe in dB.

2.4.2.6 Null Filling

Null filling is an array optimization technique that reduces the null between the lower lobes in the elevation plane. For arrays with a narrow vertical beam- width (less than 12°), null filling significantly improves signal intensity in all coverage targets below the horizon.

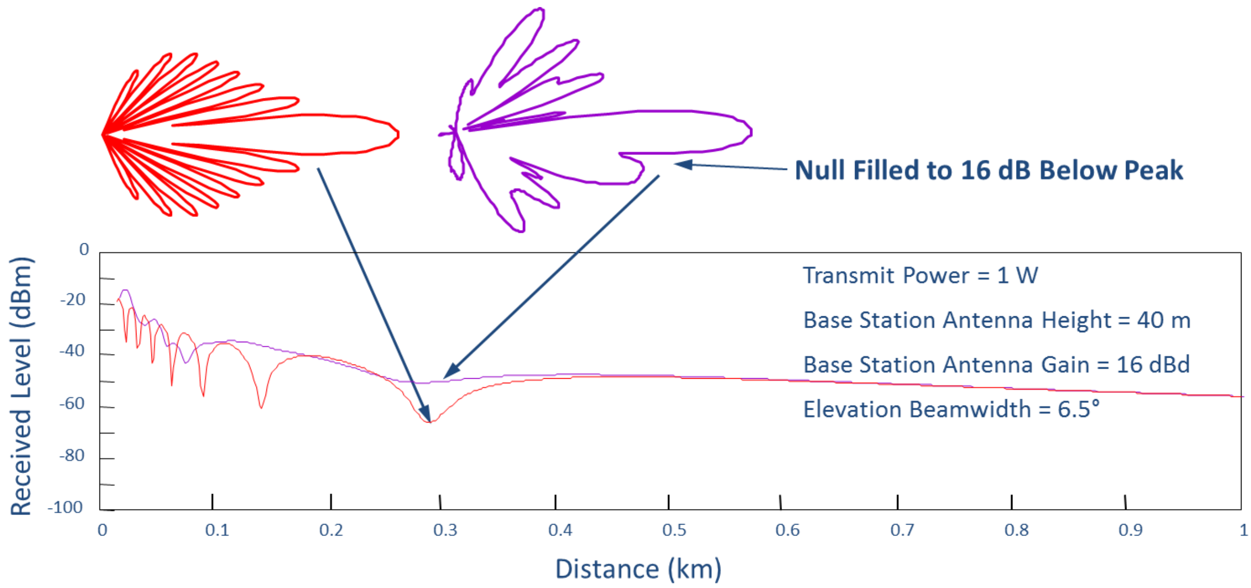


Fig 6: Null Filling

2.4.2.7 Upper Sidelobe Suppression

Upper sidelobe suppression (USLS) is an array optimization technique that reduces the undesirable sidelobes above the main lobe. For arrays with a narrow vertical beamwidth (less than 12°), USLS can significantly reduce interference due to multi-path or when the antenna is mechanically downtilted.

USLS is the relative dB difference between the peaks of the main beam peak of the first upper sidelobe.

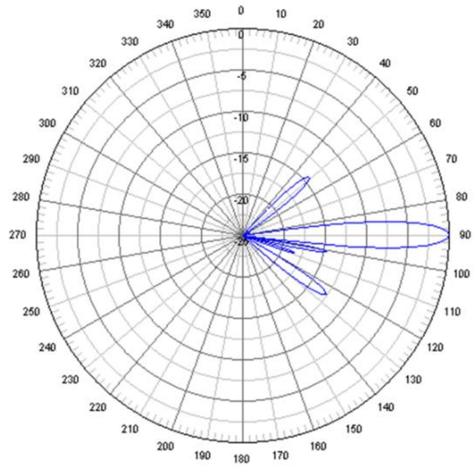


Fig 7: Upper Side Lobe Suppression

2.5 Traditional Antenna and Limitations for Capacity Solution

Traditional antennas have single beam with horizontal beam width of 90deg, 65deg, 45deg and 33deg with different gain. But normally for three sector to cover 360 deg, 65deg HBW antennas are commonly used.

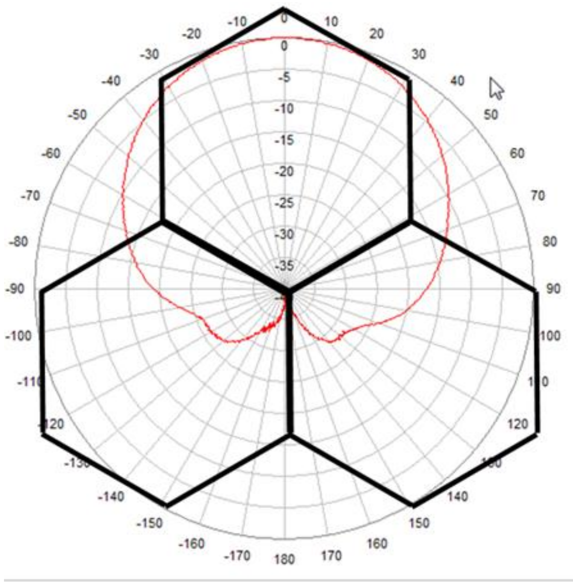


Fig 8: Traditional Site Geometry

The following table is a basic chart where showing the relationship between antenna gain, height and beam width.

Table 3: Antenna Basic

		Gain at 3dB Horizontal Aperture						Length of the Antenna (Ft)		
		360	180	120	90	60	33	800/900	1800/1900	VBW
No Of Radiator Vertically Spaced (0.9)	1	0	3	4	6	8	10.5	1	0.5	60
	2	3	6	7	8	11	13.6	2	1	30
	3	4.5	7.5	8.5	10.5	12.5	15.1	3	1.5	20
	4	6	9	10	12	14	16.6	4	2	15
	6	7.5	10.5	11.5	13.5	15.5	18.1	6	3	10
	8	9	12	13	15	17	19.6	8	4	7.5

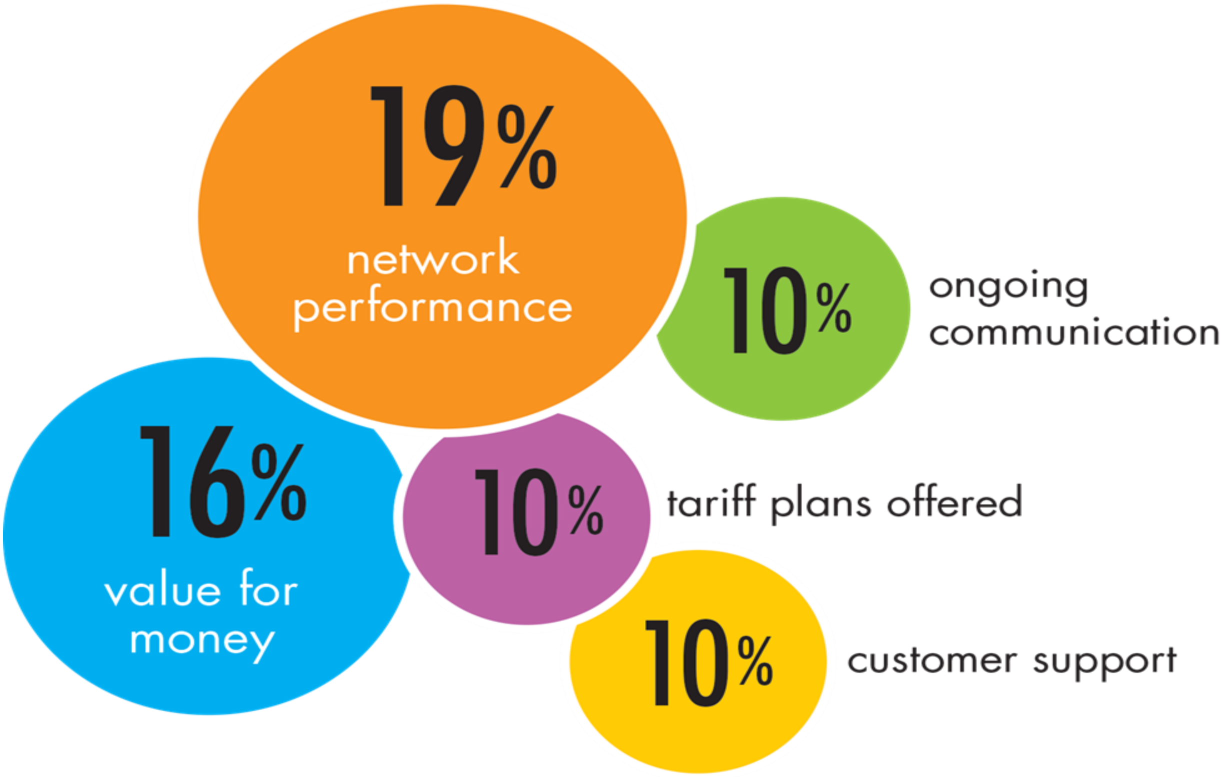
From above table we can understand if we want to get better gain to give better coverage then antenna size will be increased. So if we want to get better gain from traditional antenna by controlling height then we have to reduce antenna horizontal beam width. When an operator wants to meet up especially capacity challenge in urban and semi urban area then they have to do sector sculpting by splitting every sector into two/three even five sectors and need double/triple the antenna number. Which increases investment in terms of OPEX & CAPEX, tower loading and as well as raise site acquisition problem which is a big problem in urban area.

Chapter 3: Proposed Solution

3.1 Multi Beam Technology to Meet-up Data Growth/ Capacity Solution

From the discussion in initial part of this document, it's clear that data demand is increasing rapidly with time. In Bangladesh data growth rate more than 100%.

It's very important to operators to give better quality network to keep this data growth but considering their ROI and other practical challenges. From some statistics it is proved that when customers get better upload and download speed, they use more data. Another important point is when customers not using their smart phone but in the back ground smart phones always update and download something. This usage should be high when the network quality is good.



Note: This Survey Done by Ericsson

Fig 9: How do you keep Smart Phone Users Happy?

From the above statistic most of the smart phone users' happiness depends on network performance.

So to meet this data demand, operators have to split existing sectors and give more capacity in all sectors all any particular sector. Multi-beam antennas are the best solution to fulfill this demand of the operators in an optimum way with better ROI.

Basic principle of multi-beam antenna is multiple beams are generated from a single antenna with a narrower horizontal beam width compare to most commonly used 65deg HBW antenna. Each antenna acts like multiple antennas according to its number of beams. In this way multi beam antenna can help to improve network coverage by adding gain and network capacity by adding more cells in one antenna as well as reduce the operational cost.

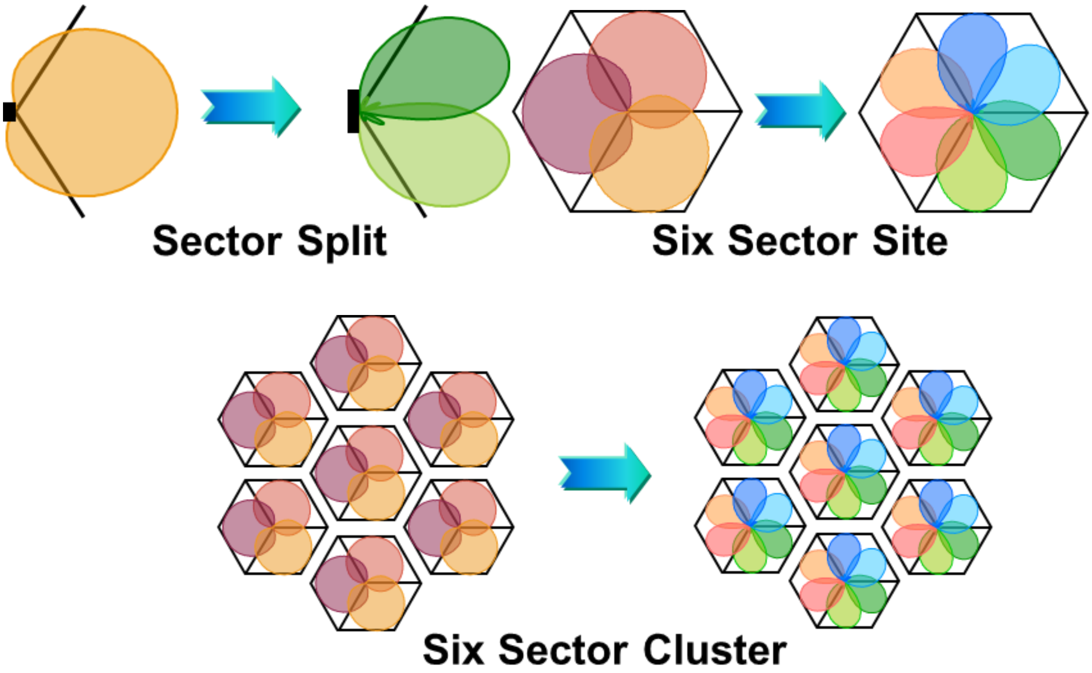
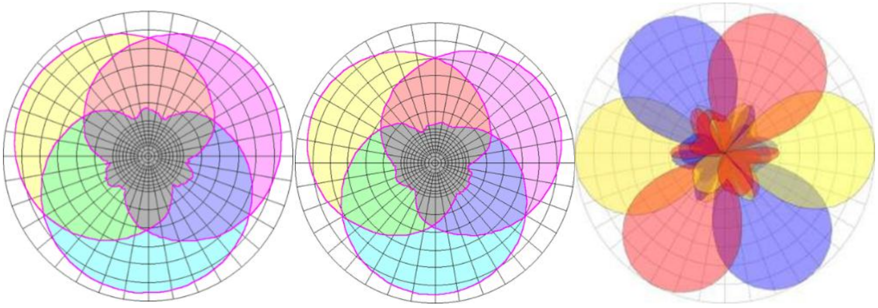


Fig 10: Sector Splitting

For bigger sector inter-sector overlap is larger. Which normally have impact on capacity. As well as faster roll off happen if we split the sector.



90 deg Sector 65 deg Sector 33 deg Sector

So, in this case I supposed that twin beam antenna will be the best solution which is better than adding new antenna in same site from technical and commercial point of view.

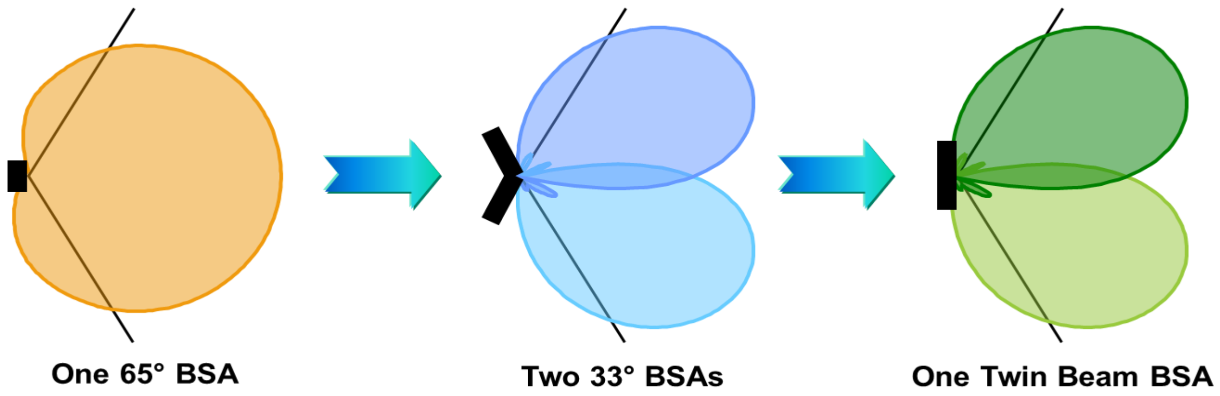


Fig 11: Sector Splitting by Twin Beam

3.1.1 Multi-beam Technology

To increase the capacity the main challenges of antenna design are

1. Keeping Lighter weight
2. Keeping Smaller Size
3. Increase Gain
4. Sharper Pattern
5. Maintain Other Parameters Good

According to general antenna basic it is really tough to design such an antenna which can meet all above requirements.

Switched Beam Arrays can be used to increase antenna capacity. Switched beam array can be used in following way.

1. Butler Matrix Array
2. Blass Matrix
3. Rotman Matrix

➢ **Conceptual Operation of Butler Matrix**

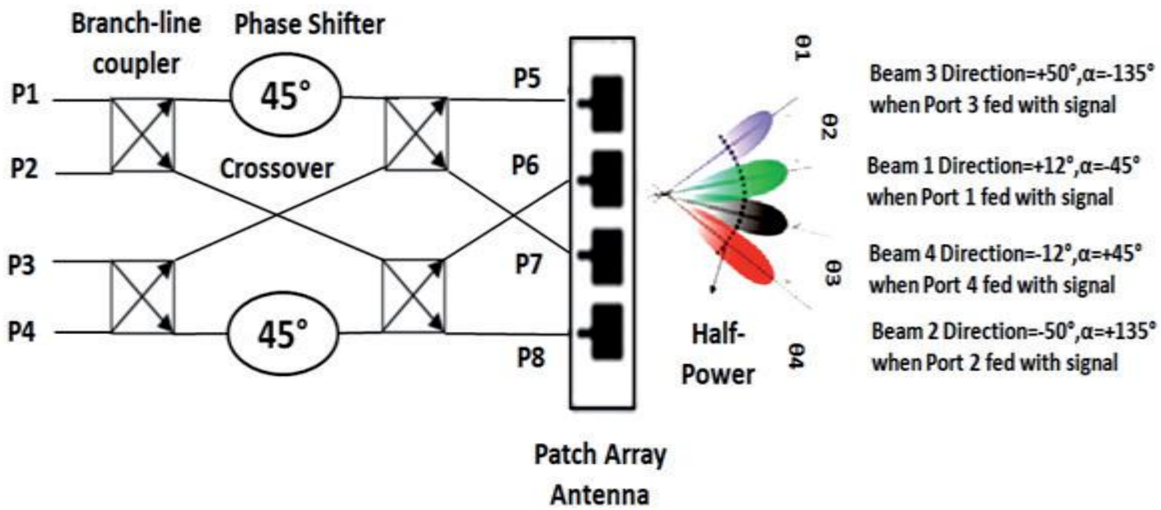


Fig 12: Butler Matrix

The conceptual operation of the Butler matrix is described briefly as follows. First, the Radio Frequency (RF) signal excites each of the input ports, and, then, the signal goes through the output ports, thereby feeding the array elements. Then, the signal is distributed equally with a constant phase between them. As a result, beam radiations are generated at a certain angle. Fig. 1 shows the topology of the Butler matrix, which is comprised of a branch-line coupler (BLC), a crossover, and a phase shifter. The beam direction is illustrated with respect to each input port. Therefore, by feeding any of input port,user can select the direction of the radiation main beam asdesired. In addition, in order to reduce the manufacturingcost and effectively integrate the Butler matrix and antenna elements, FR4 board is utilized during printed circuit broad.

- **Butler Matrix Structure:**

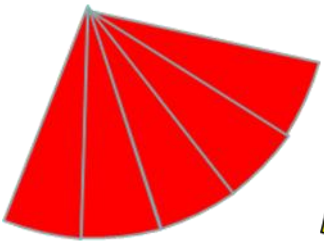
A new design is used that optimizes the size of the Butler Matrix structure. This is achievable by reducing electrical length of the conventional BLC, which is the keyelement in designing Butler Matrix by implementing the shunt arm to be half of the length of the through arm.

3.1.2 Multi Beam Antenna Types and Application Cases

Now a days antenna manufacturers are investing a lot for R&D of multibeam technology. Available multibeam antennas are

1. Twin Beam
2. Tri-Beam
3. Five Beam
4. Nine Beam
5. Eighteen Beam

- **Five Beam, Nine Beam or Eighteen Beam**



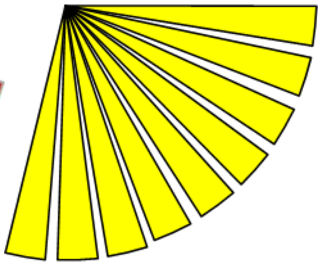


Fig 13: Five Beam **Fig 14: Nine Beam**

Five beam, Nine Beam & Eighteen Beam antennas are normally used in special cases for giving capacity solution for huge traffic like big stadium or big gathering area. As these antennas horizontal beam with of every beam is much narrower so the gain is much higher. So during network planning with this antenna overshooting and interference with neighboring site is very important. In Bangladesh five antennas use case can be

1. Stadium
2. Bissaw Ijtema
3. Book Fair

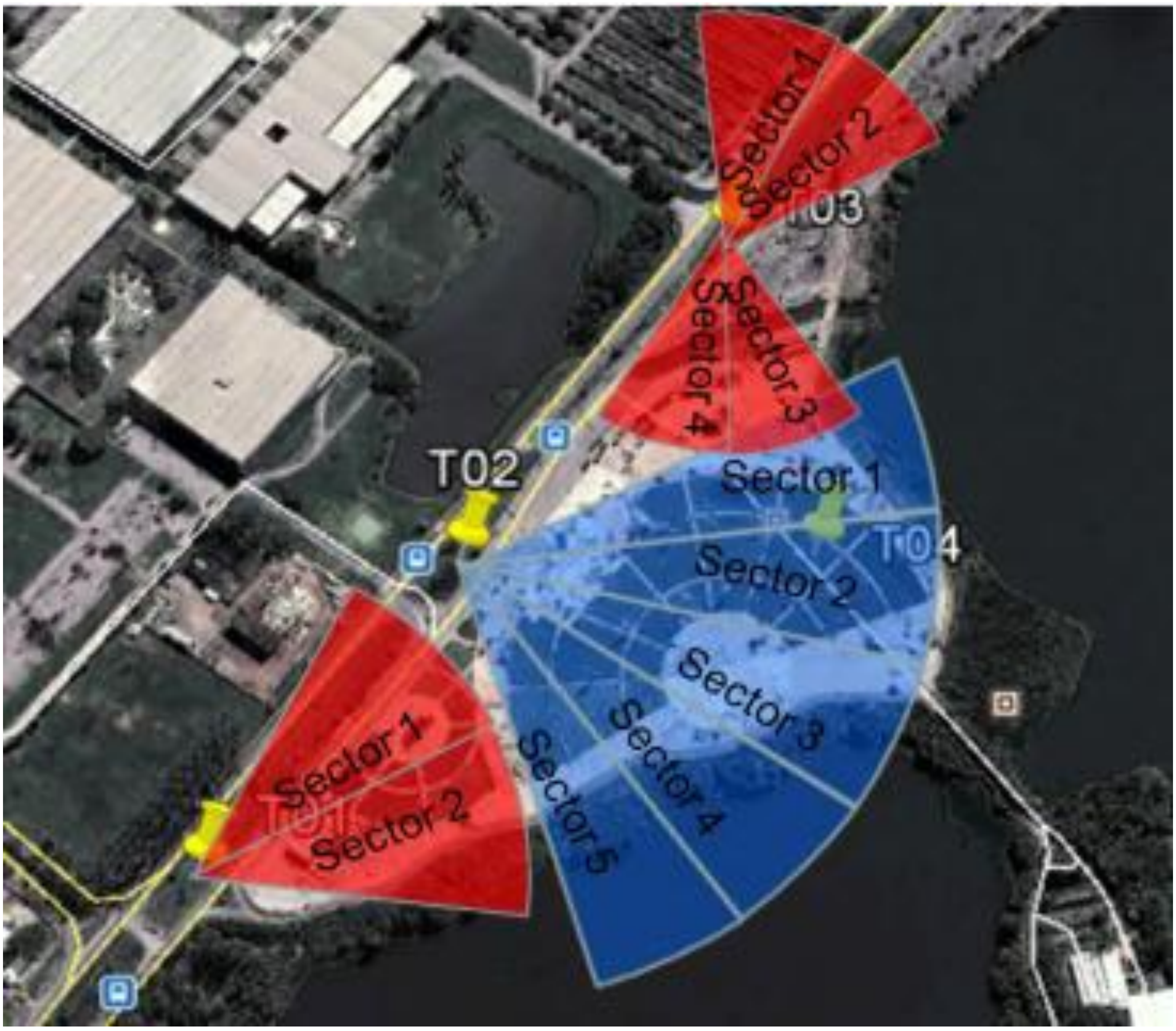


Fig 15: Picture of using Multi-Beam Antennas

- **Twin Beam & Tri-Beam**

Normally twin beam and tri beam antenna is using for dense urban/dense semi urban area where need to double or triple network capacity according to traffic.

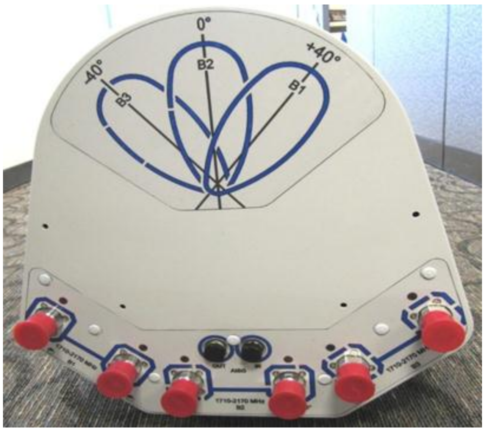


Fig 16: Tri-Beam Antenna

In this project we are working with only twin beam antenna. Which is used alternative of two 33deg horizontal beam width antenna or replacing of one existing 65deg horizontal beam width antenna according to capacity requirement.

3.1.3 Comparison of Twin Beam antenna and Traditional Antenna

- **Better Gain and Wider Coverage:**

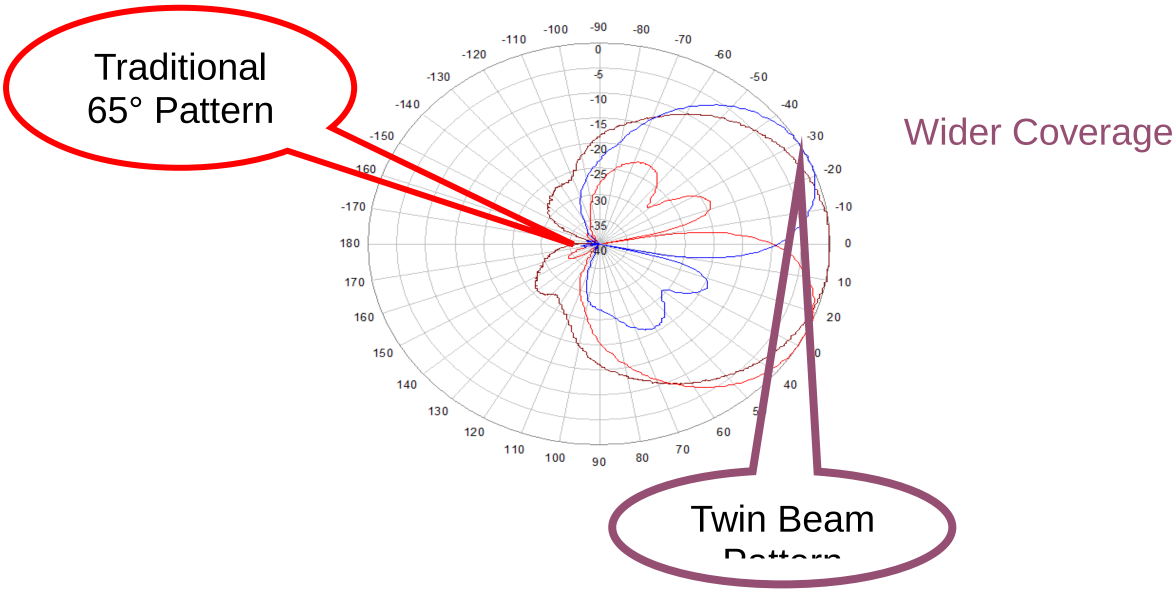
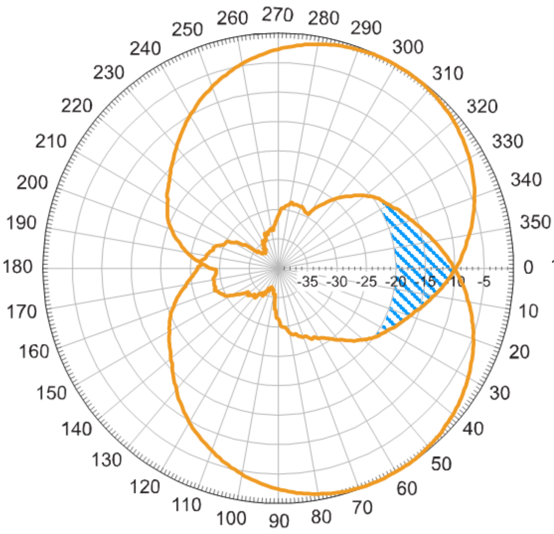


Fig 17: Pattern Comparison of Traditional Antenna and Twin Beam Antenna

- **Faster Roll Off:**



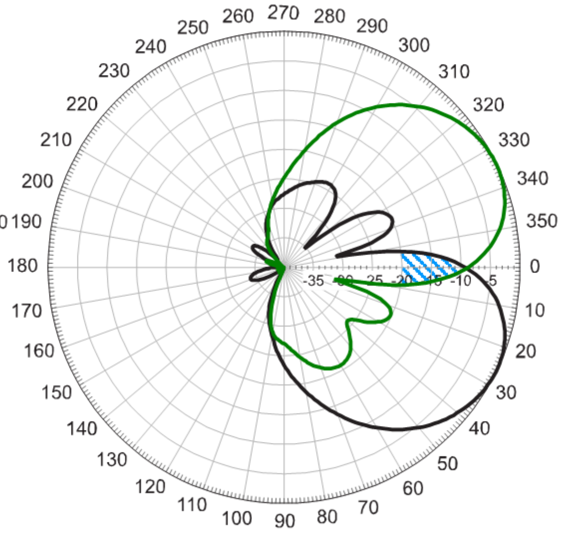


Fig 18: Traditional 65 deg Antenna PatternFig 19: Twin Beam Antenna Pattern

From above antenna patter we can see that twin beam antenna has smaller handover region in compare to two traditional 65 deg antenna which gives better handover success rate and better call drop rate.Faster roll off compare to 65deg antenna. It has a very sharper pattern which give a good coverage in sector edge.

- **Better Sidelobe Suppression:**

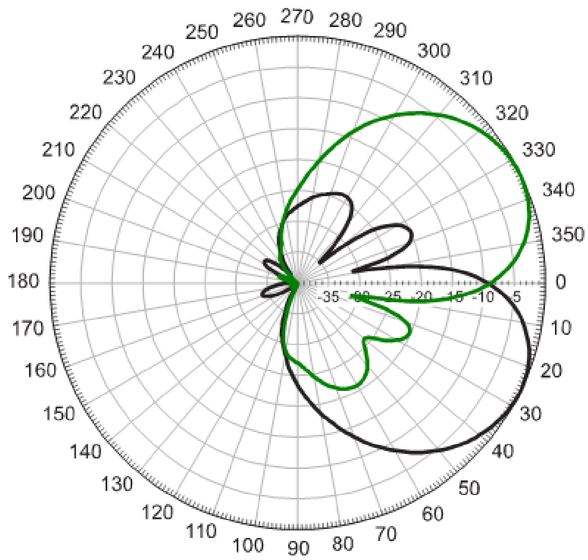


Fig 20: Excellent Sidelobe Suppression

It has also excellent sidelobe suppression which increase interference rejection.

➢ **Better Front to Back Ratio:**

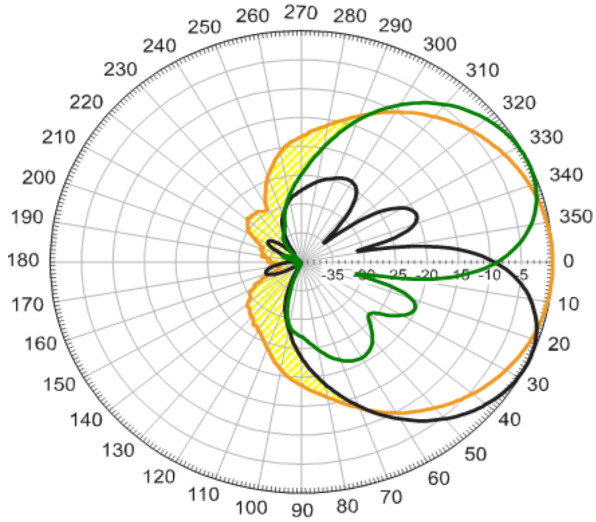


Fig 21: Better Front to Back Ratio

Here in twin beam antenna Its front to back ratio allso very good which also increase interference rejection and give a comfort zone for network planning.

➢ **Better in Size:**

Physical dimension of twin beam antenna is not much bulky compare to traditional antenna. If we replace 66 deg antenna by twin beam antenna and compare both as follows.

Table 4: Physical Parameter Comparison of Twin Beam and Traditional 65deg Antenna

	Twin Beam	**Traditional 65 Deg**
	HBXX-3817TB1-VTM	**HBXX-6516DS-VTM**
W	11.9 Inch	12.0 Inch
H	54.7 Inch	50.9 Inch
D	7.1 Inch	6.5 Inch
We	16.5 Kg	13.9 Kg

Note: Both antenna manufectured by Commscope

If we think a twin beam antenna intead of two traditional 33deg antenna then the physical comperision as follows.

Table 4: Physical Parameter Comparison of Twin Beam and Traditional 33deg Antenna

	Twin Beam	Traditional 33 Deg
	HBXX-3817TB1-VTM	**HBXX-3319DS-VTM**
W	11.9 Inch	22.2 Inch
H	54.7 Inch	57.0 Inch
D	7.1 Inch	4.9 Inch
We	16.5 Kg	17.3 Kg

Note: Both antenna manufectured by Commscope

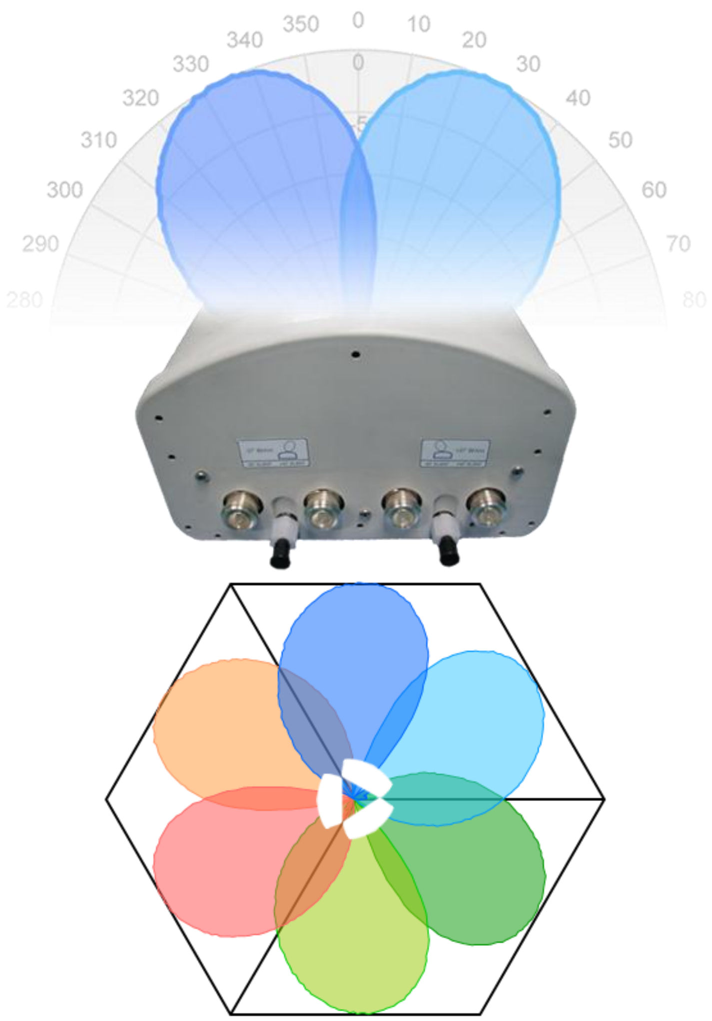
So, if we think to make three sectors to six secotrs by this 33deg horizontal beam width antenna then tower loading and wind loading will be massive.

Key Benefits Compare to Traditional Antennas:

- Improve utilization of existing network infrastructure
- Address needs of high-density markets with limited site capacity
- Delay addition of CDMA or W-CDMA carriers
- Optimize data transfer rates for 3G/4G/LTE markets
- More capacity due to increased sectorization
- Ideal solution for high traffic sectors and events
- Extends value of existing cells
- Fast and easy deployment
- Logistics / storage
- SIX sectors in one single band site
- TWELVE sectors in a dual band basis
- Smaller windload requires less or no structure revision
- No impact on contract / lease cost for antennas in third party structures
- Sectors in the antenna optimized for small overlap
- Lower softer handover / interference
- Smaller possibility of miss-alignment
- Sector sculpting offers narrower beam width that reflector-shaped lobe antennas
- Each antenna downtilt can be independently adjusted for greater flexibility innetwork optimization

Chapter 4: Project Work

4.1 Background of the Project:



3X1=6

Fig 22: Sector Splitting and Twin Beam Antenna

One of the leading operator of Bangladesh facing capacity problem in certain area/region. They are thinking to add cell/sector to enhance the capacity on that particular base station. So from traditional point of view, to add new cell or sector they need to add new antenna with 33deg HBW in same site or have to make new sites by using 65deg HBW antenna. Which will

- Increase number of antennas or number of sites. If increase number of antennas then tower load will be increased which might be created house owner issues for RT sites. If want to build a new site, then site acquisition will be a big issue in recent days.
- Increase Capex and Opex

But if they use twin beam antenna then

- Back-to-back Broadcast Channel (BCCH) re-use capability for 2G
- Enhanced RF footprint (higher gain)
- Better interference containment (better roll-off)
- Faster site deployment

So objectives of this project

• Showing Customer the comparison of the performance of the existing cross pole antennas at two chosen area of one site with that of Andrew's Twin beam antenna HBXX-3817TB-VTM. One site according to pre data number of sectors made doubled and another site an additional sector added by replacing one single beam antenna.

• The data to be analyzed will be that of drive test plots (pre and post)and KPI data (pre and post) collected through OSS/OMCR of Customer.

• Site performance should not degrade critically to that of existing antennas or better in terms of carried capacity/all the calls related KPI's like Total traffic, SD block, TCH block, TASR & HOSR etc.

4.2 Datasheet of Proposed Twin Beam Antenna and Traditional Alternative Antennas

4.2.1 Proposed Twin Beam

Product Specifications

COMMSCOPE®

POWERED BY ANDREW.

HBXX-3817TB1-VTM

Andrew® Twin Beam Capacity Antenna, 1710–2180 MHz, 2x 38° horizontal beamwidth, RET compatible

- Enhances network capacity through six sectors site application with only three antenna faces
- Single panel design supporting two separate beams perfectly optimized at horizontal pointing angles of +27 degrees and −27 degrees from boresite
- Maximizes frequency spectrum utilization to increase Average Revenue Per User (ARPU)
- Reduces antenna count to minimize Cap-Ex and Op-Ex costs
- High gain with excellent sector edge roll-off and azimuth sidelobe suppression
- Each antenna downtilt can be independently adjusted for greater flexibility in network optimization

Electrical Specifications

Frequency Band, MHz	1710–1880	1850–1990	1920–2180
Gain, dBi	19.2	19.5	19.7
Beam Centers, Horizontal, degrees	±27	±27	±27
Beamwidth, Horizontal, degrees	38	36	34
Beamwidth, Vertical, degrees	7.5	7.1	6.7
Beam Tilt, degrees	0–10	0–10	0–10
Horizontal Sidelobe, dB	20	20	20
USLS, dB	17	17	17
Gain Roll-off at Boresite, dB	9	9	9
Gain Roll-off at Boresite Tolerance, dB	±2	±2	±2
Front-to-Back Ratio at 180°, dB	30	32	32
CPR at Boresight, dB	22	21	18
Isolation, Cross Polarization, port to port, dB	30	30	30
VSWR | Return Loss, dB	1.4 | 15.6	1.4 | 15.6	1.4 | 15.6
PIM, 3rd Order, 2 x 20 W, dBc	-150	-150	-150
Input Power per Port, maximum, watts	250	250	250
Polarization	±45°	±45°	±45°
Impedance	50 ohm	50 ohm	50 ohm

Electrical Specifications, BASTA*

Frequency Band, MHz	1710–1880	1850–1990	1920–2180
Gain by all Beam Tilts, average, dBi	18.9	19.1	19.3
Gain by all Beam Tilts Tolerance, dB	±0.4	±0.4	±0.6
	0 ° | 18.7	0 ° | 18.9	0 ° | 19.3
Gain by Beam Tilt, average, dBi	5 ° | 19.0	5 ° | 19.2	5 ° | 19.5
	10 ° | 18.9	10 ° | 19.1	10 ° | 19.0
Beamwidth, Horizontal Tolerance, degrees	±1.5	±1.3	±2.2
Beamwidth, Vertical Tolerance, degrees	±0.4	±0.3	±0.5
USLS, dB	20	20	21
Front-to-Back Total Power at 180° ± 30°, dB	30	31	29
CPR at Boresight, dB	24	22	20

* CommScope® supports NGMN recommendations on Base Station Antenna Standards (BASTA). To learn more about the benefits of BASTA, download the whitepaper Time to Raise the Bar on BSAs.

Fig 23: Antenna Datasheet

4.2.2 Other Alternative

HBW 65 Deg Antenna

Product Specifications

COMMSCOPE®

POWERED BY ANDREW.

HBXX-6516DS-VTM

Andrew® Quad Port Teletilt® Antenna, 1710–2180 MHz, 65° horizontal beamwidth, RET compatible

- Each DualPol® array can be independently adjusted for greater flexibility
- Excellent gain, VSWR, front-to-back ratio, and PIM specifications for robust network performance
- Ideal choice for site collocations and tough zoning restrictions
- Great solution to maximize network coverage and capacity
- The values presented on this datasheet have been calculated based on N-P-BASTA White Paper version 9.6 by the NGMN Alliance

Electrical Specifications

Frequency Band, MHz	**1710–1880**	**1850–1990**	**1920–2180**
Gain by all Beam Tilts, average, dBi	17.2	17.2	17.5
Gain by all Beam Tilts Tolerance, dB	±0.3	±0.3	±0.5
Gain by Beam Tilt, average, dBi	0 ° | 17.0 5 ° | 17.3 10 ° | 17.0	0 ° | 17.1 5 ° | 17.4 10 ° | 17.0	0 ° | 17.4 5 ° | 17.7 10 ° | 17.2
Beamwidth, Horizontal, degrees	67	66	64
Beamwidth, Horizontal Tolerance, degrees	±2.7	±2.3	±3.5
Beamwidth, Vertical, degrees	7.5	7.0	6.6
Beamwidth, Vertical Tolerance, degrees	±0.5	±0.4	±0.4
Beam Tilt, degrees	0–10	0–10	0–10
USLS, dB	18	19	19
Front-to-Back Total Power at 180° ± 30°, dB	26	26	26
CPR at Boresight, dB	22	22	22
CPR at Sector, dB	9	9	9
Isolation, dB	30	30	30
VSWR | Return Loss, dB	1.4 | 15.6	1.4 | 15.6	1.4 | 15.6
PIM, 3rd Order, 2 x 20 W, dBc	-153	-153	-153
Input Power per Port, maximum, watts	350	350	350
Polarization	±45°	±45°	±45°
Impedance	50 ohm	50 ohm	50 ohm

General Specifications

Antenna Brand	Andrew®
Antenna Type	DualPol® quad
Band	Single band
Brand	DualPol® | Teletilt®
Operating Frequency Band	1710 – 2180 MHz

Mechanical Specifications

Color	Light gray
Lightning Protection	dc Ground
Radiator Material	Low loss circuit board
Radome Material	PVC, UV resistant
RF Connector Interface	7-16 DIN Female
RF Connector Location	Bottom

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Fig 24: Traditional 65deg Antenna Datasheet

HBW 33 Deg Antenna

Product Specifications

COMMSCOPE®

POWERED BY ANDREW

HBXX-3319DS-VTM

Andrew® Quad Antenna, 1710–2170 MHz, 33° horizontal beamwidth, RET compatible

Electrical Specifications

Frequency Band, MHz	**1710–1880**	**1850–1990**	**1920–2170**
Gain, dBi	20.4	20.6	20.8
Beamwidth, Horizontal, degrees	36	35	34
Beamwidth, Vertical, degrees	6.5	6.2	5.9
Beam Tilt, degrees	0–10	0–10	0–10
USLS, dB	15	15	15
Front-to-Back Ratio at 180°, dB	40	40	40
CPR at Boresight, dB	24	23	24
Isolation, dB	30	30	30
Isolation, Intersystem, dB	28	30	30
VSWR | Return Loss, dB	1.5 | 14.0	1.5 | 14.0	1.5 | 14.0
PIM, 3rd Order, 2 x 20 W, dBc	-153	-153	-153
Input Power per Port, maximum, watts	300	300	300
Polarization	±45°	±45°	±45°
Impedance	50 ohm	50 ohm	50 ohm

Electrical Specifications, BASTA*

Frequency Band, MHz	**1710–1880**	**1850–1990**	**1920–2170**
Gain by all Beam Tilts, average, dBi	20.0	20.0	20.3
Gain by all Beam Tilts Tolerance, dB	±0.5	±0.5	±0.8
Gain by Beam Tilt, average, dBi	0 ° | 20.1 5 ° | 20.1 10 ° | 19.7	0 ° | 20.0 5 ° | 20.1 10 ° | 19.7	0 ° | 20.4 5 ° | 20.5 10 ° | 19.9
Beamwidth, Horizontal Tolerance, degrees	±2.8	±1.6	±2.4
Beamwidth, Vertical Tolerance, degrees	±0.3	±0.3	±0.4
USLS, dB	15	16	16
Front-to-Back Total Power at 180° ± 30°, dB	36	38	37
CPR at Boresight, dB	25	24	24

* CommScope® supports NGMN recommendations on Base Station Antenna Standards (BASTA). To learn more about the benefits of BASTA, download the whitepaper Time to Raise the Bar on BSAs.

General Specifications

Antenna Brand	Andrew®
Antenna Type	DualPol® quad
Band	Single band
Brand	DualPol® | Teletilt®
Operating Frequency Band	1710 – 2170 MHz

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December 14, 2014

Fig 25: Traditional 33deg Antenna Datasheet

4.3 Project Summary:

• Comparing the performance of the existing single beam antennas at a chosen 1 site in Mymensing Road, Tangail, Bangladesh with that of Andrew's Twin beam antenna HBXX-3817TB1-VTM.

• The data to be analyzed will be that of drive test plots (pre and post) and KPI data (pre and post) collected through OSS/OMCR of Customer.

• Site performance should not degrade critically to that of existing antennas or better in terms of carried capacity/all the calls related KPI's like Total traffic, SD block, TCH block, TASR & HOSR etc.

• Sites to evaluate the performance of HBXX-3817TB1-VTM were identified atTangail. This Customer circle operates on the 2100 WCDMA band.

• Cluster sites are 3 sector GBT sites already radiating with one GSM antenna per sector.

• The trials were initiated on the 11th December 2015 for all selected sites in a cluster in Tangail and installation for l sites got completed by 14th December 2015.

• Pre-drive test was already done by Customer/Customer drive test team. Post drive test and optimization was done following the completion of installation at all trial sites.

• Optimization was done by Customer RF team and took almost a week to complete.

• The site details like azimuth and height are noted down and Andrew antennas were installed where earlier existing antennas were installed. Pre & Post RSCP Dedicated**.**

4.4 Project Work Flow Chart

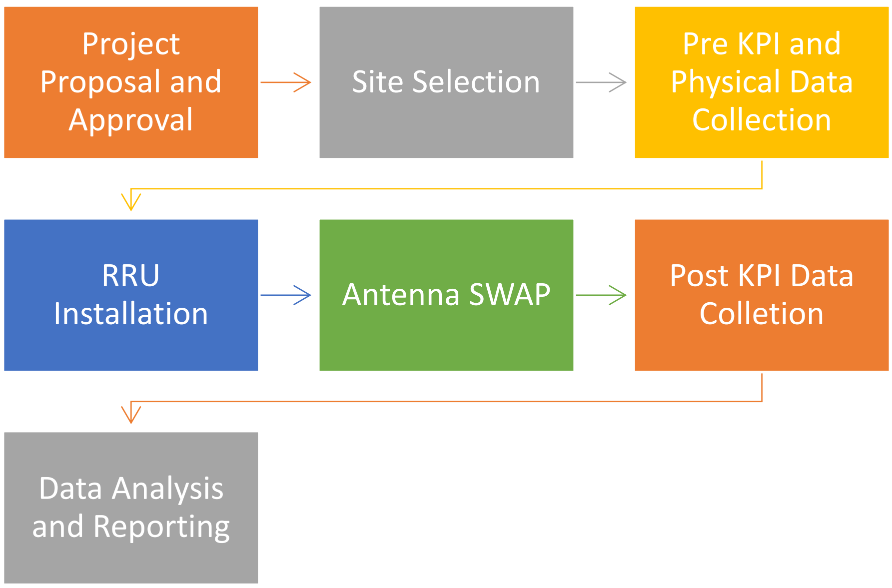

Fig 26: Project Flow Chart

4.5 Responsibility Matrix

Table 6: Responsibility Matrix

	Responsibility	Customer	My Team (In-house)	My self	Solution Team (From Abroad)
1	Trial Proposal				
2	Approval				
3	Evaluation Criteria				
4	Guideline of Trail Procedure (Details)				
5	Site Selection				
6	Set KPI which have to be checked				
7	Pre KPI data and Physical Data Collection				
8	RRU Installation				
9	Antenna Swap				
10	Post KPI data collection				
11	Data analysis				
12	Reporting				

	Index
	Main Role
	Monitoring/Supportive Role
	No Role

4.5.1 Trial Proposal and Approval:

At first submitted a project proposal to customer focusing on which value will be added in customer network by introducing this multi-beam antenna. Theoretically customer have understood the value added points according to present challenges which have been facing in terms of network capacity and approved the project.

4.5.2 Fix-up Evaluation Criteria

Discussion with the customer evaluation criteria have been fixed and agreed. Here some important points are noted as considerations according to the suggestion of this antenna experts from antenna manufacturer end.

Table 7: Evaluation Criteria

Evaluation Criteria	Considerations
1. Existing coverage footprint shall be improved and no bad coverage spot shall be introduced due to this antenna (will be verified by drive test). 2. Peak throughput, payload (total data transmitted), and dropped call rate shall be improved. 3. Pre and post KPI will be evaluated based on averaging 7 days cell busy hour KPI. 4. OSS KPI **(Traffic, CDR,HOSR-3GThroughput**) shall not degrade for neighboring cells due to this antenna impact. And identical KPI shall be improved for target cell. 5. Antenna F/B shall be improved.Value shall beincreased -5 to -7dBm from previous antenna at a distance of 20m. 6. Any degradation due to force measures shall be analyzed and agreed by both party (Impacting neighboring sites will not impact)	1. This Antenna Increases capacity & increase spectrum efficiency as same frequency could be used by two beams 2. Pre Swap antenna gain shall be less than or equal to this antenna 3. Traffic usage doesn't change during the trial period. 4. When calculate through put, must add the two beam traffic together to compare with pre figures, as two beams coverage area are the same as pre antenna. In this case we could get better output, otherwise, half coverage may not realize better figure than pre antenna. But user throughput have to see separately.

4.5.3 Site Selection:

Twin beam antenna or multi-beam antenna is mainly a capacity solution which may add some additional coverage also compare to traditional single beam antenna. So based on this it is suggested to customer select a cluster/site where they are facing capacity problem due to heavy traffic like Dhaka/Chittagong and its surrounding cities. For that have selected some OSS KPI as follows.

Table 8: OSS KPI List for Site Selection

1	RRC Setup Success Rate
2	RAB Establishment Success Rate (CS, PS-HS, PS_EU)
3	Packet R99 Access Success Rate
4	Packet HS Access Success Rate
5	Speech RAB drop Rate
6	PS R99 RAB Drop Rate
7	CS Drop Rate
8	PS Drop Rate_HSDPA
9	PS Drop Rate_HSUPA
10	Soft HO Success Rate
11	Speech IRAT HO Success Rate
12	IRAT Cell Change Success Rate
13	HSDPA USER
14	HSDPA User Throughput
15	HSUPA User Throughput

According to the guideline customer select some sites in Dhaka and Chittagong region. Among those**8915(Site ID: **8915) at Mymensing Road, Tangail have been selected for trail.

Another important thing to be noted that as capacity problem is mainly facing 3G network. So it was suggested implement this antenna in 3G due to data demand at 3G. That's why selected site is a 3G site.

4.5.4KPI Which Have to be checked:

For the twin beam antenna case in a 3G scenario, the primary success criteria that would be recommend were peak throughput, payload (total data transmitted) and dropped call rate, along with radio resource efficiency, which can be related to overall capacity.

So following KPI can be summarized the above mentioned points.

RRC Setup Success Rate (%)	CS RAB Establish Succ Rate (%)	RAB Establishment Success Rate PS Interactive (%)	RAB Establishment Success Rate PS Interactive HS (%)	RAB Establishment Success Rate PS Interactive EUL (%)	Packet R99 Access Success Rate (%)	Packet HS Access Success Rate (%)	PS R99 RAB Drop Rate (%)	PS HS RAB Drop Rate (%)	Soft HO Success Rate	Speech IRAT HO Success Rate (%)	IRAT cell change Succ Rate (%)	Number of Users	HSDPA Throughput(Mbps)

TCH Traffic: It measures carried traffic by traffic channel

CSSR: call setup success rate

SDCCH: The bi-directional Standalone Dedicated Control Channel (SDCCH) is subsequently used for purposes such as call set-up, mobile station attach/detach, location update and short message submission.

Radio Capacity: It measures throughput.

Radio Utilization: It measures utilization of remote radio unit.

Beside this for Coverage RSCP and for qualityEx/No are recommended.

RSCP:

RSCP stands for Received Signal Code Power – the energy per chip in CPICH averaged over 512 chips.

Eb/No:

By definition Eb/No is energy bit over noise density, i.e. is the ratio of the energy per information bit to the power spectral density (of interference and noise) after dispreading.

Eb/No = Processing Gain + SIR

For example, if Eb/No is 5dB and processing gain is 25dB then the SIR should be -20dB or better.

Eb/No target

The Eb/No targets are dependent on the service:

4.5.5Pre KPI Data and Physical Data Collection:

According to the above mentioned guideline customer collect the Pre KPI data and physical data of existing single beam antenna. To collect KPI data they have used the following tools and software.

1. Tems Software(Version 16.2)
2. Three Mobile Set
3. Data card
4. Laptop
5. Digital Power Hub
6. GPS
7. Camera
8. Car

4.5.6 Additional RRU Installation:

As this is a sector splitting solution so customer have to add additional RRU. If it is twin beam antenna and existing sector are 3 then they have to double the number of RRU. Every twin beam antenna have been connected with two RRU.

This portion have been done by customer.

4.5.7 Antenna Swap:

After installation of RRU, customer have to give NCR time and my team dismantled existing antenna and installed new antenna.

Three manpower have engaged in this activities. Required tools are as follows.

Antenna tilt and height fix according to my guideline.

4.5.8 Post KPI Data Collection:

By same procedure of collection of pre KPI data, customer have collected post KPI data from field and send to me.

4.5.9 Data Analysis and Reporting:

Data analysis and reporting done by myself according to the guidance of antenna manufacturer experts based on following data which collected from site.

4.5.9.1 Physical Data

Pre:

Table 9: Pre Physical Parameter Audit

Site Na		**Electricaltilt(Deg)**	**Mechanicaltilt(deg)**	**Azimuth (deg)**	**Height(fromground)inmeters**	**Tower Height**	**Antenna Gain (dBm)**
XT89XX	**Sector1**	4	0	90	30.5	32	17.7
	Sector2	4	0	180	30.5	32	17.7
	Sector3	6	0	280	30.5	32	17.7

Post:

Table 10: Post Physical Parameter Audit

SiteName	Sectors	**Electrical Downtilt(Deg)**	**Mechanicaltilt(deg)**	**Azimuth (deg)**	**Height(fromground)inmeters**	**Tower Height**	**Antenna Gain (dBm)**
XT89XX	**Sector1**	6	0	110	30.5	32	19.7
	Sector2	6	0	200	30.5	32	19.7
	Sector3	7	0	300	30.5	32	19.7

4.5.9.2KPI Data analysis

Pre and Post RSCP(Coverage):

Pre Post

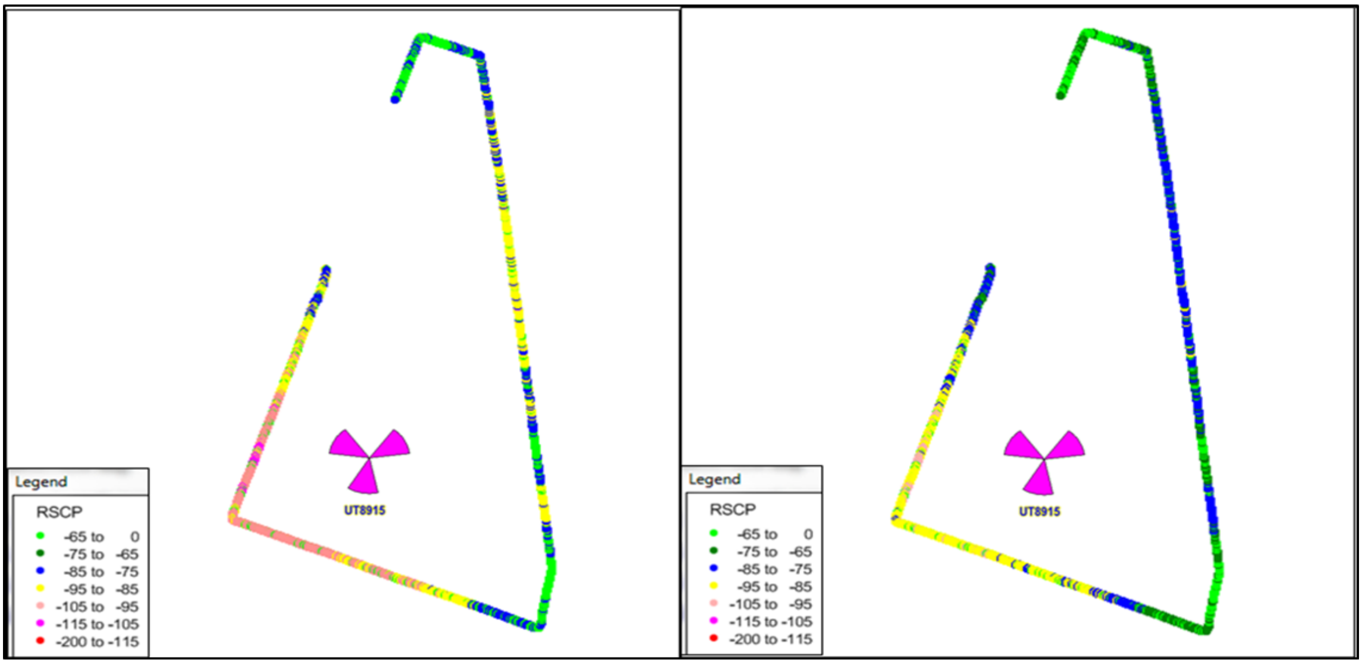

Fig 27: RSCP plot

From pre post drive test it is clearly identified after installation of twin beam antenna that received signal code power is bit better at maximum area compare pre. So coverage is improved slightly. Which clearly justify evaluation criteria of twin beam antenna.

Pre & Post Ec/No Dedicated(Quality):

Pre Post

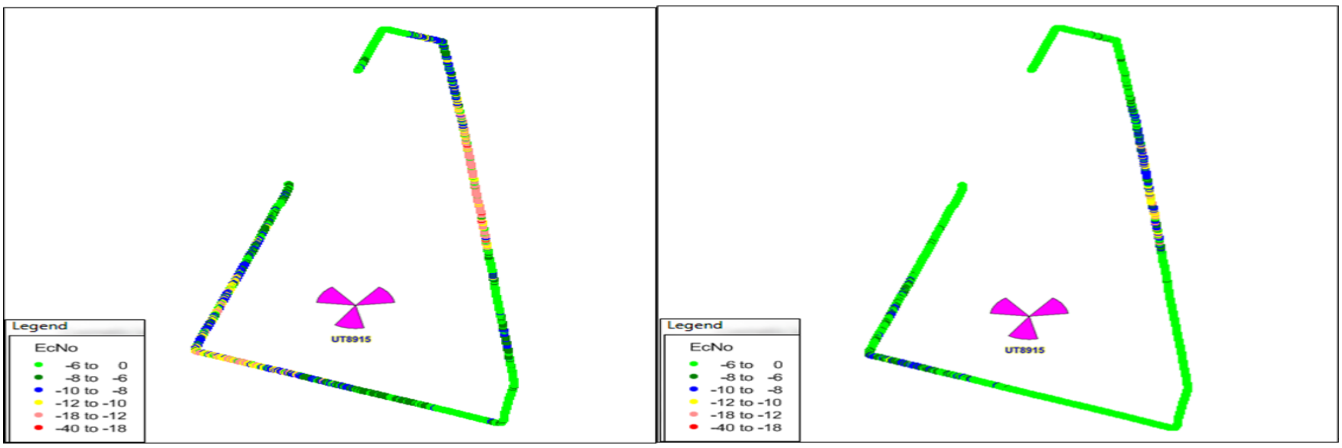

Fig 28: EcNo Plot

From pre and post Ec/No it is clearly seen that energy per code or per bit to noise ratio is significantly improved in post drive. So call quality improved significantly after twin beam antenna installation. Which is the main objective of this project.

4.5.9.3KPI Comparison of Pre & Post

Table 11: KPI Comparison

	RRC Setup Success Rate (%)	CS RAB Establish Succ Rate (%)	RAB Establishment Success Rate PS Interactive (%)	RAB Establishment Success Rate PS Interactive HS (%)	RAB Establishment Success Rate PS Interactive EUL (%)	Packet R99 Access Success Rate (%)	Packet HS Access Success Rate (%)	PS R99 RAB Drop Rate (%)	PS HS RAB Drop Rate (%)	Soft HO Success Rate	Speech IRAT HO Success Rate (%)	IRAT cell change Succ Rate (%)	Number of Users	HSDPA Throughput(Mbps)
Pre	98	99.1	99	99.1	98.2	99.1	98	0.6	0.6	97	89	98	35	0.3
	98.9	99.9	98	99.1	99.9	99.1	98	0.5	0.5	97.8	80	100	33	0.2
	99.1	99.1	98.5	98.9	99.1	98.9	99	0.4	0.7	98.9	75	99	38	0.2
	99.5	99.9	99	99	99.9	99	98	0.4	0.63	99.8	90	99	29	0.1
	99	99.9	97	99.2	97.9	99.2	99	0.4	0.62	99	92	97	45	0.3
	98.7	100	97.8	98.9	99	98.8	99	0.4	0.31	98.7	90	98	28	0.2
	98.7	100	97.9	99.1	97	99	99	0.3	0.3	98	96	98	36	0.1
Post	99.6	99.9	99.1	99.1	99.1	99.3	98	0.4	0.6	99.8	89	98	55	0.4
	99.6	100	99	99	99.9	99.4	98	0.3	0.6	99.9	80	100	45	0.3
	99.5	100	98.9	98.9	98.9	99.6	99	0.4	0.65	99.8	68	100	46	0.4
	99.5	100	99.1	99.1	99	98	99	0.4	0.58	99.9	90	99	34	0.2
	99.5	100	99.2	99.2	99.2	99.5	99	0.3	0.56	99.8	92	97	54	0.5
	99	100	98.9	98.9	98.9	99.7	99	0.2	0.23	99.9	90	98	43	0.3
	98.7	100	99.1	99.1	99.1	99.9	99	0.2	0.28	99.9	96	98	60	0.2

From above table of 7days pre and post drive test data we see that most of the KPI have improved after installation of twin beam antenna which had been fixed as evaluation criteria.

4.5.9.4 F/B Ratio Comparison

Table 12: Front to Back Ratio Comparison

RSCP at 20m Distance	Sectors	Front RSCP Level	Back RSCP Level	F/B Ratio
Previous Antenna	Sector 1	-52dBm	-140dbm	88dBm
	Sector 2	-55dBm	-151dBm	96dBm
	Sector 3	-65dBm	-145dBm	85dBm
Present Antenna	Sector 1	-46dBm	-145	99dBm
	Sector 2	-48dBm	-160	112dBm

	Sector 3	-50dBm	-152	102dBm

So, according to evaluation criteria F/B ratio should be improved -5 to -7dBm compare to previous antenna. But in practical it is improved more. Which will reduce the interference probability with the neighboring sites in back end.

Chapter 5: Conclusion and Future Work

5.1 Summary of the project:

By considering the present requirement, we can summarize this project as follows.

• Both sector has good coverage area and RSCP has been increased than before.

• Traffic in the trial site has significantly increased by approx. 40%.

• No critical degradation has been noticed in CSSR or any major Parameters.

• SDDCH blocking is either same as before or improved.

• TCCH blocking has improved significantly.

• TCH drop is either same as before or improved.

• Total Handover Success ratio is either same as before or improved

5.2 Future Work:

5.2.1 On This Particular Project:

1. KPI improvement was less than the expectation so in future need to do more optimization as well as need to do some planning level change to get better result at this particular site.

2. Another experimental trail is going to happen very soon in different region.

5.2.2Multibeam

According to the requirement of massive data demand, in coming future five beam, nine beam, even eighteen beam antenna can be introduced to meet the data demand.

5.2.3Smart Beam

Smart beam antenna will be a good solution to meet future requirement more preciously by which we can control antenna azimuth, beam width and beam tilt remotely according to live traffic position.

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