

Exploring Reserve Price (RP) and Average Revenue Per User (ARPU)

Renju John

Department of EEE

Birla Institute of Technology and Science, Pilani, Rajasthan, India

Abstract: Indian Telecom market is a huge attraction for the entire world on the context of being the cheapest and the largest telecom market in the world. The sector which allows 100% FDI participation has seen withdrawal of many international players like Vodafone and Telenor. This paper attempts to solve this mystery by using the 5G auctions 2022 as a reference model and its benefits over the 4G Auctions. The Auction model of SMRA has been questioned in this paper and newer effective models like CCA has been proposed. The Power of 5G in enabling India to be a fully developed nation by 2047 has been reemphasized in this paper. Finally what is a sustainable revenue model for the operators and its linkage to the reserve price has been closely examined. Through this I have tried to establish the missed link between ARPUs and the RPs which could be the answer to a decade long spectrum worries for the nation.

Keywords: Spectrum Auction, SMRA, Reserve Price, Average revenue Per User

I. INTRODUCTION

The Indian telecom market follows a 5 Pong model. This is what I would like to call as the **Telecom 360 Model** spanning Spectrum, licensing, Infrastructure Operations and market. And this circle has repeated in a cycle mostly post 2010 identified as the regenerative age of Indian Telecom.



Figure 1: Telecom 360

As India migrates from 4G to 5G one first needs to understand if there are drastic changes in the spectrum and Infrastructure components what are the tangible benefits and expectations from 5G over 3G and 4G.

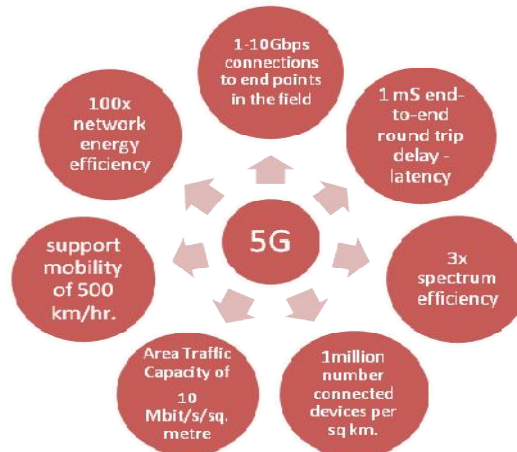


Figure 2 Benefits of 5G

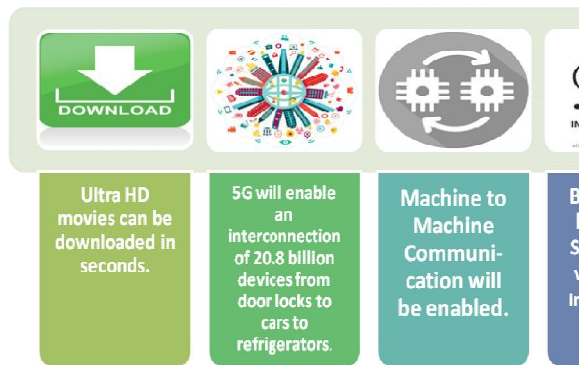


Figure 3 5G and India

For India to seize the 5G opportunity, it is critical that all stakeholders act immediately through a collaborative approach, supported by an enabling ecosystem and the right regulatory support. Since 5G impacts a wide range of industries, close coordination between various government departments and sector regulators is necessary for the success of 5G in India. A collaborative approach involving all stakeholders — the government, sector regulator, telecom operators, network equipment vendors, technology players and companies across various industries — will help develop the 5G ecosystem roadmap in India

II. MATERIAL AND METHODS

Evaluating the data points.

The data points for this study have been prepared from the manual of Telecom India Statistics 2021, Statistics Division Economic Research unit. 07/04/2022. The recent press release by the Telecom Regulator TRAI dated TRAI Press Release 77/2023 released 24 August 2023 has also helped to provide valuable insights to the findings. If one look at the percentage of Spectrum offered to percentage of spectrum bid by the operators we see a steep climb from 33% to 71%. The focus has completely shifted from Midband to C –Band and mm waves in the 5G Auctions

Table 1: Comparison of 5G over 4G Auctions ^[1]

YEAR	Band	FDD/TDD	Category	Offered(Mhz)	Subscribed(Mhz)	Percent
2022	600	FDD	SUB	660	0	0%
2022	700	FDD	SUB	550	220	40%
2022	800	FDD	SUB	136.25	20	15%
2022	900	FDD	SUB	74.4	11.8	16%
2022	1800	FDD	MID	267.2	88.4	33%
2022	2100	FDD	MID	155	30	19%
2022	2300	FDD	MID	60	0	0%
2022	2500	FDD	MID	230	20	9%
2022	3500	TDD	C	7260	5490	76%
2022	26000	TDD	mm Wave	62700	44950	72%
	Total			72092.85	50830.2	71%
YEAR	Band	FDD/TDD	Category	Offered(Mhz)	Subscribed(Mhz)	Percent
2016	600	FDD	SUB	0	0	
2016	700	FDD	SUB	1540	0	0%
2016	800	FDD	SUB	148	30	20%
2016	900	FDD	SUB	19	0	0%
2016	1800	FDD	MID	443	350	79%
2016	2100	FDD	MID	720	170	24%
2016	2300	FDD	MID	320	320	100%
2016	2500	FDD	MID	600	370	62%
2016	3500	TDD	C	0	0	
2016	26000	TDD	mm Wave	0	0	
	Total			3790	1240	33%

SMRA Auction

India Currently follows the Simultaneous Multiple Round Ascending Auction (SMRA) Lots are auctioned individually but simultaneously in discrete bidding rounds with ascending prices for each spectrum lot and the auction continues until no new bids are submitted.

Since the reserve price is linked (indexed) to the market discovered price of the previous auction, the underlying expectation is that market conditions are either likely to remain the same or improve over the course of the period for which spectrum is been assigned. This has often come under contention as operators argue that market ought to determine the value of the spectrum, rather than being embedded into the reserve price.

Auctioning the 26 GHz bands presented a critical opportunity for 5G deployments as it represented the largest amount of contiguous spectrum available in the millimetre-wave bands for DOT. Spectrum acquisition should not hamper the ability of operators to invest in technology up gradation.

ARPU

Indian operators have been long trying to keep an ARPU of Rs 200 since 2010 and to touch Rs 350 by the end of Rs 2025. Operators see 5G as the biggest enabler to this goal. Let us also have a detailed look at how the auctions have fared as the country progressed from 3G to 5G

Table 2: ARPU over the years ^[2]

YEAR	ARPU(IDEA)	ARPU(Airtel)	ARPU(Vodafone)	ARPU(Jio)	ARPU(BSNL)	ARPU(VI)
2010	167	220	177	0	99	0
2012	159	189	185	0	78	0
2013	169	196	194	0	81	0
2014	111	195	199	0	117	0
2015	179	187	175	0	123	0
2016	132	172	205	300	118	0
2021	0	163	0	178.8	86	135
2022	0	200	0	180.5	85	139

More bands on Offer more revenue on offer and more spectrums at affordable cost leading to more bidding. The revenue of an operator has seen close co relations of up to 0.81 with the Reserve price in the past. Thus when future 5G auctions are conducted indexing to 2022 auctions the reserve prices have to be set correct. Else the already failing balance sheets of the operators will fail to invest in the next gen infrastructure thereby offsetting the advantages.

Table 3: Indian Auction over the years^[3]

YEAR	Revenue (Rs Bn)	Offer(Mhz)	Bid (Mhz)	Revenue/Mhz(Mn)	(Offer/Bid)%	Operators	Bands	Days	Rounds	R/D	Auction Model	Technology	Generation
2010	1062	1785	1785	594.96	100%	9	2	34	183	5.4	SMRA	GSM	3G
2012	94.7	271.25	89.5125	1057.95	33%	5	2	2	14	7.0	SMRA	GSM/CDMA	3G
2013	64	124.25	18.6375	3433.94	15%	1	3	1	1	1.0	SMRA	GSM/CDMA	3G
2014	611.62	353.2	289.624	2111.77	82%	8	3	10	68	6.8	SMRA	GSM	4G
2015	1098.75	418.25	372.2425	2951.70	89%	7	4	19	115	6.1	SMRA	GSM	4G
2016	657.89	2354.55	965	681.75	41%	7	7	5	31	6.2	SMRA	GSM	4G
2021	778.15	2308.8	855.6	909.48	37%	3	5	2	14	7.0	SMRA	GSM	5G
2022	1501.73	72000	51240	29.31	71%	4	9	7	40	5.7	SMRA	GSM	5G

Let us also have a look at what were the average Reserve Prices over various circles and categories just before the commencement of the 5G Auctions per 2021 Auctions.

Table 4: Bid Percent^[4]

Bands	Offer	Bid	PC
700	660	0	0%
800	232.5	150	65%
900	98.8	38.4	39%
2100	175	15	9%
2300	560	500	89%
2500	230	0	0%
Total	2308.8	855.6	37%

Player	Mhz	Rs(Cr)	PPH(Rs)
Rjio	488.35	57122.65	1170
Airtel	355.45	18698.75	526
VI	11.8	1993.4	1689
Total	855.6	77814.8	909
MarketRPM			91

III. CASE STUDY: Understanding RP-ARPU LINK Spectrum Auction 2022

Table 6.1: Spectrum Auction 2022(Band)

Table 6.2: Spectrum Auction 2022(TSP's)

YEAR	BAND	TECH	CAT	Offer(Ghz)	Bid(Ghz)	PER		Ghz	Ghz	Ghz	Ghz	Ghz
2022	600	FDD	SUB	0.7	0.0	0%		SubBand	Midband	Cband	mm-Wave	Total
2022	700	FDD	SUB	0.6	0.2	40%	VI	0.28	1.52	0.85	5.35	8
2022	800	FDD	SUB	0.1	0.0	15%	BSNL	0.67	0.65	1.54	17.45	20.31
2022	900	FDD	SUB	0.1	0.0	16%	Airtel	0.35	1.87	2.2	17.6	22.02
2022	1800	FDD	MID	0.3	0.1	33%	Rjio	0.89	1.44	2.44	22	26.77
2022	2100	FDD	MID	0.2	0.0	19%	Total(After 5G Auction)	2.19	5.48	7.03	62.4	77.1
2022	2300	FDD	MID	0.1	0.0	0%						
2022	2500	FDD	MID	0.2	0.0	9%	5G Auctions 2022	0.2	0.1	5.5	45	50.8
2022	3500	TDD	C	7.3	5.5	76%	Prior	1.99	5.38	0	0	7.37
2022	26000	TDD	mm Wave	62.7	45.0	72%	Govt Allocation	0	0	1.54	17.45	18.99
							Total(After 5G Auction)	2.19	5.48	7.04	62.45	77.16
	Total			72.1	50.8	71%						

3.1 Spectrum Valuation of 5G bands 3500 Mhz and 26 Ghz

3500 Mhz In order to arrive at the price of this band, the TRAI used the earlier approach that is used in its recommendation dated 1st Aug 2018. *RP of 3500 MHz = 30% of 1800 MHz.*^[5] TRAI estimated the radio waves in the 3500 MHz travelled only 30% of what they did in the 1800 MHz band. Hence, the operators will be 70% more BTS to cover an area in the 3500 MHz compared to the 1800 MHz band. **26/28 GHz** In order to arrive at the RP for this band, they simply took the ratio of the auction prices for various countries of 3500 MHz and Millimeter-Wave Bands and calculated the average. This came out to be 2.2%. *Hence the RP of the 26/28 GHz band = 2.2% of 3500 MHz.*

Table 7: Calculation of RPH (Revenue per Hz) HPS (Hertz per Subscriber) RPH(Revenue Per Hertz)

Calculations provided in appendix

No	LSA	CAT	Total(Ghz)	ReV(Bn)	Sb(Mn)	RPS	HPS	RPH
1	3	M	10.32	214	112.2	159	103	1.54
2	5	A	17.8	779	384.03	169	47	3.60
3	7	B	25.7	756	464.79	136	60	2.26
4	7	C	19.82	303	185.18	136	173	0.79
	Total					150	96	1.57

India is divided into 22 Local Service Areas (LSA’s) into 3 metros (M) and categories A B and C based on their revenue earning potential. The table indicates the earning potential of the categories Post 5G Auctions

Indian Operators are experimenting with transmission of signal on a whole new band of spectrum of 20~50GHz. The 26 GHz wave identified in India is acknowledged as the mm waveband. It makes use of higher frequencies than the radio waves that have long been used for mobile phones.

However the major disadvantage in using mm waves is that due to such high frequencies of mm waves, they are not able to travel through buildings or obstacles .They can be absorbed by foliage and rain. Especially in a monsoon friendly country like India with a thick green landscape this is a major deterrent. This is also one major reason why the C-Band of 3500 Mhz has seen equal attention in 5G Auctions 2022 to render 5G service.

3.2 RPs and ARPUs

However, auctions in India are not entirely free from challenges. Auctions can be affected by the presence of externalities, market power and collusion on the buyer side and asymmetric information between buyer (Operator) and seller (Government). This might result in a winner’s curse where the winner of the auction ends up paying more than the value of the auctioned resource. For auctions to be successful, the design of the auction is critical. India’s local circumstance which include inability of the common man to spend high on data cannot be overlooked in the spectrum Auctions. SMRA Auctions are also vulnerable to gaming (demand reduction, signaling) and since 22 LSA’s are involved the bid strategy are often complex. The Price Per Mhz/Population was 1.46 Euros in 2012 as compared to 0.2 Euros declared by OF Com in 2012^[6]

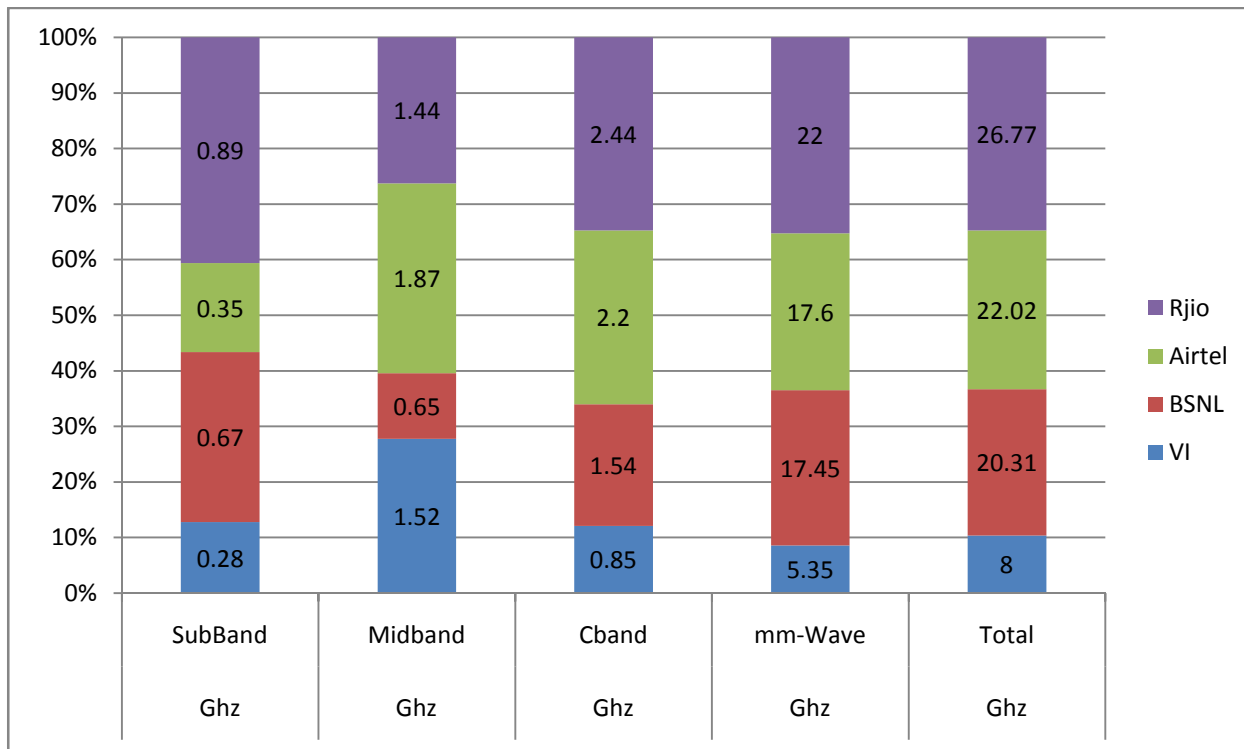


Figure 4 Allocation of spectrum among the 4 major players^[7]

Table 8 PPM Price PerMhz

Year	2016			2022			2016/2022
	MHz	Cost(Bn Rs)	PPM(Mn)	MHz	Cost (Bn Rs)	PPM(Mn)	
Airtel	173.8	142.44	820	19867.8	430.84	21.7	38
Jio	269.2	136.72	508	24740	880.78	35.6	14
Vodafone	365.2	202.8	555	0	0		
Idea	349.2	127.98	366	0	0		
VI	714.4	330.78	463	6228.4	187.99	30.2	15

Table 9: Comparison of Figures Pre and Post 5G Auctions 2022^[8]

	SubBand	Midband	Cband	mm-Wave	Total
VI	0.28	1.52	0.85	5.35	8
BSNL	0.67	0.65	1.54	17.45	20.31
Airtel	0.35	1.87	2.2	17.6	22.02
Rjio	0.89	1.44	2.44	22	26.77
Total(After 5G Auction)	2.19	5.48	7.03	62.4	77.1
5G Auctions 2022	0.2	0.1	5.5	45	50.8
Prior	1.99	5.38	0	0	7.37
Govt Allocation	0	0	1.54	17.45	18.99
Total(After 5G Auction)	2.19	5.48	7.04	62.45	77.16

IV. RESULTS

What has been the most heartening factor of 5G Auctions 2022 is the parameter I would like to call as the **PPM Price per Mhz**. It has come down by almost 22 times with Airtel reaping the maximum benefit of almost 38 times. This price benefit has come because the reserve price of the newly offered C-Band and mm wave has not been indexed to the previous Auction since it has been on offer for the first time to offer 5G services. Telecom Service Providers (TSPs) make use of radio frequency spectrum to send and receive data. With increasing number of consumers, 1.14 Bn as on August 2023 [9] more data is being consumed. But this data remains crammed on the same frequency bands. That means less bandwidth for everyone, causing slower service and more dropped connections. (Table 8)

If the prices in the key 5G bands (700 & 600) are not revised further down then 5G in India will start incrementally and continue to ride on legacy 4G networks till the new 5G bands, especially in the low-frequency bands, become further affordable. Hence, till that time a common man will not see a huge difference, as the coverage of 5G will be limited to a few pockets in the densely populated urban areas, and voice will continue to run on legacy 4G networks. (Table 6.1)

Spectrum is also available in abundance, in all three band kinds — Sub GHz (less than 1GHz, like 600, 700 MHz), Mid Band (3.5 GHz), and Millimeter Wave (24/28 GHz). (Table 6.1)

Historically, the prices of spectrum in India have been unusually high. This is especially true for sub GHz bands like 800 & 900 MHz bands. The real culprit was the exponentially high price of the 2100 MHz band in the year 2010. The prices of 800 & 900 MHz were initially set as 2 times 3G (2100 MHz), and 700 MHz as 4 times. Later these prices got lowered a bit, but never at a level that we can call “realistic and optimal”. (Table 3)

The government has auctioned only sub-sets of the total frequencies and the average reserve price in every subsequent auction has witnessed an upward revision. The outcomes for most spectrum auctions except the 2010 auction which saw 100% bidding and 2022 which saw significant decline in PPM are discouraging. There is a lack of enthusiasm among operators due to unrealistic pricing. (Table 3)

Desired Price per Mhz=91 as per the market Expectation (Table 4)

Desired RPS (Revenue per Subscriber) should be Rs 150 compared to ARPU Rs 142 currently (Table 7).

V. DISCUSSION AND CONCLUSION

The mm Wave band from 20~50 GHz gives 10 times more available bandwidth than the entire 4G cellular band. Many manufacturers like Huawei and Qualcomm are making components that can be operated in the range of millimeter waves and semiconductor technologies that are suitable to operate at frequencies up to 90 GHz, especially in V-band (57 to 66 GHz) and E-band (71 to 86 GHz) applications.

The operator increased its participation to 71% in the 5G Auctions and the Government raked 93% more revenue over its previous Auction. Finally the long lacking Government Operator synergy seems to have resurfaced in this 5G Auction. However the challenge is to align this to the operator dream of ARPU of Rs 350/-by 2025.

We need to study the possibility of experimenting CCA auctions for 5G and beyond, which though difficult to design has reaped better benefits over SMRA in many developed countries as empirical data suggests. Proposed in 2006 the combinatorial clock auctions have been used in 10 major auctions between 2012 to 2016. CCA allocates multiple units where bidders may value the units as complements. CCA is considered better than SMRA and requires high level of bidder sophistication. CCA helps overcome a classic risk of India being stuck with an unwanted subset of the target package of spectrum in various Local service Areas (LSAs) as well as the winner’s curse in which the winner has overpaid for spectrum in 2021 and 2022.

In the long run **5G gets deployed as an independent vertical which no direct linkage with the existing 4G network**. And since it is impossible to create a standalone network by only using mid-band (3.5 GHz), and Millimeter Wave (26 & 28 GHz), we need the Sub-GHz spectrum (600, 700, 800 & 900 MHz) to drive network quality/coverage and to enable 5G voice due to better coverage of the sub band waves.

The current price of the 800 MHz Rs 5000 Cr/MHz. **Assuming 600 & 700 MHz prices will be pegged at this level, in order to acquire a 2x15 MHz spectrum TSP has to shell out Rs 75000 Cr (10 Billion USD)!** This he will have to do on top of the funds needed to acquire 3.5 GHz & Millimeter-Wave Bands.

The Indian operators need access to a new subs GHz band (600 & 700 MHz) in order to unlock the true value of 5G. And for the consumers the value is not just data speeds alone, it is also about reliable and ubiquitous voice connectivity. The consumer's experience with the current 4G/GSM voice is pathetic. So much so that most of the time we end by calling into WhatsApp. With 5G this nightmare has to end. Also, the operators should not be in any way constrained in their service offering capabilities
5G blended on top of 4G will have constraints. These issues can be easily overcome by deploying a standalone 5G network, laced with a 5G voice (called NR voice) running on top of a large chunk of Sub GHz spectrum. Only then will make 5G more useful and valuable for India and its consumers.

REFERENCES

- [1]. TRAI Press Release 98/2023 released 27 September 2023
- [2]. 5G Spectrum Table: Telecom Talk 02 Aug 2022
- [3]. TRAI, Spectrum Auction Report October 2016.
- [4]. TRAI PIR Report January-March 2023
- [5]. TRAI Press Release 77/2023 released 24 August 2023
- [6]. Kathuria, Rajat,, Evaluating Spectrum Auction in India, Indian Council for Research on International Economic Relations (ICRIER) April 2019
- [7]. Dr Varma, Ashok Kumar, Promotional Mix for Indian Telecom Industry, Journal of Modern Management & Entrepreneurship (JMME): Vol 10 April 2020
- [8]. Statistics Division, Telecom India Statistics 2021, Economic Research unit. 07/04/2022
- [9]. Sridhar Prasad ,Spectrum Split Circles Cut the Knot ET Telecom June 15 2022.
- [10]. GSA, Response to spectrum design 10.10.2017

Appendix I

Calculation of HPS and Range

No	LSA	CAT	Total(Ghz)	Mhz	% of Total	Mn	HPS
1	AP	A	3.44	3440	4.5%	82	42
2	Assam	C	3.22	3220	4.2%	25	127
3	Bihar	C	3.25	3250	4.2%	93	35
4	Delhi	M	3.43	3430	4.5%	55	63
5	Gujarat	A	3.74	3740	4.9%	66	56
6	Haryana	B	3.68	3680	4.8%	27	139
7	Himachal	C	3.21	3210	4.2%	9	363
8	J & K	C	3.22	3220	4.2%	12	261
9	Karnataka	A	3.47	3470	4.5%	66	52
10	Kerala	B	3.95	3950	5.1%	42	93
11	Kolkata	M	3.43	3430	4.5%	24	144
12	MP	B	3.71	3710	4.8%	77	48
13	Maharashtra	A	3.61	3610	4.7%	93	39
14	Mumbai	M	3.46	3460	4.5%	34	102
15	North East	C	3.24	3240	4.2%	12	263
16	Odisha	C	3.23	3230	4.2%	34	96
17	Punjab	B	3.56	3560	4.6%	35	101
18	Rajasthan	B	3.61	3610	4.7%	64	57
19	Tamil Nadu	A	3.54	3540	4.6%	77	46
20	U.P.(E)	B	3.54	3540	4.6%	100	35
21	U.P.(W)	B	3.65	3650	4.7%	62	58
22	WB	C	3.67	3670	4.8%	57	65
	Total		76.86	76860	100.0%	1146	
	Average						104

Comparisons have been made between the amounts of spectrum held in the circle versus the total number of Subscribers

HPS= (Spectrum in Circle)/Number of Subscribers

Circle Average Obtained =104 Hz

According to error analysis the reported value of a Physical Quantity is

RV=MV +/- MAE, where

$$MAE = \frac{1}{n} \sum_{i=1}^n |x_i - \bar{x}|$$

n=22, MV=104

MAE=61

No	LSA	CAT	HPS	Deviations	Absolute
1	AP	A	42	-62	62
2	Assam	C	127	24	24
3	Bihar	C	35	-69	69
4	Delhi	M	63	-41	41
5	Gujarat	A	56	-47	47
6	Haryana	B	139	35	35
7	Himachal Pradesh	C	363	259	259
8	J & K	C	261	157	157
9	Karnataka	A	52	-51	51
10	Kerala	B	93	-11	11
11	Kolkata	M	144	40	40
12	MP	B	48	-56	56
13	Maharashtra	A	39	-65	65
14	Mumbai	M	102	-2	2
15	North East	C	263	159	159
16	Odisha	C	96	-8	8
17	Punjab	B	101	-3	3
18	Rajasthan	B	57	-47	47
19	Tamil Nadu	A	46	-58	58
20	U.P.(E)	B	35	-69	69
21	U.P.(W)	B	58	-45	45
22	WB	C	65	-39	39
		Ave	104		61

Here the HPS becomes 104 +/- 61 = [43,165]

BIOGRAPHY

Renju John

(Samsung Global Scholar, 2006)

(IISc Science Young Fellow 2002)

Independent researcher Telecom360