

RPH, HPS the New Paradigm in Spectrum Auction

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Abstract—India is divided into 22 Service Areas consisting of 19 Telecom Circle Service Areas and 3 Metro Service Areas for providing Cellular Mobile Telephone Service (CMTS). The country's mobile Penetration 84% and Internet penetration 60%. The 22 LSAs were conceived in 1995 were based on revenue earning potential in 1995 but after the 5G Auctions 2022 we have to move a finer granulation of the market. This is because 22 LSAs are heterogeneous in its willingness to pay across the range of digital services. Indian Telecom is a 4-player market, R.Jio, Airtel, VI, and BSNL. Post 5G Auctions there has to be closer alignment with the market characteristics. Customizations according to LSA may not be practical. IoT, machine-to-machine communication Gaming, and Augmented reality will see a huge demand in the period leading from 2023. 5G implies short range data intensive communication. It came without surprise when the mm waves saw the maximum subscription in this auction. mm waves account for high data capacity with less penetration. Hence we will see a migration from to micro and Pico cells. LSA will have to model on micro cells for high intensity usage. Operators will need to focus on minimum viable area-Smallest area compatible with profitable operations. This will need redesign of the current LSAs and split circle to reduce barrier promote competition and innovation.

Keywords—LSA (Local Service Area), 5G, Auction, ARPU (Average Revenue per User), HPS (Hertz per Subscriber), RPH (Revenue per Hertz), RPS (Revenue per Subscriber).

I. INTRODUCTION

In the rapidly evolving landscape of India's telecommunications sector, the intricate web of Service Areas and their role in shaping the industry has become a subject of paramount importance. India, a nation known for its vast and diverse population, is segmented into 22 distinct Service Areas, each playing a pivotal role in the delivery of Cellular Mobile Telephone Service (CMTS). These Service Areas comprise 19 Telecom Circle Service Areas and 3 Metro Service Areas, serving as the backbone for the nation's communication infrastructure (Sinha & Sathiyarayanan, 2012).

India's digital journey has been nothing short of remarkable, with a mobile penetration rate soaring to an impressive 84% and internet penetration at 60%. However, the transformation of these Service Areas didn't happen overnight. Originally conceived in 1995, they were designed to harness revenue-earning potential in that era. Yet, the recent watershed moment in the telecommunications industry arrived with the 5G Auctions of 2022, triggering the need for a finer, more nuanced understanding of the market dynamics.

One crucial insight emerged from this shift – the inherent heterogeneity within the 22 Local Service Areas (LSAs). These LSAs, originally established on revenue projections from 1995, now reveal vast disparities in their willingness to embrace the spectrum of digital services. As India's telecom market is primarily driven by four major players – R.Jio, Airtel, VI, and BSNL – the post-5G Auction era calls for a closer alignment with the ever-changing market characteristics (Thakur, 2022). However, the challenge lies in the practicality of tailoring customizations according to each LSA's unique characteristics. While the demand for digital services continues to surge, with IoT, machine-to-machine communication, gaming, and augmented reality poised for exponential growth from 2023 onwards, 5G technology introduces short-range data-intensive communication, signaling a paradigm shift.

Notably, the 5G Auctions saw an unsurprising surge in subscriptions for mm waves – high data capacity channels with limited penetration. Consequently, a shift towards micro and Pico cells is anticipated, as LSAs must adapt to accommodate high-intensity usage scenarios.

In this dynamic landscape, telecom operators face the imperative of focusing on the minimum viable area – the

smallest geographic footprint compatible with profitable operations. Achieving this objective necessitates a comprehensive redesign of the existing LSAs, potentially calling for the subdivision of larger circles to foster competition and innovation while dismantling barriers to entry.

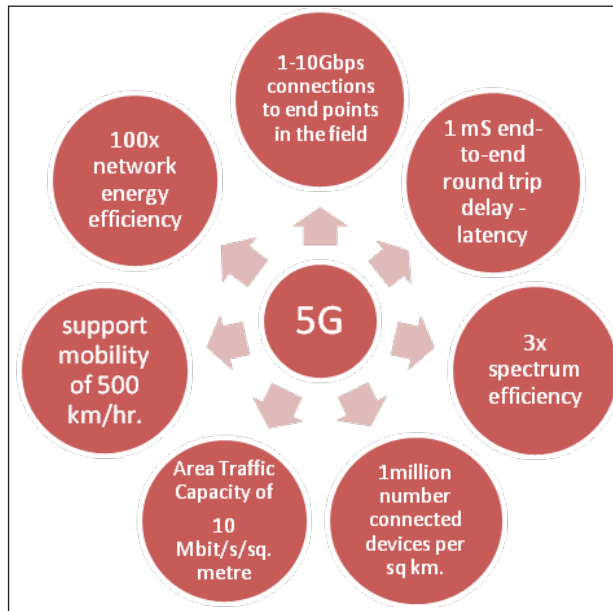


Fig. 1: Benefits of 5G

II. LITERATURE REVIEW

The telecommunications landscape in India is undergoing a profound transformation with the advent of 5G technology. To understand and adapt to this transformation, it is essential to explore the intricate dynamics of the telecom industry and its various service areas.

India's telecommunications industry has come a long way since its inception, experiencing remarkable growth in mobile penetration and internet connectivity. The delineation of 22 LSAs in 1995 aimed to capture revenue-earning potential, but the recent 5G Auctions in 2022 revealed the need for a more nuanced understanding of these service areas. The inherent heterogeneity among LSAs, emphasizing that they differ significantly in their willingness to adopt digital services. In this context, four major telecom players—RJio, Airtel, VI, and BSNL—dominate the Indian market, calling for a closer alignment with market characteristics. (TRAI, Spectrum Auction Report, 2016).

Telecom Service Providers (TSPs) are facing challenges due to increased data consumption due to increase in the

customer base, reaching 1.14 billion as of August 2023, (TRAI, Press Release 98, 2023) causing congestion on existing frequency bands. Mobile broadband users are increasingly seeking live streaming video content on various devices and at any location, creating significant challenges for mobile network operators. These operators are under immense pressure to deliver high-quality services to all subscribers within the constraints of their limited radio resources (Panchapakesan, 2021). To address this, they are exploring higher frequency bands, specifically the 26 GHz mmWave band (Telecom Statistics India, 2022), in the range of 20~50 GHz. This allows for more bandwidth and faster data transmission, improving service quality and reducing dropped connections (Mageshwari, Snehapriya, Sasikala, Vijayasanthi, & Elamathi, 2021). The advent of 5G technology signifies a paradigm shift in the telecommunications landscape. With 5G's short-range, data-intensive communication capabilities, the author notes that mm waves have seen the highest subscription in the 5G Auctions, as they provide high data capacity with less penetration. 5G is proficient address the growing mobile traffic demands of Indian Consumers and be profitable by delivering new level of cost-efficiency, digitalization, and new revenue streams with innovative use cases (Shrivastava, 2022). As a result, the telecom industry is expected to migrate towards micro and Pico cells, necessitating the redesign of LSAs for high-intensity usage. This shift will require operators to focus on the minimum viable area, the smallest geographical footprint compatible with profitable operations, leading to the potential subdivision of larger circles to promote competition and innovation (TRAI, Evolution of Mobile Communications (4G and 5G)).

III. RESEARCH METHODOLOGY

A. Research Design and Approach

In this comprehensive paper, our objective is to conduct a meticulous examination of the existing METRICS, such as Average Revenue Per User (ARPU), Minutes of Usage (MOU), and others, with a keen focus on identifying the voids that emerge following the 5G Auctions. Our analytical effort seeks to penetrate the intricate layers of these metrics, dissecting them into finer components to provide unparalleled insights into the matrices that drive profitability in the post-5G landscape.

To address the unique dynamics of the 5G market, we propose the introduction of two novel parameters: Revenue per Hz (RPH) and Hz per Subscriber (HPS). These

metrics aim to encapsulate the micro-level intricacies of the 5G ecosystem. They represent a significant shift in the paradigm of subscriber-operator expectations in the 5G era.

The first of these parameters, RPH, endeavours to align the revenue generated with the spectral resources allocated, catering to the distinct needs and anticipations of both subscribers and operators in the 5G realm. It serves as a vital indicator of the efficiency and sustainability of 5G services.

Meanwhile, HPS, the second parameter, offers valuable insights into the allocation of spectral resources on a per-subscriber basis, shedding light on the efficient utilization of bandwidth and spectrum in delivering 5G services. This metric plays a pivotal role in shaping network optimization strategies and ensuring an optimal balance between capacity and user experience.

As we delve deeper into this exploration, we will encapsulate the essence of these two parameters, providing a clear and comprehensive overview of their significance in the post-5G landscape. Our aim is to empower stakeholders in the telecommunications industry with the knowledge needed to navigate the evolving terrain and maximize the potential for profitability and sustainability in the dynamic world of 5G.

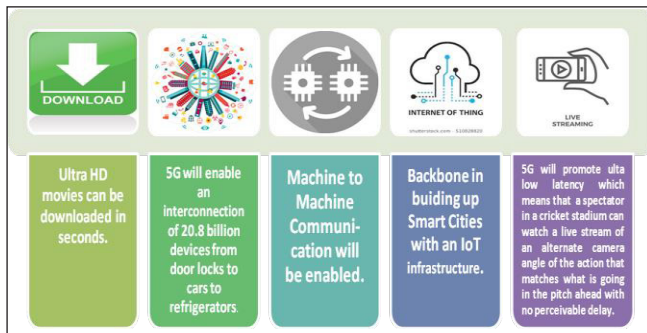


Fig. 2: Expectations for 5G

IV. DATA COLLECTION, DISCUSSION AND CALCULATION

A. Data Collection and Analysis Methods

Let us first have a look at how the various bands are owned by the Indian TSPs post the 5G Auction.

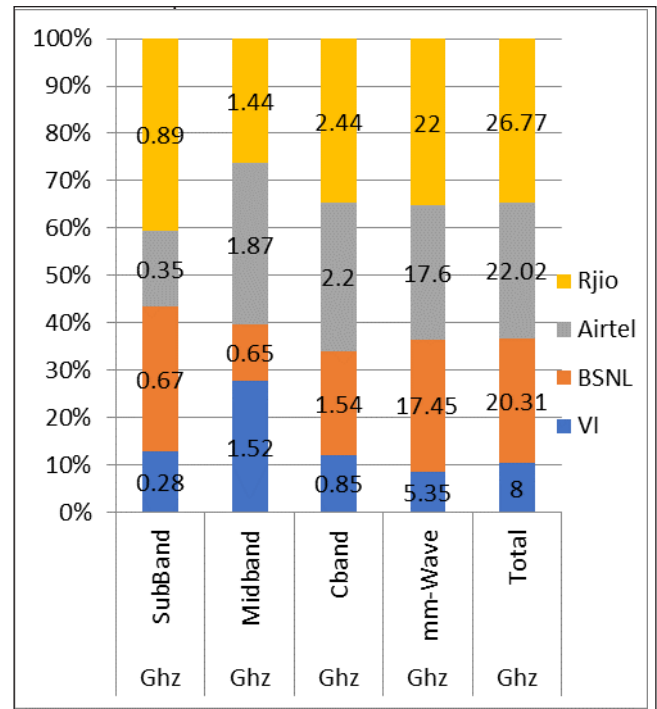


Fig. 3: Spectrum Band Split (Varma, 2020)

One also needs to have an understanding of how the spectrum is owned in the 22 LSA's currently by the 4 major Telcos. Jio and Airtel both private players are the major players especially in the mm waves and C-Band category which form the basis for 5G spectrum (TRAI, Press Release No.77/2023, 2023). Though state owned BSNL is indicating a healthy possession of 5G bands it has been provided by heavy subsidisation by the government through its budget and its capability to compete with the best two is clearly questionable given it's under preparation to 5G infrastructure. The Union Cabinet has approved a third revival package for state-owned telecom operator Bharat Sanchar Nigam Ltd (BSNL) with an outlay of Rs 89,000 crore for allotment of 4G and 5G spectrum through equity infusion (ENS Economic Bureau, 2023). The approval sets the stage for the struggling telco to launch 4G, and, eventually, 5G services. Through this move, the state-owned telco will obtain spectrum in the 700 MHz, 2.5 GHz, 3.3 GHz and 26 GHz bands. BSNL will provide 4G services via the 2.1 GHz spectrum band (TRAI, PIR Report January-March, 2023). According to previous reports, BSNL expects to cover all telecom circles in India with its 4G services by the end of its upcoming financial year, which ends in March 2024, BSNL is likely to launch 5G services in 600

MHz, 3.3 GHz and 26 GHz bands, according to previous reports. (Prasad, 2022) These spectrum bands have been reserved by the Department of Telecommunication and after the 4G launch, all sites will be upgraded to 5G.

Table 1: Spectrum Split Category Wise

Circle	Total
A	17.8
B	25.7
C	23.04
M	10.32

Table 2: Spectrum Split Circle Wise

Circle	State	CAT	Total(Ghz)
1	AP	A	3.44
2	Assam	C	3.22
3	Bihar	C	3.25
4	Delhi	M	3.43
5	Gujarat	A	3.74
6	Haryana	B	3.68
7	HP	C	3.21
8	J&K	C	3.22
9	Karnataka	A	3.47
10	Kerala	B	3.95
11	Kolkotta	M	3.43
12	MP	B	3.71
13	Maharashtra	A	3.61
14	Mumbai	M	3.46
15	NE	C	3.24
16	Odisha	C	3.23
17	Punjab	B	3.56
18	Rajasthan	B	3.61
19	TN	A	3.54
20	UP (E)	B	3.54
21	UP(W)	B	3.65
22	WB	C	3.67

The average spectrum holding /LSA are 3.5 Ghz post 5G Auctions. The following is the ARPU of the consolidated 4 players in the last 10 years.

Table 3: ARPU 2010-2022

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

Let us also analyse how the Revenue has fared over the years from 2010-2022 over various auctions for the regulators.

Table 4: Spectrum Offered and Subscribed

YEAR	Revenue (Rs Bn)	Offer(Mhz)	Bid (Mhz)	Revenue/Mhz(Mn)	(Offer/Bid)%
2010	1062	1785	1785	594.96	100%
2012	94.7	271.25	89.5125	1057.95	33%
2013	64	124.25	18.6375	3433.94	15%
2014	611.62	353.2	289.624	2111.77	82%
2015	1098.75	418.25	372.2425	2951.70	89%
2016	657.89	2354.55	965	681.75	41%
2021	778.15	2308.8	855.6	909.48	37%
2022	1501.73	72000	51240	29.31	71%

The Bid % has visibly increased in the 5G Auctions 2022. The 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. 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 (Kathuria, Kedia, Sekhani & Bagchi, 2019).

Table 5: Circle Split ARPU

Circle A	162.42
Circle B	131.92
Circle C	135.99
Metro	136.72
PVT	150.83
Govt	60.87
Overall	142.32

Table 6: MOU Usage LSAs

	Min	Hrs
Circle A	840	14.0
Circle B	958	16.0
Circle C	1202	20.0
Metro	841	14.0
All India	946	15.8
Circle A	12	
Circle B	11	
Circle C	16	
Metro	9	
All India	12	

One can clearly see that revenue earning potential categorisation of LSAs is not applicable post 5G auctions. Let us also investigate what are the major contributors of the revenue. Also the MOU and number of SMSes per month indicate revision of circles. Given the higher MOUs 700 MHz spectrum with higher penetration and lesser call drops is recommendable for C Bands.

Table 7: Download and Upload Speeds

Circle	Total (Ghz)	LSA	Ave(Ghz)	Download(MBps)	Upload (MBps)
A	17.8	5	3.6	13.72	4.58
B	25.7	7	3.7	12.94	4.21
C	23.04	7	3.3	12.17	3.51
M	10.32	3	3.4	12.70	4.40
Average				12.88	4.18
Total	76.86	22			

Given the higher than average download and upload speeds available in A and B Category we are bound to see a greater revenue earning potential in these segments as downloading movies at 5G speed will never stop to fascinate the common man. Let us further analyse the revenue components of the Indian Telcos.

Table 8: ARPU Split

Rental Revenue	0.82	1%
Revenue from calls	15.25	10%
Revenue from SMS	0.21	0%
Revenue from data	126.7	85%
Revenue from VAS	1.31	1%
Others	3.52	2%
Out Roamers	1.31	1%
Total	149.12	100%
Inter Operator	-6.54	
Net	142.58	

The revenue from data will propel into the early 90's given the focus on data intensive communication post 5G. India has already advanced from 64th position to 60th position in the speed index post the 5G auctions. Mobile data speed increased by 115% to 36.3 Mbps. VI's inability to roll out 5G has seen rapid loss of connections since 5G launch in October 2022.

Table 9: Circle Wise and Player Wise Revenues

Player	Q3	Q4	AQR	YR	Bn
Jio	22586.32	22985	22785.66	91142.64	911.4264
Airtel	18290.13	18500.36	18395.25	73580.98	735.8098
VI	7328.74	7210.63	7269.685	29078.74	290.7874
BSNL	1985.74	2083.59	2034.665	8138.66	81.3866
Total				201941	2019.41

AGR	Q3	Q4	AQR	YR	Bn
Metro	5369.74	5348.61	5359.175	21436.7	214
A	19415.37	19511.15	19463.26	77853.04	779
B	18744.22	19079.12	18911.67	75646.68	756
C	7493.48	7656.02	7574.75	30299	303
Total				205235.4	2052

B. Discussion

Here I have extrapolated the player wise and category wise service revenue for the year 2023-2024 using Q3,Q4 figures of 2022-2023 to include the 5G Auctions which concluded in October 2022. India market is anticipated to be a 3 Trillion industry by the end of 2023 of which 2/3rd will be wireless subscriber revenue.

Emergence and Requirement of New Matrices

Let us strike a comparison between the subscribers and the spectrum available which will give rise to 2 matrices:

- RPH Revenue Per Hz
- HPS Hz Per Subscriber
- RPH*HPS=RPS(ARPU)

Table 10: HPS (Hertz Per Subscriber)

No	LSA	CAT	Total(GHz)	Mhz	% of Total	Mn	HPS	% of Total	Tele-density	Attention	Rev(Dn)	ARPU	RPH
1	Delhi	M	3.43	3430	4%	55	63	5%	273%	T3			
2	Kolkata	M	3.43	3430	4%	24	144	2%	143%	T3			
3	Mumbai	M	3.46	3460	5%	34	102	3%	137%	T3			
				3440	13%	112	103	10%	184%		214	159	2.1
1	AP	A	3.44	3440	4%	82	42	7%	93%	T1			
2	Gujarat	A	3.74	3740	5%	66	56	6%	92%	T2			
3	Karnataka	A	3.47	3470	5%	66	52	6%	102%	T3			
4	Maharashtra	A	3.61	3610	5%	93	39	8%	102%	T1			
5	Tamil Nadu	A	3.54	3540	5%	77	46	7%	101%	T3			
				3560	23%	384	47	34%	98%		779	169	16.5
1	Haryana	B	3.68	3680	5%	27	139	2%	89%	T2			
2	Kerala	B	3.95	3950	5%	42	93	4%	122%	T3			
3	MP	B	3.71	3710	5%	77	48	7%	67%	T2			
4	Punjab	B	3.56	3560	5%	35	101	3%	114%	T3			
5	Rajasthan	B	3.61	3610	5%	64	57	6%	80%	T2			
6	U.P.(E)	B	3.54	3540	5%	100	35	9%	66%	T1			
7	U.P.(W)	B	3.65	3650	5%	62	58	5%	66%	T2			
				3671	33%	408	76	36%	80%		756	154	10.0
1	Assam	C	3.22	3220	4%	25	127	2%	71%	T2			
2	Bihar	C	3.25	3250	4%	93	35	8%	56%	T1			
3	Himachal Pradesh	C	3.21	3210	4%	9	363	1%	120%	T1			
4	J & K	C	3.22	3220	4%	12	261	1%	91%	T1			
5	North East	C	3.24	3240	4%	12	263	1%	79%	T1			
6	Odisha	C	3.23	3230	4%	34	96	3%	77%	T2			
7	WB	C	3.67	3670	5%	57	65	5%	82%	T2			
				3291	26%	242	173	21%	82%		303	104	1.8
					Total	1146					2052	147	

Table 11: Categorisation into Attention Circles

No	LSA	CAT	Total(GHz)	Mhz	% of Total	Mn	HPS	% of Total	Tele-density	Attention
1	AP	A	3.44	3440	4.5%	82	42	7.2%	93%	T1
2	Assam	C	3.22	3220	4.2%	25	127	2.2%	71%	T2
3	Bihar	C	3.25	3250	4.2%	93	35	3.1%	56%	T1
4	Delhi	M	3.43	3430	4.5%	55	63	4.8%	273%	T3
5	Gujarat	A	3.74	3740	4.9%	66	56	5.8%	92%	T2
6	Haryana	B	3.68	3680	4.8%	27	139	2.3%	89%	T2
7	Himachal	C	3.21	3210	4.2%	9	363	0.8%	120%	T1
8	J & K	C	3.22	3220	4.2%	12	261	1.1%	91%	T1
9	Karnataka	A	3.47	3470	4.5%	66	52	5.8%	102%	T3
10	Kerala	B	3.95	3950	5.1%	42	93	3.7%	122%	T3
11	Kolkata	M	3.43	3430	4.5%	24	144	2.1%	143%	T3
12	MP	B	3.71	3710	4.8%	77	48	6.8%	67%	T2
13	Maharashtra	A	3.61	3610	4.7%	93	39	5.1%	102%	T1
14	Mumbai	M	3.46	3460	4.5%	34	102	3.0%	137%	T3
15	North East	C	3.24	3240	4.2%	12	263	1.1%	79%	T1
16	Odisha	C	3.23	3230	4.2%	34	96	2.9%	77%	T2
17	Punjab	B	3.56	3560	4.6%	35	101	3.1%	114%	T3
18	Rajasthan	B	3.61	3610	4.7%	64	57	5.6%	80%	T2
19	Tamil Nadu	A	3.54	3540	4.6%	77	46	6.7%	101%	T3
20	U.P.(E)	B	3.54	3540	4.6%	100	35	3.7%	66%	T1
21	U.P.(W)	B	3.65	3650	4.7%	62	58	5.5%	66%	T2
22	WB	C	3.67	3670	4.8%	57	65	4.9%	82%	T2
	Total		76.86	76860		1146				
	Average						104		101%	

C. Calculation

Calculation of HPS [Detailed calculation in Appendix]

According to error analysis the reported value of a Physical Quantity is $RV = MV \pm MAE$, where

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

$$n=22, MV=104$$

$$MAE=61$$

Here the HPS becomes $104 \pm 61 = [43, 165]$

Any circle above/below this will be an outlier and will require circle level rework 104 is the desired HPS after the 5G Auctions and 147 is the desired ARPU/RPS taking mean as a reasonable estimate since number of LSA's is

only 22. This indicates a marginal increase of only Rs 5 per month from the previous value of Rs 142. Clearly we are limiting 5G to incremental gains and chaining its transformative potential. Now I will examine which are the current LSAs which require immediate rework AP, Bihar, Maharashtra and UP [E] lies below the range and spectrum supply has been under compromised implying there is less spectrum allocated currently and Himachal, J and K and NE it has been over compromised implying there is more than required Spectrum allocated. These are flagged as T1 categories and would require immediate reworking in terms of sub splitting these. 4 of these 6 outliers lie in category C indicating we need to rework the category C circle as first priority post 5G. To ensure homogeneity to provide niche services T2 flagged circles need to touch 100% teledensity.

- RPS of CA and CB are currently lucrative and needs to be retained.
- CM has reached saturation
- CC needs immediate revision.

Hence we observe using both matrices HPS and RPH combined it is circle C which needs immediate revision post 5G.

V. CONCLUSION

1. Clearly we are limiting 5G to incremental gains and chaining its transformative potential. The expected target of ARPU per market estimates is Rs 300 by 2025 at least another Rs 125 above the current figure.
2. The Pricing Strategies of players are aligned in this direction:
 - Vodafone Idea
 - Ranges from Rs 399 to Rs 2299 in 8 variants.
 - Airtel
 - Ranges from Rs 299 to Rs 1499 in 6 variants.
 - Reliance Jio
 - Ranges from 299 to 1499 in 5 variants.
 - BSNL
 - Ranges from 199 to 999 in 5 variants.
3. AP, Bihar, Maharashtra and UP [E] lies below the range and spectrum supply has been under compromised implying there is less spectrum allocated currently and Himachal, J and K and

NE it has been over compromised implying there is more than required Spectrum allocated. These are flagged as T1 categories and would require immediate reworking in terms of sub splitting these. 4 of these 6 outliers lie in category C indicating we need to rework the category C circle as first priority post 5G. To ensure homogeneity to provide niche services T2 flagged circles need to touch 100% teledensity.

4. ARPU should not only be the sole revenue indicator Desired indicators like RPS (Revenue per Subscriber) HPS (Hertz per Subscriber) and Revenue per Hz (RPH) must be read hand in hand to see revenue efficiency of spectrum allocation.

VI. FUTURE CHALLENGES

1. 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.
2. 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.
3. Cheap data should be coupled with quality data as we must improve our broadband index ranking with the 5G Spectrum.

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