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GSMA's response: Auction of Spectrum in frequency bands identified for IMT/5G

Dear Shri Syed Tausif Abbas,

The GSMA commends the government of India for undertaking a collaborative planning for a Spectrum Roadmap as a diverse and timely portfolio of spectrum bands is vital to a broadly available and efficient Mobile Broadband connectivity. The currently assigned mobile spectrum in India is the heart of the country's connectivity, as it directly enables the core mean of communication for the people of India, especially shown in the COVID-19 pandemic, impacting all socio-economic fronts. In the next decade, mobile infrastructure needs must be met timely and efficiently across all spectrum ranges[1] in low- (such as <1 GHz), mid- (such as 3.5 GHz and 6 GHz) and high bands (mmWaves).

Going forward, and based on international best practice, the GSMA recommends such roadmap to consider a timeframe between of 10 years in order to better accommodate emerging spectrum needs, technological evolution and international developments. A roadmap should also be able to present not just the release date of a certain range, but also the conditions the spectrum will be made available, including, but not limited to pricing parameters, obligations and commitments, studies to be made, and any other matter that bring legal certainty to encourage investments.

The importance of Mobile Broadband can also be supported by the fact that Mobile Broadband penetration representing 50.35 per 100 inhabitants in India (TRAI Broadband Consultation Paper, 2020) and 97% of the total Broadband subscriptions. Clearly, there is an opportunity to develop even further, and spectrum is key to make it happen.

India had 731 million unique subscribers and 500 million mobile internet subscribers at the end of 2020.[1] Over the next five years, it is expected there will be more than 155 million new mobile internet users. India is also seeing rapid migration to mobile broadband, driven by the expansion of 4G coverage to almost 99 per cent of the population as well as by some of the most affordable handsets and data plans in the world.

[1] https://www.gsma.com/spectrum/resources/5g-spectrum-positions/

This ongoing shift to 4G is reflected in the rapid adoption of smartphones in India, where mobile data usage per smartphone is among the highest in the world. Between 2016 and 2020, smartphones as a share of total connections more than doubled, from 33 per cent to almost 70 per cent. By 2025, India is projected to become the second-largest smartphone market in the world.[2]

As the GSMA report "India's 5G Future – Maximising Spectrum Resources"[3] highlights, 5G can play a vital role in India's economy. In the past five years, India has been one of the fastest-growing mobile broadband markets, with 4G networks available to almost 99 per cent of the population and consumers benefitting from some of the lowest prices for mobile services and devices in the world. However, low average revenue per user (ARPU) levels and high regulatory costs have limited operators' ability to invest in upgrading their networks. This is already impacting network quality and is expected to affect 5G roll-out, which require more capital-intensive investments than 4G.

The above data represents a commendable effort by the Indian Mobile Industry despite a low spectrum score of 21.5[4] (out of 100) in GSMA's Global Mobile Connectivity index report. In contrast, top ten countries that score maximum in Spectrum dimension have greater quantity of spectrum per operator in multiple bands. Of the top ten countries with maximum spectrum score, seven – Switzerland, Germany, Finland, Japan, Norway, Australia and New Zealand – are also placed in the top twenty of the overall Connectivity Index scores – telling us that the key is access to good quality spectrum, in sufficient quantity, and timely released under appropriate conditions. This is also supported by empirical evidence, which shows that policies that reduce the amount of spectrum available to operators, delay the assignment of spectrum and increase the cost of spectrum all negatively impact two important consumer outcomes - network coverage and quality.[5]

Given the large-scale investment footprint of Mobile Network Operators in India, they are in an ideal position to spur the much-needed innovation and partner with new age start-ups. GSMA notes that the large national mobile infrastructure mobile network operators have built over the years serves not only the citizens of India, but also government and enterprises. As a critical national infrastructure, these large investments must be protected and encouraged.

The GSMA also highlights that the delayed use of globally harmonised IMT spectrum will impact India's international competitive position through lack of interoperability, reduced broadband capability and diminished ability to benefit from new services and applications.

5G supports significantly faster mobile broadband speeds. The technology will also help enable the full potential of the Internet of Things, from virtual reality and autonomous cars, to the industrial internet and smart cities, 5G will be at the heart of the future of communications. Today's most popular mobile applications also benefit from 5G by ensuring continued growth and quality.

In order to get the most out of 5G, spectrum is needed across low-, mid- and high-bands to deliver widespread coverage and support all use cases. Frequencies in the 3.5 GHz range (3.3-4.2 GHz) have in particular been used as the basis for the first roll-outs of 5G globally, driving the wider ecosystem, device diversity and competition. The range is at a balancing point between coverage and capacity that provides the perfect environment for the earliest 5G connectivity.

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[2] https://www.gsma.com/spectrum/resources/indias-5g-future-depends-on-affordable-spectrum/
[3] https://www.gsma.com/spectrum/resources/indias-5g-future-depends-on-affordable-spectrum/
[4] https://www.gsma.com/r/wp-content/uploads/2020/09/GSMA-Mobile-Connectivity-Index-Methodology-2020.pdf
[5] https://www.sciencedirect.com/science/article/abs/pii/S0308596121001324

To meet the IMT-2020 requirements, an initial 80-100 MHz per operator is needed in 5G-enabled mid-bands. Making less spectrum available will impact service quality, decrease peak data rates and increase the necessary network investments. For example, moving from 40 MHz to 100 MHz in 5G mid-bands will result in double peak data rates, while decreasing channel sizes, will increase network density.

In India, it is important that more than 300 MHz of spectrum in the mid-bands is made available to the mobile industry, as it will mean operators having access to the spectrum necessary to meet the ITU 5G target parameters. If this is not available, operators will not have sufficient spectrum to deploy 5G in a cost-efficient manner that benefits consumers and the wider economy.

However, this is just the first step towards building resilient connectivity. Many countries – including South Korea, Japan and most of Europe, North America and the Middle East and North Africa - have already moved beyond the Radio Regulations to assign even more mid-band spectrum, especially in 3.3-4.2 GHz. This is important in urban areas with high population densities, as operators will have to densify the network with small cells to deliver the 5G downlink and uplink data rates.

While higher range bands for 5G means denser networks; making additional mid-spectrum available reduces the need for further extensive cell site densification, which sometimes isn't even possible, thus reducing infrastructure investment and also delivering important environmental benefits. In the medium-to-longer term, it is therefore important that India releases around 2 GHz of mid-band spectrum for 5G going forward, including in the 3.5 GHz range and the 6 GHz band.

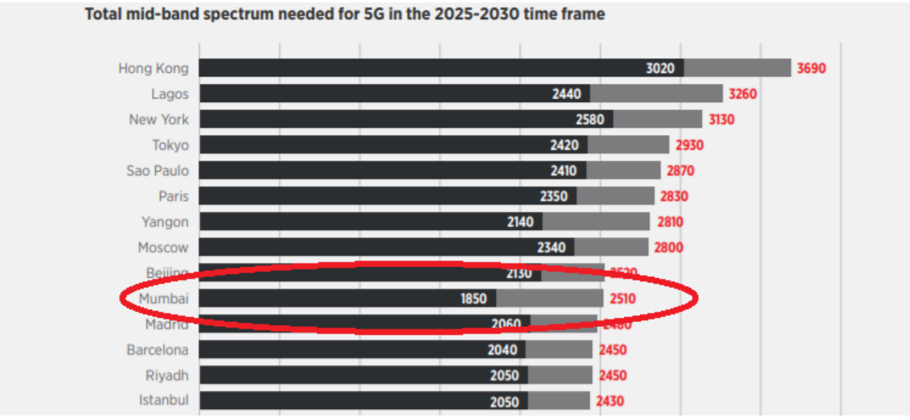
5G needs a significant amount of new harmonised mobile spectrum in the three key frequency ranges to support coverage and capacity. For example, ensuring that more than 300 MHz of mid-band spectrum is available for 5G during the next auction at a reserve price that allows industry to deploy across all service areas could result in more than 200 million additional 5G connections and increase the overall economic benefits of 5G by at least $75 billion. This would impact coverage, quality of services and consumer fees positively. Hence, it is vital to timely make adequate spectrum available in mid bands supported by low and high bands:

Low: Due to the limited amount of spectrum available, bands that offer coverage for wide areas (such as **700 MHz and 800 MHz**) will eventually exhaust their capacity. Long-term planning without new obligations is necessary in countries that want to obtain the flexibility of using the band for mobile services. The low frequencies will support extended coverage in urban, suburban and rural environments and will help support Internet of Things (IoT) services. In particular, the **600 MHz band** (N71) will be important in the long term to provide additional capacity in coverage bands that allow supporting the increase in the massive use of Internet of things services, and 5G stand alone.

WRC-19 also approved the agenda for the WRC-23 that will consider the identification of additional mid- and low-frequency bands. An important step in the evolution of 5G is spreading the benefits of 5G to rural areas and accelerating the IoT revolution. Therefore, the GSMA is supporting efforts to identify more spectrum below 1 GHz at WRC-23 to improve 5G coverage.

Mid: Mid-bands offer a good combination of coverage and capacity benefits. This includes spectrum in the **3.3 to 4.2 GHz range**, which is expected to form the basis for many initial 5G services and the complementary 6 GHz, currently under study by the ITU. While high frequencies are necessary to achieve the lowest latency for 5G, the 3.3 to 3.8 GHz band will be the most important for 5G in the short term and offers a perfect combination of capacity (the amount of traffic it can handle) and optimal coverage (the distance the signal travels). The use of the band 3.3-4.2 GHz for mobile broadband has been harmonised at various points in the last fifteen years in both the International Telecommunication Union (ITU) and regional groups. Study from Coleago Consulting[6] shows that operators will need 2 GHz of spectrum during this decade.

The research considered a wide representation of global cities, which included Mumbai. As the following table shows, Mumbai has significant requirements for mid-band spectrum across all scenarios of different activity factors. 6 GHz band is also a critical band for Mumbai to be able to meet the ever rising demands for 5G mobile broadband.



Another important band is the **1,400 / 1,500 MHz band**. This band is strategically located between the low bands of 700, 850 and 900 MHz and the averages of 1,800 and 2,500 MHz, has aggregation capacity and has been forming a vital addition to mobile broadband service. It was identified for IMT in CRM-15 and is capable of providing a combination of capacity and coverage, as well as being a means to alleviate high bandwidth consumption through downloads.

As mentioned above, **6 GHz** should also be in the pipeline. While Region 1 will discuss the 6425-7125 MHz band for IMT at WRC-23, Regions 2 and 3, that includes India, will discuss the upper 100 MHz. The GSMA members from all three ITU Regions were surveyed and 90% of MNOs' responses placed the band 6425-7125 MHz as their high priority for IMT implementation in the future, whether in a new IMT identification at WRC-23 or making use of the existing global mobile allocation.

MNOs are doing this because they believe they can be competitive and the total cost of ownership analysis of 5G NR backs them up. However, a fragmented approach towards key 5G bands, if followed by emerging countries like India will give away the benefits of economies of scale and the true benefits of 5G might get delayed resulting in socio-economic loss to the citizens.

High: The ITU has analysed the IMT spectrum requirements for frequency bands above 24 GHz. The results are presented in three ranges: **24.25-33.4 GHz, 37-52.6 GHz and 66-71 GHz**. different parameters, including application-based approaches and technical performance. Individual information from various countries was also included, each of which established its needs based on its own national considerations. Results vary depending on the approach and parameters used. In this range, 26 GHz and 28 GHz have emerged as two of the most important bands. These have the potential to offer broader harmonisation with minimal equipment complexity. The combination of 5G and mmWaves leads to a new level of mobile performance with ultra-high speeds and low latencies. Momentum behind the 28 GHz band is growing, with the availability of commercial

[6] https://www.gsma.com/spectrum/resources/5g-mid-band-spectrum-needs-vision-2030/

devices and services. For the 26 GHz band, the results of WRC-19 had a major impact on the ability of mobile operators to make the most of the band.

The decision of making a specific range available to a specific service should consider the socio-economic impact it will bring and, at the same time, the capacity of the licensees to develop and maintain this importance and impact within the years. This includes making spectrum available when it is been awarded to other services (sometimes under-used or not in use) in order to make sure the most relevant service – with available technology and focusing on economies of scale – is made available, considering short-, mid- and long-term demand.

Most notably, the speed, reach and quality of 5G services will be heavily dependent on governments' and regulators' support to provide timely access to the right amount and type of spectrum, and under the right conditions and prices.

The issue of spectrum management policy has never been more vital. Making sufficient amounts of affordable spectrum available is central to expanding and upgrading mobile broadband services – and will be core to the success of 5G in India. However, instances of spectrum licences being sold for extremely high prices, or going unsold due to the high reserve prices, are a cause for concern. These outcomes undermine not only consumer mobile services and the wider digital economy, but also impact India's effort in becoming a $5 trillion economy.

The causes of extremely high prices are often policy factors that appear to prioritise other objectives, such as maximising short-term state revenues, above long-term support for the digital economy through improved mobile services. Key issues arise when regulatory authorities:

- Fail to make sufficient amounts of mobile spectrum available, which creates scarcity and artificially inflates prices;
- Set excessive auction reserve prices, final prices or annual spectrum fees;
- Hold assignment processes that discourage participation via complicated procedures or a lack of transparency; and
- Fail to consider local industry factors, including issues such as lower ARPUs and long-term sustainability.

Spectrum is a valuable and scarce public asset that must be put for public use in a timely manner. The primary goal for the Indian government should therefore be to encourage the timely and best use of spectrum in widespread, high quality networks. Efficient spectrum awards maximise access to affordable mobile broadband services, which, in turn, drive a significant impact on the digital and the overall economy.

The GSMA report "India's 5G Future – Maximising Spectrum Resources" takes a closer look at how effective spectrum pricing can support India's National Digital Communications Policy and help boost the country's economy. The key findings were:

Over the past 10 years, spectrum prices in India have been significantly higher than those of other countries, both in Asia and other developing countries. This is reflected in the median unit price of spectrum per population (adjusting for inflation and purchasing power parity) and especially when adjusting for operator revenues, which captures the value of the mobile market in the short-to-medium term. When considering spectrum pricing at a circle-level, more than half of the prices paid have been above the global average since 2010, while almost 20 per cent have been at very high prices.

As a result, mobile operators in India pay significantly higher costs for spectrum compared to other large emerging markets and high-income countries. This directly impacts operators' return on investments and their ability to invest in upgrading networks.

Reserve prices can have an important role in discouraging speculators and frivolous bidding, recovering the administrative costs of the award process and limiting collusion incentives amongst bidders. However, they should also allow room for price discovery, encourage participation and avoid spectrum going unsold. Given what has happened in previous Indian auctions, including the March 2021 auction when 62 per cent of available spectrum went unsold, the primary objective should be to ensure that all available spectrum is assigned in a manner that maximises consumer welfare and economic efficiency.

Given that more spectrum will be required to fulfil consumer demand, an auction should be seen as a frequent affair where operators have flexibility to manage demand at regular intervals. Affordable pricing is key to manage the level of enthusiasm for more investments and catering to the socio-economic needs of the country.

In 2018, TRAI recommended a price of INR 4.9 billion (around $67 million) per MHz for spectrum in the 3.3-4.6 GHz bands. When adjusting for purchasing power parity, market size and licence length, this is higher than reserve prices in almost all other countries that have assigned the band so far – and higher than most of the actual prices paid. When taking revenues into account, the reserve price is significantly higher than what has been set in other markets.

The current pricing for 3.5 GHz therefore puts the future of the band in jeopardy and there is a risk it will end up being another example of a band that is not used efficiently in India. This will make it more challenging for the industry to deploy 5G throughout the country, which risks exacerbating the digital divide and hindering the wider socioeconomic impacts. Fortunately, the government still has an opportunity to change course.

5G must be seen as a mass technology, as it is capable of not only supporting mobile broadband subscribers but also millions of IoT chipsets that will directly affect and shape the lives of Indians post-pandemic.

In summary:

- India has some of highest prices for spectrum in the world, which have led to key spectrum bands going unsold and directly limits the industry's ability to invest in upgrading mobile networks. This is already impacting network quality and it is expected to affect 5G roll-out.

- Deploying 5G networks in India will require capital-intensive investments. The mobile industry will only be able to roll-out 5G in a cost-efficient manner across all service areas if they have sufficient spectrum and if the cost of access does not limit operators' ability to make the necessary network investments.

- 5G can play a vital role in India's economy, with benefits of at least $455 billion in the next two decades – but poorly designed spectrum policies will put that at risk. For example, ensuring that more than 300 MHz of mid-band spectrum is available for 5G during the next auction at a reserve price that allows industry to deploy across all service areas could result in more than 200 million additional 5G connections and increase the overall economic benefits of 5G by at least $75 billion.

- Backhaul spectrum is also needed in the 5G era. New backhaul bands are needed to support evolving network requirements and growing traffic, current backhaul bands will still play an important role but need support to maintain relevance in the 5G era - especially through wider channel sizes.

Please accept assurances of the GSMA’s highest regards.

Yours Sincerely,

Jeanette Whyte
Head of Public Policy, APAC

Q.1 Whether spectrum bands in the frequency range 526-617 MHz, should be put to auction in the forthcoming auction? Kindly justify your response.

Development of the spectrum below the 700 MHz band has been the subject of discussion in many parts of the world. The 600 MHz band was developed in the US using the 3GPP Band 71 plan which to date is the available equipment for this band.

However, discussion on the band 470-698 MHz has been continuing in other areas. AWG is currently considering the best option to follow for a harmonised 600 MHz band plan in the Asia-Pacific region. This may be a development of the 3GPP Band 71 that is being used in the US – the so-called B2 plan – or a slightly different bespoke band plan starting at 612 MHz, known as B1. The GSMA believes that, with both of these alternatives currently being considered in AWG, TRAI would best serve Indian consumers by allowing for the flexibility for either approach to be taken until a harmonised decision is made.

The other issue is that, under Agenda Item 1.5 at WRC-23, Region 1 is currently developing long-term plans for the whole band 470-960 MHz. This may see further consideration of spectrum below both 3GPP Band 71 and the AWG options. Development of equipment for sub-600 MHz bands, whether for FDD, TDD or supplementary downlink, is a long-term issue. However, access to such spectrum may be a valuable way of enhancing rural broadband in the future.

Accordingly, 526-617 MHz should not be auctioned in the forthcoming auctions as presently there is no supporting ecosystem for this band. But it should be reserved for IMT in line with ITU identifications.

Q.2 If your answer to Q1 above is in affirmative, which band plans and duplexing configuration should be adopted in India? Kindly justify your response.

Please refer to Q.1.

Q.3 In case your answer to Q1 is in negative, what should be the timelines for adoption of these bands for IMT? Suggestions to make these bands ready for adoption for IMT may also be made along with proper justification.

Please refer to Q.1.

Q.4 Do you agree that 600 MHz spectrum band should be put to auction in the forthcoming auction? If yes, which band plan and duplexing configuration should be adopted in India? Kindly justify your response.

Yes, we believe that enhancing low-band capacity is crucial for Indian consumers to access 5G both in rural areas and on rural roads. It will also improve indoor capacity in urban and suburban areas.

However, if TRAI's goal is to increase take-up of mobile broadband in rural areas it must do so with the right conditions. It is not sufficient to simply improve mobile coverage: the mobile industry must be able to do so in order to offer affordable connectivity.

The GSMA studies[7] the coverage gap (the % of the world's population not covered by the mobile internet) and the usage gap (the % of the world's population that is within mobile coverage but not using it) on an annual basis. By 2020, the coverage gap had reduced to 6%, meaning that the vast number of people not using the mobile internet were already covered by a mobile network.

The largest reason for this is digital literacy and awareness, an issue which cannot be resolved by a spectrum auction on its own. However, the second most important issue is affordability.

Seeking to maximise state revenues from spectrum has a negative socio-economic impact. Research shows there are strong links between high spectrum prices and slower network speeds as well as lower coverage and lower take-up. Licensing authorities should set reserve prices conservatively and then allow the market to determine a fair price. High spectrum fees carry risks to network investment and the affordability of services.

India's mobile operators offer service with some of the lowest ARPUs in the world and their ability to continue offering service at these low price points is dependent on best-practice assignment and licensing. Onerous conditions and high licence fees will stifle take-up of broadband services.

The sensitivity of Indian consumers to price points also makes us feel that alternative services to terrestrial mobile are unlikely to impact broadband penetration to a large degree. Studies claiming that satellite broadband can provide a solution to solve the usage gap issues mentioned above appear to the GSMA to be wide of the mark. Rather, it is likely in the 5G era that Indian consumers who are used to ARPUs of US$1.74 by mobile connection (and US$2.63 by unique subscriber), will continue to use terrestrial mobile services.

Regarding band plan, we believe TRAI should closely follow developments of the work being carried out in AWG with the potential to follow either AWG B1, AWG B2 or 3GPP Band 71. All of these are FDD plans.

The low frequencies will support extended coverage in urban, suburban and rural environments and will help support IoT services. These can provide additional capacity in coverage bands that allow supporting the increase in the massive use of Internet of things services, and 5G stand alone.

Q.5 For 3300-3670 MHz frequency range, which band plan should be adopted in India? Kindly justify your response.

3GPP n77 covers the range 3.3-4.2 GHz while n78 covers the range 3.3-3.8 GHz. These are both TDD plans and have the largest ecosystem of any 5G band between them. Therefore, the n78 (3300-3800MHz) should be adopted in India.

To increase flexibility as well as make spectrum usage more efficient, Time Division Duplex (TDD) is becoming increasingly common and important and should focus on a full synchronised frame structure via an agreement amongst operators. The frame format the GSMA supports is delineated as DDDSU for most of the cases. This approach provides a good compromise between download and upload speeds with a low latency.

The GSMA would like to highlight that spectrum being made available in upper mid-bands will not be sufficient in the medium-to-long term. While 3.3-3.67 GHz may be sufficient for 5G launch based on the current market

[7] https://www.gsma.com/mobilefordevelopment/blog/the-state-of-mobile-internet-connectivity-the-coverage-gap-continues-to-narrow-but-the-usage-gap-remains-wide/

situation with 3 operators, it is likely that in India, where some of the urban areas are extremely densely populated, this will quickly be insufficient in many cases.

The GSMA believes that an average of 2 GHz of mid-band spectrum will be needed in the 2025-2030 timeframe to deliver 5G. A research study from Coleago Consulting on global mid-band 5G spectrum needs shows that careful consideration of 5G spectrum demand in the 2025-2030 time frame is crucial. This is due to the development of new use cases, the rapid take-up of 5G and the need to mitigate the risk of a challenging and costly environment in the near future. The research proposes that regulators make 2 GHz (on average) of mid-band spectrum available for the development of 5G, including FWA. This includes the 2.6 GHz, 3.5 GHz, 4.8 GHz and 6 GHz ranges.[8]

While 5G launch will be possible in the 3.3-3.67 GHz band, India should consider where future mid-band 5G capacity will be delivered. The main options being considered globally are the upper 3.5 GHz range (generally 3.8-4.2 GHz, or in India's case 3.67-4.2 GHz) or the upper 6 GHz band (6.425-7.125 GHz).

The GSMA believes at least one of these options will be necessary in India in the 2025-2030 timeframe.

Q.6 Do you agree that TDD based configuration should be adopted for 24.25 to 28.5 GHz frequency range? Kindly justify your response.

All mmWave band plans are TDD, including the 26 and 28 GHz bands[9]. The frame format the GSMA supports is delineated as DDDSU for most of the cases. This approach provides a good compromise between download and upload speeds with a low latency.

Last year, mobile technologies and services generated 4.7% of GDP across the globe[10]. By 2024, the contribution is predicted to increase to 4.9% of GDP. This can only happen, however, if sufficient spectrum resources are in made available to provide the capacity for innovation and development.

5G requires spectrum in three different ranges: low- (e.g. 700 MHz), mid- (e.g. 3.5 GHz) and high-bands (mmWaves) to unlock several different use cases. While low-bands provide coverage and mid-bands represent a great mix of coverage and capacity, high-bands are responsible for ultra-high speeds and super low latencies.

Important to mention again, research from Coleago Consulting on global mid-band 5G spectrum needs shows that careful consideration of 5G spectrum demand in the 2025-2030 time frame is crucial. This is due to the development of new use cases, the rapid take-up of 5G and the need to mitigate the risk of a challenging and costly environment in the near future. The research proposes that regulators make 2 GHz (on average) of mid-band spectrum available for the development of 5G, including FWA. This includes the 2.6 GHz, 3.5 GHz, 4.8 GHz and 6 GHz ranges.

At the same time, applications with data transmission at tens of gigabits, IoT, FWA, augmented reality, 8K video streaming, industrial automation, remote surgery, autonomous vehicles, etc. are further unlocked with mmWaves.

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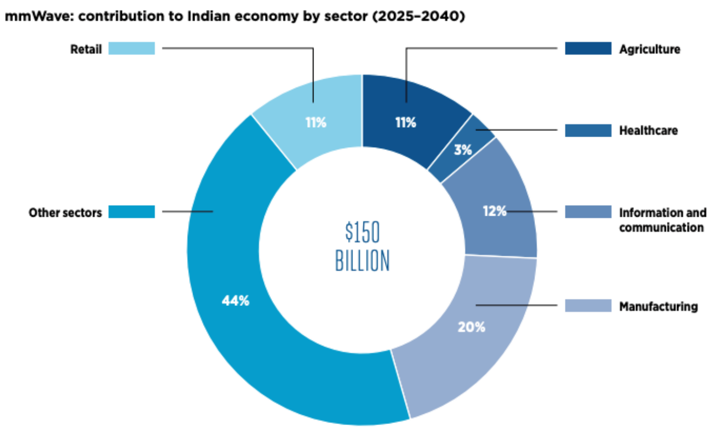
[8] https://www.gsma.com/spectrum/wp-content/uploads/2021/07/5G-Mid-Band-Spectrum-Needs-Vision-2030.pdf
[9] https://www.gsma.com/spectrum/resources/mmwave-5g-a-digital-india-cornerstone/ and https://www.gsma.com/spectrum/resources/26-ghz-28-ghz/
[10] https://www.gsma.com/mobileeconomy/

The GSMA commissioned a global report on mmWave socio-economic benefits[11] and results show the unique performance benefits of mmWaves, including ultra-high speeds and low latencies, will drive the revolutionary impact of the most advanced 5G services in the South and South East Asia and the Pacific Islands regions by USD 45bn in GDP.

GSMA's report "The Impacts of mmWave 5G in India"[12] found that mmWave to deliver $150 billion in additional GDP for India over 2025–2040.



In this range, 26 GHz and 28 GHz have emerged as two of the most important bands. The number of countries and regions where spectrum is licensed and operators are launching commercial services or conducting trials highlights the momentum behind mmWaves – 22 countries with completed assignments. For example, 28 GHz has been deployed in USA, Japan, Taiwan and South Africa and interest is growing.

26 GHz was identified for IMT at WRC-19. That landmark decision means national governments around the world now have the opportunity to consider assigning it for use in 5G networks. At the same time, data growth is driving the need for additional frequencies to meet 5G demands, such as in 28 GHz.

The GSMA recognises and supports actions by governments and operators in many countries to test and assign the 28 GHz band for 5G under its existing mobile allocation in the ITU's Radio Regulations and, therefore, we believe this is an important decision to be made in India for the future of 5G.

Finally, we would like to draw attention to the high-level figures that back up this 2019 report, and the fact that we believe that the global impact of 5G by 2034 will be US$2.2 trillion. This report was carried out by telecoms analysts TMG.

Separate to this, we would like to share informally some data from a new report that will be released by GSMA Intelligence in the first quarter of 2022. This forecasts that around half of that growth to come in the 2030-2034 timeframe and the global 5G market by 2030 will have an impact on global GDP of around US$1 trillion.

[11] https://www.gsma.com/spectrum/resources/mmwave-5g-benefits/
[12] https://www.gsma.com/spectrum/resources/mmwave-5g-a-digital-india-cornerstone/

Given these two separate, and complementary, pieces of analysis showing the size of the global market for 5G, we ask TRAI to treat any other reports from other industries with care especially where they show numbers that seem unrealistically high.

Q.7 In case your response to Q6 is in affirmative, considering that there is an overlap of frequencies in the band plans n257 and n258, how should the band plan(s) along with its frequency range be adopted? Kindly justify your response.

Frequency planning of 26 GHz and 28 GHz require the use of 3GPP band plans n258 (24.25 to 27.5 GHz), n257 (26.5-29.5 GHz) and a subset of n257 used in North America and elsewhere, n261 (27.5 to 28.35 GHz). There will be significant market volume supporting each of these bands once the mmWave market starts to mature and the GSMA expects all to be used broadly in the future. mmWave technology is still in its infancy and operators will need flexibility to consider the device ecosystem for the spectrum which they hold.

While flexibility is thus required in which band plans will be included in the UEs offered by Indian operators, these are all distinct parts of a wider TDD range from 24.25-29.5 GHz. As such, the auction should consider the assignment of sufficient 800 MHz-1.2 GHz spectrum quantity per operator and giving them the flexibility to choose which equipment to use.

Commercial synchronisation between operators will, as always with TDD systems[13], be needed to enhance spectral efficiency.

Q.8 Whether entire available spectrum referred by DoT in each band should be put to auction in the forthcoming auction? Kindly justify your response.

With the caveats mentioned above the GSMA supports the spectrum discussed for auction. In general terms, spectrum should be made available as soon as practical and looking into its future use, except the 526 MHz to 617 MHz which doesn't have any ecosystem or band plan yet. Limiting the amount of spectrum available can lead to higher prices, due to artificial scarcity. High prices have been proven to generate lower speed, limited coverage and may impact the price of services to users. It is also important to ensure that spectrum is made available clear and free of interference.

Q.9 Since upon closure of commercial CDMA services in the country, 800 MHz band is being used for provision of LTE services, a. Whether provision for guard band in 800 MHz band needs to be revisited? b. Whether there is a need to change the block size for 800 MHz band? If yes, what should be the block size for 800 MHz band and the minimum number of blocks for bidding for existing and new entrants? (Kindly justify your response)

The 20 MHz guard band is not required in a planned FDD environment. Therefore, the guard band should be revisited as it is no longer necessary and spectral efficiency demands that it be removed.

While lot sizes of 5 MHz have often been used in the development of auction design for sub-1 GHz auctions around the world, these have always been with the aim of developing a frequency table in which MNOs are comfortable with and, as operators have already acquired spectrum in previous auctions in this band, the same 1.25 MHz block size can be used if the market believes so. While wider channels will be required to offer LTE or 5G NR services, the market will be able to decide on the aggregation of such channels. A well designed auction will be key to support any decision on this matter.

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[13] https://www.gsma.com/spectrum/resources/3-5-ghz-5g-tdd-synchronisation/

Q.10 Do you agree that in the upcoming auction, block sizes and minimum quantity for bidding in 700 MHz, 900 MHz, 1800 MHz, 2100 MHz, 2300 MHz and 2500 MHz bands, be kept same as in the last auction? If not, what should be the band-wise block sizes and minimum quantity for bidding? Kindly justify your response.

In addition to the choice of auction format[14], there are also various tools available to regulators in designing auctions to promote competition or increase the likelihood of efficient outcomes, although there are often trade-offs involved in their use. Lot / block sizes for example are one of those.

Smaller lots can provide access to important spectrum for more operators than when larger lots are used. Lots that are too small increase the need for bidders to aggregate multiple lots and may lead to operators acquiring spectrum which they are unable to use.

Therefore, an optimal lot size is generally based on the market structure and should be of at least the minimum size a technology can support in a certain band – generally 5 MHz for lower bands and 10 MHz for mid-bands. Operators would be more suited to, therefore, respond to this question with a specific lot size per band.

It is important to note the benefits of contiguous spectrum. In order to gain up to 15% of capacity and save up to 90% of energy, as well as bring better speeds and simpler networks, reshuffling blocks after the auction is the best way forward, including where part of the spectrum is already assigned.

Q.11 In case it is decided to put to auction spectrum in 526-698 MHz bands, what should be the optimal block size and minimum quantity for bidding? Kindly justify your response.

Please refer to Q.10.

Q.12 What should be optimal block size and minimum quantity for bidding in 3300-3670 MHz band? Kindly justify your response.

Please refer to Q.10. Note that channel sizes for the n78 spectrum band are 10, 15, 20, 25, 30, 40, 50, 60, 70, 80, 90 and 100 MHz. Therefore, we recommend blocks of 10 MHz.

Q.13 What should be optimal block size and minimum quantity for bidding in 24.25-28.5 GHz? Kindly justify your response.

Please refer to Q.10. Note that channel sizes for mmWaves are 50, 100, 200 and 400 MHz. Therefore, we are not against blocks of 100 MHz.

Q.14 Whether any change is required to be made in the existing eligibility conditions for participation in Auction as specified in the NIA for the spectrum Auction held in March 2021, for the forthcoming auction? If yes, suggestions may be made in detail with justification.

Operators would be more suited to respond to this question.

[14] https://www.gsma.com/spectrum/resources/spectrum-auctions/

Q.15 In your opinion, should the suggested/existing eligibility conditions for participation in Auction, be made applicable for the new spectrum bands proposed to be auctioned? If not, what should be the eligibility conditions for participating in Auction? Kindly justify your response.

Operators would be more suited to respond to this question.

Q.16 Is there a need to prescribe any measure to mitigate possible interference issues in 3300-3670 MHz and 24.25-28.5 GHz TDD bands or it should be left to the TSPs to manage the interference by mutual coordination and provisioning of guard bands? Kindly provide justification to your response.

To increase flexibility as well as make spectrum usage more efficient, Time Division Duplex (TDD) is becoming increasingly common and important. TDD uses the same frequency for each duplex direction, with a frame that includes different time periods and slots for uplink or downlink communications. By changing the duration of these, network performance can be tailored to meet different needs and help provide the best possible experience.

However, for this to work all TDD networks, either LTE or 5G, operating in the same frequency range and within the same area have to be synchronised. Base stations need to transmit at the same fixed time periods and all devices should only transmit in dedicated time periods. Failure to do so creates interference, which has a major impact on performance as well as coverage.

On behalf of the mobile industry, the GSMA urges regulators to prioritise TDD synchronisation, or other suitable alternatives, to address interference issues among networks, from both a national and an international perspective. By doing so, a bright future for 5G is one step closer. Therefore, as TDD requires a synchronised frame structure via an agreement amongst operators. If an agreement is not reached, a general mandatory frame structure is suggested.[15]

Guard bands are not necessary in any of the cases where TDD synchronization is present. If specific frame structures are needed for a particular use case, geographical separation may be better suited.

On market specific interference issues, such as with FSS and FSS Broadcasting need to be considered for a clear plan before the auction is approved.

Coexistence between IMT and fixed satellite services (FSS) at 3.5 GHz was the subject of a 2019 Transfinite study for the GSMA. It considered adjacent band compatibility between IMT and FSS earth stations in the 3.4-3.8 GHz band. The study considered a number of different IMT deployments (macro and small cell), IMT emissions masks (based on 3GPP limits), FSS links (with different elevation angles) and FSS earth station receiver masks.

The results of the study indicate that, for IMT macro deployment and all combinations of spectrum masks and FSS links considered in the study, a guard band of 18 MHz would allow an I/N = -10 dB FSS protection criterion to be satisfied (some administrations stipulate a less conservative figure than this including in the US, which uses -6 dB). For IMT small cell deployment, a guard band of 0 MHz would allow this.

The study highlights that the performance of FSS earth station receivers will be very important in determining their resilience to interference from other services in adjacent bands. In event of interference to an FSS earth station, increasing the guard band will in many cases have little impact and will not be the best way of resolving

[15] https://www.gsma.com/spectrum/resources/3-5-ghz-5g-tdd-synchronisation/

interference cases, with other mitigation measures: site shielding or improved FSS receiver filtering being more effective[16].

Broadcasting applications in the fixed satellite service (FSS) bands have also been using spectrum at 3.5 GHz in India. Considerations centre around either continuing those services in the band or migrating them to higher bands. Brazil worked to develop a bespoke LNB filter with a performance gain above the previous commercially available devices. The model has been finalised, is 100% effective and is now commercially available – requiring no guard band.

However, as the extent of 5G mid-band spectrum needs became clearer during the process, and after careful consideration with the entire industry, the decision took another path. Brazil decided that broadcasting services would be migrated to the Ku-band.

This approach was seen to have several benefits, not least creating a pathway to the future availability of the 3.8-4.2 GHz range for 5G. Historically, Ku- and Ka-band satellite services have been more susceptible to rain fade and Brazil, which has periods of high rainfall, has been a strong supporter of C-band satellite services in times gone by. The Brazilian move follows a global trend of using higher bands for satellite. It shows confidence that the satellite industry has moved beyond reliance on C-band with the development of advanced satellite modulation techniques. Delivery of services in higher bands without rain fade issues is now becoming the global standard.

Defence and Navic coexistence issues need to be debated with all interested parties for a single solution as well.

Q.17 In case your response to the above question is in affirmative, a. whether there is a need to prescribe provisions such as clock synchronization and frame structure to mitigate interference issues, as prescribed for existing TDD bands, for entire frequency holding or adjacent frequencies of different TSPs? If yes, what should be the frame structure? Kindly justify your response. b. Any other measures to mitigate interference related issues may be made along with detailed justification.

The frame format the GSMA supports for the entirety of frequencies is delineated as DDDSU for most of the cases. This approach provides a good compromise between download and upload speeds with a low latency.

Guard bands are not necessary in any of the cases where TDD synchronization is present. If specific frame structures are needed for a particular use case, geographical separation may be better suited.

Q.18 Whether the roll-out obligations for 700 MHz, 800 MHz, 900 MHz, 1800 MHz, 2100 MHz, 2300 MHz and 2500 MHz as stipulated in the NIA for last auctions held in March 2021 are appropriate? If no, what changes should be made in the roll out obligations for these bands?

At the moment, there are already rollout obligations in place and, therefore, there is no need to replicate in a new band. The current approach may continue in consultation with Indian operators.

On a general mechanism of rollout obligations, we wish to highlight that many licensing authorities impose obligations[17] on licensees to provide a particular level of service coverage within a specified time frame. They

[16] https://www.gsma.com/spectrum/wp-content/ uploads/2021/04/Transfinite-3.4-3.8-GHz- Compatibility.pdf
[17] https://www.gsma.com/spectrum/resources/mobile-coverage/

also include requirements to offer certain services, or quality-of-service levels, as well as measures relating to universal access and consumer protection objective.

In deciding whether to impose such obligations, licensing authorities should consider:

- The benefits and costs of such obligations, and
- Whether there are less costly means to achieve the objectives.

Whether regulatory obligations are needed or not depends on the market. All governments have to carefully consider whether their approach is likely to increase the quality and reach of next-generation mobile broadband, compared with the existing well-proven approach of mobile operator competition. Stringent coverage or service requirements carry risks.

Obligations may force operators to deploy networks and services faster than economically or commercially sensible to do so. For instance, this could arise where technology is still at an early stage with a number of technical challenges remaining or where equipment prices are relatively high before more widespread international take-up.

Obligations also risk forcing operators to incur losses (e.g., by deploying networks in advance of sufficient demand for the services). This can create financial difficulties particularly for entrants without established cash flows.

Extensive coverage obligations imposed on all licences may lead to costly duplication of network infrastructure. A number of regulators have sought alternative ways to ensure access in rural areas while avoiding inefficient network duplication e.g.:

- 'Shared' obligations on all operators to ensure coverage in rural areas before rolling out to urban areas
- Obligations to provide mobile broadband to locations currently lacking access to other forms of broadband.

Where obligations are imposed, they should be made clear prior to the auction or assignment process so that operators can develop a viable business case. Costly obligations can be reflected in lower auction prices. Governments should therefore assess whether the impact on auction revenue is an appropriate trade off to extend mobile coverage or whether the adoption of an alternative approach would be more efficient.

Where operators fail to meet their licence conditions regulators are confronted with the dilemma of whether to take the drastic step to revoke the licence, with potential harm to competition or postpone, or abandon the licence condition.

Relaxation of licence conditions can lead to legal challenges by other operators who have met conditions or by potential new entrants who may have bid for the licence if they had known the obligations would not be enforced. These are just some examples of why it is important to get licence obligations right from the beginning, or not use them at all.

If improved coverage is rural areas is the aim, a better approach is to actively support the commercial provision of services. This can be done by:

- Releasing spectrum in lower frequency bands;

- Allowing for network and spectrum voluntary sharing;
- Earmarking auction proceeds for to subsidise improved coverage; and
- Removing or minimising mobile-specific taxes and charges.

Q.19 What should be associated roll-out obligations for the allocation of spectrum in 526-698 MHz frequency bands? Should it be focused to enhance rural coverage? Kindly justify your response.

Please refer to Q.18.

Q.20 What should be associated roll-out obligations for the allocation of spectrum in 3300-3670 MHz frequency band? Kindly justify your response.

Please refer to Q.18.

Q.21 What should be associated roll-out conditions for the allocation of spectrum in 24.25 to 28.5 GHz frequency range? Kindly justify your response.

Please refer to Q.18.

Q.22 While assessing fulfilment of roll out obligations of a network operator, should the network elements (such BTS, BSC etc.), created by the attached VNO, be included? If yes, kindly suggest the detailed mechanism for the same. Kindly justify your response.

Please refer to Q.18.

Q.23 Whether there is a need to review the spectrum cap for sub-1 GHz bands? If yes, what should be the spectrum cap for sub-1 GHz bands. Kindly justify your response.

Spectrum caps[18] should be carefully determined/reviewed so that all operators can deploy networks in a technically and economically efficient manner. Before such caps are applied/reviewed, authorities should undertake a rigorous market analysis to ensure that there are entities who can make efficient use of any released spectrum and ensure continued competition and choice in the market. A range of specific measures have been used in practice with the aim of promoting competition particularly in the early stages of market development, especially when new bands are released.

Spectrum caps are not always needed and can be effective in attracting entrants to participate in licensing assignment processes but also may need to be reviewed. In case of existing bands, spectrum caps need to be monitored so that they do not limit later market consolidation leading to a loss in competition as operators with larger customer bases may have greater need for additional spectrum. Additionally, fragmented spectrum holdings raise costs and lower quality of service.

Spectrum caps may be appropriate in some circumstances to ensure that the overall competition in the market is not impacted and that operators are able to use their allocated in an optimal and efficient manner. TRAI has earlier recommended spectrum cap of 100 MHz in 3300 MHz-3600 MHz when 300 MHz spectrum was available. As now 370 MHz is available in 3300-3670 MHz, the spectrum cap of 100 MHz may be revised accordingly.

[18] https://www.gsma.com/publicpolicy/mobilepolicyhandbook/spectrum-management-and-licensing

Q.24 Keeping in mind the importance of 3300-3670 MHz and 24.25- 28.5 GHz bands for 5G, whether spectrum cap per operator specific to each of these bands should be prescribed? If yes, what should be the cap? Kindly justify your response.

Please refer to Q.23.

Q.25 Whether there should be separate spectrum cap for group of bands comprising of 1800 MHz, 2100 MHz, 2300 MHz and 2500 MHz bands together? If yes, kindly suggest the cap along with detailed justification.

Please refer to Q.23.

Q.26 Whether overall spectrum cap of 35% requires any change to be made? If yes, kindly suggest the changes along with detailed justification.

Please refer to Q.23.

Q.27 For computation of overall spectrum cap of 35%, should the spectrum in 3300-3670 MHz and 24.25-28.5 GHz bands be included? Kindly justify your response.

Please refer to Q.23.

Q.28 Any other suggestion regarding spectrum cap may also be made with detailed justification.

Please refer to Q.23.

Q.29 What should be the process and associated terms and conditions for permitting surrender of spectrum for future auctions? Kindly justify your response.

Operators would be more suited to respond to this question.

Q.30 What provisions may be created in the spectrum surrender framework so that any possible misuse by the licensees, could be avoided? Kindly justify your response.

Operators would be more suited to respond to this question.

Q.31 In case a TSP acquires spectrum through trading, should the period of 10 years to become eligible for surrender of spectrum, be counted from the date of original assignment of spectrum or from the date of acquisition through spectrum trading? Kindly justify your response.

Operators would be more suited to respond to this question.

Q.32 Whether provision for surrender of spectrum should also be made available for the existing spectrum holding of the TSPs? If yes, what should be the process and associated terms and conditions? Kindly justify your response.

Operators would be more suited to respond to this question.

Q.33 Whether spectrum surrender fee be charged from TSPs? If yes, what amount be levied as surrender fee? Kindly justify your response.

Operators would be more suited to respond to this question.

Q.34 Which factors are relevant in the spectrum valuation exercise and in what manner should these factors be reflected in the valuation of spectrum? Please give your inputs with detailed reasoning.

As the "India's 5G Future – Maximising Spectrum Resources"[19] report highlights, 5G can play a vital role in India's economy. In the past five years, India has been one of the fastest-growing mobile broadband markets, with 4G networks available to almost 99 per cent of the population and consumers benefitting from some of the lowest prices for mobile services and devices in the world. However, low average revenue per user (ARPU) levels and high regulatory costs have limited operators' ability to invest in upgrading their networks. This is already impacting network quality and is expected to affect 5G roll-out, which require more capital-intensive investments than 4G.

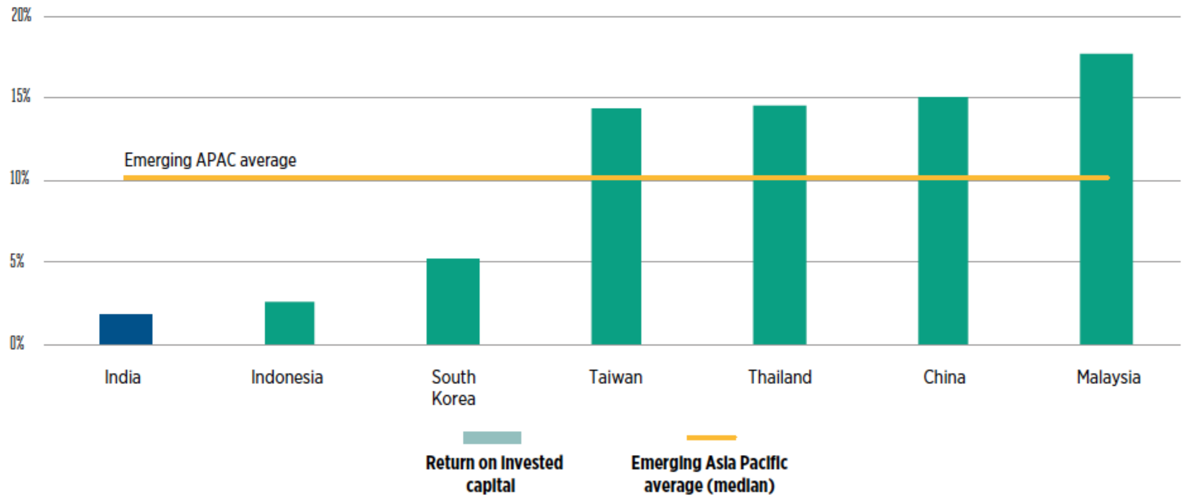
Low ARPUs combined with high spectrum and regulatory costs are impacting the mobile industry's ability to invest in 4G expansion and 5G deployment. The expansion of 4G connectivity and roll-out of 5G provides an opportunity to close the digital divide. This is reflected in India's National Digital Communications Policy (NDCP), which sets out a positive vision for the industry to attract investment of $100 billion to enhance India's digital infrastructure and to provide universal broadband connectivity to every citizen.

The government intends to achieve this objective by supporting the next generation of digital services (including 5G) and by scaling up 30 digital themes across nine key areas, based on its vision of providing citizens with ubiquitous and affordable internet and digital access. Mobile will play a central role in realising these ambitions and is crucial to achieving the NDCP's goals to connect, propel and secure India. However, while the mobile industry has helped to accelerate connectivity in the past five years, low ARPUs combined with high regulatory and spectrum costs have resulted in lower returns on investment compared to other countries.

This impacts operators' ability to invest and innovate, which affects Indian consumers who, for example, have some of the lowest average download speeds in the APAC region. Slow speeds impact the user experience and result in inequality in terms of timely access to data rich information. Going forward, low investment returns will also impact 5G network deployments, with India expected to lag behind other large emerging economies such as China, Brazil, Russia and Indonesia in the roll-out of 5G coverage.

[19] https://www.gsma.com/spectrum/resources/indias-5g-future-depends-on-affordable-spectrum/

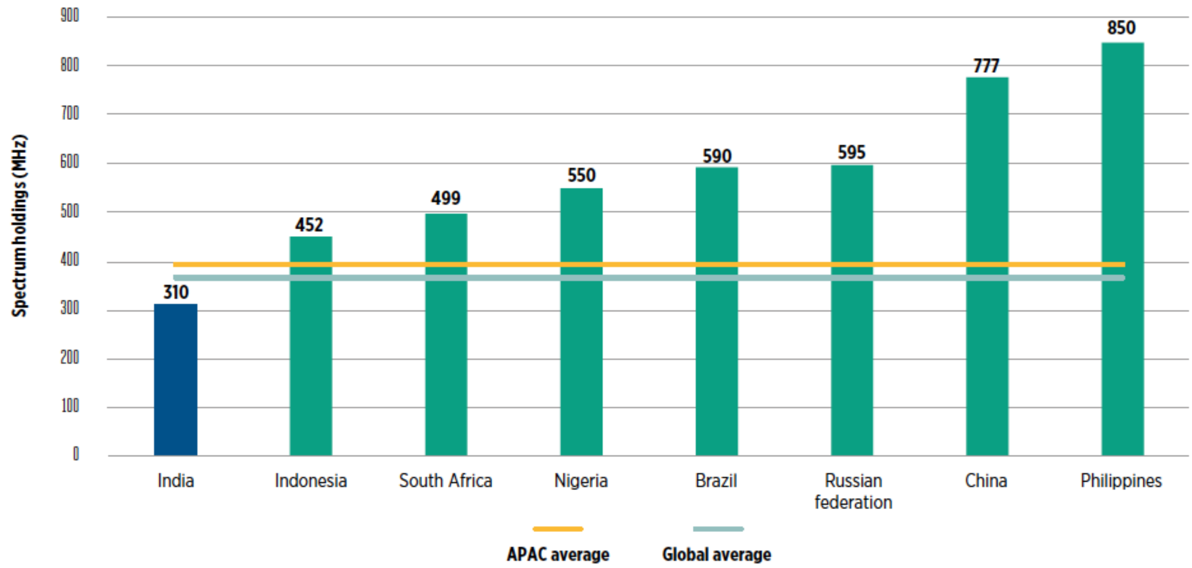
Return on invested capital



Return on invested capital (ROIC) is a financial measure that quantifies how well a company generates cash flow relative to the capital it has invested in its business; expressed as a percentage and calculated as ROIC = (Net Operating Profit – Adjusted Taxes) / Invested Capital. For each country, the ROIC is calculated based on the average for operators where data is available.

Since 2010, India has had several auctions that resulted in limited assignments due to high reserve prices. Consequently, the spectrum holdings of India's mobile operators are lower than those of comparable economies as well as the global and regional averages.

Total spectrum assignments to operators in selected countries (below 3700 MHz)

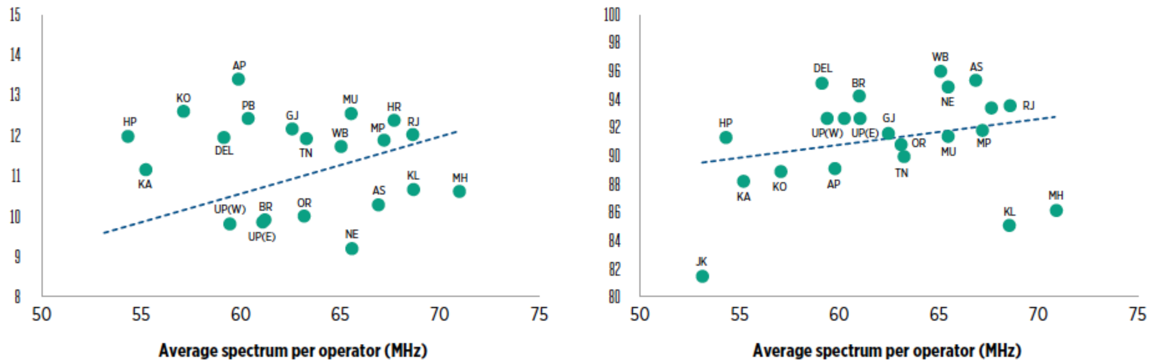


This has had a direct impact on consumers. In 2020, average download speeds in India were less than half the global average. If all the available bands had been fully assigned, download speeds may have doubled and been much closer to other countries (though still not at the same level).

Furthermore, the correlation between spectrum availability and network quality and coverage is highlighted by regional spectrum assignments in India, as telecom circles with better networks are also likely to have larger amounts of spectrum assigned. This means that the consumer experience outcomes are much better in those circles with more assigned spectrum.

Circle holdings and download speeds (Mbps)

Circle holdings and 4G availability (%)



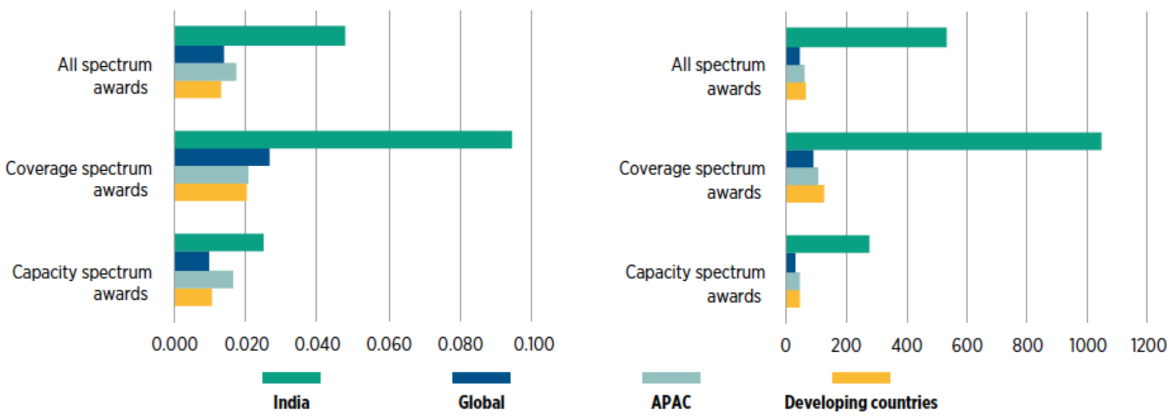
Source: GSMA Intelligence, DoT, TRAI and Speedtest data sourced from Ookla (2020). 4G availability refers to the proportion of operators' known locations where a device has access to a 4G LTE service. Holdings in each circle reflect the average assigned to the main four operators in 2020.

Over the past 10 years, spectrum prices in India have been significantly higher than those of other countries, both in Asia and other developing countries. This is reflected in the median unit price of spectrum per population (adjusting for inflation and purchasing power parity) and especially when adjusting for operator revenues, which captures the value of the mobile market in the short-to-medium term (Figures 8a and 8b). When considering spectrum pricing at a circle-level, more than half of the prices paid have been above the global average since 2010, while almost 20 per cent have been at very high prices.

As a result, mobile operators in India pay significantly higher costs for spectrum compared to other large emerging markets and high-income countries. This directly impacts operators' return on investments and their ability to invest in upgrading networks.

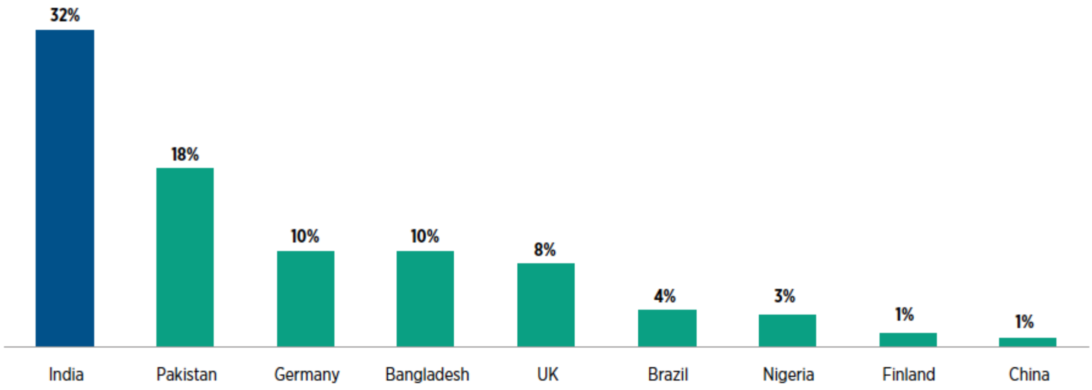
Median unit prices: India versus global and regional comparators, 2010–2021 ($/MHz/year/population[8])

Median unit prices: India versus global and regional comparators, 2010–2021 (per million of revenue ($)[9])



Source: GSMA Intelligence, based on spectrum pricing data for 114 countries. Spectrum prices have been adjusted for inflation, PPP and license duration (Figure 8a) and operator revenues and license duration (Figure 8b).

Spectrum costs as a proportion of annual recurring revenue, 2019



Note: Spectrum costs combine annual spectrum fees as well as auction payments. The latter are annualised based on the license length and the weighted average cost of capital (WACC). WACC estimates for the telecoms sector in each country are sourced from WACC Expert.

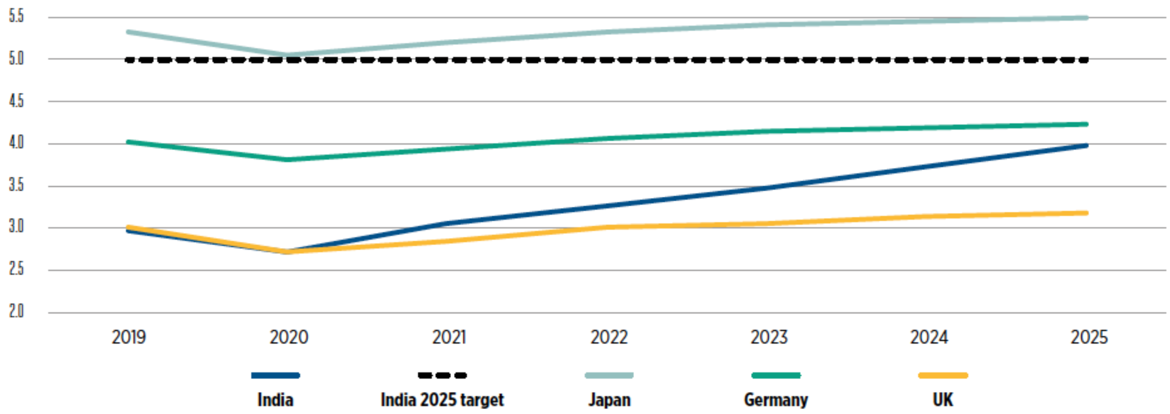
COVID-19 has unleashed an economic and human development crisis, both in India and globally. India's economy contracted by 8 per cent in 2020, although the government remains committed to India becoming a $5 trillion economy by 2025. This ambitious aim will require a post-pandemic acceleration in growth. As a general purpose technology, mobile can enable other sectors to work towards this goal. Studies have shown that a 10 per cent increase in mobile broadband penetration can increase GDP by 1-2 per cent.

5G presents an opportunity to propel India to the next generation of digital connectivity and deliver significant social and economic benefits. Over the next 20 years, 5G is expected to contribute around $455 billion to the Indian economy, accounting for more than 0.6 per cent of GDP by 2040.

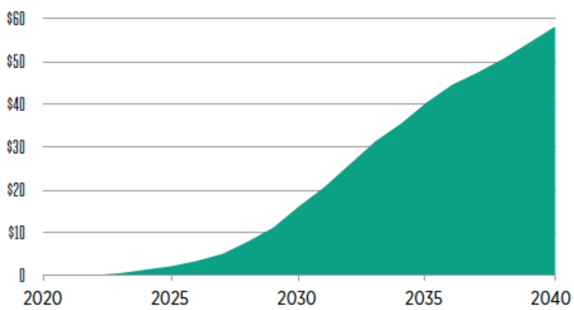
What makes the opportunity so significant is 5G's ability to drive innovation across all sectors powered by four use cases: enhanced mobile broadband; ultra-reliable low-latency communications; massive Internet of Things; and fixed wireless access. In India, benefits are expected to be realised in the manufacturing sector, representing 20 per cent of the total benefit, and in the retail, ITC and agricultural sectors.

The public administration sector, including healthcare and education, is also expected to benefit from 5G, thanks to smart cities and smart government 5G-enabled applications. The pandemic has only highlighted the need for reliable and resilient connectivity for all sectors of the economy. Practical use cases will also be developed post spectrum awards, as many sectors and organisations prepare for a significant shift in the way they behave, operate and transact. In order to change, however, they need strong connectivity.

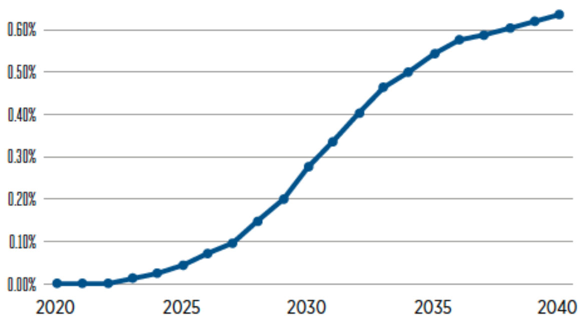
GDP forecast for India compared to select countries and India's 2025 target, 2019–2025 ($ trillion, 2020 prices)



Expected economic contribution of 5G in India (billion)



Expected economic contribution of 5G in India as a percentage of annual GDP



The impact of 5G will be influenced by spectrum policy.

Policymakers can play a significant role in enabling the impacts of 5G by providing timely access to the right amount and type of spectrum at affordable prices across all service areas. Worldwide, there is already a significant variation in the amount of spectrum assigned by countries, and the prices paid at auctions, which means the potential of 5G services will vary between countries. This, in turn, directly impacts the socio-economic benefits of 5G and the competitiveness of national economies

Modest reserve prices are needed

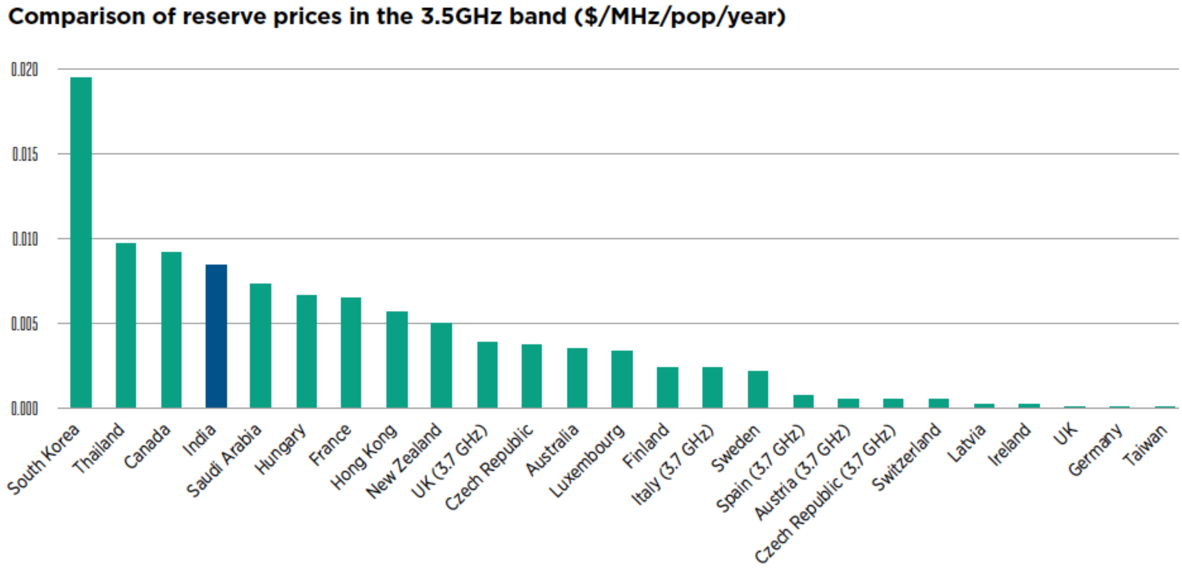
Reserve prices can have an important role in discouraging speculators and frivolous bidding, recovering the administrative costs of the award process and limiting collusion incentives amongst bidders. However, they should also allow room for price discovery, encourage participation and avoid spectrum going unsold. In this respect, the reserve price should not reflect the value of the spectrum being auctioned – this will be determined by the auction itself. Given what has happened in previous Indian auctions, including the March 2021 auction when 62 per cent of available spectrum went unsold, the primary objective should be to ensure that all available spectrum is assigned in a manner that maximises consumer welfare and economic efficiency.

Such a quantum of spectrum remaining unsold, and further majority sold at reserve price indicate that the level of reserve price set was not in line with market expectation and best practice.

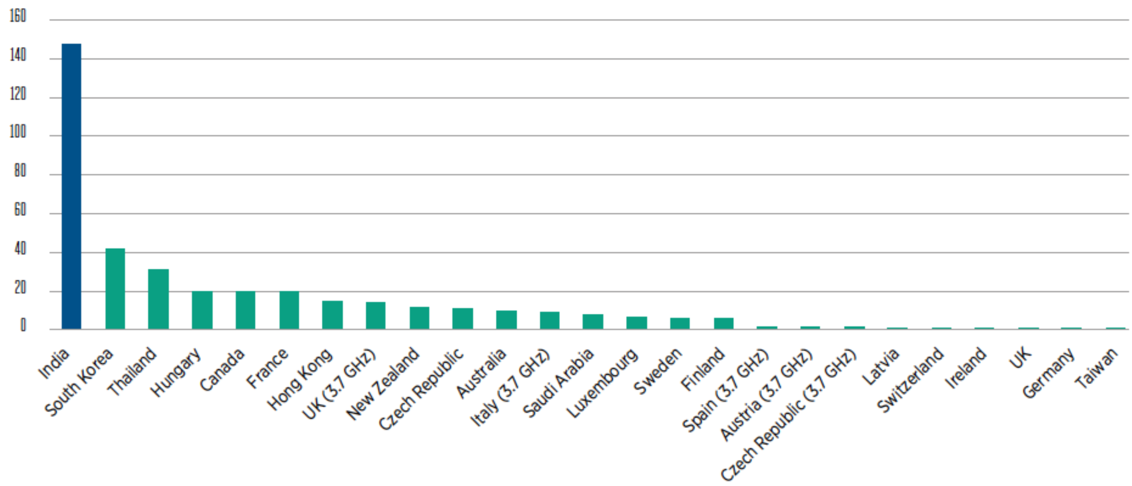
Given that more spectrum will be required to fulfil consumer demand, an auction should be seen as a frequent affair where operators have flexibility to manage demand at regular intervals. Affordable pricing is key to manage the level of enthusiasm for more investments and catering to the socio-economic needs of the country.

In 2018, TRAI recommended a price of INR 4.9 billion (around $67 million) per MHz for spectrum in the 3.3-4.6 GHz bands. When adjusting for purchasing power parity, market size and licence length, this is higher than reserve prices in almost all other countries that have assigned the band so far – and higher than most of the actual prices paid. When taking revenues into account, the reserve price is significantly higher than what has been set in other markets.

The current pricing for 3.5 GHz therefore puts the future of the band in jeopardy and there is a risk it will end up being another example of a band that is not used efficiently in India. This will make it more challenging for the industry to deploy 5G throughout the country, which risks exacerbating the digital divide and hindering the wider socioeconomic impacts. Fortunately, the government still has an opportunity to change course. 5G must be seen as a mass technology, as it is capable of not only supporting mobile broadband subscribers but also millions of IoT chipsets that will directly affect and shape the lives of Indians post-pandemic.



Comparison of reserve prices in the 3.5GHz band (per million of revenue ($) per MHz per year)



5G can play a vital role in India's economy. To make the most of this opportunity, increasing mid-band spectrum allocations and striking the right balance between raising revenues and delivering efficient spectrum awards will be key.

In summary:

- India has some of highest prices for spectrum in the world, which have led to key spectrum bands going unsold and directly limits the industry's ability to invest in upgrading mobile networks. This is already impacting network quality and it is expected to affect 5G roll-out.

- Deploying 5G networks in India will require capital-intensive investments. The mobile industry will only be able to roll-out 5G in a cost-efficient manner across all service areas if they have sufficient spectrum and if the cost of access does not limit operators' ability to make the necessary network investments.

- 5G can play a vital role in India's economy, with benefits of at least $455 billion in the next two decades – but poorly designed spectrum policies will put that at risk. For example, ensuring that more than 300 MHz of mid-band spectrum is available for 5G during the next auction at a reserve price that allows industry to deploy across all service areas could result in more than 200 million additional 5G connections and increase the overall economic benefits of 5G by at least $75 billion.

Pricing approaches:

Also, there are a range of spectrum pricing approaches with different terms. Options include whether charges are levied as an upfront sum, annually or a combination of both, and whether the charge is fixed or varies with revenues. Objectives in setting prices may also vary from recovery of regulatory costs to promoting efficiency or government revenue objectives.

Auctions can directly determine market value and prices that reflect the market value of spectrum. When done correctly they help promote efficient spectrum use. Where these market mechanisms are not used, authorities can estimate the market value of spectrum (e.g., administrative incentive prices).

One way to estimate market value is considering the costs operators avoid by gaining an additional increment of spectrum. An alternative approach is using benchmarks based on recent auctions. The accuracy of benchmarking depends on using comparable spectrum bands, conditions, and countries. For important spectrum bands, where the cost of errors is high, the combined use of both modelling and benchmarking can further improve accuracy. Benchmarks also require normalisations, such as via ARPU or revenue, depending on local market conditions. It is uncommon that technical efficiency is solely analysed as other factors such as incremental CAPEX and OPEX, revenue, and device ecosystem have higher impacts.

Setting a final price upfront for the licence is often seen by economists as preferable to annual charges. However, upfront fees need careful consideration to be set as affordable as possible, as those carry greater risks to operators and may be harder to justify when future technological and market development is uncertain. Instalment payments can also be made available to operators, adding another possibility to their financial strategy.

Where authorities impose annual charges or new charges for licence renewal, regulatory risks to investment can be reduced by authorities following a transparent pricing framework with clear criteria.

Referencing an operator's customer base or its network size when setting prices deters both competition and investment. Such pricing may also undermine efficient spectrum use as operators with few customers would face minimal spectrum charges.

Pricing Approach	Advantages	Disadvantages
Administrative costs	• Appropriate where there is no excess demand for spectrum	• May not lead to efficient spectrum use where there is excess demand for the spectrum and where spectrum assignment is not market based
Share of revenue	• Shares risk between government and operator	• Trading off predictability for flexibility would only be beneficial in some circumstances • Requires modelling based on assumptions. • Needs a clear calculation based on spectrum ranges or may end too high, limiting investment •
Avoided cost modelling	• Provides a direct estimate of the value (cost savings) of an increment of spectrum	• Requires modelling based on assumptions • May overestimate or underestimate value, risking investments
Net present value	• Provides a direct and fair estimate of the value of an increment of spectrum, based on costs and revenue	• Requires modelling based on assumptions • May overestimate value if not conservatively done

		• Requires an analysis of a new entrant cost and revenue forecasting
Benchmarking	• Simple and transparent where close benchmarks exist and correct normalisations are used	• Will be inaccurate if the analysis does not fully account for differences in factors impacting on market value

Q.35 In what manner, should the extended tenure of spectrum allotment from the existing 20 years to 30 years be accounted for in the spectrum valuation exercise? Please support your response with detailed rationale/ inputs.

Time is always one of the variables when valuating spectrum, but it is important to mention the first decade tends to generate the highest benefit for operators, especially where there is a limited supply of spectrum, noting that this is also the period with the highest costs as well as the highest risks. As technologies develop, and new bands are added to the portfolio of spectrum, spectrum value is likely to change over time. Therefore, the validity of the licence should not be a simple multiplying variable to the calculation.

Please also refer to Q.34.

Q.36 What could be the likely impact of the following auction related telecom reforms announced by the Government in September 2021 on the valuation of various spectrum bands? (a) Rationalization of Bank Guarantees to securitize deferred annual spectrum payment instalments in future auctions (b) No spectrum usage charges (SUC) for spectrum acquired in future auctions (c) Removal of additional SUC of 0.5% for spectrum sharing (d) Provision for surrender of spectrum In what manner, should the above provisions be accounted for in the valuation of spectrum? Please support your response with detailed justification. Need for fresh exercise of valuation versus use of March 2021 auction determined prices in 800 MHz/900 MHz/1800 MHz/2100 MHz/2300 MHz bands

The SUC / annual fees charged to the operators in India was not a best practice, and not followed around the world. By removing SUC for all future auctions, India has just corrected its approach and aligned to global best practice in this regard.[20]

Any reduction or elimination of such payments should not increase any upfront fees as those have been charged on top of the value of spectrum.

Please also refer to Q.34.

Q.37 Whether the auction determined prices of March 2021 auction be taken as the value of spectrum in the respective band for the forthcoming auction in the individual LSA? Should the prices be indexed for the time gap (even if less than one year or just short of one year)? If yes, please indicate the basis/ rate at which the indexation should be done, with reasons.

A new approach to the valuation of spectrum is needed. Please refer to Q.34.

[20] https://www.mobileworldlive.com/blog/intelligence-brief-assessing-the-impact-of-indian-market-reform

Q.38 If the answer to the above question is in negative, whether the valuation for respective spectrum bands be estimated on the basis of the various valuation approaches/methodologies being followed by the Authority in the previous recommendations, including for those bands (in an LSA) for which either no bids were received, or spectrum was not offered for auction?

Please refer to Q.34.

Q.39 Whether the method followed by the Authority in the Recommendations dated 01.08.2018 of considering auction determined prices of the auctions held in the previous two years be continued, or the prices revealed in spectrum auctions conducted earlier than two years may also be taken into account? Kindly justify your response.

A new approach to the valuation of spectrum is needed. Please refer to Q.34.

Q.40 Whether the valuation exercise be done every year in view of the Government's intention to have an annual calendar for auction of spectrum? Please support your response with detailed justification.

A new approach to the valuation of spectrum is needed that should be proportionate to potential revenue generated by additional spectrum bands acquired through the auction. Please refer to Q.34.

Q.41 Whether there is a need to bring any change in the valuation approaches / methodologies followed by the Authority for spectrum valuation exercises in view of the changing dynamics in the telecom sector largely due to the usage of various spectrum bands by the TSPs in a technologically neutral manner? If yes, please provide suggestions along with a detailed justification about the methodology.

Spectrum auctioned in India is already technology neutral.

In any event, technology neutrality should not be seen as a means of charging more for spectrum when new technologies are introduced. Restricting the use to particular technologies and services exacerbates spectrum scarcity and prevents customers from gaining access to new and better services. Removing technology-specific restrictions (beyond those needed to manage co-existence) enables a market to maximise the benefits from its spectrum resources on an ongoing basis. Operators' ability to introduce new, more spectrally efficient mobile technologies is critical to meeting growth in demand. Importantly, technology neutrality should also not incur the payment of fees.

Again, charges for changing licences to be technology neutral risks delaying the benefits of new technology to end-users.

Q.42 In your opinion, what could be the possible reasons for the relative lack of interest for the spectrum in the 2500 MHz band? Could this be attributed to technological reason(s) such as development of network/device ecosystem or availability of substitute spectrum bands or any other reasons(s)? Please support your response with detailed justification.

Please refer to Q.34.

Q.43 Whether the March 2021 auction determined prices be used as one possible valuation for the spectrum in 2300 MHz band for the current valuation exercise? If yes, should these prices be indexed for the time gap and at what rate? Please justify your response.

A new approach to the valuation of spectrum is needed. Please refer to Q.34.

Q.44 Whether auction determined prices of October 2016 (i.e. for the auction held earlier than two years) be used as one possible valuation for the spectrum in 2500 MHz band for the current valuation exercise? If yes, should these prices be indexed for the time gap and at what rate? Please justify.

A new approach to the valuation of spectrum is needed. Please refer to Q.34.

Q.45 Whether the value of the spectrum in 2300 MHz/ 2500 MHz bands should be derived by relating it to the value of spectrum in any other band by using technical efficiency factor? If yes, which band and what rate of efficiency factor should be used? If no, then which alternative method should be used for its valuation? Please justify your response with rationale and supporting studies, if any.

A new approach to the valuation of spectrum is needed. Please refer to Q.34.

Q.46 In your opinion, what could be the possible reasons for the relative lack of interest for the spectrum in the 700 MHz band? Could this be attributed to technological reason(s) such as development of network/device ecosystem or availability of substitute spectrum bands or any other reasons(s)?

Please refer to Q.34.

Q.47 Whether the value of spectrum in 700 MHz band be derived by relating it to the value of other spectrum bands by using a technical efficiency factor? If yes, with which spectrum band, should this band be related and what efficiency factor or formula should be used? Please justify your views with rationale and supporting studies, if any.

Please refer to Q.34.

Q.48 If your response to the above question is in negative, what other valuation approach(es) be adopted for the valuation of 700 MHz spectrum band? Please support your response with detailed methodology.

Please refer to Q.34.

Q.49 Whether the valuation of the 3300-3670 MHz spectrum band should be derived from value of any other spectrum band by using technical efficiency factor? If yes, what rate of efficiency factor should be used? If no, which other method(s) should be used for its valuation? Please justify your response with rationale and supporting documents, if any.

Please refer to Q.34.

Q.50 In case you are of the opinion that frequencies in the range 526- 698 MHz should be put to auction in the forthcoming spectrum auction, whether the value of 526-698 MHz be derived by using technical efficiency factor? If yes, with which spectrum band, should this band be related and what efficiency factor or formula should be used? Please justify your suggestions.

Please refer to Q.34.

Q.51 If your response to the above question is in negative, which other valuation approach(es) should be adopted for the valuation of these spectrum bands? Please support your suggestions with detailed methodology, related assumptions and any other relevant factors.

Please refer to Q.34.

Q.52 Whether the value of spectrum in 24.25 - 28.5 GHz band be derived by relating it to the value of other bands by using technical efficiency factor? If yes, with which spectrum band, should this band be related and what efficiency factor or formula should be used? Please justify your suggestions.

Please refer to Q.34.

Q.53 If your response to the above question is in negative, which other valuation approaches should be adopted for the valuation of these spectrum bands? Please support your suggestions with detailed methodology, related assumptions and other relevant factors.

Please refer to Q.34.

Q.54 Whether international benchmarking by comparing the auction determined price in countries where auctions have been concluded be used for arriving at the value of these new bands? If yes, then what methodology can be followed in this regard? Please explain.

Please refer to Q.34.

Q.55 For international benchmarking, whether normalization techniques be used for arriving at the valuation of these new bands in the Indian context? If yes, please justify your response with rationale / literature, if any.

ARPU, revenues and GDP are to be considered. Please refer to Q.34 on the findings of our work for India and additional GSMA literature on https://www.gsma.com/spectrum/resources/effective-spectrum-pricing/.

Q.56 Whether a common methodology / approach should be used for valuation of all sub-1 GHz bands, which are currently planned for IMT? If yes, suggest which methodology/ approach should be used. Please give your views along with supporting reasoning and documents / literature, if any.

Please refer to Q.34 on the findings of our work for India and additional GSMA literature on https://www.gsma.com/spectrum/resources/effective-spectrum-pricing/.

Q.57 Whether the extrapolated ADP based on a time-series analysis, may be considered as the valuation itself or some normalization may be performed taking into account the financial, economic and other parameters pertaining to a particular auction? If yes, which factors should be considered and what methodology should be followed?

Please refer to Q.34.

Q.58 Whether the value arrived at by using any single valuation approach for a particular spectrum band should be taken as the appropriate value of that band? If yes, please suggest which single approach/ method should be used. Please justify your response.

Please refer to Q.34.

Q.59 In case your response to the above question is negative, will it be appropriate to take the average valuation (simple mean) of the valuations obtained through the different approaches attempted for valuation of a particular spectrum band, or some other approach like taking weighted mean, median etc. should be followed? Please justify your response.

We suggest the most affordable approach is used after comparison. Please also refer to Q.34.

Q.60 Is there any valuation approach other than those discussed above or any international auction experience/ approach that could be used for arriving at the valuation of spectrum for 700 MHz/ 800 MHz/ 900 MHz/ 1800 MHz/ 2100 MHz/ 2300 MHz/ 2500 MHz/ 3300-3670 MHz/ 24.25 - 28.5 GHz/ 526 - 698 MHz bands? Please support your suggestions with a detailed methodology and related assumptions.

Please refer to Q.34.

Q.61 Should the reserve price be taken as 80% of the valuation of spectrum? If not, then what ratio should be adopted between the reserve price for the auction and the valuation of the spectrum in different spectrum bands and why?

Reserve prices should have the highest discount possible in this case, in order to find the best market price via auction. Please refer to Q.34.

Q.62 Whether the realized/ auction determined prices achieved in the March 2021 auction for various spectrum bands can be directly adopted as the reserve price in respective spectrum bands for the forthcoming auction? If yes, should these prices be indexed for the time gap since the auction held in March 2021 and at which rate the indexation should be done?

A new approach to the valuation of spectrum is needed. Please refer to Q.34.

Q.63 Should the method followed by DoT in the previous auction in respect of collecting bid amount from the successful bidder in case spectrum is not available in a part of the LSA be followed in the forthcoming auction? Please justify your response in detail.

A new approach to the valuation of spectrum is needed. Please refer to Q.34.

Q.64 What percentage rate of upfront payment should be fixed in case of each spectrum band?

There should not be any upfront payment. We suggest yearly equal instalments spread over the period of the license after moratorium period. Please refer to Q.34.

Q.65 What should be the applicable period of moratorium for deferred payment option?

We suggest yearly equal instalments spread over the period of the license after the moratorium period of 6 years. Please refer to Q.34.

Q.66 How many instalments should be fixed to recover the deferred payment?

We suggest yearly equal instalments for the period of the license, after the moratorium period. Please refer to Q.34.

Q.67 What rate of discount should be used while exercising prepayment/deferred payment option, in order to ensure that the net present value of payment/ bid amount is protected? Please support your suggestions for Q64 to Q67 with proper justifications.

Reserve prices should have the highest discount possible in this case, in order to allow price discovery via auction. Please refer to Q.34.

Q.68 To facilitate the TSPs to meet the demand for Private Cellular Networks, whether any change(s) in the licensing/policy framework, are required to be made. If yes, what changes are required to be made? Kindly justify your response.

The development of new mobile technologies alongside the cloud, big data and machine learning are transforming how vertical industries can operate.

These range from creating smart utility grids and automating manufacturing, to delivering goods by drones and supporting advanced public safety and transport networks. Policymakers play a vital role by managing the spectrum which underpins these developments. However, great care needs to be taken to ensure verticals are fully supported without harming other wireless users – especially the consumers and businesses who rely on 4G and 5G.

Verticals[21] traditionally deployed private networks to support their connectivity needs. However, this is changing as the requirements of verticals evolve to include more advanced capabilities. As a result, they are increasingly looking to partner with telecom providers – including public mobile operators, using licensed spectrum. This allows them to benefit from telecom operators' more extensive networks, more substantial spectrum assets, expertise and, typically, the operators' lower cost base. However, some verticals may continue to operate their private networks and thus may desire access to additional spectrum to support advanced broadband capabilities.

This represents a challenge for policymakers as widespread demands for additional spectrum outweigh supply. It is also difficult given some verticals may want direct access to spectrum in priority 4G and 5G mobile bands (e.g. 700 MHz and 3.5 GHz) so they can benefit from the mobile equipment ecosystem and thus lower deployment costs.

It is vital that policy makers support the needs of verticals by ensuring they can get the connectivity they need to support their use cases, without undermining other spectrum users and upholding fair and efficient assignment of mobile bands. A core concern is the use of dedicated set-asides for verticals as this poses significant risks to wider mobile services, most notably slower 5G networks and reduced coverage. There are alternative options to support verticals – including other ways to provide access to spectrum for these networks.

[21] https://www.gsma.com/spectrum/resources/mobile-networks-for-verticals/

Setting spectrum aside leads to insufficient spectrum to operators, preventing the delivery of all 5G requirements and capabilities. Also, scarcity enlarges the prices paid for spectrum. High fees are strongly linked to reduced network investment and, thus, slower rollouts, limited coverage, and reduced data speeds.

The needs of industries differ quite significantly from current mobile networks. This can lead to a divergence in spectrum management approaches which can have an impact on spectrum availability and its services. Where industries require access to specific licenced bands, they can do so through the spectrum assigned to mobile operators via sharing and leasing agreements, for example.

- Commercial mobile operators support the needs of a wide variety of vertical sectors and will have added capabilities with 5G;
- Spectrum leasing or, when carefully planned, other types of spectrum sharing can be viable options for supporting verticals who want to build private networks;
- Spectrum that is set-aside exclusively for verticals in core mobile bands risks being underused and can undermine fair spectrum awards;
- Spectrum that is set-aside for mobile networks for verticals in core mobile bands can also threaten the wider success of 5G – including slower rollouts, worse performance and reduced coverage;
- Policymakers should consider the coexistence challenges when different use cases need to be supported in the same mobile band; and
- Policymakers should carefully consider their options and consult stakeholders to ensure they most efficiently support the needs of verticals without undermining other spectrum users.

The GSMA is available to work with TRAI to develop these points further.

Q.69 To meet the demand for spectrum in globally harmonized IMT bands for private captive networks, whether the TSPs should be permitted to give access spectrum on lease to an enterprise (for localized captive use), for a specific duration and geographic location? Kindly justify your response.

Yes. Please refer to Q.68.

Q.70 In case spectrum leasing is permitted, whether the enterprise be permitted to take spectrum on lease from more than one TSPs? ii. What mechanism may be prescribed to keep the Government informed about such spectrum leasing i.e., prior approval or prior intimation? iii. What timeline should be prescribed (in number of days) before the tentative date of leasing for submitting a joint request by the TSPs along with the enterprise, for approval/intimation from/to the Government? iv. Whether the spectrum leasing guidelines should prescribe duration of lease, charges for leasing, adherence of spectrum cap provisions, roll out obligations, compliance obligations. If yes, what terms and conditions should be prescribed? v. What other associated terms and conditions may be prescribed? vi. Any other suggestion relevant to leasing of spectrum may also be made in detail. (Kindly justify your response)

Please refer to Q.68.

Q.71 Whether some spectrum should be earmarked for localized private captive networks in India? Kindly justify your response.

Set-asides from 5G/IMT spectrum available for commercial use can have serious consequences for mobile networks. Localised private networks can have access to unlicensed bands or lease spectrum from MNOs.

With spectrum leasing, licensed bands that have already been assigned to an organisation (such as a mobile operator) on an exclusive basis can be rented by another user, typically for a limited period of time and/or for a portion of the spectrum included in the licence. Examples include leasing spectrum to wireless internet service providers in rural areas or leasing to support localised private networks for use by industry verticals.

A primary motivation for spectrum leasing is the potential commercial benefit to lessors in terms of revenue generation and cost savings from leasing unutilised frequencies for certain uses or periods. It can provide a flexible opportunity to meet the specific spectrum demands of industrial or enterprise customers, rural telecoms providers or other mobile operators. It is also generally simpler to achieve than trading, which typically requires the regulator's involvement.

Please refer to Q.68.

Q.72 In case it is decided to earmark some spectrum for localized private captive networks, whether some quantum of spectrum be earmarked (dedicatedly) from the spectrum frequencies earmarked for IMT services and/or spectrum frequencies earmarked for non-IMT services on location-specific basis (which can coexist with cellular-based private captive networks on shared basis)? Kindly justify your response with reasons.

Please refer to Q.68 and 71.

Q.73 In case it is decided to earmark some quantum of spectrum for private captive networks, either on exclusive or shared basis, then a) Spectrum under which band(s) (or frequency range) and quantum of spectrum be earmarked for Private Network in each band? Inputs may be provided considering both dedicated and shared spectrum (between geographically distinct users) scenarios. b) What should be the eligibility conditions for assignment of such spectrum to private entities? c) What should be the assignment methodology, tenure of assignment and its renewal, roll-out obligations? d) What should be the pricing mechanism for assignment of spectrum in the band(s) suggested for private entities for localized captive use and what factors should be considered for arriving at valuation of such spectrum? e) What should be the block size and spectrum cap for different spectrum band(s) suggested in response to point (a) above. f) What should be the broad framework for the process of (i) filing application(s) by enterprise at single location, enterprise at multiple locations, Group of companies. (ii) payment of spectrum charges, (iii) assignment of frequencies, (iv) monitoring of spectrum utilization, (v) timeline for approvals, (vi) Any other g) Any other suggestion on the related issues may also be made with details. (Kindly justify your response with reasons)

Please refer to Q.68 and 71.

Q.74 What steps need to be taken to facilitate identification, development and proliferation of India specific 5G use cases for different verticals for the benefit of the economy and citizens of the Country? Kindly provide detailed response with rationale.

5G supports significantly faster mobile broadband speeds. The technology will also help enable the full potential of the Internet of Things, from virtual reality and autonomous cars, to the industrial internet and smart cities, 5G will be at the heart of the future of communications. Today's most popular mobile applications also benefit from 5G by ensuring continued growth and quality.

As per GSMA's "India-becoming-5G-ready"[22] report, it is forecasted that India will have 88 million of 5G connections by 2025. Once the critical mass is achieved, there will be significant rise and requirement for the adequate access spectrum.

5G needs a significant amount of new harmonised mobile spectrum in the three key frequency ranges to support coverage and capacity. As per GSMA's estimate, a drop from 100 MHz in the 3.5 GHz range to 60 MHz per operator would lead to 64% increase in cell sites and the subsequent costs. In turn, this would impact coverage, quality of services and consumer fees negatively. Hence, it is vital to timely make adequate spectrum available in mid bands supported by low and high bands.

The decision of making a specific range available to a specific service should consider the socio-economic impact it will bring and, at the same time, the capacity of the licensees to develop and maintain this importance and impact within the years. This means that a spectrum related level playing field is required, including keeping commercial services, including internet and satellite companies, at the same level of fees, obligations and regulations applicable to mobile operators, in order to guarantee the best use of spectrum and the best services to users and enterprises.

This includes making spectrum available when it is been awarded to other services (sometimes under-used or not in use) in order to make sure the most relevant service – with available technology and focusing on economies of scale – is made available, considering short-, mid- and long-term demand.

Most notably, the speed, reach and quality of 5G services will be heavily dependent on governments' and regulators' support to provide timely access to the right amount and type of spectrum, and under the right conditions. Therefore, governments, regulators and the mobile industry should cooperate to make this next-generation a success via a roadmap, considering:

- Timely spectrum availability by following international band plans and releasing usable spectrum before needed as 5G requires spectrum within all three key frequency ranges to deliver widespread coverage and support all use cases: low- (such as sub-1 GHz), mid- (such as 3.5 ad 6 GHz) and high-bands (mmWaves)
- Exclusively licensed spectrum should remain the core 5G spectrum management approach. Spectrum sharing and unlicensed bands can play a complementary role
- Setting spectrum aside for verticals in priority 5G bands (i.e. 3.5/26/28 GHz) could jeopardise the success of public 5G services and may waste spectrum. Sharing approaches like leasing are better options where verticals require access to spectrum
- Specially for 5G, that will require a higher amount of investment, Governments and regulators should avoid inflating 5G spectrum prices as this may limit network investment and drive the cost of services up. This includes excessive reserve prices or annual fees, limiting spectrum supply, excessive obligations and poor auction design. Reasonable pricing by setting reserve prices below a conservative estimate of market value – obligations and treating annual fees as part of reserve price
- Investment Friendly Terms and Conditions with well-established defined rights that allow for trading and avoid onerous roll out obligations
- Ensuring right conditions that avoid power limits, prioritise contiguous spectrum and careful decide on protection to adjacent services only when needed

[22] https://data.gsmaintelligence.com/api-web/v2/research-file-download?id=42565634&file=2758-140519-5G-India.pdf

- To increase flexibility as well as make spectrum usage more efficient, Time Division Duplex (TDD) is becoming increasingly common and important and should focus on a full synchronised frame structure via an agreement amongst operators. The frame format the GSMA supports is delineated as DDDSU.