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India as a Playground for Spectrum Management in Developing Nations

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1. Executive Summary

The unprecedented growth in the mobile sector in India has led to an increased demand on the availability of spectrum. Spectrum management needs to consider both the technical efficiency and the economic efficiency in order to be utilized efficiently, economically, rationally and optimally. Moreover, in view of growing, conflicting and competing demand on spectrum, there is a need for a transparent process of allocation of frequency spectrum for use by various services and users.

Currently, in India, wireless telecommunication services are provided through three technologies – Global System of Mobile communications (GSM) in the 900/1800 MHz range, Code Division Multiple Access (CDMA) in 800 MHz and CorDECT in 1900 MHz range. With the available 900 and 800 MHz ranges completely allotted and large holding by defense, there is an urgent need for coordination of additional spectrum in these bands by defense, possible through creation of exclusive ‘defense band’. In future auctioning of spectrum, the auction design process needs to be more thorough, taking into account various contextual factors and mergers and acquisitions among potential bidders. This is necessary to allocate the spectrum to those who value it most with an increased revenue potential to government and also provide a possibility of a level playing field for new entrants’ vis-à-vis incumbents. Both, the new licenses and additional spectrum must now be allotted in a technology-neutral fashion to achieve maximum spectral efficiency.

Third generation (3G) systems represent the next step in evolution of mobile cellular communication, delivering high speed, mobile internet access, entertainment and triple-play converged communication services with greater capacity and spectral efficiency. In this respect TRAI has come out with recommendations for spectrum allocation in the ranges as identified by ITU and pricing mechanism with ascending auctions where bids start at a pre-determined base price. Deployment and adoption of 3G networks play a very important role in taking the Indian economy forward.

Moving forward, we believe providing 3G services at the 900 MHz band provides several advantages in terms of cost of deployment, ease of meeting the objectives for rural penetration that the government has set, user affordability of services and handsets, recovery of CAPEX and OPEX at the service provider’s end, building a true nationwide harmonized network and upgrading existing networks in a more economically viable option in the wake of uncertainty pertaining the future technology trends, India leapfrogging to 4G era and introduction of converged services licenses. With non-availability of additional 900 MHz range frequencies, at least till it is coordinated by defense, the current license holders gain a premium on their net worth (as is in the case of Hutch).

To meet all of the above objectives and in band transition of existing licenses to IMT-2000 (3G), there are some regulatory challenges. Extending the terms and conditions of current licenses and service definitions, creation of exclusive ‘defense band’, achieving technology neutrality in spectrum allocations, tenure of spectrum licenses, management of interference, differential USO funding arrangements, consumer education, consumer protection etc. are some of them that need be overcome before the full realization of recommended actions.

2. Introduction

The country is witnessing an unprecedented growth in the mobile sector. At the end of October 2006, the total mobile subscriber base was more than 131 million with 95.5 million GSM subscribers and more than 36 million CDMA subscribers. The country's tele-density (measured as the no. of subscribers per 100) was 15 with urban tele-density of over 40, way ahead of 1.9 in the rural areas. However, the country's tele-density has touched the target set in National Telecom Policy 1999 about three years ahead of the original stipulated timeline of 2010. Government has set a revised target to have a subscriber base of 250 million and tele-density of 22% by 2007 and a rural tele-density of 16 by 2010.

In the pre-reform period, prior to 1991, growth in Telecom services was primarily driven by public sector monopoly with very marginal growth. As the incremental tele-density between 1948 and 1998 was only 1.92%. Telecommunication development in the initial stage of the reforms process beginning with NTP'94 started at a slow pace, but accelerated under NTP'99, which provided for migration from fixed license regime to revenue sharing regime. Cost oriented telecom tariffs were also introduced by TRAI in 1999. From 2003 onwards, certain results by the Government and the Regulator, such as introduction of Calling Party Pays (CPP) regime, Unified Access Service Licensing (UASL) regime, lowering of access deficit couple with introduction of revenue share regime in ADC triggered further growth. The future growth in telecom services will be wireless centric. With the entry of multiple operators offering various telecom services using different kind of wireless technologies, and with convergence trends, the task of spectrum management is becoming more critical and complex.

In this paper we start by understanding existing spectrum allocation in India for 2G / 2.5G cellular mobile services. The different phases in which this spectrum has been allocated and the different technologies that service providers are using. Following that we discuss the 3G rollout plan in India from spectrum allocation and licensing points and how it compares with the international standards set by ITU. We then explore the alternatives available to service providers' with respect to the spectrum usage, rural penetration and roll-out of future services which many developing countries can follow suit. We analyze the importance of the 900 MHz range of spectrum and how it can play a significant role in achieving the objectives the government has laid down for telecom industry per se.

3. Spectrum Management

Spectrum management influences the evolution of the mobile communication industry. There are two types of issues regulators have to take into account while considering spectrum management.

First, there is the issue of Technical efficiency. It refers to the requirement that different uses of radio frequency by different users should not interfere with each other due to signal overlay. Availability and use of standard equipment compliant with international standards, use of unauthorized frequency bands, power needs under different frequency bands, available bandwidth under a particular frequency band and the distance it can travel, i.e. the maximum distance after which towers are needed to propel the signal forward, finding optimal location of antennae to minimize the attenuation effects, successful transmission and reception of

signals, problem of cross-talk, handling interconnect among differing frequency bands and the general problem of channel radio interference. Achieving technical efficiency demands engineering solutions.

The second issue that regulators have to deal with in relation to spectrum management is that of Economic Efficiency. Spectrum is a scarce resource. Allocating it among alternative and competing uses involves judgment. Allocating correct amount of spectrum needs to certain uses or classes of uses, assigning usage rights to certain users or group of users, adjusting established policies as technology and markets evolve over time, pricing the spectrum to generate revenues, designing optimal spectrum policy for its efficient use, i.e. spectrum is channeled to its most productive uses, determining frequency bands for the current use and safeguarding the feasibility and adoption of future technologies, deciding which standards to follow are some of the economic considerations involved in spectrum management. Some other non-market objectives like national security, safety and equal access also need to be pursued.

3.1 Spectrum Allocation in India

The Spectrum Management functions in India, including licensing are performed by the Wireless Planning and Coordination (WPC) wing of the Department of Telecommunications (DoT). National Frequency Allocation Plan (NFAP) forms the basis for development, manufacturing and spectrum utilization activities in the country. In pursuance of the New Telecom Policy, 1999, the NFAP-2000 was evolved and made effective from 01.01.2000. At the time of formulation of NFAP-2000, it was recognized that there will be need to review the NFAP generally every two years in line with the Radio Regulations of the International Telecommunications Union (ITU) in order to cater to newly emerging technologies as well as to ensure equitable and optimum utilization of the scarce limited natural resource of radio frequency spectrum. Accordingly, NFAP-2000 was revised and new NFAPs evolved in the years 2002 (NFAP-2002) and year 2004 (NFAP-2004). In 2005, a draft plan was formed in May 2005, which had undergone one revision by Nov 2005.

[See Appendix-A for the frequencies marked by WPC for Wireless Access System (Fixed/Mobile) as per the National Frequency Allocation Plan – 2005 (Revised Draft)]

Currently, in India, wireless telecommunication services are provided through three technologies – Global System of Mobile communications (GSM), Code Division Multiple Access (CDMA) and CorDECT. The bands recognized for providing the 2G/2.5G mobile services internationally and in India are given in Table 1 below1 [Refer Table-1 below]

800 MHz band has been earmarked for CDMA based systems, while 900 MHz is for GSM based cellular systems. The 1880-1900 MHz band has been earmarked for micro-cellular technology based on TDD mode (corDECT). So far as the 1800 MHz band is concerned, the NFAP-2002 states that up to 2x10 MHz could be coordinated on case by case basis for WLL systems based on FDD access mode after the full utilization of allocated spectrum in 800 MHz band. This band can and has been used for GSM operators. The WLL system introduced in the country have used CDMA technology (in the 800 MHz band) and in the year 2003 when the concept of Unified Access Service licensing was introduced, these systems in the FDD access mode were used to provide cellular mobile services. Thus, so far as the 1800 MHz band is concerned, as per NFAP 2002 it is possible to use both GSM and CDMA based FDD access mode systems.

Table 1 – Spectrum allocations for 2G / 2.5G cellular mobile services

	International Allocations	Indian Allocation
450 MHz	Spectrum allocated in some countries: 452.5-457.475 paired with 462.5-467.475 452 – 456.475 paired with 462-466.475 450-454.8 paired with 460-464.8 411.675 – 415.850 paired with 421.675-425.850 415.5-419.975 paired with 425.5-429.975 479-483.48 paired with 498-493.48 455.23-459.99 paired with 465.230-469.99 451.310-455.730 paired with 461.31-465.73 Details are given in table 3.3	Not allocated
800 MHz	824 – 849 MHz paired with 869 –894 MHz	824 – 844 paired with 869 – 889 MHz (Used to provide WLL (M) & CDMA based mobile services)
900 MHz	890 – 915 MHz paired with 935 – 960 MHz	890 – 915 paired with 935-960 MHz (Out of 2 X 25 MHz, 2 X 1.6 MHz is with the Railways) [Used by 1st, 2nd & 3rd Cellular Mobile Service Providers for GSM]
1800 MHz	1710 – 1785 MHz paired with 1805 – 1880 MHz	1710 – 1785 paired with 1805 – 1880 MHz (Used by 4th CMSP and for additional allocations to 1st, 2 nd and 3rd CMSPs.)
1900 MHz	1850 – 1910 MHz paired with 1930 – 1990 MHz (North American PCS band)	1880–1900 MHz is earmarked for Micro cellular technologies based on TDD (corDECT)

3.2 Spectrum auctions in India

The licensing and allocation of spectrum for cellular services till date have been done in two phases. Licenses were first auctioned in 1991 for the basic and cellular services in the 900 MHz range. For licensing purposes during the first phase, DoT divided the country into 21 circles, categorized as Metros, A, B or C depending upon their revenue potential. For cellular services it was decided to have two operators per service area. Financial bids for metro licenses were evaluated on the rentals to be charged to the customer for the first three years, given the airtime tariffs as fixed by DoT. Bids for other circles were evaluated on the present value of the annual license fee for the duration of the license. The single round highest bidding mechanism resulted in high license fee in the first phase.

During the second phase of licensing in 2001, spectrum in the 1800 MHz range was licensed. Fostering competition and resolving the scenario of high tariffs and low service roll-out rates were the impetus to award license to 4th GSM operator in this phase (Third operator in all the circles is the state-owned BSNL). The government came up with a new bidding process called Informed Ascending Bidding Process (IABP). The bidders were to bid on entry fee and the license awardees had to pay a license fee as revenue share. The bidding process itself was to have three rounds, with the highest pre-qualified offer in the first and second rounds to be treated as the reservation price in the subsequent round. Though the whole process was smoother

¹ Source: TRAI, May 13 2005, Recommendations on Spectrum related issues

and as compared to the first phase, the collections during the second phase were much lower than expected. At the end of final round, government got 1.42% more than the highest bid in the first round which implies a non-significant improvement over single-round bidding.

[Refer Appendix-B for the Spectrum Allotted to Operators using GSM / CDMA based systems in different service areas.]

We believe the bid design process in India need to be more thorough, taking into account the contextual issues like M&A among the potential bidders and changes to original conditions at which the incumbents have been previously allotted spectrum so that new entrants can make arrangements with incumbents towards providing services.

On the spectral efficiency front, as compared to China's 65 MHz to support a 300 million subscriber base, India has used up 55 MHz and is still far behind the target 200 million subscribers by 2007, though fast catching up. This is because of a higher number of operators in India (7 major) as against China's 2 and the need to provide a buffer band between allocations of spectrum to each of these operators. Therefore, we believe that unless and until there is some M&A, there is no scope for a new entrant.

3.3 Criteria for additional spectrum

Till now, spectrum varying from 2*4.4 MHz to 2*10 MHz has been allocated to service providers using GSM technology and 2*2.5 MHz to 2*5 MHz has been allocated to service providers using CDMA technology. For GSM category, policy of allotment of spectrum is subscriber based. Under Unified Access Services License (UASL) an initial spectrum of 2.5 MHz is given to CDMA operators on case by case basis. Additional spectrum beyond 2.5 MHz is to be considered for allocation after ensuring optimal and efficient utilization of the already allocated spectrum.

At present spectrum allocation criteria is different for GSM and CDMA operators. We are of the opinion that spectrum allocation criteria should be technology neutral. Therefore, while retaining the subscriber base approach, the quantum and steps for additional spectrum allocation should be technology agnostic. Also, India's highest allocation of spectrum for GSM operators (2*10 MHz) and CDMA operators (2*5 MHz) is way below the international averages of 2*20 MHz and 2*14 MHz respectively. Therefore to meet the short-term and long-term objectives set by government, additional spectrum in 900/1800 MHz range and 800/1900 MHz for CDMA operators is required, specially for Metros, A and B circles.

3.4 Spectrum holdings by Defense

Defense has always been a major user of spectrum in India. In 890-915/935-960 MHz band, Defense occupies 4.8+4.8 MHz. Similarly, in 1710-1785/1805-1880 MHz. Defense occupies 60+60 MHz in Metros and 65 + 65 MHz in other areas. The balance of 15 + 15 MHz in Metros and 10 + 10 MHz in other places had been coordinated by Defense. In 1920-1980/2110-2170 MHz Defense has 60+60 MHz. We can therefore observe a direct clash of the two users – civilian bands and the military bands. This can be attributed to the India defense equipment being of erstwhile Soviet Union origin that operates in different bands than the EUROCOM standards separating military bands for NATO forces and civilian bands.

Creation of an exclusive defense band and freeing up civilian bands will lead to additional spectrum in 800 and 900 MHz range and will resolve the traffic rate and call-drop problems being faced today in high density urban centers. Additional spectrum in metros cannot be made available without a major reworking of defense networks and

4. Third Generation (3G) Mobile Cellular Communications

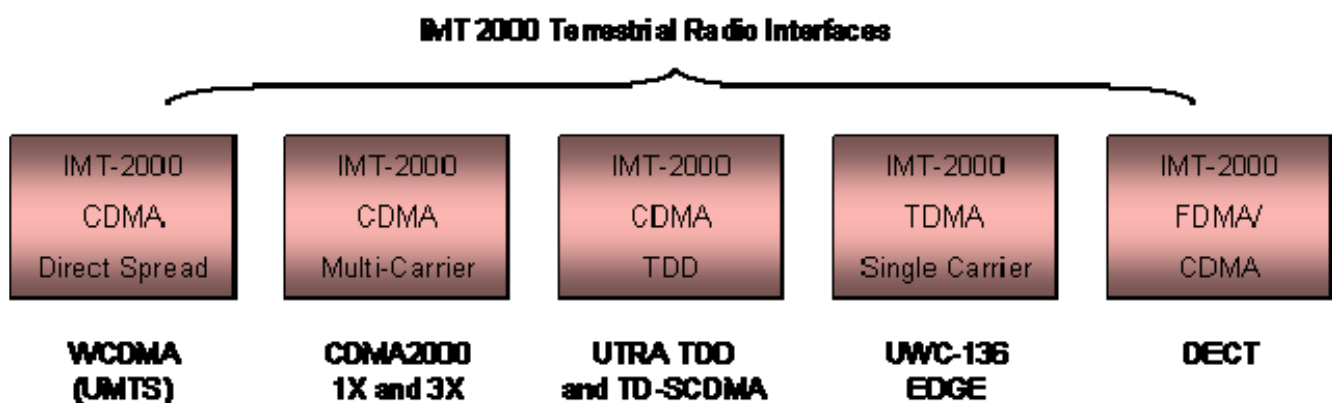
On September 27, 2006, TRAI came out with its recommendations on 3G spectrum allocation and pricing to the Department of Telecommunications. This marks the entry of Indian telecom sector into the next generation of mobile cellular communications. Let's see how India is posed with respect to the international frequency allocations for IMT-2000

4.1 International Mobile Telecommunication (IMT)-2000

IMT-2000 is the global standard for Third-Generation (3G) wireless communications, defined by set of independent ITU recommendations. It provides a framework for worldwide wireless access by linking the diverse systems of terrestrial and/or satellite based networks and takes advantage of the synergies between digital mobile communications technologies and systems for fixed and mobile wireless access systems. IMT-2000, also known as Third Generation Mobile Systems, fulfills the goal of making anywhere, anytime communications a reality. IMT-2000 has defined the following guidelines for evaluating radio interfaces:

- 144 Kbit/s (for vehicular speed)
- 384 Kbit/s (for medium speed), and,
- 2048 Kbit/s (for indoor, low speed)

The terrestrial radio interfaces defined by ITU-R for IMT-2000 are²:



IMT-2000 can operate in the frequency bands identified in the Radio Regulations (RR) as intended for use on a worldwide basis by administrations wishing to implement IMT-2000 as follows:

- WARC-92 identified the bands:
 - 1885 – 2025 MHz
 - 2110 – 2200 MHz
- WRC-2000 identified the bands³:

- 806 – 960 MHz*
- 1710 – 1885 MHz
- 2500 - 2690 MHz

* The whole band 806-960 MHz is not identified on a global basis for IMT-2000 due to variation in the primary mobile service allocations and uses across the three ITU regions

4.2 3G Rollout plan in India

In its recommendations to the Department of Telecommunications on September 27, 2006, 'Allocation and pricing of spectrum for 3G services and Broadband Wireless Access', TRAI has identified 3G as 'the next step in the evolution of mobile cellular communication'. It has considered CDMA-2000 1X EVDO and Wideband Code Division Multiple Access (WCDMA) (Universal Mobile Telecommunication System (UMTS)) for 3G services.

3G services will enable video broadcast and data-intensive services such as stock transactions, e-learning and telemedicine through wireless communications. All telecom operators are waiting to launch 3G in India to cash in on revenues by providing high-end services to customers, which are voice data and video enabled. India lags behind many Asian countries in introducing 3G services.

The Telecom Regulatory Authority of India has recommended the allocation for 3G services to be in the 450 MHz, 800 MHz and 2.1 GHz band. Five blocks of 2*5 MHz in the 2.1 GHz band, one block of 2*5 MHz in the 450 MHz band, and 2 blocks of 2*1.25 MHz in the 800 MHz band have been recommended to be licensed through ascending auction procedure. The recommended base price for the acquisition of spectrum for 3G services was set at 800 million rupees (US\$17.4 million) for "A" circles and the Delhi and Mumbai metros, 400 million rupees for "B" circles and the Chennai and Kolkata metros, and 150 million rupees for "C" circles.

Table-2: 3G Roll Out Plan

Band	Block	Designation
450 MHz (2*5 MHz)	2*5 MHz	Block A
800 MHz (15 carriers in 2*20 MHz)	2*2.5 MHz	Block B
2.1 GHz (2*25 MHz)	2*5 MHz	Block C
	2*5 MHz	Block D
	2*5 MHz	Block E
	2*5 MHz	Block F
	2*5 MHz	Block G

As per TRAI's recommendation,

"Since the quantum of spectrum in the 800 MHz band is limited, the Authority recommended that this band be allocated among the UASL CDMA operators. DoT should also allocate 2 x 5 MHz in the 450 MHz band to one of the existing UASL CDMA operators based on the specified allocation process."

² Source: Recommendation ITU-R M.1457

³ Source: Recommendation ITU-R M.1036-2

5. Moving Forward

In the previous sections we have brought out the India scenario with respect to spectrum management as it has been and as it stands today. In this section we analyze some of the alternatives available to the telecom service providers in India from the spectrum usage point of view and how, if actually exercised, can India be a playground for the future roll-out of services and the way to go for most of the developing nations. We analyze the importance of the 900 MHz range of spectrum and how it can play a significant role in achieving the objectives the government has laid down for telecom industry per se.

5.1 Digital Dividend – Through 900 MHz?

900 MHz networks are quite old networks. The origin of these networks can be traced back to Europe between 1995 and 1998. Later 1800 MHz networks were built. 900 MHz networks emit on frequency ranges around 900 MHz, which is a relatively high frequency when compared to other RF applications like car radio etc.

Such high frequencies have some big advantages. The network is not impacted by influences of weather. Only a small antenna is needed to transmit and receive signals at these frequencies, thereby making it more portable onto wireless handsets. Although, higher the frequency, the smaller the reach of the network.

However, 900 MHz is a low frequency for cellular networks. As a result of this, the 900 MHz network has a bigger and more penetrating reach than 1800 or 1900 MHz networks. Therefore for a good coverage, lesser number of masts are needed and a huge cost saving on that front. A big disadvantage of a low frequency network is that the capacity too is less as compared to higher frequency networks. However, considering the areas yet out of reach of telecom services, the issue of capacity constraint does not arise. Therefore, moving forward, the capacity offered by 900 MHz networks is sufficient for penetration in areas where telecom services, especially mobile cellular services are either absent or has a very low roll-out.

5.2 Rural Penetration

According to TRAI figures, as of June 2006, of the 607491 villages in the country, 540669 villages (89%) have been connected. But there are still around 36,000 villages without a single Village Public Telephone (VPT) as of August 2006. Moreover, VPT coverage is not uniform as major disparities exist among individual states.⁴

Though there has been no constraint of spectrum for the operators in rural areas, the mobile coverage in such areas is very small and almost incidental. Whatever coverage and network infrastructure is there is also the one setup by state-owned BSNL. This can primarily be attributed to the low ARPU and lesser no. of subscribers in rural areas vis-à-vis the CAPEX requirement in setting up cell sites and towers in such requirement, thereby making urban center more lucrative from business point of view to the private operators.

However, the growing saturation in terms of no. of mobile subscribers in metros has put a brake on the growth in metros for operators. With government making the rollout of rural telecom services as its top priority, and in order to meet the target of 250 million subscribers by 2007 and a rural tele-density of 16 by 2010,

⁴ Source: Tele.net, August 2006

there is an urgent need to extend services in these areas. The liberalization of Universal Service Obligation Fund (USOF) to private operators for both passive and active infrastructure and bringing mobile services under the ambit of USOF makes way for increased focus and expansion plans for providing mobile services in rural areas. So far only Rs. 18 billion of the USOF has been utilized as against the total collected non-lapsable sum of over Rs. 70 billion.

In rural, sparsely populated and/or low-traffic density area, an important consideration for the deployment of wireless systems is the coverage advantages of the lower frequency ranges. Lower frequency radio waves propagate farther than higher frequency radio waves. This results in a greater coverage per cell site in cellular system operating in a lower frequency range. This results in the need for fewer cells to provide service for a geographic area, and thereby lower cost for building up network infrastructure.

TRAI has recommended the use of 450 MHz band by CDMA providers. The usage of 450 MHz equipment especially in semi-urban and rural areas would be advantageous from coverage point of view because of propagation characteristics at such frequencies. On the other hand, the deployment of equipment in this frequency band may increase the multi band handset price. Operators also need to consider the availability and the price of the equipment in this frequency range. Thus, the operators would have to weigh various advantages and disadvantages in deployment of 450 MHz frequency band.

The case for the use of 900 MHz frequency band for rural coverage is still stronger – largely because there is no constraint of spectrum for operators in rural areas and the widespread availability of equipment and handsets at varying levels of prices makes the adoption rates and service roll-out easier, cheaper and integrated with the nationwide network build-up. One can use single-band devices compatible with 900 MHz network (mainly the first devices from the beginning of cell phone era). Low penetration and roll-out of telecom services in these areas imply the non-issue of capacity constraint in the 900 MHz spectrum unlike the current scenario in high-density urban centers.

Moreover, in order to reduce costs associated with network rollout and improve affordability and financial viability, infrastructure sharing between operators is the way forward for rural penetration.

5.3 Importance of IMT-2000 for India

Today, 3G technologies enable high capacity voice networks which translate into more affordable telephony services, but most important, they also provide ubiquitous broadband access. Thus IMT-2000 can be considered as a means to development of connectivity and fast provision of voice, data and multimedia services in underserved regions, factor of integration in the information society, achieve universal service and internet access goals, diversification of the telecommunications services offering, provision of new advanced wireless services.

The number of mobile subscribers is increasing significantly in India (more than 5 million subscribers per month as of December 2006) and considering the average tele-density of around 15 (as of August 2006), has a great potential when the penetration rates are concerned. But due to economic conditions, users may be able to allocate very little of their income to telecommunications. With additional services like video-conferencing and high-speed mobile internet and high infrastructure costs, some usage fee of IMT-2000 is

expected to be towards the higher side. Thus we can identify some of the special needs of users and operators for India.

- User affordability for services and terminals. For operators, recovery of evolution/ migration CAPEX and OPEX costs.
- Coverage and deployment obligations as in the target coverage/service penetration and roll-out schedule set by regulators
- Easy roaming, facilitated by low prices and by availability of compatible technologies/ terminals in foreign countries
- Flexibility in determining and finalizing the transition
- Mass application of IMT-2000 because of the need for applications such as tele-education, tele-medicine, e-government, rural economic development, access to internet at affordable prices etc.
- Sharing of radio/network resources for rapid rollout and coverage to facilitate speedy deployment of new technologies and lower the costs to operators
- Develop market analysis and business case in purview of population literacy, disposable income etc.

Though ITU recommends IMT-2000 systems be deployed in any of the bands identified by the ITU for IMT-2000 in the Radio Regulations, the ITU-R Recommendation M.1036 states that administrations may deploy IMT-2000 systems in bands other than those identified in the Radio Regulations. Following this, in some countries (for example, the United States), system upgrades to IMT-2000 are taking place in the cellular bands (800 MHz and 900 MHz) and in the PCS bands (1800 MHz and 1900 MHz).

5.4 Advantages of deploying 3G services at 900 MHz networks

In 2005, the ITU-D published a “Guidelines on the smooth transition of existing mobile networks to IMT-2000 for developing countries”. In this report, the importance of in band transition to IMT-2000 is emphasized.

“The adoption of flexible policies for the national allocation of the radio spectrum and for the choice of technologies provides market incentives for the development and deployment of advanced wireless services throughout the world. Regulators may wish to allow operators to transition their pre-IMT-2000 systems to IMT-2000 using their existing licensed spectrum, so that operators would not need to deploy these systems in new spectrum bands. This spectrum flexibility benefits operators by allowing them to spend capital resources on improving their system and can keep costs low”

In low density areas, it will be more costly to deploy IMT-2000 systems in non-harmonized frequency bands that in those that are harmonized and utilized by majority of operators due to lack of economies of scale. Deploying UMTS/HSDPA technology in 900 MHz spectrum can help mobile operators cost-effectively deliver UMTS/HSDPA services because the lower frequency provides a significant increase in the coverage area of a base station and, potentially, enables better signal penetration for in-building coverage in urban areas. W-CDMA (UMTS) in the 900 MHz band is a cost effective way to deliver truly nationwide high-speed wireless coverage. It achieves a 60 percent reduction in cell sites required to serve rural areas and

delivers improved Quality of Service in urban areas by enhancing in-building penetration by 25 percent⁵. Nortel, Qualcomm and Orange demonstrated this capability during the 3GSM World Congress in Barcelona in February 2005. The deployment of "in-band" solutions, such as CDMA2000 at 850MHz or UMTS at 900MHz, can reduce the operator's initial 3G CAPEX for coverage purposes by up to 70% when compared with deployments at 2100 MHz frequency band.⁶

In terms of technology, both GERAN (GSM/EDGE Radio Access Network) and UTRAN (UMTS Terrestrial Radio Access Network) can be used to realize large cell radii as required in sparsely populated areas. But due to different frequency ranges, where GERAN and UTRAN are envisaged to operate today, GERAN is more suitable for large cells. One reason for that is that GERAN is operated in 900 MHz, 800 MHz. By operating in 450 MHz and 900 MHz range, UTRAN can be used as complement to GERAN to enhance the traffic capacity and to offer significantly higher data rates.

The operators of wireless systems in lower frequency ranges, such as those below 1 GHz, can provide services in both rural and dense urban areas using the same network in terms of technology and frequency range. Though, in high density areas, due to the significantly high traffic load, it may be necessary to deploy additional spectrum.

Besides the basic voice services, developing countries like India, also need to look to expand the definition of universal service/access to include data services, such as Internet access. As per TRAI's recommendations to government,

"Broadband wireless access (BWA) technologies enable high-speed data communication over wireless links. It offers significant advantages over wireline broadband systems based on cable network or DSL, having better coverage, speedy deployment, high scalability, lower maintenance and upgrade costs, and phased investment to match market growth..... BWA technologies are seen as complementary to 3G technologies, with possible co-existence and extension between 3G and BWA systems to extend coverage in specific areas or to respond to consumer needs."

Wireless systems, such as IMT-2000 have been designed to handle both basic voice as well as low-to-high speed data services. IMT-2000 technologies with their higher data rates can bring advanced services to a wider range of users, while meeting important social needs such as providing high speed connectivity to clinics, schools, libraries, governments, tele-centers and other priority users. In addition to Internet access, many other applications essential for developing countries, such as e-health/ telemedicine, can be provided over IMT-2000 at a reasonable cost when deployed over 900 MHz frequency range.

Given the significant initial capital expenditures necessary to deploy entirely new IMT-2000 systems, operators may find upgrading the networks in existing spectrum a more economically viable option. For offering the same service (data rates) the cell range of UMTS900 in rural areas is about two times that of 3G/UMTS in 2 GHz band. 3GPP has introduced and completed technical specifications for deploying UMTS/WCDMA at 900 MHz⁷

⁵ Source: <http://www.3g.co.uk/PR/Jan2006/2505.htm>

⁶ Source: "The Dollars and Sense of 3G" by Signal Research

⁷ 3GPP TR 25.816 V7.0.0 (2005-12)

5.5 Non-Availability of 900 MHz spectrum in India

The total spectrum for GSM 900 and GSM 1800 frequency bands is 2x100 MHz (2 X 25 MHz of GSM 900 + 2 X 75 MHz of GSM 1800). Most of GSM 900 spectrum has already been allocated including allocation of 2 x 1.6 MHz to Railways for GSM-R systems but in GSM 1800 most of it is still being used by other users like Defense etc. Efforts are being made for allocation of additional spectrum in GSM 1800 band (1710-1785 MHz paired with 1805-1880 MHz band). The maximum allocated spectrum in a service area at present in 1800 MHz band is 2 x 12 MHz (varies from region to region). However, the frequency band 1710-1785 MHz paired with 1805-1880 MHz is extensively utilized by Air Force and Army and a maximum of 2 X 25 MHz spectrum. Even in GSM 900 MHz band spectrum around 2 X 4.8 MHz is being used by Defense in all the circles except Delhi and Mumbai.

Therefore, the non-availability of 900 MHz spectrum means the existing service providers holding licenses in this frequency band have an edge over others new entrants.⁸ Additionally, as discussed in previous sections, setting up of 'Defense Band' can free up the much need additional spectrum in 800/900 MHz range, driving the penetration and growth of telecom services a notch higher.

5.6 Leapfrogging Beyond 3G

The world is entering an age of seamless mobility where broadband will be as common as air, everything will go digital and everything will be mobile. There will be a demand for systems that combine cellular and internet technologies. While current 3G services are working to enable transactional wireless communications like location-based services, wireless shopping, personal services, email and multimedia data transfer, these are at much lower speeds compared to the 100 Mbps to 1 Gbps potential of 4G technologies. As demand builds for high-quality, streaming video and audio, only 4G systems will be able to accommodate growing consumer and business expectations. The other advantages of 4G are high speed, high capacity, low bit cost and completely IP based. Developing countries like India, where significant investments have not been made for 3G yet, may leapfrog directly to 4G to gain benefits.

Additionally, Broadband Wireless Access (BWA) along with Wireless LAN (WLAN) technologies is expected to fuel a similar kind of growth as has been in telephony by wireless systems. As mentioned above, BWA technologies are seen as complimentary to 3G. However, some of the spectrum bands proposed for BWA technologies might overlap with bands that are recommended for IMT-2000 systems. One example is the 2500-2690 MHz band, which is an IMT-2000 band but also hold potential for use by BWA technologies. There are other IMT-2000 bands also which can be used by 'Beyond 3G' technologies. Within the IEEE standards families of 802.16 and 802.20, there are a number of different technologies in development or currently existing, including WiMax, WiBro, Flarion, iBurst, RipWave, and IPWireless, with other potential technologies in future. Some of these technologies are expected to lower the system costs to as much as 1/10th of IMT-2000.

In the wake of these uncertainties, with respect to spectrum licensing and usage, a better way for incumbent operators could be to go for in-band transition to IMT-2000, before incurring costs for expensive spectrum licenses. This means providing 3G services through transitioning existing networks at 900 MHz

⁸ A part of the high valuation of Hutchinson Essar can also be attributed to the fact that it holds licenses in 900 MHz band

instead of licensing additional spectrum in 2100 MHz range and to go for spectrum licenses for future, more profitable, lower cost technologies, as and when they are available.

5.7 Converged Licensing

Full mobility convergence was achieved in India through the Unified Access Services License (UASL) introduced by Department of Telecommunications in 2003. This license permits provision of voice and data services and is technology neutral in its scope. Moving forward, we can expect convergence happening at the device level. Licensing policy at that time will need to address this reality and allow carriers to offer fixed (e.g. WLL), mobile, data, broadcast services etc. Such converged licenses are possible at all levels: network facility, services, ISP, content layers etc. Such licenses will also promote carriers in enabling different tiering of service plans and may, in fact, may not be too far in future considering the latest roll out of IPTV services by MTNL in Delhi and TRAI also hinting at its approach towards achieving technology neutrality to DoT in its latest recommendations related to 3G licensing and pricing.

Additionally, move to digitize terrestrial broadcasting in future will free up spectrum in 700 MHz range which may then be up for grabs under the converged license. Therefore, it may very well be in the interests of service providers to push for lower frequency ranges for greater penetration, and going onto higher frequencies only when additional spectrum is needed.

6. Challenges ahead

The growing demand of wireless technologies, scarcity of spectrum, interference issues and the number of technologies contending for overlapping spectrum bands raises several challenges for national regulatory authorities (NRAs).

The in band transition to IMT-2000 we discussed in this paper requires that there are no regulatory limitations on the use of a particular technology in the existing mobile bands. Regulations and license conditions specifying the use of a particular technology or standard in bands need to be eliminated. Second, service definitions may also have to be modified to accommodate the new flexibility. This can be achieved by keeping the definitions broad and non-specific. Regulators can also enhance the existing licenses and identify some preferred technologies (broad-sets) in order to meet the demands of end users and operators. Given a choice from among the preferred technologies, the operators can still select the most appropriate technology from the set of technologies as well as the timing of the introduction of the new technology. Harmful interference between licensees using pre-IMT-2000 and IMT-2000 systems may be addressed by specific technical rules that seek to avoid harmful interference between operators on adjacent channels in the same area. These technical rules include out-of-band emission limits, power flux density or field strength limits at the edge of the service areas or borders, guard-bands, and coordination requirements.

Apart from the in band transition challenges, in order to justify investment in new wireless infrastructure and applications, wireless operators will require ex ante regulatory certainty on such issues as the tenure of spectrum licenses, the management of interference, and their abilities to install infrastructure on public and private lands. Issues pertaining to the types of licenses, differential universal service obligation funding

arrangements, different network access obligations and various interconnect issues also need to be looked into and addressed.

The significantly increased demand for radio frequency spectrum may need re-farming certain bands and relocating certain services to some other bands quickly to keep up with the pace of innovation.

Consumer education, consumer protection, universal access, security, lawful interception, creation of exclusive 'defense band' etc. are some of the other challenges that will need to be addressed.

APPENDIX

A. Frequency Ranges as per NFAP-2005 (Revised Draft)

Frequency Range	Remarks
54-68 MHz	The requirement of Fixed/Mobile services in the band 54-68 MHz may be considered on case-by-case basis.
450.5- 457.5 MHz paired with 460.5- 467.5 MHz	Induction of wireless access systems (fixed/mobile) telecommunication services may be considered for coordination on case by case basis in the frequency band 450.5- 457.5 MHz paired with 460.5- 467.5 MHz.
470-520 MHz	Requirements of fixed and mobile services will be considered in the frequency band 470-520 MHz on case-by-case basis
520-585 MHz	Requirements of fixed and mobile services may be considered in the frequency band 520-585 MHz on case-by-case basis.
824-844 MHz paired with 869-889 MHz	Frequency band 824-844 MHz paired with 869-889 MHz has been earmarked for wireless access systems (fixed/mobile) for telecommunication services
890-902.5 MHz paired with 935-947.5	Frequency band 890-902.5 MHz paired with 935-947.5 MHz has been earmarked for cellular mobile telephone systems.
902.5 - 915 MHz paired with 947.5 – 960 MHz.	Additional requirements up to 6.2 + 6.2 MHz for cellular mobile telephone systems may be coordinated on a case-by-case basis in the frequency band 902.5 - 915 MHz paired with 947.5 - 960 MHz. These may not be contiguous and may be in smaller chunks of 0.6 MHz and may not be same in all cases, while efforts would be made to make available in larger chunks to the extent feasible.

1710-1785 MHz paired with 1805-1880 MHz	<p>Requirements of cellular and wireless access systems (fixed/mobile) for telecommunication services in the frequency band 1700-2000 MHz may be coordinated on a case by case basis. Cellular mobile telephone systems may be coordinated for (10+10) MHz in the frequency band 1710-1785 MHz paired with 1805-1880 MHz and on full utilization of allocated spectrum in 800 MHz band, additional (10+10) MHz of spectrum may be coordinated for wireless access systems (fixed/mobile) for telecommunication services, in the frequency bands 1710-1785 MHz paired with 1805-1880 MHz on a case-by-case basis.</p> <p>This additional spectrum could be in chunks of (5+5) MHz if possible, otherwise smaller chunks in multiples of 1.25 MHz could be considered for allocation on case-by-case basis. These allocations may not be contiguous. However, efforts would be made to make the spectrum width as large as possible.</p>
1880-1900 MHz	<p>Requirements of micro cellular wireless access systems (fixed/mobile) for telecommunication services based on TDD access techniques, especially indigenously developed technologies, capable of coexistence with multiple operators will be considered in the frequency band 1880-1900 MHz on a case by case basis.</p>
1900-1910 MHz	<p>Additional requirements of micro cellular wireless access systems (fixed/mobile) for telecommunication services based on TDD access techniques, especially indigenously developed technologies, capable of coexistence with multiple operators in the frequency band 1900-1910 MHz may also be progressively considered on a case- by- case basis in exceptional circumstances in specific areas taking due account of existing usages.</p>
1885-2025 MHz paired with 2110-2200 MHz	<p>Requirements of IMT-2000 (3G) applications in the frequency bands 1885-2025 MHz paired with 2110-2200 MHz may be coordinated with existing users initially for 1920-1980 MHz paired with 2110-2170 MHz (FDD mode) and 2010-2025 MHz (TDD mode) depending on the market needs and availability, as far as possible.</p>

B. Spectrum Allocation in different service areas

S.No.	Service Area	GSM Based systems		CDMA based systems	
		Operator	Frequency Allotted	Operator	Frequency Allotted
1	Delhi-Metro	Bharti Cellular Ltd	10+10 Mhz	MTNL	3.75+3.75 MHz
		Hutchinson Essar Mobile Service Ltd	10+10 Mhz	Reliance Infocomm. Ltd	5+5 MHz
		MTNL	6.2+6.2 MHz	Tata Teleservices Ltd	5+5 MHz
		Idea Cellular Ltd	6.2+6.2 MHz		
2	Mumbai Metro	BPL Mobile Comm.	10+10 Mhz	MTNL	5+5 MHz
		Hutchinson Max	10+10 Mhz	Reliance Infocomm. Ltd	5+5 MHz
		MTNL	8+8 Mhz	Hughes Telecom(I) Ltd/	5+5 MHz
		Bharti Cellular Ltd	8+8 Mhz	Tata Teleservices Ltd	
3	Kolkata Metro	Bharti Mobitel Ltd	8+8 Mhz	BSNL	2.5+2.5 MHz
		Hutchinson Essar Mobile Service Ltd	8+8 Mhz	Reliance Infocomm. Ltd	5+5 MHz
		BSNL	6.2+6.2 MHz	Tata Teleservices Ltd	2.5+2.5 MHz
		Reliable Internet	6.2+6.2 MHz		
4	Chennai Metro	Aircel Ltd.	6.2+6.2 MHz	BSNL	2.5+2.5 MHz
		Bharti Mobinet Ltd.	6.2+6.2 MHz	Reliance Infocomm. Ltd	5+5 MHz
		BSNL	6.2+6.2 MHz		3.75+3.75 MHz
		Hutch Essar South	6.2+6.2 MHz	Tata Teleservices Ltd	
5	Andhra Pradesh	Idea Cellular Ltd.	8+8 Mhz	BSNL	2.5+2.5 MHz
		Bharti Mobile Ltd.	8+8 Mhz	Reliance Infocomm. Ltd	5+5 MHz
		BSNL	8+8 Mhz	Tata Teleservices Ltd	5+5 MHz
		Hutch Essar South	6.2+6.2 MHz		
6	Assam	Dishnet DSL (UASL)	4.4+4.4 MHz	(to BSNL alongwith North East)	
		Reliance Telecom	6.2+6.2 MHz		
		BSNL	6.2+6.2 MHz		
		Bharti Televenture	4.4+4.4 MHz		
7	Bihar	Reliance Telecom	6.2+6.2 MHz	BSNL	2.5+2.5 MHz
		BSNL	6.2+6.2 MHz	Reliance Infocomm. Ltd	3.75+3.75 MHz
		Reliance Cellular (UASL)	6.2+6.2 MHz	Tata Teleservices Ltd	2.5+2.5 MHz
		Dishnet DSL (UASL)	To be allotted		
8	Gujarat	Fascel Ltd.	9.8+9.8 MHz	BSNL	2.5+2.5 MHz
		Idea Cellular Ltd.	6.2+6.2 MHz	Reliance Infocomm. Ltd	3.75+3.75 MHz
		BSNL	7.4+7.4 MHz		2.5+2.5 MHz
		Bharti Cellular Ltd	6.2+6.2 MHz	Tata Teleservices Ltd	
9	Haryana	IDEA Mobile	6.2+6.2 MHz	BSNL	2.5+2.5 MHz
		Aircel Digilink	6.2+6.2 MHz	Reliance Infocomm. Ltd	2.5+2.5 MHz
		BSNL	6.2+6.2 MHz	Tata Teleservices Ltd	2.5+2.5 MHz
		Bharti Cellular Ltd.	6.2+6.2 MHz		
10	Himachal Pradesh	Bharti Telenet Ltd.	6.2+6.2 MHz	BSNL	2.5+2.5 MHz
		Reliance Telecom	4.4+4.4 MHz	Reliance Infocomm. Ltd	2.5+2.5 MHz
		BSNL	6.2+6.2 MHz		2.5+2.5 MHz
		Escorts Telecom	4.4+4.4 MHz	Tata Teleservices Ltd	
11	Jammu & Kashmir	Dishnet DSL (UASL)	To be allotted		
		Bharti cellular Ltd. (UASL)	4.4+4.4 MHz	BSNL	2.5+2.5 MHz
		BSNL	6.2+6.2 MHz		
		Dishnet DSL (UASL)	4.4+4.4 MHz		
12	Karnataka	Spice communications	6.2+6.2 MHz	BSNL	2.5+2.5 MHz
		Bharti Mobile Ltd.	10+10 MHz	Reliance Infocomm. Ltd	5+5 MHz
		BSNL	8+8 MHz		3.75+3.75 MHz
		Hutch Essar	8+8 MHz	Tata Teleservices Ltd	

S.No.	Service Area	GSM Based systems		CDMA based systems	
		Operator	Frequency Allotted	Operator	Frequency Allotted
13	Kerala	BPL Mobile	6.2+6.2 MHz	BSNL	2.5+2.5 MHz
		IDEA	8+8 MHz	Reliance Infocomm. Ltd	3.75+3.75 MHz
		BSNL	8+8 MHz	Tata Teleservices Ltd	2.5+2.5 MHz
		Bharti cellular Ltd.	6.2+6.2 MHz		
14	Maharashtra	BPL Mobile Cellular	6.2+6.2 MHz	MTNL	2.5+2.5 MHz
		Idea Cellular Ltd.	10+10 MHz	Reliance Infocomm. Ltd	3.75+3.75 MHz
		BSNL	8+8 MHz	Hughes Telecom(l) Ltd/	5+5 MHz
		Bharti Cellular Ltd	6.2+6.2 MHz	Tata Teleservices Ltd	
15	Madhya Pradesh	BTA celcom.	6.2+6.2 MHz	BSNL	2.5+2.5 MHz
		Reliance Telecom	6.2+6.2 MHz	Reliance Infocomm. Ltd	3.75+3.75 MHz
		BSNL	6.2+6.2 MHz	Tata Teleservices Ltd	2.5+2.5 MHz
		Bharti cellular Ltd.	6.2+6.2 MHz		
16	North East	Reliance Telecom	4.4+4.4 MHz	BSNL (including Assam)	2.5+2.5 MHz
		BSNL	6.2+6.2 MHz		
		Dishnet DSL (UASL)	4.4+4.4 MHz		
		Bharti	4.4+4.4 MHz		
17	Orissa	Reliance Telecom	6.2+6.2 MHz	BSNL	2.5+2.5 MHz
		BSNL	6.2+6.2 MHz	Reliance Infocomm. Ltd	3.75+3.75 MHz
		Bharti cellular (UASL)	6.2+6.2 MHz	Tata Teleservices Ltd	2.5+2.5 MHz
		Dishnet DSL (UASL)	4.4+4.4 MHz		
18	Punjab	Spice communications	8+8 MHz	BSNL	2.5+2.5 MHz
		Bharti Mobile Ltd.	8+8 MHz	Reliance Infocomm. Ltd	3.75+3.75 MHz
		BSNL	6.2+6.2 MHz		5+5 MHz
		Hutch Telecom	6.2+6.2 MHz	HFCL	2.5+2.5 MHz
19	Rajasthan	Aircel Digilink	6.2+6.2 MHz	BSNL	2.5+2.5 MHz
		Hexacom India Ltd.	6.2+6.2 MHz	Reliance Infocomm. Ltd	3.75+3.75 MHz
		BSNL	6.2+6.2 MHz	Shyam Telelink Ltd.	5+5 MHz
		Escorts Telecom	4.4+4.4 MHz	Tata Teleservices Ltd	2.5+2.5 MHz
20	Tamil Nadu	BPL Mobile Cellular	6.2+6.2 MHz	BSNL	2.5+2.5 MHz
		Aircel Ltd.	10+10 MHz	Reliance Infocomm. Ltd	3.75+3.75 MHz
		BSNL	8+8 MHz		2.5+2.5 MHz
		Bharti cellular Ltd.	6.2+6.2 MHz	Tata Teleservices Ltd	
21	Uttar Pradesh (W)	IDEA	6.2+6.2 MHz	BSNL	2.5+2.5 MHz
		BSNL	6.2+6.2 MHz	Reliance Infocomm. Ltd	3.75+3.75 MHz
		Hutchinson Essar (UASL)	6.2+6.2 MHz	Tata Teleservices Ltd	2.5+2.5 MHz
		Bharti cellular Ltd.	6.2+6.2 MHz		
22	Uttar Pradesh (E)	Aircel Digilink	6.2+6.2 MHz	BSNL	2.5+2.5 MHz
		Bharti cellular (UASL)	6.2+6.2 MHz	Reliance Infocomm. Ltd	3.75+3.75 MHz
		BSNL	6.2+6.2 MHz		2.5+2.5 MHz
		Escorts Telecom	4.4+4.4 MHz	Tata Teleservices Ltd	
23	West Bengal	Reliance Telecom	6.2+6.2 MHz	BSNL	2.5+2.5 MHz
		Bharti cellular (UASL)	4.4+4.4 MHz	Reliance Infocomm. Ltd	2.5+2.5 MHz
		Hutchinson Essar (UASL)	4.4+4.4 MHz	Tata Teleservices Ltd	2.5+2.5 MHz
		BSNL	6.2+6.2 MHz		
		Dishnet DSL (UASL)	4.4+4.4 MHz		

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