
# TELECOM REGULATORY AUTHORITY OF INDIA

## Recommendations

## on

## Allocation and pricing of spectrum for 3G and broadband wireless access services

**September 27, 2006**

**TRAI House**
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**Africa Avenue,**
**New Delhi, India**
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No. 101-36/2006-MN
Sep 27, 2006

**Sub: Recommendations on Allocation and pricing of spectrum for 3G and BWA services**

1. Kindly refer to DOT's letter No L-14047/09/2005-NTG dated May 22, 2006 vide which TRAI's recommendations on the methodology for allotment of spectrum for 3G services and its pricing aspects were sought. TRAI also considered appropriate to include issues related to wireless broadband access because of its relevance in Indian context, due to similarity with 3G specially in respect of high data rates / throughput delivered.

2. The Authority issued a consultation paper on 'Allocation and pricing of spectrum for 3G services and Broadband Wireless Access' on 12th June 2006 highlighting the issues on Allocation of spectrum for 3G services and its Pricing and Allocation and pricing of spectrum for BWA technologies. The Authority conducted an Open House Discussion in Delhi on July 7, 2006, and following this, held one-on-one meetings with various stakeholders, Defense services, and Department of Space to gain an in-depth understanding of different stakeholders' views and arguments.

3. Based on inputs received during the consultation process and in-house analysis, TRAI has come out with the recommendations on Allocation and pricing of spectrum for 3G and BWA services and issued today. A copy of the same along with Press Release is enclosed

4. These recommendations are also being posted on TRAI's website (www.trai.gov.in)

(Nripendra Misra)
Chairperson, TRAI

The Secretary,
Department of Telecommunications,
Ministry of Communications and IT,
Sanchar Bhavan, New Delhi-110001

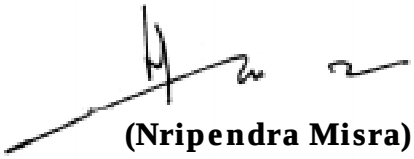
# PREFACE

The growth of the telecom sector in the country has been very impressive. While making recommendations on third generation (3G) mobile technology, the challenge before the Authority was to make the benefits of technology more widely available to people. Mobile phones mainly addressing the voice-centric needs are spreading fast. This growth became possible in an environment where supply of telecom services was not constrained based on pre-determined demand. The Authority's policy to encourage competition, a level-playing field, and to maintain a technologically neutral stance had a significant role in this growth. The unmet demand was huge and therefore there has not been a situation of glut in supplies in telecom sector. There is no sign of slowing down. The subscriber base is growing by approximately 5 million every month. By end-2007, India would have crossed 200 million phone subscribers. Future growth of wireless services is critically dependent upon the availability of adequate spectrum.

2. The Authority is committed to the view that the consumers must get the benefit of new technology and variety of services. It also believes that the telecom service providers should have the flexibility to choose from the range of technologies available and the regulatory policies must not restrict the choice of the operator. Therefore, the Authority considered it appropriate to offer its recommendations both on 3G technology and on broadband wireless access (BWA) systems at the same time. It would also ensure that the spectrum issues are considered in a holistic manner and piecemeal or ad-hoc solutions do not find place in future planning. The Authority has also made suggestions on the wider issue management of spectrum, which is now a scarce resource in the country. The future growth in telecom would largely depend on the way we manage our spectrum.

3. Most respondents have been very generous with their time and participation during our consultation process. Each participant emphasized the need

for a longer-term vision and planning. In making these recommendations, the Authority has given due importance to principle of transparency, efficiency, certainty in matter of allocation, pricing of spectrum and subscriber's affordability. Our effort has been to remain as close as possible to the reality of the environment which alone can ensure time-bound implementation.



**(Nripendra Misra)**
**Chairman, TRAI**

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# EXECUTIVE SUMMARY

## Introduction

S.1. The Government sought recommendations from the Authority on the methodology for allotment of spectrum for 3G services and its pricing aspects.

S.2. Third generation (3G) systems represent the next step in the evolution of mobile cellular communication. 2G systems focus on voice communication, while 3G systems support increased data communication. They allow high-speed data of at least 144 kbps, mobile Internet access, entertainment, and triple-play converged communications services, and have markedly greater capacity and spectrum efficiency than 2G systems.

S.3. In addition to issues relating to 3G, the Authority believed that it would be relevant to discuss and seek comments on spectrum allocation and pricing for broadband wireless access (BWA) technologies as well, to help boost broadband penetration in the country, especially in the rural areas. It is essential that any forward-looking spectrum policy should take into account the developments in 3G and BWA to create a clear and stable regulatory framework.

S.4. Keeping in mind the goal of setting out a path for the current and future availability of spectrum, and with the main principles of encouraging competition and growth, and a level-playing field, and maintaining a technology neutral stance, the Authority has made recommendations on:

- Band identification for 3G services
- Allocation methodology and pricing for 3G spectrum
- Band identification, allocation and pricing of BWA spectrum

S.5. During the consultation process, it became clear that many competing users and uses were competing for scarce spectrum. The Authority recognized that in order to ensure that the growth of telecom services, which is mainly concentrated in wireless services, continues unabated, a clear roadmap for spectrum availability is essential. Thus, in addition to these recommendations, the Authority has also made suggestions on spectrum management in the Indian context.

## Spectrum management

S.6. The organizational frameworks and methods of spectrum management are still primarily tied to a legacy where only a few government departments and agencies were spectrum users. Considering the growth and development of wireless technologies and services, a long-term view on overall spectrum management policy including the organizational structure for spectrum management is necessary. A liberal and transparent approach is necessary so that it matches with the overall policy approach.

S.7. Although these issues were not explicitly discussed in the consultation paper and the Authority is not making any specific recommendations on these issues, the Authority considers it necessary to deliberate on these issues before coming to the specific recommendations on 3G and BWA spectrum.

S.8. The Authority has discussed the need to ensure availability of adequate spectrum, to ensure efficient utilization of the spectrum, and making the processes of spectrum allocation completely transparent, and based on a road map and well-researched plan. The Authority believes that it will be important for concerned agencies to ensure that the non-availability of spectrum does not come in the way of deploying any wireless technology. Further, monitoring of spectrum use to avoid hoarding and interference also need to be strengthened. Finally, the organizations of spectrum management need to be strengthened. This whole issue is not to be dealt with in piecemeal but should be taken up as a long-term policy issue. From this perspective, it becomes necessary to handle it through an inter-departmental coordination committee under DoT at the highest level.

S.9. To co-ordinate the availability of spectrum among various major users it is proposed that a National Frequency Management Board (NFMB) may be constituted under the Chairmanship of MoC&IT, with Chairman/TRAI, Secretary/DoT, Secretary/Defence, Secretary/Department of Space, Secretary/I &B, Secretary/DIT, Chairman of the Railway Board, and two academicians from the field of telecom, IT, spectrum policy, and related areas as its Members.

## Identification of spectrum bands and their allocation for 3G services

S.10. The Authority has recommended that the Government should not treat the allocation of 3G spectrum in continuation of 2G spectrum.

S.11. The Authority has identified the 450 MHz, 800 MHz, and 2.1 GHz bands for immediate allocation for 3G services. The PCS1900 band has been identified as a possibility in the near future depending on the success of trials and vacation by incumbent users.

S.12. The Authority has recommended that 2 x 25 MHz of spectrum in blocks of 2 x 5 MHz should be allocated for 3G services.

S.13. Based on the current growth rates, it is expected that the number of carriers needed for CDMA subscriber voice traffic in all the service areas will be at the most 12 to 13 carriers. Additionally, in circles where there are three CDMA operators, the Authority has recommended re-aligning the band to form 15 carriers. Thus, two to three carriers can be earmarked for 3G services in the 800 MHz band.

S.14. 450 MHz band has excellent propagation characteristics, and will be suited especially for coverage in rural areas. The Authority recommended that 450 MHz band should also be identified for CDMA operators on a separate plank with rural roll out commitment.

S.15. As the PCS1900 band will not be available in the near future, and hence, a mixed band allocation will not be possible in the near future. However, the Government should conduct the trial to verify practical feasibility of coexistence of mixed band allocations, and in case the co-existence is found feasible and economically practicable, then it should work towards re-farming of the PCS1900 band, specifically 2 x 10 MHz in the near future to enable the future growth of 3G cellular services in India.

## Allocation methodology and pricing for 3G spectrum

S.16. In order to enable future growth of 3G services, it is essential that the DoT has a time bound road map for making available additional and sufficient spectrum.

S.17. 2 x 32.5 MHz of spectrum will be available in a time scenario of 6-9 months for 3G services.

S.18. With the current availability of 2 x 25 MHz of spectrum in the 2.1 GHz band, five operators should be accommodated in blocks of 2 x 5 MHz in this band in the first lot. Remaining operators should be allocated spectrum as and when it is available. 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.

S.19. An UASL CDMA operator will have the option to seek 2 x 1.25 MHz in the 800 MHz band at a determined price. Additionally, it will have the option of taking spectrum in either the 2.1 GHz or 450 MHz bands. In case it opts for the 2.1 GHz band, the UASL CDMA operator will have to bid along with the other operators. In case it is among the successful bidder, he will have an option of either retaining 2 x 1.25 MHz in the 800 MHz and getting an additional 2 x 3.75 MHz in the 2.1 GHz band, or giving up the option on 2 x 1.25 MHz in the 800 MHz band and getting 2 x 5 MHz in the 2.1 GHz band.

S.20. In the 450 MHz band, if more than one operator opts for 2 x 5 MHz, the Authority recommended that a single stage bidding process be conducted. The reserve price for 2 x 5 MHz in the 450 MHz band will be half of the reserve price set for 2.1 GHz band for that service area.

## Spectrum pricing

S.21. The Government should charge a spectrum acquisition fee from all operators wishing to provide services using the 800 MHz band and/or 450 MHz band. The allocation criteria followed for the identified carriers in 800 MHz should also be a spectrum acquisition fee.

S.22. The Government may allocate spectrum blocks in the 2.1 GHz band using a simultaneous ascending auction system. If there are more operators interested in the 450 MHz or 800 MHz bands than the amount of available spectrum, then a one-stage bidding process should be organized to decide the winners.

S.23. Ascending auctions have a reserve price, a minimum price above which bidders must place their bids. The Authority has recommended a specific reserve price for the 2.1 GHz and 450 MHz bands. For the 800 MHz band 3G carriers, the Authority recommended that the second-highest winning bid in the 2.1 GHz auction should be pro-rated to a per-2 x 1.25 MHz price.

S.24. DoT should have a one year moratorium on incremental annual spectrum fees for 3G spectrum from the time of spectrum assignment. After this one year, the DoT should charge operators an additional annual spectrum charge of 1 per cent of the operator's total adjusted gross revenue (AGR).

S.25. There are specific roll out obligations and conditions to be enforced for the 2.1 GHz and 450 MHz bands.

## Spectrum for BWA technologies

S.26. The Authority considered the following bands for BWA systems: 700 MHz, 2.3 - 2.4 GHz, 2.5 - 2.69 GHz, 3.3 - 3.4 GHz, 3.4 - 3.6 GHz, 5.15 GHz - 5.35 GHz & 5.725 GHz - 5.875 GHz.

S.27. In order to ensure that sufficient spectrum is available for BWA systems, the Authority recommended that at least 200 MHz of spectrum should be made available for BWA to accommodate growth requirement until 2007, and an additional 100 MHz of spectrum should be coordinated by 2010.

S.28. Operators with current spectrum assignments in the 3.3-3.4 GHz band should be given the option to migrate to circle-wide operations by December 2006, and the DoT should then allocate this spectrum for BWA technologies as discussed subsequently.

S.29. The DoT should coordinate with DoS to get 100 MHz for broadband wireless applications in the 3.4 - 3.6 GHz band immediately.

S.30. Use of the 5.15-5.35 GHz and 5.725-5.875 GHz bands may be allowed on a technology neutral, non-protected, non-exclusive basis as delicensed bands in also the outdoor deployments of terrestrial wireless technologies.

S.31. DoT should coordinate some part of 700 MHz spectrum for making it available for rural wireless networks in the near future. Also keeping in mind the suitability of 2.3-2.4 GHz band for BWA applications and the need for additional spectrum later, the Authority recommended that DoT should plan to vacate/re-farm this 100 MHz band from the existing users by end-2007 and allocate it for BWA services.

S.32. The Authority also recommended that the DoT should initiate the process to vacate portions of the 2.5 - 2.69 GHz band that might not be in use at this time, or which have marginal uses limited in nature. This spectrum should be earmarked for wireless telecommunications systems, and the Authority will recommend the precise allocation at a later stage depending on technological developments and market demand.

S.33. The Authority recommended allocation of the 200 MHz of spectrum in the 3.3-3.4 GHz and 3.4-3.6 GHz bands to 13 operators in contiguous blocks of 15 MHz each. The Authority will make recommendations about future

allocations of spectrum in bands such as 2.3 GHz, 2.5 GHz, or 700 MHz, as and when these bands are made available.

S.34. Twelve blocks of BWA spectrum as identified should be allocated among UASLs, CMSPs, or Category A and B ISPs for circle level deployments. One block of spectrum should be allocated to Category A, B, and C ISP licenses in cities or SSAs with population less than one million. DoT may use a first-come first-serve allocation mechanism for this one block of spectrum if needed.

S.35. DoT should organize a one-stage sealed bid auction for every circle to allocate BWA spectrum for circle-wide licensees. Reserve prices have been specified.

S.36. There are specific roll out obligations and conditions for operators offering BWA services.

# CHAPTER 1. INTRODUCTION

## Background

1.1 **The Department of Telecommunications (DoT), vide their letter D.O. No. L-14047/09/2005-NTG dated May 22, 2006 sought recommendations from the Telecom Regulatory Authority of India (TRAI, henceforth 'the Authority') on the methodology for allotment of spectrum for 3G services and its pricing aspects.**

1.2 As of mid-2006, there are 2.4 billion mobile phone subscribers worldwide.[1] With 123 million mobile subscribers in August 2006, India is home to 4.8 per cent of these subscribers, and has joined the five-member hundred million mobile subscribers club. The circle wise and operator wise subscriber number has been provided in Annex A. The current teledensity is about 14.50, and we are close to reaching the teledensity target of 15, which is the target for 2010 in the New Telecom Policy (NTP) of 1999. With the present growth rate, the Government's new target of 250 million telephone subscribers by end-2007 (Figure 1) is achievable. Most, if not all of these subscribers use voice-centric services. World over also, second generation (2G) subscribers form the bulk of the mobile phone base, with up to 90 per cent subscribing to either GSM or CDMA2000 1x services.[2] In India too, mobile operators have deployed either CDMA2000 or GSM networks to provide 2G cellular services.

1.3 Third generation (3G) systems represent the next step in the evolution of mobile cellular communication. 2G systems focus on voice communication, while 3G systems support increased data communication. They allow high-speed data of atleast 144 kbps, mobile Internet access, entertainment, and triple-play converged communications services, and have markedly greater capacity and spectrum efficiency than 2G systems.[3]

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[1] GSM World, Quarterly Statistics, available at: http://www.gsmworld.com/news/statistics pdf/gsma_stats_q2_06.pdf

[2] The Authority classifies GSM and CDMA2000 1xRTT as 2G technologies, and CDMA2000 EV-DO and WCDMA as 3G technologies.

[3] CDMA Development Group, Delivering Voice and Data: Comparing CDMA2000 and GSM/GPRS/EDGE/UMTS, December 2005, available at http://www.cdg.org/resources/white_papers/files/Capacity%20Dec%202005.pdf; Huber, J. F., The GSM Evolution to UMTS, ITU Seminar IMT-2000, 10-13 September 2002, available at

1.4 The International Telecommunication Union (ITU) developed 3G standards under the name of International Mobile Telecommunications-2000 (IMT-2000), with a set of five terrestrial radio interface specifications as given in Table 1.

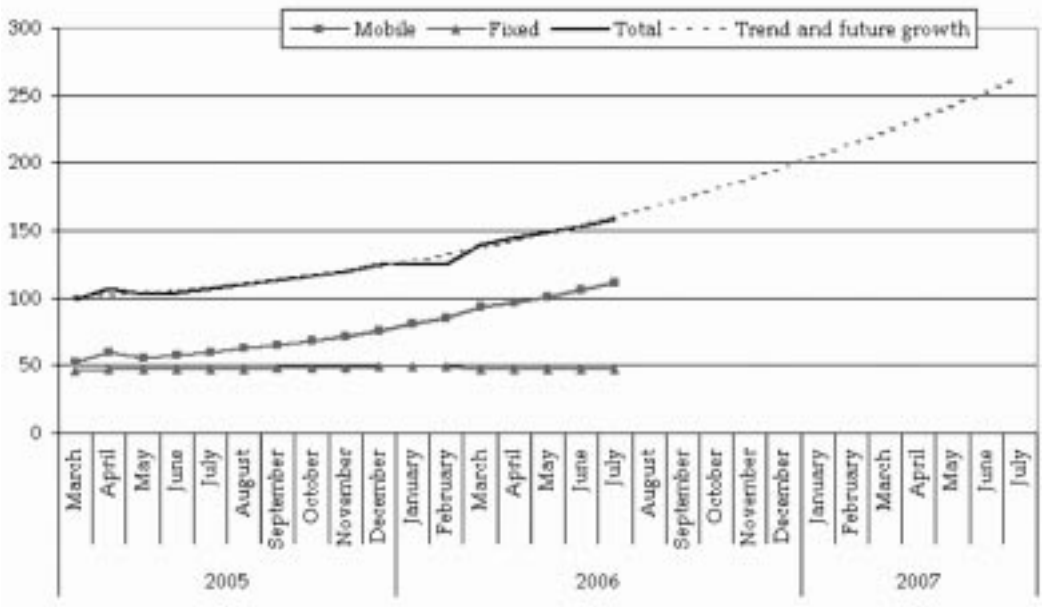


**Figure 1: Growth trends in telephone penetration in India[4]**

| ITU designations | Designation | Technology |
|---|---|---|
| IMT-Direct Spread (DS) | UTRA FDD | Wideband Code Division Multiple Access (WCDMA) |
| IMT-Multi-Carrier (MC) | CDMA2000 | Code Division Multiple Access (CDMA) |
| IMT-Time-Code (TC) | UTRA TDD | Time Division-Synchronous Code Division Multiple Access (TD-SCDMA) |
| IMT-Single Carrier (SC) | UWC-136 | Time Division Multiple Access (TDMA) |
| IMT-Frequency Time (FT) | DECT | Digital European Cordless Telephone (DECT) |

**Table 1: IMT-2000 air interfaces[5]**

1.5 Following the recommendations from the World Radiocommunication Conferences, WARC-92 and WRC-2000, the ITU identified that frequency arrangements for implementation of the terrestrial component of IMT-2000 should be in the following bands:

http://www.itu.int/ITU-D/tech/imt-2000/moscow2002/4-2huber.pdf#search=%22wcdma%20capacity%20gsm%22

[4] TRAI data

[5] http://www.itu.int/osg/spu/imt-2000/technology.html

- 806-960 MHz
- 1710-1885 MHz
- 1885-2025 MHz
- 2110-2200 MHz
- 2500-2690 MHz

1.6 In May 2005, the Authority, after a public consultation, had made recommendations to the Government on spectrum related issues. In this, the Authority noted that, "there is a shortage of 2G spectrum," and "the release of additional 2G spectrum in the required time frame so as to meet this shortfall may not be possible." Noting that the release of spectrum in the IMT-2000 bands could be possible in a shorter time frame, the Authority found that it was "possible to shift some users from 2 G bands to IMT-2000 band, thereby creating space for new and marginal users in the existing 2 G bands," and hence, "the Authority recommend[ed] that 3G spectrum allocation to the existing operators should be viewed as an extension of 2G spectrum allocations."[6] The Authority made this recommendation specifically because at that time, no other band was available to accommodate the fast growth of cellular telephony in India.

1.7 Since 2005, changes in the availability of spectrum and stakeholder inputs necessitate a new approach to respond to the Government's request. First, the Defence services have agreed to vacate 2 x 20 MHz in the 1800 MHz band, in addition to 25 MHz in the 2.1 GHz UMTS band. The availability of additional spectrum in the 1800 MHz band provides sufficient room for growth of 2G services for the medium term. Second, CDMA operators reported that dual band CDMA2000 handsets, which could operate in the 800 MHz and 2.1 GHz bands, were not immediately available. They again requested that spectrum should be allocated in the PCS1900 band, which allows the use of available 800/1900 MHz equipment and thus ensures a level playing field. Third, a stakeholder has indicated that it is willing to pay up to Rs. 1,500 crore for a pan-India allocation of 2 x 5 MHz of spectrum. The Authority's recommendation of May 2005 was that spectrum in the 2.1 GHz band should be allocated without a one-time acquisition fee.

[6] TRAI, Recommendations on Spectrum related issues, May 2005, paragraph (¶) 3.7.2

1.8 In addition to addressing the issue of allocation and pricing of spectrum for 3G, the Authority believed that it would be relevant to discuss and seek comments on spectrum allocation and pricing for broadband wireless access (BWA) technologies as well, to help boost broadband penetration in the country, especially in the rural areas. Moreover, decisions about spectrum allocation for 3G technologies will have a bearing on the growth of BWA technologies and related services. Since both BWA and 3G offer high speed mobile data access, it is essential that any forward looking 3G spectrum policy should take into account the developments in BWA and its requirements as well – creating a clear and stable regulatory framework.

1.9 The Authority issued a consultation paper on 'Allocation and pricing of spectrum for 3G services and Broadband Wireless Access' on 12th June 2006. The consultation paper invited stakeholders' written comments on the issues raised by June 30, 2006, and these comments were put on TRAI's website. In the consultation paper, the Authority identified the main issues that the recommendations should address. These are:

- Allocation of spectrum for 3G services
- Pricing of allocated spectrum
- Allocation and pricing of spectrum for BWA technologies

1.10 The Authority conducted an Open House Discussion in Delhi on July 7, 2006. Following this, it held one-on-one meetings with Defence services, Department of Space, academicians from IIT, Kanpur, IIT Chennai, IIT Delhi, and the Indian School of Business, and various stakeholder including service providers namely M/s Tata, M/s Idea, M/s Reliance Infocom, M/s BSNL, M/s Spice, M/s Aircel, M/s Bharti, M/s Hutch, and M/s HFCL, industry groups viz. CDMA Development Group, Cellular Operators Association of India, and the Association of Unified Service Providers of India, and equipment vendors M/s Intel, M/s Ericsson, M/s Motorola, M/s Qualcomm, M/s Nokia, M/s Alcatel and M/s Lucent to gain an in-depth understanding of different stakeholders' views and arguments. The Authority has also researched the issues.

1.11 Based on inputs received during the consultation process, the Authority has identified some specific issues that the recommendations will have to now address:

- Which bands should we allocate for IMT-2000 services?
- What should be the timeframe for the allocation of the identified bands?
- How many operators should be allocated spectrum at present and how many when spectrum becomes available in the future, and the quantum of spectrum to be allocated per operator?
- Through what mechanism should spectrum be allocated?
- What should be the price of spectrum, if any, in the identified bands?
- For BWA technologies, similar issues of allocation and pricing exist.

## Principles followed in the recommendations

1.12 The recommendations deal with a variety of issues, and the Authority has identified the principles that form the basis of the decisions made in this set of recommendations. For transparency and clarity, the principles followed are enumerated below but in no order of priority:

*(i)* *The maximization of consumer interest*: This will involve supporting and encouraging the diffusion of new and advanced technologies, setting a framework that ensures affordability and universal access to the new communications technologies

*(ii)* *Responsible and efficient use of spectrum*: Spectrum should be available for use by those who value it the most, and use it in the most efficient way to provide maximum possible capacity

*(iii)* *Aiding growth of the sector*: The current growth of the cellular and telecommunications sector should continue unabated

*(iv)* *Ensure technology and service neutrality/convergence*: Keeping in mind the trend towards convergence of voice, video, and data streams by digital wireless technologies, it will be important to remain technology and service neutral to reduce regulatory risk and have a future and growth oriented policy framework

*(v)* *Recovery of costs and pricing of spectrum*: Pricing mechanisms should not only encourage efficiency, but also ensure that the costs associated with making spectrum available, i.e. re-farming or vacating incumbent

users, and managing spectrum should form the basis of any pricing scheme. In addition, the price of spectrum should reflect the scarcity of spectrum and capture the value that is due to it.

*(vi)* *Orient spectrum policy to the future*: The recommendations the Authority makes should ensure that India is not locked in to using one technology indefinitely, but allows the entry of new technologies in the future with the least regulatory burden

*(vii)* *Competition*: Competition in facilities and service provision will help bring down prices, improve consumer choice and service, and help make the sector more efficient

*(viii)* *Keeping a level playing field*: No conditions should exist which favour one group of stakeholder more than another, with the only exception being the public interest – if there is a choice to be made between maintaining a level playing field and maximizing the public interest, the public interest should prevail

*(ix)* *Sharing of infrastructure*: In order to reduce costs associated with network rollout and improve affordability and financial viability, infrastructure sharing between operators should be promoted

## Scope of the recommendations

1.13 During the consultation process, some stakeholders commented that the scope of the present consultation should be limited only to the aspects on which DoT sought the Authority's recommendations, i.e. 3G spectrum allocation and pricing. It may be noted that as per Clause 11 (1) (a) of the TRAI (Amendment) Act of 2000, the Authority is empowered to make recommendations, either *suo moto* or on a request from the licensor on matters including:

- Terms and conditions of license to a service provider
- Measures for the development of telecommunication technology and any other matter relatable to telecommunication industry in general.
- Efficient management of available spectrum.

1.14 The consultation process included questions on BWA spectrum issues because the Authority believed that these technologies are relevant to the growth of telecommunication services in India. In addition, specific licensing issues such as roll out obligations and spectrum allocations also required the Authority's attention. Given these conditions, the Authority has also addressed and made recommendations on BWA spectrum issues.

1.15 In view of the scarce availability of spectrum and the increasing demand by wireless technologies, the Authority feels that now there is an urgent requirement to have a fresh and comprehensive look at the present practices of spectrum allocation and pricing as well as ensuring its efficient usage. The Authority is conscious of the fact that these issues were not included in the consultation process, but has decided to broadly flag these important issues in Chapter 2 for charting the future roadmap.

# CHAPTER 2. SPECTRUM MANAGEMENT

2.1 The future growth in telecom services would be wireless centric. Even at present, spectrum management is very vital and with the entry of multiple operators offering various telecom services using different kinds of wireless technologies, and with the trends of convergence, the task of spectrum management is becoming more critical and complex.

2.2 Before liberalization of telecom services, the users of spectrum were mostly limited to a few government departments and agencies. Now the number of spectrum users has increased manifold. Further, technological advances have opened the possibility of development of new wireless technologies like software-defined radios (SDRs), smart antennas, and IP-based wireless networks that are shifting the network's intelligence to the periphery from the core. The intelligence in wireless devices facilitates better use of spectrum, and this necessitates a paradigm shift in spectrum management.

2.3 These technological developments initiated a debate about four years ago on whether spectrum is land or sea, that is, if it should be treated as an exclusive or shared resource.[7] This implies that in an era when wireless devices are intelligent enough to take care of interference, they need only certain guidelines and not rigid spectrum management.

2.4 The spectrum management transition from a 'land' to 'sea' approach will ultimately lead to the situation where no exclusive allocation of spectrum to a service provider is required. Instead, all service providers would only follow certain well-defined technical specifications and they will have an access to a common pool of spectrum. This is similar to the situation where nobody owns an ocean, but all shipping companies that have access to it are subjected to certain shipping and navigational guidelines. Delicensing of Wi-Fi spectrum is a very important step in this direction. The Office of Communication (Ofcom), UK's telecoms regulator and spectrum manager,

[7] *See* The Economist, Freeing the airwaves, May 29, 2003; FCC, Spectrum Policy Task Force Report, 2002, available online at: http://www.fcc.gov/sptf/reports.html; Benkler, Y., Some Economics of Wireless Communications,

Harvard Journal of Law & Technology, Volume 16, Number 1 Fall 2002; Ofcom, Spectrum Framework Review, 2004; Faulhaber, G. R. & Farber, D. J., Spectrum Management: Property Rights, Markets, and The Commons, Working Paper 02-12. AEI-Brookings Joint Center, Dec 2002

devotes a substantial part of their resources to spectrum management and they have indicated that in the next five years, there will be a complete shift in their spectrum management policy. In a 2004 review of their spectrum framework, Ofcom indicated that almost 95 per cent of the spectrum in the early 2000s was through a command and control approach. The balance was through market-oriented or delicensed approach. By 2010-11 Ofcom expects that in their jurisdiction, these figures will be almost reversed i.e. 80 per cent market driven and delicensed approach and 20 per cent command and control approach.[8] A few other countries are also following this approach.[9] Such an approach to spectrum management is necessary to have the complete flexibility and market orientation. The fundamental approach has to be that whenever a new wireless technology is developed and if the service provider senses a business case, the non-availability of spectrum should not come in the way of its deployment. There are many such technologies already deployed in some countries that may not clash with the existing wireless systems deployed, and so they should be able to deploy their equipment. Of course, in a market-oriented approach, every stakeholder should get a fair chance and opportunity. Specific technologies have not been discussed herein because as a technology neutral regulator, we do not want to project specific technology biases. This is a macro level approach that is suggested for spectrum management.

2.5 There are various issues that are important from the point of view of spectrum management. The telecom sector has been opened and the country is committed to a liberal policy approach. The same approach is also necessary in the management of spectrum. The procedure and the processes remain tied to the legacy. A liberal and transparent approach is necessary so that it matches with the overall policy approach.

2.6 Although these issues were not explicitly discussed in the consultation paper and the Authority is not making any specific recommendations on these issues, the Authority considers it necessary to deliberate on these issues before coming to the specific recommendations on 3G and BWA

[8] Ofcom, Spectrum Framework Review, ¶1.3

[9] FCC, Spectrum Policy Task Force Report, 2002

spectrum pricing and allocation in subsequent chapters. The Authority also considers that this is not a one-time issue, and considering the growth and development of wireless technologies and services, a long-term view on overall spectrum management policy including the organizational structure for spectrum management is necessary. These issues are enumerated below:-

(i) Availability of adequate spectrum so that its inadequacy does not hinder the progress and growth of telecom services in the country.

(ii) Implementation of various policy, regulatory and technological related solutions to ensure efficient utilization of the spectrum.

(iii) The process of spectrum allocation including various clearances is to be completely streamlined and wherever possible the usage of ICT to its full potential in this process should be encouraged. The allocation procedure should be completely transparent, and based on a road map and well researched deployment plan.

(iv) The concerned agencies for spectrum management should develop the technical expertise and the expertise to anticipate the developments in national and international markets and accordingly take a timely action so that whenever service providers demand to use a particular wireless technology in the public interest then the non-availability of spectrum does not come in the way of deploying any wireless technology.

(v) Effective monitoring and periodical updating of usage of spectrum to avoid the hoarding of spectrum by the service providers. Monitoring from the interference point of view also need to be strengthened.

(vi) Organizational strengthening.

2.7 These issues are enumerated in detail in the subsequent paragraphs.

## Availability of spectrum

2.8 The Authority in its earlier recommendation on spectrum related issues has emphasized that adequate availability of spectrum is necessary for growth of telecom services and to ensure quality of service (QoS) standards. The scarcity

of spectrum is mainly because the equipment available in the market works in certain frequency ranges. With the development of technology as explained above, this restriction of availability of equipment in specific frequency ranges might go away in the foreseeable future. However, due to economy of scale and interoperability issues in a global scenario, service providers may like to deploy the equipments that are manufactured at a global scale. In fact, this was one of the key objectives of the ITU while finalizing the spectrum requirements for IMT-2000 services in various WARC / WRC meetings between 1992 and 2003. Again, in the forthcoming WRC 2007 meeting these issues will be discussed and elaborated.

2.9 The second factor affecting the availability of spectrum is that the existing users might not be able to use the equipment in a frequency range, which today is required by another user because of the factors mentioned above. This leads to necessity of migration of existing users to different media or different spectrum. This whole issue is not to be dealt with in piecemeal but should be taken up as a long-term policy issue. From this perspective, it becomes necessary to handle it through an inter-departmental coordination committee under DoT at the highest level.

2.10 Sometimes, in a scenario where multiple operators use various technologies to offer similar services, the issue of identifying particular spectrum bands for particular technologies or other related issues, which in the perception of a particular stakeholder may affect the level playing field, are highlighted and get more attention. All these issues are very important for a healthy competition but the Authority believes that in the process we should not lose sight of the fact that every service provider needs spectrum to offer quality service to customers at an affordable price and to contribute to the growth of telecom services in the country. Different technologies offering similar services may sometimes need spectrum in the same frequency band. From that point of view, the technical and service neutrality aspect of spectrum management is to be emphasized.

## Efficient utilization of spectrum

2.11 Based on experience with mobile telephony, it is estimated that about 60 per cent of mobile phone calls originate or terminate within buildings.

This means that various technological solution like fixed-mobile convergence, low power coverage using micro and pico cells, and also reserving a part of the spectrum only for in-building coverage will enhance the efficiency of utilization of the spectrum. The Authority had also discussed this issue in its earlier recommendation of May 2005 on spectrum related issues. These solutions for in building coverage are already being deployed in some countries like the UK and Switzerland, and it is likely to spread to other countries. A service provider and equipment manufacturer also raised this issue in the consultation process. The Authority considers that this aspect should be studied in detail and its use should be commenced in the country.

2.12 Around 700 million people live in rural areas in India, where the population density is significantly lower than the urban areas'. The number of service providers who use spectrum to offer various services in each service area is about 4 to 7, or sometimes even more. Since spectrum management currently follows the principle of exclusive allocations, similar to management of land, each service provider is given an exclusive spectrum and it might not always be possible to ensure that the allocated spectrum is efficiently utilized. Under these circumstances, the operators themselves should have the commercial arrangements to share not only the passive infrastructure but also the radio part of the network. This kind of arrangement is already being used in other countries like France, Scotland, and Sweden. In this arrangement, it is not necessary that all service providers put up their radio networks in all parts of their service areas. The large number of licensees in each service area can divide the coverage area among themselves and they can sign intra-circle roaming agreements so that their subscribers may get services in each other's networks. This would be very effective arrangement to ensure efficient utilization of spectrum and network resources. The idea of infrastructure sharing is also very useful in the process of ensuring in-building coverage as discussed above. Of course, it is to be ensured that this does not affect competition and subscriber choice. Service providers should also deploy various technological means such as synthesized frequency hopping (SFH), multi-layer network architecture, smart antennas, and advanced coding

and modulation techniques, to ensure most efficient utilization of spectrum. Further, the recommendations in the subsequent chapters discuss pricing and other license conditions, like rollout obligations, to ensure efficient utilization of spectrum.

## Streamlining of spectrum allocation processes

2.13 Various service providers feel that there is a delay in allocation of frequencies, SACFA clearance, etc. The SACFA clearance procedure is the same that was being practiced when there were a limited number of wireless users. Although WPC has been making efforts to reduce the time required for various clearances, the Authority feels that piecemeal and incremental improvement in this process will not help. Ten years has been a long time to live with the legacy approach, and a completely disruptive approach and revamping is necessary.

2.14 Current developments in computer hardware and software technology make it possible to develop a countrywide data base of various wireless installations of various users in a personal computer or a few networked PCs in the WPC office. With the help of this database and standard available software it should be possible to process the SACFA clearance through an online method. The results of this online processing of SACFA applications would be communicated to the applicant within the maximum period of 3 to 4 days. Different type of restrictions in various areas, e.g. tower heights near airports/airbases, etc. could also be fed into this database, and with digitized mapping/geographic information systems (GIS) available for various areas, it should be possible to process such information through an automated system. If in this online processing of application there is a problem with any existing user like the Airport Authority, Defence services, or Railways, then the applicant may be advised to sort out the issue on one to one basis. Otherwise, the applicant could change the parameters of his installations including shifting of site. Thus, the whole process should not take more than a week or 10 days. The Authority has also previously recommended that sites with tower heights less than 40 meters in rural areas may be exempted from SACFA clearance.[10] It should not be

necessary to hold periodical meetings with all SACFA members as being done in the current dispensation.

2.15 It is understood that WPC has already initiated the computerization of spectrum management process. However, the potential of computerization already created in WPC has not yet achieved the desired results. The Authority considers that this process should be expedited and ultimately a stage should be reached wherein the applicants seeking SACFA clearance should submit their application online and should get the response online as discussed above. This whole process should be implemented in a time bound manner. This would help in bringing the complete transparency in spectrum management process. The service providers would have to prepare a road map and well researched document plan.

## Effective monitoring of usage of spectrum

2.16 After allocation of spectrum, its usage is to be periodically monitored so that there is no hoarding of spectrum. As mentioned earlier, spectrum availability is to be linked to a roadmap and well researched deployment plan, and the monitoring of spectrum use should be carried out keeping in view this plan.

2.17 With increased penetration of wireless services, the monitoring wing is to be strengthened to ensure that there is no interference among different spectrum users.

2.18 The timely and full realization of spectrum usage fee is must for discouraging any kind of hoarding.

## Organizational strengthening

2.19 The Authority considers that the existing organization structure for spectrum management needs more autonomy and independence. Technical expertise should be developed not only in managing the spectrum, but also for anticipating the development of various wireless technologies and their applications. In various countries, the spectrum management agencies

[10] TRAI, Recommendations on Growth of Telecom services in rural India, October 3, 2005, ¶7.12.3

are part of the independent telecom regulator so that the whole process of spectrum management becomes more specialized and efficient.

2.20 As mentioned earlier, it would be necessary for regulator, licensor, licensees, WPC, technology developers, equipment manufacturers, and various R&D institutions to continuously interact on spectrum related issues. All the stakeholders have to continuously feed the necessary inputs to the concerned agencies. The organizational structure could be considered in four parts which is explained below:

(i) A unit responsible for management of existing spectrum among existing users;

(ii) A unit which is responsible for availability of extra spectrum including vacation re-farming of spectrum;

(iii) Spectrum monitoring unit; and

(iv) A unit focusing on future developments of various wireless technologies, its applications in global scenario and its applicability to Indian conditions.

2.21 The Authority understands that it may be practically difficult to implement these organizational changes in one stroke, and considering the legacy burden, a phased but determined shift may be necessary. To co-ordinate the availability of spectrum among various major users it is proposed that a National Frequency Management Board (NFMB) maybe constituted under the Chairmanship of MoC&IT with Chairman/TRAI, Secretary/DoT, Secretary/Defence, Secretary/Department of Space, Secretary/I&B, Secretary/DIT, Chairman of the Railway Board, and two academicians from the field of telecom, IT, spectrum policy, and related areas as its Members. This NFMB would get inputs for its functioning from various units mentioned above through the CEO of Spectrum Management Organization. The NFMB may meet regularly and review the progress of spectrum related issues. The frequency planning and spectrum management process would be continuously updated on the basis of tasks assigned by the NFMB.

2.22 Since as per Section 11 (1) (a) (viii) of TRAI Act, the Authority is responsible for making recommendations either suo moto or on a request from the

licensor on efficient management of available spectrum, it would be advisable that unit focusing on future developments of wireless technologies should work as a separate division in TRAI. This unit should have experts in the field of technological, economics and commercial aspects of spectrum management. This unit should feed inputs on various global and national developments of spectrum related issues to NFMB mentioned above and also respond to related reference from DoT as envisaged in the TRAI Act.

2.23 As mentioned earlier, the Authority is aware of the fact that it had not included all the issues mentioned above in the consultation process and if the Government agrees in principle then the detailed recommendations on the subject could be finalized through a consultative process on the specific issues mentioned above. Considering the importance of spectrum related issues, the Authority included these issues in the recommendations to ensure the efficient management of scarce resource like spectrum.

2.24 Based on the general principles, laid down in the recommendations so far, the Authority has discussed the recommendations on allocation and pricing of spectrum related issues in subsequent chapters.

# CHAPTER 3. IDENTIFICATION OF SPECTRUM BANDS AND THEIR ALLOCATION FOR 3G SERVICES

3.1 The ITU has broadly identified a range of bands that the country Governments may allocate for IMT-2000 services (paragraph, henceforth , ¶1.5). Table 2 below provides an overview of the bands in which 3G services are either planned or operational in various countries. Annex C provides information on some international allocations for 3G services.

| Band (Designation) | Uplink (MS to BS) | Downlink (BS to MS) |
|---|---|---|
| 450 MHz | 452.5-457.475 MHz | 462.5-467.475 MHz |
| 800 MHz (or 850 MHz) | 824-849 MHz | 869-894 MHz |
| 900 MHz | 890-915 MHz | 935-960 MHz |
| 1700 MHz (Korean PCS) | 1750-1780 MHz | 1840-1870 MHz |
| 1900 MHz (US PCS) | 1850-1910 MHz | 1930-1990 MHz |
| 2.1 GHz (UMTS/2.1 GHz) | 1920-1980 MHz | 2110-2170 MHz |

**Table 2: Bands in use internationally for 3G services[11]**

3.2 In the consultation paper, the Authority has considered WCDMA, evolving from GSM and CDMA 2000 1xEV-DO, evolving from CDMA 2000 as 3G technologies. While there are multiple evolution paths for operators to migrate from 2G to 3G systems in GSM and CDMA networks, however, given the widespread deployment of GSM and CDMA, the existing telecom operators will have an edge in offering 3G technologies as identified by the Authority. The future development of 1xEV-DO including revised versions and WCDMA/HSDPA would greatly influence the usage in terms of both services and affordability. The use of BWA has been discussed in Chapter 5 and the service providers would be making an informed choice for optimum results and widest coverage. At present, cellular services in India operate in the bands given in Table 3.

[11] Source: National regulators, industry groups

| Band | Uplink (MS to BS) | Downlink (BS to MS) | Technology deployed |
|---|---|---|---|
| 800 MHz | 824-844 MHz | 869-889 MHz | CDMA |
| 900 MHz | 890-915 MHz | 935-960 MHz | GSM |
| 1800 MHz | 1710-1785 MHz | 1805-1880 MHz | GSM |

**Table 3: Indian cellular bands and deployed technologies**

**Evaluation of various spectrum bands identified by ITU in Indian context:**

## A. 2.1 GHz band

3.3 According to the National Frequency Allocation Plan, 2002 (NFAP 2002), "IMT-2000 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 in the Frequency Division Duplex (FDD) mode, and 2010-2025 MHz in the Time Division Duplex (TDD) mode depending on market needs and availability, as far as possible." This band of 1920-1980 MHz paired with 2110-2170 MHz is commonly referred to as the 2.1 GHz band.

3.4 In May 2005, the Authority had made recommendations to the Government on spectrum related issues. Based on the information available then, the Authority had identified the 2.1 GHz band for 3G services. The Authority had then recognized the shortage of spectrum in the 800, 900 and 1800 MHz bands and the assessment was that allocation of 2.1 GHz band for 3G services may relieve to some extent the congestion in already identified bands for 2G services on account of subscriber migration from 2G to 3G services.

3.5 Since May 2005, there have been significant developments leading to re-determination of spectrum for 3G services by the Authority. The Department of Telecom (DoT) in close coordination with Defence services is implementing a project for vacation of 2 x 20 MHz in the 1800 MHz band. Separately, the Authority has already requested DoT to resume certain specific allocations in 800 MHz band from agencies that have presently negligible or no use of this allocated band. It is hoped that with these measures, the telecom service providers will have additional spectrum in the short run to accommodate their future growth within the currently allocated 800, 900, and 1800 MHz bands. The details of suggested resumption of spectrum is at Annex D.

3.6 DoT in close coordination with Defence have also undertaken the Plan for vacation of 25 MHz in the 2.1 GHz uplink band. DoT already has 2.1 GHz downlink band hence there will be spectrum available though not adequate for telecom service operators to offer 3G services in about 6 to 9 months time span.

3.7 The Authority in Chapter 2 has highlighted spectrum as a very scarce resource. Re-farming to make available identified spectrum bands for telecom services involves huge cost and has its limitations. A serious crunch situation is on the horizon. Therefore, any policy on spectrum must reflect this reality. It should also ensure efficient management and usage of spectrum. Moreover, in a scenario of fast developing alternate technologies, the Authority is strongly of the view that the pricing of spectrum is a necessity for sustaining technology neutrality.

3.8 Earlier, the Authority had anticipated that there could be a consolidation in the mobile sector but the current situation is that the number of operators in different service areas is increasing as some of the regional players are trying to have a pan-India footprint. The available spectrum is limited and can be distributed only among limited number of operators. One of the most commonly used selection criteria of such eligible operators for allocation of spectrum could be on the basis of price to be paid by them. **Hence, the Authority recommends that the 3G can not be perceived as an automatic extension of 2G and would need to be viewed as a kind of stand alone service for specialized needs and its allocation criteria has to be specific separately. The existing license provisions empower DoT to review and redefine spectrum allocation procedure and policies.**

3.9 Based on the inputs received from stakeholders during the recent consultation process, it emerges that there is a sharp division amongst stakeholders specifically between GSM and CDMA operators. As discussed in ¶1.7, CDMA operators have made repeated representations regarding violation of the level playing field if 3G services are identified in the 2.1 GHz band only. They have argued that the majority of WCDMA systems around the world operate in the 2.1 GHz band and both equipments and handsets are easily available for WCDMA operations in this band. The inter-operability in the 900 MHz/1800 MHz and 2.1 GHz bands for WCDMA is not an issue.

Thus, both the technology, availability of equipment at competitive prices and the economy of scale is heavily loaded in favour of WCDMA operations. It would be possible for service providers with GSM technology to deploy 3G services network, i.e. WCDMA in a short span of about 6-9 months. The CDMA operators have further argued that these features are non-existent for CDMA2000 1xEV-DO in the 2.1 GHz band. Dual band CDMA equipment and handsets in the 800 MHz and 2.1 GHz bands are presently not available. Moreover, the manufacturers may also not strike the economies of scale even if the equipments/handsets are developed in future and thus will have serious pricing implications. The service operators with CDMA technology seriously apprehend that the identification of 2.1 GHz band for 3G will be both technologically and financially unviable proposition. This would deny a level playing field for CDMA operators.

3.10 The contention of the CDMA operators and also the manufacturers linked with CDMA technology have been seriously evaluated by the Authority. The apprehension of CDMA service operators perhaps is not well founded. Japan and South Korea have operators offering CDMA services in the 2.1 GHz and 1700 MHz bands respectively.[12] In the United States, Cingular Wireless offers WCDMA services in the PCS1900 band.[13] As far as the economies of scale is concerned, it is seen that all of these operations are confined to limited areas, but that they have been able to overcome the limited economies of scale. In addition, China Unicom and Russia's Skylink have begun trials for CDMA EV-DO services in the 2.1 GHz band.[14] Thus, the economies of scale issue for EV-DO operators in the 2.1 GHz band may get resolved in the medium term. There are indications that chipset and equipment manufacturers are already in advanced stages of development of CDMA 1xEV-DO hardware in the 2.1 GHz bands. The market size of India is large enough to leverage the volumes for bringing down prices and

[12] CDMA Development Group worldwide database; Ericsson presentation, 3G & Spectrum Allocation: Sharing Ericsson's Experience, 2006, available at: http://www.ncc.gov.ng/Workshop%20Papers/3G%20Spectrum/NCC%203G%20Spectrum%20Allocation%20latest.pdf#search=%22ericsson%20kddi%20dl%20ul%22

[13] The Shosteck Group, In-Band W-CDMA: The Commercial Potential for 850, 900, 1800, and 1900 MHz Deployment, March 2005

[14] CDG Worldwide database (http://www.cdg.org/worldwide/index.asp), and Lucent, Lucent Technologies and Russia's SKYLINK Test CDMA2000 Solution For 2.1 GHz Spectrum Band, September 8, 2004, http://www.lucent.com/press/0904/040908.nsb.html

the economies of scale can easily be captured both for manufacturing and service operations. The experience in 2G confirms this assertion. As the deployment timeframe in 2.1 GHz may not be simultaneous, the Authority has addressed the issue of first mover advantage by exploring alternative spectrum for CDMA 1xEV-DO services so that both GSM and CDMA service providers can offer 3G services to their subscribers simultaneously.

3.11 **The Authority recommends that the DoT should immediately allocate 2 x 25 MHz of spectrum in the 2.1 GHz band as per the allocation mechanism described subsequently.**

## B. The PCS1900 band

3.12 Telecom service providers with CDMA technology have strongly advocated in favour of a mixed band allocation. Their apprehensions against the allocation of 2.1 GHz band for CDMA 1xEV-DO have already been stated in 3.9. Their contention is that the Government should allocate spectrum in PCS 1900 band (1850-1910 MHz paired with 1930-1990 MHz) to ensure a level playing field and thus not stifle the growth of CDMA operations in the country. The Authority has seriously considered the possibility of simultaneously allocating both PCS1900 and the 2.1 GHz band for 3G Services to CDMA and GSM based telecom service operators i.e. 'mixed band plan'.

3.13 The problem with the 'mixed band plan' is that the 2.1 GHz uplink band (1920-1980 MHz) overlaps with the PCS1900 downlink band (1930-1990 MHz). GSM operators claim that there will be interference at the WCDMA base station receiver and the CDMA2000 handset receiver if both bands operate simultaneously. To overcome this interference problem, CDMA operators have suggested using only the small non-overlapping portion of the PCS1900 band (1900-1910 MHz paired with 1980-1990 MHz) and installing filters in the CDMA base station transmitter and WCDMA Node-B receiver to mitigate interference.

3.14 There are three issues in the immediate implementation of the 'mixed band plan' proposal:

(i) The Indian Defence services are extensive users of the PCS1900 band (1850-1910 MHz paired with 1930-1990 MHz). Low power TDD

CorDECT systems also use 1880-1900 MHz, with an additional band earmarked in the 1900-1910 MHz range for future microcellular TDD technologies. Further, the PCS1900 band downlink overlaps with the 2.1 GHz uplink band, except for 10 MHz between 1980-1990 MHz. Thus, only a limited amount of 2 x 10 MHz (1900-1910 MHz paired with 1980-1990 MHz) could be available for IMT-2000 operations in PCS1900 band, that too only if the future requirements of microcellular TDD technologies are covered in some other band.

(ii) The Authority had a series of meetings with the senior officials of Defence services. It made a specific request for vacation of 1850-1910 MHz paired with 1930-1990 MHz to the Defence services. The response has not been favourable and the Defence services do not foresee vacation of this band in the near future.

(iii) If one considers this 2 x 10 MHz allocation proposal, there is a possibility that the CDMA base station transmitter operating between 1980-1990 MHz will interfere with the WCDMA base station receiver operating in the 1920-1980 MHz range and reduce the capacity of the WCDMA system. In addition, the WCDMA handsets will cause interference with the CDMA handsets, leading to possible worsening of quality of service. As a result, any allocation in the PCS1900 band in addition to the 2.1 GHz band will require interference mitigation measures, which might impose additional costs on both the systems.

3.15 During the consultation process, a number of CDMA and GSM operators and equipment vendors made detailed presentations to the Authority on the effects and implications of the 'mixed band plan'. The Authority also had in-depth discussions with both the Cellular Operators Association of India (COAI) and the Association of Unified Service Providers of India (AUSPI) about the 'mixed band plan' and the technical issues surrounding its implementation. Specifically, AUSPI suggested that while interference will occur, however, using appropriate filters and spatial separations between the antennas will mitigate the problem. COAI on the other hand sees the interference caused to WCDMA operations as extremely difficult and costly to overcome, and are of the opinion that the 'mixed band plan' is not technically feasible. A summary of these technical presentations is at Annex

E. In order to substantiate their claims in field conditions, AUSPI has recently offered to conduct a trial to measure the interference between PCS1900 and 2.1 GHz systems. The Authority also held detailed technical discussions with experts from the country's leading academic institutions on the interference issue and its technical solution.

3.16 In order to obtain an authoritative/academic perspective on this issue and examine the feasibility of the mixed band plan, the Authority contracted a consultant, IIT Delhi. FITT carried out detailed simulations and analysis of the interference problem, to verify if a mixed-band plan was feasible, and if yes, then how and with what effects. The results of the report, also attached in Annex F show that it is feasible to have a mixed-band allocation, i.e. systems can operate simultaneously in 2 x 10 MHz in the PCS1900 band and 2 x 25 MHz in the 2.1 GHz band provided adequate filters are installed and a dead-space is provided between the two bands. The resulting mixed band plan would be:

(i) PCS1900: 1900-1910 MHz paired with 1980-1990 MHz (2 x 10 MHz)

(ii) 2.1 GHz: 1920-1970 MHz paired with 2110-2160 MHz (2 x 50 MHz)

(iii) Dead space: 1970-1980 MHz (10 MHz)

3.17 The following steps will be required to successfully operate in the above 'mixed band plan':

(i) PCS1900 operators will have to put filters on their base station transmitters to ensure that spurious emissions falling within the 2.1 GHz uplink band are eliminated, and

(ii) 2.1 GHz operators will have to put filters in their Node-B receivers to ensure that they maintain sufficient adjacent channel selectivity from the PCS1900 transmitter.

(iii) Operators will have to plan their networks to maintain a minimum level of horizontal and vertical antenna isolation, i.e. they will have to keep a vertical spacing between co-located WCDMA and EV-DO base station antennas, or have sufficient distance between the different base stations if they are at the same height as explained in Annex F.

3.18 The Authority has independently analyzed the findings of the consultant and is of the view that the issues of interference are not insurmountable. It should be possible to work out specifications for installation of effective filters. However, it will be an additional cost to both CDMA and WCDMA operators. Even then, interference in the handset of CDMA subscribers may not be totally ruled out.

3.19 These issues were also discussed at great length with the technical experts from Qualcomm and Lucent. They also made technological presentations down playing the argument of interference and strongly argued in favour of mixed band plan.

3.20 In addition to theoretical simulations of technical feasibility of the mixed band plan, the CDMA operators proposed to conduct a field trial to verify the possibility of co-existence of PCS1900 and UMTS 2.1 GHz system in a defined geographical area. The Authority has already recommended to DoT that industry representatives, equipment vendors, telecom experts, and the Government should conduct the trial to verify the possibility of co-existence of PCS1900 and 2.1 GHz systems and the feasibility of the mixed band plan at the earliest. The matter is presently before the DoT. Therefore, the result of such a trial are not available for these recommendations.

3.21 The Authority in its earlier recommendations had decided not to follow the mixed band plan due to the interference problem and due to Defence services completely ruling out the possibility of vacation of 2 x 10 MHz in the PCS1900 band. Now the Association of Unified Service Providers (AUSPI), consisting of the CDMA operators, are offering the equipment for trial for mixed band operation at their own cost and Defence has not completely ruled out the availability of the above mentioned spectrum. Since we have both GSM and CDMA operations in India, the Authority is of the view that the issue of practical feasibility of coexistence of mixed band operations should be settled once and for all. Therefore, **the Authority recommends that the Government should conduct the trial to verify practical feasibility of coexistence of mixed band allocations, and in case the co-existence is found feasible and economically practicable, then it should work towards re-farming of the PCS1900 band, specifically 2 x 10 MHz to enable the future growth of 3G cellular services in India.**

3.22 Even if the trial is successful, it may still not be possible to deploy both PCS1900 and 2.1 GHz system in the country simultaneously as the availability of 25 MHz in 2.1 GHz band is expected in next six to nine months and vacation of PCS1900 band may take longer time given its extensive use by Defence services. **Since spectrum is not currently available in the PCS 1900 band, it may not be possible at present to implement the mixed band plan.**

## C. In band 3G

3.23 Since the mixed band solution was not feasible in a short-time span, the Authority explored other possibilities for CDMA operators to deploy 1xEV-DO. The equipment for EVDO services is readily available in the 800 MHz band, however, the majority of the carriers available in 800 MHz band are already in use and additional carriers will also be needed to cater for the growth in medium term scenario for CDMA operators. CDMA operators have represented that adequate spectrum to accommodate future 2G growth may not be available if 800 MHz band is also used for 3G services.

3.24 The table showing the number of operators using CDMA technology in the 23 circles in the country is at Annex G. Only Punjab and Rajasthan have four CDMA operators. The rest have three or less. In almost all the circles, only two CDMA operators are growing in terms of subscriber base. Currently, in three circles, viz. Gujarat, Rajasthan and West Bengal, the spectrum available in the 800 MHz band is less than 2 x 20 MHz. This is because non-telecom users are using part of the 800 MHz band. As mentioned in 3.5, the Authority has requested DoT for immediate resumption of the spectrum so that the additional spectrum is available for the growth of CDMA services. **The resumption of unused spectrum should be implemented in a time bound manner in next 3 months.**

3.25 Even in Punjab and Rajasthan, only two out of four operators have significant market share and growth rate. The analysis is given in Table 4. It is felt that 12 carriers would be sufficient to accommodate the subscriber base growth in 2G in the medium term.

| Circle | CDMA operator | July 2006 subscriber base | Market share in CDMA | Average monthly growth (August '05-July '06) |
|---|---|---|---|---|
| Punjab | BSNL | 8,048 | 1% | -5% |
| | Reliance Infocomm | 705,065 | 59% | 3% |
| | HFCL Infocom | 58,881 | 5% | -1% |
| | Tata Teleservices | 427,450 | 36% | 15% |
| | **Total CDMA** | **1,199,444** | | |
| Rajasthan | BSNL | 46,705 | 3% | -3% |
| | Reliance Infocomm | 959,194 | 67% | 7% |
| | Shyam Telelink | 26,892 | 2% | 1% |
| | Tata Teleservices | 405,957 | 28% | 21% |
| | **Total CDMA** | **1,438,748** | | |

**Table 4: Subscriber base, market shares, and growth of CDMA operators in Punjab and Rajasthan**

3.26 The circles facing serious spectrum constrains in the 800 MHz band currently include Mumbai, Delhi, Punjab, Gujarat and Rajasthan. These circles have registered an average monthly growth of about 3.5 per cent in subscriber base in recent months (Table 5) and have only a few carriers available as on June 2006.

| | Number of carriers available (June '06) | Average monthly growth in CDMA (April-July '06) |
|---|---|---|
| Mumbai | 2 | 2.7% |
| Punjab | 2 | 2.6% |
| Rajasthan | 2 | 4.7% |
| Delhi | 3 | 3.3% |
| Gujarat | 4 | 4.4% |

**Table 5: Spectrum constrained circles**

3.27 In order to maximize the availability of carriers in 800 MHz band, the Authority has done an exercise of rationalization of spectrum following the established subscriber base criteria. It has also taken note of the likely resumption of spectrum in 800 MHz band from those agencies that have negligible or very little use of spectrum.

3.28 Based on the current growth rates, it is expected that the number of carriers needed for CDMA subscriber voice traffic in all the service areas will be at

the most 12 to 13 carriers. If the present growth and expansion of the CDMA operators is taken into consideration it is evident that some operators have more spectrum than required and not justified on the basis of subscriber base and future expansion. **There is a need for rationalization in such cases. It will be possible to free some carriers, reallocate them to the fast growing operators, and thus open the possibility to separately earmark two to three carriers for 3G services in the 800 MHz band.**

3.29 The Authority also examined the option of adding one more carrier to the existing 800 MHz without making major adjustments. One stakeholder suggested that it would be possible to increase the number of carriers in the 800 MHz without seeking additional spectrum. The Authority discussed this option with the technology developer (Qualcomm) and a vendor (Lucent). The Authority found that it was possible, by adjusting the inter-carrier and inter-operator guard bands, and ensuring harmonization of carrier allocations in the present Indian 800 MHz band, to increase the total number of carriers available in 800 MHz band from 14 to 15 without significant capacity degradation and where the number of operators are three. If the number of operators is four, then the number of carriers can only be 14. The maximum achievable will be one additional carrier. This takes the total number of carriers available for CDMA operations in the 800 MHz band to 15 (details of the arrangement are in Annex H). If the number of carriers increases by one to 15, then the spectrum constraints in circles like Mumbai and Delhi ease, allowing for more rapid growth than estimated and improving the utilization of spectrum. This process might inconvenience some consumers because their handsets will need manual programming, as they are older and incapable of over-the-air-programming (OTAP). However, estimates inform us that the number of such handsets in the market is about 20 per cent, declining sharply over the next year. This problem could thus be resolved for the residual consumers through effective awareness program by operators within the next few months. **Thus, the Authority recommends that the Government work with operators in the next three months to modify the existing 800 MHz band plan, adjusting guard bands to add one 1.25 MHz carrier.**

3.30 Once 15 carriers are available in the 800 MHz band, a few carriers will be available both for the future growth in voice and allocation for EV-DO service.

In order to find the correct mix, the Authority estimated the growth of voice traffic based on current trends. Based on the Authority's recommendations in 3.28 and 3.29, post-rationalization and with the availability of 15 carriers in the 800 MHz band, we expect the bulk of subscribers in the future will be shared between two operators. As a result, it is expected that in all circles, at most 13 carriers will be needed in the medium term to accommodate the growth in 2G CDMA subscribership (Annex I). The allocation of 13 carriers for voice traffic will leave two carriers that could be used for voice or data.

3.31 Since 15 carriers can be obtained only when there are at the most three CDMA operators, this arrangement is not currently applicable to the Punjab and Rajasthan circles where there are four CDMA operators. However, given the growth trends of these operators (Table 4), it is evident that 12 carrier should be sufficient to accommodate the voice traffic in these circles into the future. **Hence, at least two carriers, i.e. 2 x 2.5 MHz, can still be dedicated for EV-DO services in the 800 MHz band even in these circles.**

3.32 The Authority also evaluated the possibility of re-farming the 890-895 MHz (paired with 935-940 MHz) band from current GSM operators operating in this band of spectrum and relocating them to either the remaining 900 or 1800 MHz bands. This would allow an additional 2 x 5 MHz for CDMA operations. The 800 MHz band plan defines 14 carriers in a 2 x 20 MHz band (824-844 MHz paired with 869-889 MHz) with specific inter-carrier and inter-operator guard bands. Internationally the 800 MHz band is 2 x 25 MHz wide, going from 824-849 MHz paired with 869-894 MHz. The Indian 800 MHz band is only 2 x 20 MHz wide because GSM operations in India's 900 MHz band (890-915 MHz paired with 935-960 MHz) began before CDMA operations. The truncation of the 800 MHz band at 889 MHz reduces its width, but prevented interference and overlap with the GSM 900 MHz operations.

3.33 Re-farming of 2 x 4.8 MHz which is presently with the Defence services in the GSM 900 MHz band from 890-895 MHz paired with 935-940 MHz will make available additional spectrum in CDMA 800 band and reduce the pressure to allocate the PCS1900 band for CDMA services. There are two re-farming possibilities:

(i) In lieu of the 900 MHz spectrum, the affected GSM operators can move to the 1800 MHz band. Since most of their equipment and handsets are dual band, they can migrate with little difficulty either on the network or customer side. However, this process may face resistance because a move to a higher frequency might require additional capital expenditure and is not feasible in the current market environment.

(ii) Defence services currently have an allocation of 2 x 4.8 MHz in the GSM 900 MHz band. They have already coordinated this section of spectrum with GSM users in the Delhi and Mumbai circles. If they can similarly coordinate with GSM users in all circles, an additional 2 x 4.8 MHz will be available in the 900 MHz band. Impacted GSM operators could move within the 900 MHz band, and will not have to incur any significant expenditure associated with band migration (say to 1800 MHz). This will allow an additional 2 x 4.8 MHz for CDMA800 operations, except for the Delhi and Mumbai circles.

3.34 One might argue that GSM operators should get the vacated 2 x 5 MHz spectrum. However, given that the possibility of allocating additional spectrum for 2G CDMA services in new bands seems unlikely in the near future, and because GSM operators will have access to an additional 2 x 20 MHz spectrum in the 1800 MHz band, the Authority believes that this measure will allow the growth of 2G and 3G CDMA services into the future. However, from the inputs the Authority has received, it appears difficult for the Defence services to vacate this band now. As a result, it will not be possible to implement this plan in a medium term period. **Keeping the long-term requirements and possible growth of CDMA services in mind, the Authority recommends that the Government should look into vacating 2 x 5 MHz of spectrum in the 900 MHz band in order to re-farm GSM operations within the band, and then allocate an additional 2 x 5 MHz for CDMA operations in the 800 MHz band.**

## D. The 450 MHz Band

3.35 The Authority examined and considered that there exists a possibility is to allocate the 2 x 5 MHz in the 450 MHz band for EV-DO services. This band is allocated in countries like Argentina, Finland, Indonesia, Oman, Pakistan, Portugal, Romania, and Russia with 23 EV-DO networks planned or

operational (Annex J). This band has excellent propagation characteristics, and will be suited especially for coverage in rural areas. In urban areas, the advantage of extended propagation characteristics does not remain because of interference issues and because larger cell sizes will be unsustainable for capacity deployments.

3.36 As stated, the availability of adequate spectrum in 450 MHz as well as the compatibility of equipment and handset are important issues. However, 450 MHz band has distinct coverage efficiency and hence this band has potent usage for 3G deployment in rural areas. The actual expenditure for a network deployment will also be low. **Therefore, the Authority recommends that 450 MHz band should also be identified for CDMA operators on a separate plank with rural roll out commitment. The terms of allocation have been made comparatively attractive to encourage the use of this band. The chapter on pricing has discussed in detail the allocative criterion for 2 x 5 MHz spectrum in the 450 MHz band for EV-DO operations.**

## Recommendations relating to the identification of bands for 3G in India

3.37 **The Authority recommends that the DoT should immediately allocate 2 x 25 MHz of spectrum in the 2.1 GHz band as per the allocation mechanism described subsequently.**

3.38 **The Authority recommends that the DoT should consider the spectrum band for 3G services as a stand-alone allocation without any linkage with 2G technologies. The allocation of spectrum for 3G would have to be viewed accordingly. The existing license provisions empower DoT to review and redefine spectrum allocation procedure and policies.**

3.39 **Since spectrum is not available in the PCS1900 band, it will not be possible to implement the mixed band plan in the near future.**

3.40 **Government should conduct trials to verify practical feasibility of coexistence of mixed band allocations at the earliest. In case the co-existence is found feasible and economically practicable, then it should work towards re-farming of the PCS1900 band, specifically 2 x 10 MHz**

**in the near future in order to allow the expansion of both 2G and 3G cellular services in India.**

3.41 **The Authority recommends that the Government work with operators to alter the existing 800 MHz band plan, adjusting guard bands to add one additional 1.25 MHz carrier. At least two carriers, i.e. 2 x 2.5 MHz, can still be dedicated for EV-DO services in the 800 MHz band even in these circles.**

3.42 **Keeping the long-term requirements and possible growth of CDMA services in mind, the Authority recommends that the Government should look into vacating 2 x 5 MHz of spectrum in the 900 MHz band in order to re-farm GSM operations within the band, and then allocate an additional 2 x 5 MHz for CDMA operations in the 800 MHz band.**

3.43 **The Authority recommends that 450 MHz band should also be identified for CDMA operators on a separate plank with rural roll out commitment. The chapter on pricing has discussed in detail the allocative criterion for 2 x 5 MHz spectrum in the 450 MHz band for EV-DO operations.**

# CHAPTER 4. ALLOCATION METHODOLOGY AND PRICING FOR 3G SPECTRUM

4.1 In the previous chapter, the Authority has identified for immediate planning and deployment specific bands of spectrum for 3G services (¶3.37-3.43). The bands identified are to be reserved only for 3G services in an unconnected manner for terms of acquisition at the initial stage and conditions of spectrum use. These bands are:

(i) 2 x 25 MHz in the 2.1 GHz band,

(ii) 2 x 2.5 MHz in the 800 MHz band, and

(iii) 2 x 5 MHz in the 450 MHz band.

4.2 Both the range of services as well as the demographic characteristics of subscribers for 3G is significantly different from 2G. As discussed in Chapter 3, the 2G services will have spectrum for their present and medium-term needs. Existing telecom service operators thus have a clear and separately identified road map for growth in 2G and 3G services with reference to spectrum availability.

4.3 Spectrum is a scarce resource. In addition, there are substantial present and future costs associated with the relocation of existing users, particularly security agencies. It has serious cost implications in term of Defence equipment and spares. This national resource, which serves as a key input to economic activity, is scarce and held by the Government in the public trust. It is therefore essential that spectrum allocation policy should be reoriented to reflect the scarcity.

4.4 This chapter addresses:

(i) Allocation of spectrum in the 2.1 GHz, 800 MHz, and 450 MHz bands to the licensed telecom service operators, and the quantum of spectrum allocated to each operator;

(ii) The framework for allocation of spectrum for 3G services;

(iii) The spectrum acquisition fees, annual charges, efficient utilization of spectrum; and

(iv) Roll out obligations for the operators.

## Spectrum allocations including determination of quantum in the 2.1 GHz band

4.5 Around the world, the number of licenses awarded for 3G have usually been three to six.[15] In India, there are four to seven GSM and CDMA operators in different circles, and a number of operators having presence in few circles are seeking to expand into new license areas. It is our assessment that due to competition and market compulsion, majority of the existing operators would like to start 3G services.

4.6 The key issue is that only 2 x 25 MHz of spectrum availability is presently indicated in the 2.1 GHz band. This quantum of spectrum is significantly lower than allocations elsewhere around the world.[16] In order to enable future growth of 3G services, **it is essential that DoT has a time bound road map for making available additional and sufficient spectrum.** As the spectrum is limited, some operators may have to wait until additional spectrum is identified in these bands. The Authority therefore has to determine the allocation criterion and the order of allocation for 3G service providers based on spectrum availability and the quantum of spectrum allocation to such operators. The exercise is to identify the first lot of telecom service operators and then gradual entry of the remaining as and when additional spectrum is available.

4.7 On studying the subscriber data for mobile services globally, it is seen that CDMA EV-DO subscribership is 11.64 per cent of all CDMA, and WCDMA subscribers are 3.85 per cent of worldwide GSM users (Figure 2). The number of 3G subscribers of the total number of mobile subscribers is 4.54 per cent as of June 2006 (Figure 3).[17]

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[15] Licensing Of Third Generation (3G) Mobile: Briefing Paper, ITU Workshop on Licensing 3G Mobile, September 2001

[16] The average amount of spectrum for 3G per operator in Europe is 43 MHz and in the Asia Pacific region it is 38 MHz. Across most of Europe, 155MHz of spectrum has been allocated for 3G or UMTS as it is known in Europe. Comments of Maravedis, ¶4.2.2; Licensing Of Third Generation (3G) Mobile: Briefing Paper, ITU Workshop on Licensing 3G Mobile, September 2001, p. 33

[17] GSM World, Quarterly Statistics, available at: http://www.gsmworld.com/news/statistics/pdf/gsma_stats_q2_06.pdf

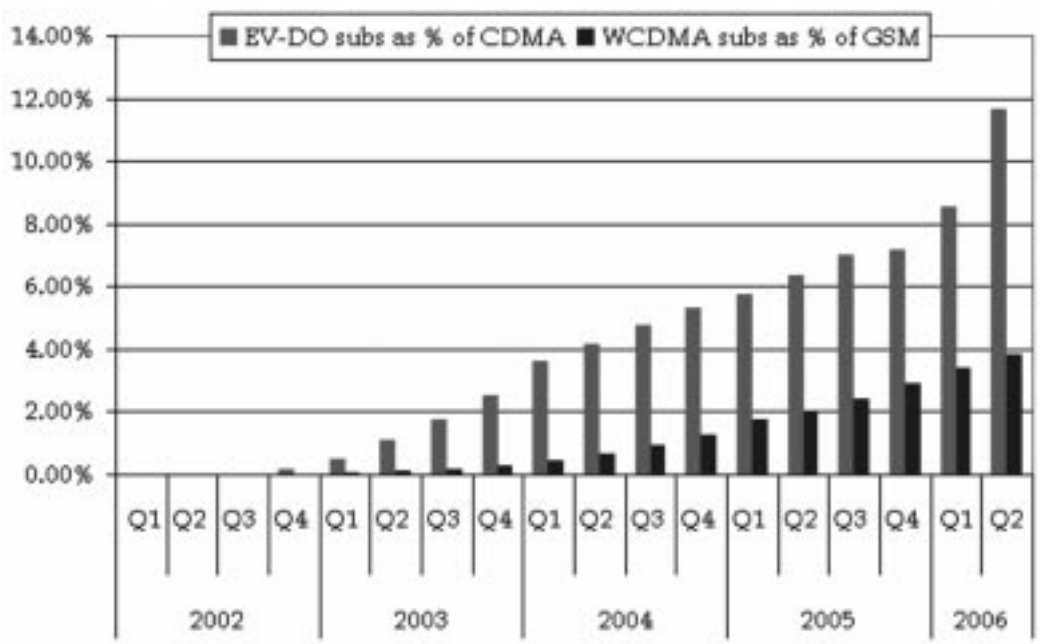


**Figure 2: Share of CDMA EV-DO and WCDMA subscribers**

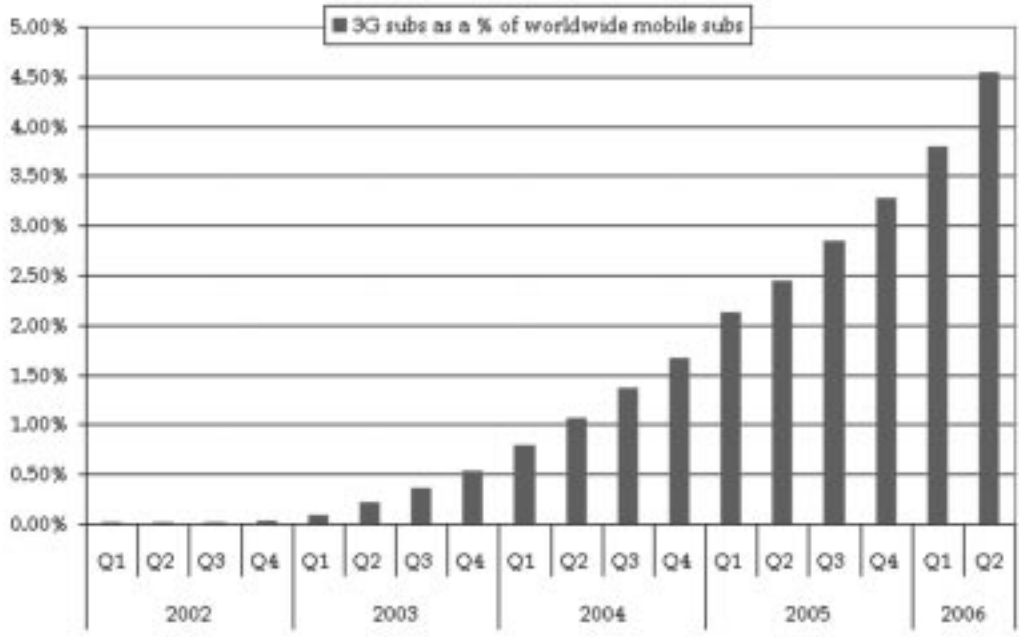


**Figure 3: 3G subscribers as a percentage of mobile subscribers internationally**

4.8 Most of the subscriber base for WCDMA is concentrated in the Asia Pacific and Western European regions, which contribute 97 per cent of the WCDMA connections. Even here, only a handful of companies have the majority of customers as of quarter ending June 2006, as shown in Table 6.[18]

| | Subscriber base (millions) | Share of international subscriber base |
|---|---|---|
| All WCDMA networks | 78.06 | 100% |
| NTT DoCoMo (Japan) | 26.21 | 33.58% |
| 3 (Italy, Germany) | 10.28 | 13.17% |
| Vodafone (Japan, Italy, Germany, UK) | 10.47 | 13.42% |
| Top three service providers | 46.97 | 60.17% |

**Table 6: Share of WCDMA subscribers across major service providers**

4.9 The data on distribution of CDMA EV-DO subscribers is no different. In September 2005, 80 per cent of EV-DO's 19.7 million subscribers were in the Asia-Pacific region. Table 7 shows the distribution of CDMA EV-DO subscribers across some of the largest operators in 2006; more than two-thirds of the international subscriber base is concentrated with four service providers.

| | Subscriber base (millions) | Share of international subscriber base |
|---|---|---|
| All EV-DO subscribers | 34.5 | 100% |
| KT Freetel, South Korea | 4.5 | 13% |
| SK Telecom, South Korea | 8 | 23% |
| Verizon Wireless, USA | 6 | 17% |
| KDDI, Japan | 5 (est.) | 14% |
| Share of these service providers | 23.5 | 68% |

**Table 7: Share of CDMA2000 EV-DO subscribers across major service providers[19,20]**

4.10 If one looks at the absolute growth of 2G and 3G services around the world, it is seen that the growth is concentrated in 2G, i.e. voice-centric applications (Figure 4). The GSM-WCDMA regional data for the two largest WCDMA use regions - Asia and Western Europe - also corroborates that the bulk of subscriber additions are in GSM and not WCDMA. In Asia, GSM is growing at an average of 34.5 million a quarter, while WCDMA is

[18] UMTS Forum, Fast Facts for Q2 2006, available at http://www.umts-forum.org/servlet/dycon/ztumts/umts/Live/en/umts/Resources_fastfacts

[19] KDDI EV-DO subscriber base figure is an estimate based on their September 2005 number of 4.32 million. *See* http://www.wirelessweek.com/article/CA6261693.html?text=steve+searles

[20] Verizon Wireless, SK Telecom, KT Freetel subscriber base figures from: CDMA Development Group, The Role of CDMA2000 in the Success of Wireless Broadband, May 2006, available at: http://www.cdg.org/resources/white_papers/files/EVO%20Case%20Study%20May%2006.pdf

growing only at 3.57 million a quarter (Figure 5). Even in Western Europe, the GSM subscriber base is growing 50 per cent more than WCDMA's (Figure 6).

4.11 Voice telephony is still the key application in mobile telecommunications today. While 3G usage is growing, perhaps it is more for enhanced voice capacity than data applications. Data applications as a significant driving force behind 3G will take some time. This observation is particularly relevant in the Indian marketplace. With a current monthly addition of around 5 million subscribers in India, it is evident that there is still unmet demand for voice service.

4.12 The Authority examined various options to determine the number of

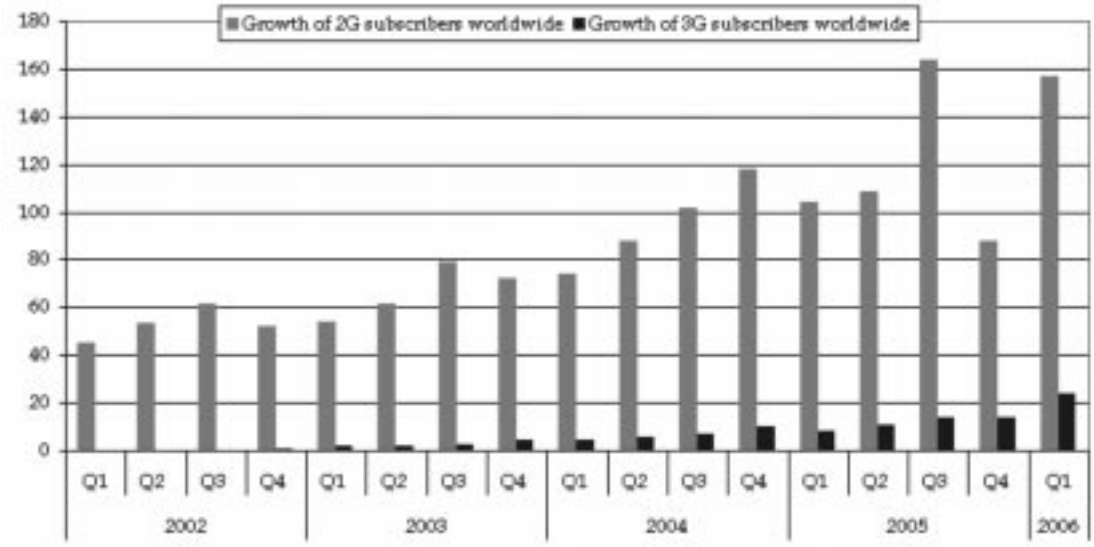


**Figure 4: Growth of 2G is much higher than 3G internationally[21]**

[21] *All figures in millions of subscribers*. Source: http://www.gsmworld.com/news/statistics/pdf/gsma_stats_q2_06.pdf

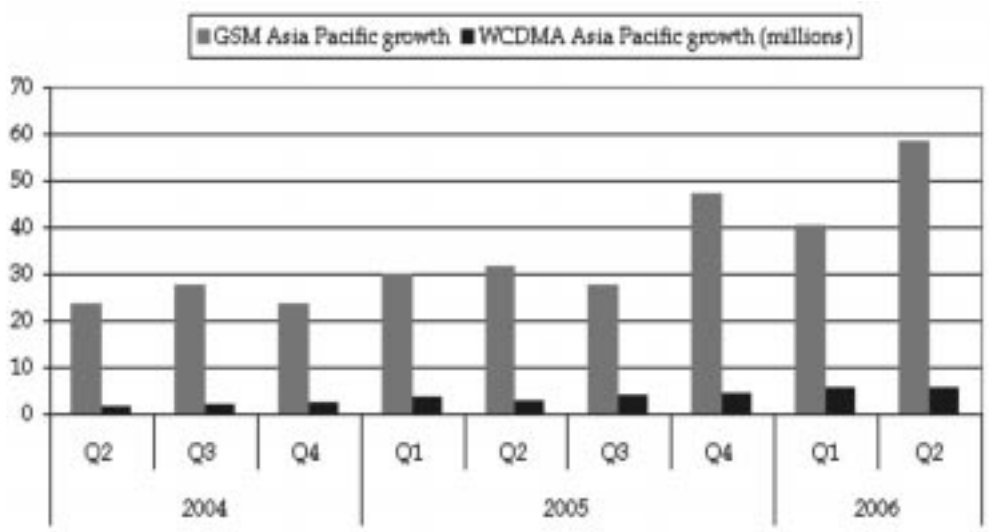


**Figure 5: Growth of GSM is much larger than WCDMA in Asia Pacific**[22]

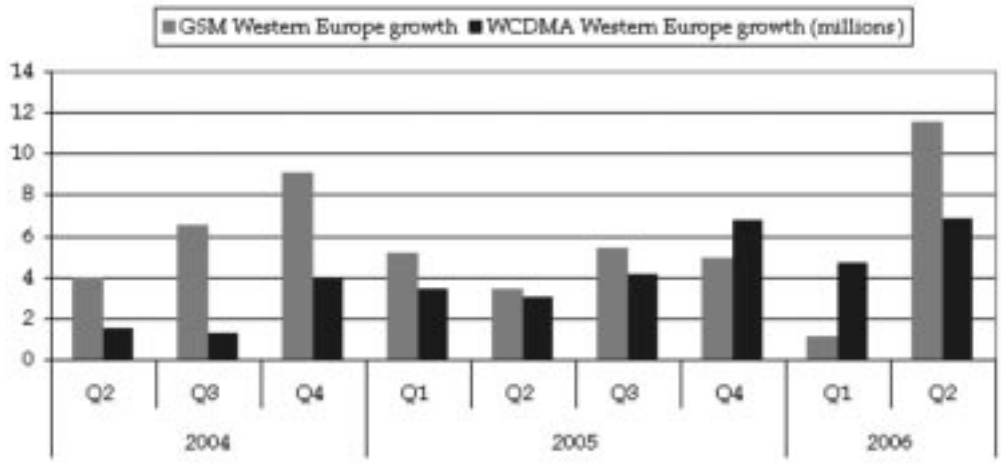


**Figure 6: Growth of GSM is higher than WCDMA in Western Europe**[23]

operators who may acquire spectrum in this band, and the following considerations have guided the Authority's finding:

(i) Internationally voice remains the main application for cellular mobile telephony. The Indian market place is growing at a very fast pace, and is primarily voice-centric. It is likely to remain unchanged for some time. The efficiency of 3G technologies is at least two to three times that of 2G,[24] and in view of the Government's target of 250 million telephone subscribers by 2007 and 500 million by 2010, the usage of

[22] http://www.gsmworld.com/news/statistics/pdf/gsma_stats_q2_06.pdf

[23] http://www.gsmworld.com/news/statistics/pdf/gsma_stats_q2_06.pdf

3G technologies will allow the telecom operators to reduce the cost of infrastructure substantially. From the data, it is abundantly clear that networks will need minimum technologically feasible additional spectrum at present to support the demand for data applications. Hence, 2 x 5 MHz should be sufficient in the medium term.

(ii) From the viewpoint of encouraging competition, it is better to have significant number of operators. If the number of operators is few, necessary measures will have to be put in place to ensure that it does not lead to cartelization and rent-seeking behaviour. From our experience with 2G services, we find that competition, as measured by the Herfindahl-Hirschman Index (HHI), is better than average where the number of operators is more than five (Annex K).

(iii) Another disadvantage in restricting the possible number of 3G operators is that fewer operators can acquire spectrum and offer service, and this reduction in supply increases the price of the spectrum. This might be detrimental to the financial viability of 3G service providers. The need of the hour is rural penetration thus bridging the digital divide and the higher sunk costs in acquiring spectrum could divert capital from the infrastructure expansion needed to reach the target of 500 million telephone subscribers by 2010.

(iv) Based on the available information, CDMA EV-DO requires a minimum of 2 x 1.25 MHz and WCDMA requires a minimum of 2 x 5 MHz to begin service. Hence, we could apportion the bands according to these criteria. Keeping with a technology neutral approach, the minimum allocation would be 2 x 5 MHz for each operator in the identified group of bands. Thus, the maximum number of operators in the 2.1 GHz band will be five in the first lot. This amount of spectrum will also be sufficient to support enhanced wireless services such as HSDPA, HSUPA, and EVDO Rev A.

4.13 **Based on the foregoing observations, the Authority recommends that**

[24] CDMA Development Group, Delivering Voice and Data: Comparing CDMA2000 and GSM/GPRS/EDGE/UMTS, December 2005, available at http://www.cdg.org/resources/white_papers/files/Capacity%20Dec%202005.pdf

**given the current availability of 2 x 25 MHz of spectrum in the 2.1 GHz band, the minimum technological need, and the need to stimulate competition in the market, five operators should be accommodated in this band in the first lot.**

## Spectrum allocation in the 800 MHz band

4.14 The Authority has identified 2 x 2.5 MHz, i.e., two carriers in the 800 MHz band that can be allocated for 3G service provision (CDMA2000 1x EV-DO) without affecting the growth of 2G services in that band.

4.15 In order to provide data via EV-DO, a CDMA2000 network has to reserve at least one exclusive 1.25 MHz carrier for data services. One carrier allows a maximum of 2.4 Mbps forward link data speeds with the average about 300-600 kbps with CDMA2000 1xEV-DO Release 0. CDMA2000 Revision A will allow peak data speeds of 3.1 Mbps on the downlink and 1.8 Mbps on the uplink. In CDMA2000, Revision B a single 1.25 MHz carrier in the forward link will deliver a peak rate of up to 4.9 Mbps.[25]

4.16 Most circles have two UASL CDMA operators. Thus, it is possible to allocate one EV-DO carrier within the identified 2 x 2.5 MHz to each UASL CDMA operator in most circles. The only exceptions are Punjab and Rajasthan, where there are three UASL CDMA operators and hence the 15-carrier band plan cannot be implemented. In the case of Punjab, three carriers can be reserved for EV-DO services without affecting the future of 2G operations. In Rajasthan, however, the growth projections indicate that 12-carriers will be needed for 2G. This means that only two carriers can be reserved for EV-DO.

4.17 By this approach, every UASL CDMA operator will have an option to get 2 x 1.25 MHz in the 800 MHz band for 3G CDMA operations. This one carrier is to be allocated only among the UASL CDMA licensees. BSNL and MTNL also operate CDMA networks, but are basic service operators (BSOs) and offer WLL (F)/WLL (M) services. BSNL and MTNL are offering mobile services using GSM technology and their subscriber growth is primarily in GSM.

[25] http://www.cdg.org/technology/3g.asp

Therefore, BSNL and MTNL will be considered for allocation of 3G spectrum as GSM and not CDMA operators.

4.18 Since it is possible to allocate one carrier each to the UASL CDMA operators, each of them will be able to begin 3G EV-DO services in the 800 MHz band at the same time as WCDMA services might begin in the 2.1 GHz band. The Authority is thus ensuring a level playing field, especially given the concerns of the CDMA operators that they will not enjoy the economies of scale for EV-DO hardware in the 2.1 GHz band as they might in the PCS1900 or even the 800 MHz bands.

**4.19 The Authority recommends that the UASL CDMA operators should be given an option of one carrier for EV-DO services in the 800 MHz band subject to conditions specified subsequently (¶4.35 and 4.42).**

## Spectrum allocation in the 450 MHz band

4.20 As of September 2006, the 450 MHz band is in use internationally for CDMA EV-DO services by nine networks (Annex J). These networks are typically green-field, and have been deployed in countries adopting both GSM and CDMA technologies.

4.21 The 450 MHz band has only 2 x 5 MHz available. This band is especially suitable for rural and semi-urban deployments, and the Authority recommends that use of the 450 MHz band should be encouraged.

4.22 **The Authority recommends that the DoT should allocate 2 x 5 MHz in the 450 MHz band to one of the existing UASL CDMA operators depending on market demand and based on the allocation process described in ¶4.35.**

## Combined spectrum availability

4.23 **Based on the findings in Chapter 3, 2 x 32.5 MHz of spectrum will be available in a time scenario of 6-9 months for 3G services.**

4.24 **The Authority recommends that this spectrum should be allocated as follows:**

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

## Participating licensees in these bands

4.25 From the comments received during the consultation process and the Authority's analysis, existing CDMA and GSM telecom operators, as well as non-telecom companies and even non-Indian telecom companies seem to be potential candidates for offering 3G services in India. The Authority notes that wider participation of service operators may bring about convergence, technological innovation in voice and data services, and improve the prospects of investment in the sector. However, the claims of the existing UASL and CMSP licensees for prioritization cannot be dismissed as they have invested in the infrastructure and their systems are in place to efficiently deliver 3G services at lower incremental cost. This will enable faster roll out of 3G services and help in achieving the objective of affordability. There are presently four to seven service providers in each circle. In addition, the operators who have presence in few circles have also applied to DoT for grant of licenses in other circles and are moving towards pan-India presence. Thus, there is or will be enough competition to ensure that the spectrum is priced competitively, discourage cartelization, and offer services that are acceptable in terms of quality and price.

4.26 One of the goals is to minimize the risk of excessive investment in the deployment of 3G networks and thereby avoid any harm to the industry at this point of take-off. Current voice-centric network deployments must continue unabated. UASL and CMSP licensees have their passive infrastructure in place and are capable of quickly deploying overlay networks for 3G. This will reduce cost of deployment and ensure that their current pace of roll out gets a further boost.

4.27 Data-centric 3G services will take off gradually. It is possible that the telecom operators may use 3G networks in the medium term for their enhanced efficiencies in carrying voice traffic, but the emphasis should be to encourage all-inclusive 3G services.

4.28 The main objective of the Authority has been to seek a balance between competition, affordability, and accelerated growth of the sector. Thus, the priority for allocating scarce spectrum must first go to the existing licensees. Convergence of services is not being overlooked as it could be addressed once additional spectrum is available.

4.29 Except in Rajasthan, in all other service areas, 2 x 1.25 MHz in the 800 MHz band is available for each UASL CDMA operator. This quantum of spectrum is available in the 800 MHz band after earmarking spectrum for the present and future growth in 2G subscriber base (Annex I). **Since the quantum of spectrum in the 800 MHz band is limited, the Authority recommends that this band be allocated to the existing UASL CDMA operators only.** The considerations behind this recommendation are as follows:

(i) The earmarking of 2.1 GHz band for both GSM and CDMA operators is though fair and technologically feasible, but the deployment may not have the same timeframe as the availability of dual band equipment/handsets for EV-DO may take some more time to develop. GSM operators will have an edge in terms of lower cost because of economies of scale and easy availability of both equipment and handsets and might then get a lead of a few months over CDMA operators in the 2.1 GHz band.

(ii) In order to ensure that the UASL CDMA operators have similar opportunity, it is only fair that they have the option to pick one carrier each in 800 MHz band for the deployment of EV-DO system. This will take care of the time advantage to GSM in 2.1 GHz band.

4.30 It is for these reasons that the two carriers in 800 MHz band have been separately earmarked for EV-DO services and have not been linked with the subscriber norms of DoT for allocation of carrier to offer 2G services in 800 MHz band. It is clarified that if the two carriers are not utilized for EV-DO, they would revert to 2G deployment on the basis of subscriber norms determined by DoT. The pricing aspect of the two carriers earmarked for EV-DO system has been discussed separately.

4.31 EV-DO services can be offered in 450 MHz band. There are a number of countries who have allocated spectrum in the 450 MHz band that is being

used to deploy EV-DO services. The existing CDMA operators did not present a strong case for allocation of 450 MHz band during the consultation process. This band has the advantage of low cost rural deployment due to wide coverage. Although the Authority has recommended participation of all the licensees i.e. both CDMA and GSM technology based service providers in the allocative process for 2.1 GHz band, there is enough justification for offering 5 MHz band in 450 MHz band to the CDMA licensee. This route also partially addresses the spectrum scarcity situation. The allocative framework suggested has an in-built price incentive for the operator opting for the 450 MHz band. However, the licensee opting for 450 MHz will then not have the choice for participating in the 2.1 GHz allocative process. In the event that multiple UASL CDMA licensees exercise the option for 450 MHz band, the allocation would based on a one-stage bidding process. The details have been discussed along with recommendations for spectrum pricing of 2.1 GHz band and 800 MHz band.

4.32 **The blocks in the 2.1 GHz band represent new allocations and are not to be considered as an extension of existing allocations. The Authority is of the view that de-linking the allocation of spectrum in the 2.1 GHz band from the allocation of spectrum for 2G services is crucial for ensuring a forward-looking and inclusive regulatory environment. Spectrum allocations in the 2.1 GHz band thus should be done to all eligible UASL and CMSP licensees using fair and equitable norms as explained subsequently, and should bear no relationship to their current spectrum allocations or subscriber base.**

4.33 **Thus, the Authority recommends that:**

(1) **In the 450 MHz band, Block A should be allocated to one of the UASL CDMA licensees;**

(2) **In the 800 MHz band, Blocks B should be allocated among the existing UASL CDMA operators;**

(3) **In the 2.1 GHz band, Blocks C through G should be allocated amongst cellular mobile service provider and unified access service license holders.**

## Allocation framework

4.34 Based on the preceding recommendations, the 450 MHz, 800 MHz, and 2.1 GHz bands are up for allocation to operators for 3G service provision. In order to maintain a level playing field between all the operators, the Authority feels it necessary to define a precise allocation framework for this process of spectrum allocation.

4.35 **The Authority recommends that the DoT follow an allocation process as follows:**

(1) The UASL CDMA operator will have the option to seek 2 x 1.25 MHz in the 800 MHz band at the price as explained in ¶4.78. Additionally, it will have the option of taking spectrum in **either the 2.1 GHz or 450 MHz bands.**

(2) In case the UASL CDMA operator opts for the 450 MHz band, it will get 2 x 5 MHz through the process described in ¶4.37.

(3) In case it opts for the 2.1 GHz band, the UASL CDMA operator will have to bid along with the other operators. In case it is among the successful bidder, it will have an option of:

a. **Either** retaining 2 x 1.25 MHz in the 800 MHz and getting an additional 2 x 3.75 MHz in the 2.1 GHz band,

b. **Or** giving up the option on 2 x 1.25 MHz in the 800 MHz band and getting 2 x 5 MHz in the 2.1 GHz band.

4.36 **In the case of Rajasthan, where there are three UASL CDMA operators and only two carriers on offer, the Authority recommends a single stage bidding process should be organized to determine which of these operators gets the carriers in 800 MHz, if all the three opts for an EV-DO carrier at the prescribed fee. The reserve price in case of bidding or spectrum acquisition fee otherwise will be equal to the second highest pro-rated bid price in the 2.1 GHz auction.**

4.37 **Similarly in the 450 MHz band, if more than one operator opts for 2 x 5 MHz, the Authority recommends that a single stage bidding process be**

**conducted. The reserve price for 2 x 5 MHz in the 450 MHz band will be half of the reserve price set for 2.1 GHz band for that service area.**

4.38 The above allocation framework ensures that CDMA operators' concerns about a level-playing field with respect to equipment availability, economies of scale, and time to market for their 2.1 GHz EV-DO services have been adequately addressed. Additionally, it encourages rural roll out through the allocation of the 450 MHz band, and ensures that the maximum spectrum allocation per 3G operator is 2 x 5 MHz, except in one scenario (2 x 6.25 MHz for an operator who opts for one carrier in the 800 MHz and 2 x 5 MHz in the 450 MHz bands).

## Spectrum pricing

4.39 Around the world, operators have paid significant sums of money for 3G spectrum allocations.[26] There is a wide variation in national allocations; Germany's auction raised $45.85 billion for six 3G licenses, while Japan allocated its three licenses free.[27] The August 2006 AWS-1 auction in the United States has raised more than $13 billion from 168 bidders for 1,122 licenses.[28]

4.40 The blind adoption of the global spectrum allocations trends may not be prudent for Indian conditions. The Authority does not wish to burden operators with unviable spectrum acquisition fees. The objective is to ensure that 3G services are affordable and do not hurt the financial viability of the operators. The Authority would also discourage any significant diversion of financial resources earmarked for infrastructure development in 2G or 3G networks towards cost of spectrum acquisition. On the other hand, given that the quantum of spectrum is limited, and effective measures should be there to discourage spectrum hoarding, encourage its efficient use, and recover the present and future costs of vacation by incumbent spectrum users in terms of management, logistical relocation, and vacating or re-farming the spectrum allocated for 3G services should be priced meaningfully.

[26] Comments of Maravedis, ¶4.2.1

[27] Comments of Maravedis, ¶4.2.1

[28] http://wireless.fcc.gov/auctions/default.htm?job=auction_summary&id=66

4.41 As stated earlier, 2 x 2.5 MHz spectrum in the 800 MHz band has been identified for CDMA 1xEV-DO services. During the consultation process some of the stakeholders argued that the present license conditions specify allocation of spectrum in the 800, 900, and 1800 MHz band. Therefore, the argument runs that allocation of 800 MHz band for EV-DO services cannot have a separate set of conditions. The license condition states, "**additional spectrum beyond the (initial cumulative maximum) may also be considered for allocation after ensuring optimal and efficient utilization of the already allocated spectrum taking into account all types of traffic and guidelines/criteria prescribed from time to time".** The DoT is already allocating various carriers depending on availability and the eligibility criterion to telecom operators with CDMA technology. However, the EV-DO services are being kept on a different footing, and are being de-linked from the subscriber-based spectrum allocation criteria prescribed. Thus, the CDMA based telecom operators will qualify for one carrier each on a stand-alone basis. The nexus with present allocation criteria therefore is non-existent. Moreover, the license condition already envisages adjustments during the validity period of license in spectrum allocation. The condition prescribed is that, "**the licensor has right to modify and/or amend the procedure of allocation of spectrum including quantum of spectrum at any point without assigning any reason.**"

4.42 Currently, if a UASL CDMA operator in 800 MHz band has to acquire an additional carrier, it will need to build a certain subscriber base. In order to provide EV-DO services, this operator will have to dedicate this carrier only for data. However, the increased subscriber base will need this additional carrier to support voice traffic. Hence, the operator will not be able to provide EV-DO services using this carrier. In order to break this cycle, the Authority believes that a non-subscriber base criterion is justified for the two carriers earmarked for EV-DO services. Since the allocation of Block B in 800 MHz at the same time as the 2.1 GHz will be independent of the currently followed subscriber base criteria, a new set of criterion to allocate this block of spectrum has been considered. **The Authority believes that a market driven price determination would be transparent, equitable, just, and non-discriminatory. Thus, the Authority recommends that the allocation criterion followed for Block B should also be a spectrum acquisition fee, set in the same framework as Blocks A, and C-G.**

4.43 **Spectrum in the 450 MHz band is also a new allocation. The Authority recommends that the Government should charge a spectrum acquisition fee for the 2 x 5 MHz block in the 450 MHz band.**

## Allocation mechanisms in a price-setting environment

4.44 There are four options for allocation mechanisms in a price-setting environment: an auction or bidding process, a beauty contest, or a fixed fee or a hybrid approach.

(i) Auctioning: Auctions are transparent, and are an efficient means to allocate spectrum when demand is greater than supply; they allocate the resource to the party that values it the most. However, auctions could result in frenzied valuations, such as in Germany or the United Kingdom that might compromise the financial viability of 3G services in India.

(ii) Beauty contest: In a beauty contest, participants are scored based on parameters set by a judge, in this case the licensor. The winner is the participant with the highest score. Spectrum allocation through a beauty contest can be used when demand exceeds supply. However, the process might not be transparent and could be contentious.

(iii) A fixed fee: In this approach, spectrum is allocated to anyone who pays the pre-determined price. However, given the Indian situation and the existence of a competitive market, this may not reflect the real market price. Fixed fees also do not protect against non-serious players acquiring and hoarding spectrum.

(iv) A hybrid of (i) to (iii) above.

4.45 Annex L shows how spectrum for 3G has been allocated using these methods in different countries around the world. As discussed earlier, spectrum is a scarce resource. The number of licensees in the 2.1 GHz, 450 MHz and 800 MHz band would be limited in the first phase of allocation. Therefore, a waiting queue will have to be determined for future allocation as per the availability. The Authority is guided by the following considerations:

(i) Maximizing spectrum utilization,

(ii) Sufficient revenue to cover present and future spectrum management, logistical relocation and re-farming or vacation costs,

(iii) Affordability of 3G services to be ensured,

(iv) Allocates a scarce resource fairly when demand is greater than supply,

(v) Transparent methodology that allows all prospective parties an equal opportunity to acquire spectrum.

(vi) Technological neutrality and level playing field situation

(vii) Determine the order of allocation for spectrum as and when additional spectrum is made available.

4.46 Each method has its advantages and disadvantages when one evaluates them keeping in mind the objective of recovering re-farming or similar costs, while simultaneously ensuring affordability of services and the sector's financial viability. An analysis of these methods is given in Annex M. Based on this analysis, the Authority evaluated different methods. The results of the comparative evaluation are below:

| | **Auction** | **Beauty contest** | **Fixed fee** |
|---|---|---|---|
| Maximizes efficiency of spectrum utilization | ✓ | ✓ | |
| Can raise sufficient revenue to cover re-farming or vacation costs | ✓ | ✓ | ✓ |
| Ensures affordability of 3G services | ~ | ✓ | ✓ |
| Allocates fairly when demand > supply | ✓ | ~ | |
| Transparent and allows equal opportunity | ✓ | ~ | |
| Technology neutrality and level playing field | ✓ | ✓ | ✓ |
| Determine the order of allocation for spectrum as and when additional spectrum is made available | ✓ | ✓ | |

4.47 Based on the evaluation, the auction route is superior to the beauty contests and the fixed fee approaches. The Authority is no doubt sensitive to the

fact that the affordability of services might be compromised if spectrum costs through auction route get exaggerated due to overvaluation or frenzied bidding. Such exaggerations might occur if participants in the bidding process are non-serious players, or if they are impractical in their valuation. However, there is overwhelming evidence that the participants realistically assess the market price in the background of customers' willingness to pay certain price for such services.

4.48 Around the world, regulators and governments have used auctions to allocate spectrum. In India too, the Government has used auctions to allocate, among other things, FM radio licenses and the fourth cellular operator licenses. The Authority has evaluated the outcome of previous auctions. Barring UK and Germany, valuations of spectrum revealed through auction route during the last six year have been reasonable, uniform, and almost stable.

## International auction experiences

4.49 Many countries have used auctions to allocate spectrum. The United States' FCC had conducted some of the earliest relevant spectrum auctions for spectrum. In 1995, for example, the FCC auctioned PCS1900 spectrum and raised $7 billion, with the average price per population across different license areas coming to $12.84.[29] Other countries have also conducted auctions for 3G licenses and spectrum (Figure 7).

[29] http://wireless.fcc.gov/auctions/04/charts/4markets.xls

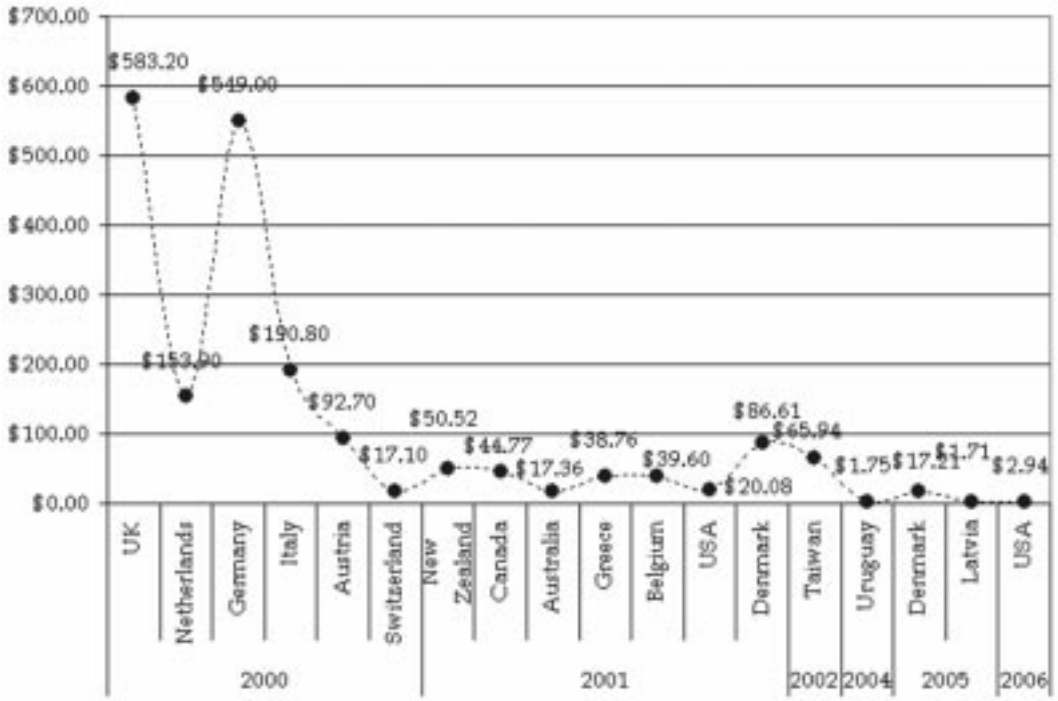


**Figure 7: International 3G license auctions in 2000-2006, price per inhabitant[30]**

4.50 Some stakeholders have commented that auctions might lead to irresponsible bidding by interested parties and might cause increase in prices. However, one stakeholder has commented that spectrum auctions do not directly raise prices.[31] Available international data suggests that beauty contest discovered lower price in 2001, 2002 and 2006 but higher price in 2000 and 2004 as compared to prices discovered in auctions and thus no definite pattern of difference between these two mechanisms of allocation was discernable (Figure 8). If both auctions and beauty contests have similar or comparable results, the Authority believes that the more transparent and fair allocation mechanism, i.e. auctions is the better choice to use.

[30] Source: news items, national and international telecom agencies, comments

[31] Comments of Tata Teleservices during the open house discussion

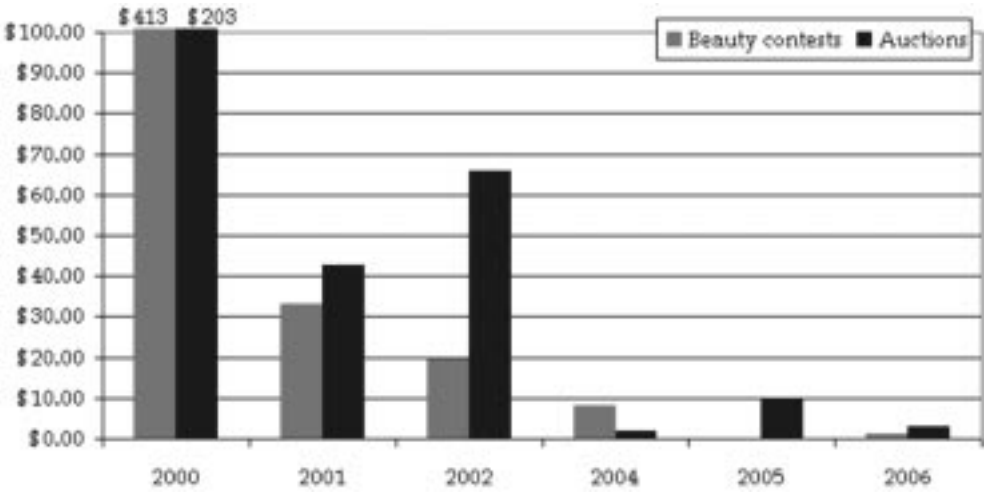


**Figure 8: Both beauty contests and auctions have similar outcomes ($/pop)**[32]

## Indian Experiences

4.51 In 2001, the Government auctioned off the fourth cellular license in many circle around India. This auction, which used an informed ascending bidding process, raised Rs. 1,633 crores across 17 circles. The license fee included an implicit spectrum fee because each license came with 2 x 6.2 MHz of spectrum for the operator in the 1800 MHz band. Unlike the auctions for the first two cellular licenses, which resulted in high bids, the fourth cellular license resulted in serious and more controlled bidding. This was because the industry was more mature in 2001 than in the early 1990s - operators, many of whom were already operating in other circles had the experience and understanding of the market to guide them in making realistic and practical bids. Hence, given this Indian experience, the Authority believes that a well-designed and well-managed auction will be appropriate as an allocation mechanism for the Indian 3G licensing and spectrum allocation process. This pattern is also in line with the trends in auction prices seen during the last three to four years in Europe and elsewhere.

4.52 In the process of evaluation of spectrum auction results, the Authority has considered the recent auction data pertaining to FM radio phase-II in which the radio licensees paid about Rs.1100 crore for the licenses. This auction, conducted by the Government in 2005, used a two-stage process where

[32] Source: national regulators and international bodies

the Government checked the bidders' eligibility and following their qualifying this stage, the auctioneer selected winners based on a single stage multi-item auction. Of the 338 licenses on offer in 91 cities, bidders took 279. The entire process lasted one month, with five stages of auctions where each stage had a different group of cities' licenses on auction. Although the licenses were for radio broadcasting and not for cellular mobile services, the Authority believes that features of the auction in FM radio licenses can be suitably adopted for a possible 3G auction.

4.53 **In order to achieve the objectives detailed in ¶4.45, and the foregoing analysis, the Authority recommends that the Government allocate spectrum Blocks C, D, E, F, and G in the 2.1 GHz band using the auction route. The auction bid price will also affect the pricing of blocks in 450 MHz and 800 MHz bands.**

## Selecting an auction process

4.54 There are a range of auction mechanisms and systems that the Government could use to allocate the spectrum blocks in the 2.1 GHz band. A number of countries have used auctions to allocate 3G licenses and spectrum. India has also seen its share of auctions - in the FM and cellular license allocations above, as well as in numerous procurement processes.

4.55 The Authority having considered all aspects and special features in telecom sector recommends the following process for auction:

(i) Allocate licenses to multiple bidders simultaneously, i.e. more than one block of spectrum (or item) in the same auction,

(ii) Allocate same sized, but possibly differently valued, blocks fairly,

(iii) Ensure, as far as possible, affordability for operators and consumers, and

(iv) Ensure transparency and openness.

4.56 This is a one-seller many-buyer (i.e. monopoly) situation. The preferred auction method would have to be some type of an ascending auction, i.e. one where bids go up with time. This method would also allow price discovery. In addition, given the multiple blocks available, and the

Authority's concern with ensuring a level playing field, it is preferable to have a simultaneous auction, i.e. one where all the blocks to be given are auctioned simultaneously. Given these needs, the Authority finds that the simultaneous ascending auction (SAA) is the best mechanism to determine a clear winner in a fair and transparent fashion.

4.57 The SAA method has emerged as a standard approach to spectrum auction and has been successfully used by the FCC for spectrum auctions on a number of occasions. Countries such Australia, Canada, Mexico, Netherlands and the UK have also used this design. Evidence available shows that auctions have been successful when extensive information has been revealed. Under this method of SAA, bidders will have good and sufficient information about prices and assignments at a point in the auction where they have the flexibility to act on the information. Information about prices and assignments improve throughout each stage of the auction. This design of auction is said to result in formation of efficient license aggregations, which is highly relevant in the Indian context where licensing is circle based. For licenses that are close substitutes, the SAA has the capability to generate near uniform prices for similar items. In the absence of resale, this design of simultaneous ascending auction proposed by the Authority should result in highly efficient results.

4.58 In order to allow competition in the provision of 3G, ensure that spectrum goes to the parties that value it the most and have the best business plans, and to have a fair process, the Authority considers that the following conditions are important, i.e. the auction should have:

(i) Only one block per winner: to allow many different operators to acquire spectrum and encourage competition,

(ii) All spectrum blocks across all license areas auctioned simultaneously: to allow operators to bid in different combinations of license areas according to their business plans and economic capacity,

(iii) Multiple rounds: to facilitate price discovery, give the spectrum to the most interested party, and to allow upward revision of bids,

(iv) Timing limits: to ensure that the auction has a time limit, and to reduce the chances of collusion,

(v) Sealed bids: to minimize the chances of collusion between operators and keep the process fair,

(vi) Price the spectrum at the bidder's respective winning bid: to ensure that winners get the spectrum at a price that they are willing to pay, subject to conditions elaborated in the auction mechanism,

(vii) Bidders should be unconnected: to prevent collusion and the possibility that one operator has access to more than one block of spectrum, which will lead to an anti-competitive situation,

(viii) Have activity rules to ensure participation (or 'current-ness') in every round: to minimize the chances of collusion, to ensure that all interested bidders remain participants, and to prevent sniping in the auction,

(ix) Should not permit bid withdrawal: to prevent the possibility of one bidder hijacking the bidding process, and ensuring that bidders remain practical in their estimations of spectrum, and

(x) Require an immediate one-time payment of acquisition fee: to prevent distortion of the bidding process based on unrealizable future expectations.

4.59 **Given the above requirements, the Authority recommends that the spectrum auction for 2.1 GHz band should use a simultaneous ascending auction system. Details of this methodology is in Annex N.**

4.60 **If there are more operators interested in the 450 MHz or 800 MHz bands than the number of available blocks, then a one-stage bidding process should be organized to decide the winners.**

## Fixation of the reserve price for the auction

4.61 Ascending auctions have a reserve price, a minimum price above which bidders must place their bids. The reserve price for the proposed auction will need to ensure the spectrum is priced at a level that reflects its minimum possible value, and that ensures that the cost of vacating the

incumbent users of this spectrum is recovered. In order to reach a reserve price that reflects the minimum possible value of the spectrum, the Authority used international spectrum prices as an indicator of possible value of spectrum.

4.62 Many European and some Asian countries had allocated their 3G spectrum before 2002. The average cost per Hz in Europe is about $40, or Rs. 1800/Hz for nation-wide allocations. Countries in the Asia Pacific region have allocated their nation-wide 3G licenses at an average cost of about $4, or Rs. 180/Hz. It is possible to use all international experiences to indicate the possible price of spectrum in India. However, some of the early spectrum allocations in Europe were at very high prices. For example, countries such as Germany ($316.21/Hz), UK ($251.79/Hz), Italy ($75.41/Hz), Netherlands ($21.74/Hz), Poland ($13.98/Hz), and France ($13.78/Hz) have among the highest per Hertz prices in the world.[33] Some attribute this to a 'now or never' syndrome that made operators bid much higher than their valuations to assure their supply of spectrum.[34]

4.63 These high price spectrum allocations were before 2002, when the market for 3G was not very well understood, and operators were more interested in grabbing spectrum as opposed to ensuring financial viability and affordability. To steer away from the distortions due to the excessive prices in Europe, and to reflect more recent trends, the Authority based on international allocations that have been made since 2002. A list of these allocations and the price of spectrum is given in Annex O. **The average price for international allocations since 2002 is Rs. 68 per Hz** (Figure 9).

[33] Comments of Maravedis, ¶4.2.3

[34] Comments of IDFC


**Figure 9: The cost ($/Hz) of spectrum allocated around the world**[35]

4.64 Since the international price of spectrum reflects nation-wide allocations, and not regional allocations as are made in India, this indicator cannot be applied directly to the Indian scenario. The relative scarcity of the 3G spectrum is different for different circles and thus the Authority is of the view that the relative scarcity should also get reflected in the minimum reserve price that serves as the starting point for the auction. Circles with relatively higher earning potential should fetch higher price for the spectrum - which is the key input - than the circles with relatively lower earning potential. Therefore, the Authority wants to ensure that the spectrum in possibly higher value circles such as the Metros and Category A are priced higher than in circles where the financial viability and affordability of 3G services might be less predictable.

[35] See Annex O

4.65 The entry fee paid by the 4th cellular operator is being used currently by new operators to get a UASL license for the applicable service area. The entry fee for different service areas is as given in Table 8.

| Circle | Entry fee (Rs. Cr) |
|---|---|
| Delhi | 170.7 |
| Mumbai | 203.66 |
| Chennai | 154.00 |
| Kolkatta | 78.01 |
| Maharashtra | 189.00 |
| Gujarat | 109.01 |
| Andhra Pradesh | 103.01 |
| Karnataka | 206.83 |
| Tamil Nadu | 79.00 |
| Kerala | 40.54 |
| Punjab | 151.75 |
| Haryana | 21.46 |
| UP (West) | 30.55 |
| UP (East) | 45.25 |
| West Bengal and A&N | 2.69 |
| Rajasthan | 32.25 |
| Madhya Pradesh | 17.45 |
| Himachal Pradesh | 2.00 |
| Bihar | 10.00 |
| Orissa | 5.00 |
| Assam | 5.00 |
| North East | 2.00 |
| Jammu & Kashmir | 2.00 |

**Table 8: 4th operator/UASL entry fee[36]**

4.66 Table 9 shows the average price paid per circle, with the average for Metro and Category A together, and B and C circles.

| Circle category | Average Entry Fee (Rs Crore) |
|---|---|
| Metros and A | 143.69 |
| B | 47.74 |
| C | 4.33 |

**Table 9: Average 4th operator/UASL entry fee by category of circle**

[36] TRAI data

**Recovering the cost of spectrum vacation**

4.67 As noted earlier, the Defence forces and other internal security agencies are currently using the 2.1 GHz uplink band, i.e. 25 MHz of spectrum that will have to be vacated if 3G services are allocated spectrum this band. One of the factors in deciding the price of spectrum is to the cost of re-farming or vacating incumbent users.

4.68 The Defence forces and other government users will require this money to set up new communication networks in place of the wireless networks that were in this re-farmed band. Further, they will have to train users on the new systems to ensure smooth operation, and overhaul of the organizational systems in place around the previous communication technology. The funds will be needed to cover the costs of condemning and scraping the older network. The Defence forces have also indicated the requirement of security of the wired channel. Yearly maintenance cost and putting in place the encryption and security systems will also need substantial funds. As such, a substantial expenditure will be needed for building a new communication network, and to overhaul the systems that are in place around this network, partially or fully. This should be appropriately reflected in deciding the prices for future spectrum.

**Reserve price for 2.1 GHz band**

4.69 The 4th cellular operator/UASL entry fee and the international price of 3G spectrum serve as useful indicators of its price both domestically and around the world. However, these prices cannot be directly applied to set the reserve price as both these prices were the final price paid by the operators. Moreover, the 4th cellular/UASL entry fee was not only for spectrum acquisition, but for the license as well. Moreover, these allocations were done in 2001, and there have been significant changes in the market situation since then. The subscriber base has increased manifold since then, and Category B and C circles might now be valued at a higher price because of the fast pace of growth seen recently. For example, for the year ending June 2006, while Metros and Category A circles' subscriber bases grew by 60 and 80 per cent respectively, Category B and C circles' grew by 90 and 142 per cent.

4.70 As discussed earlier, the Authority wants to encourage affordability in the provision of 3G services and ensure that an auction does not lead to unreasonable pricing of spectrum. Noting that in an auction, the market will find its own clearing price, the Authority believes that the reserve price for 3G spectrum should be approximately Rs. 1000 to 1100 Crores for one block of 2 x 5 MHz of spectrum in the 2.1 GHz band.

4.71 Since the spectrum is being allocated on a circle basis to each operator, it is necessary to set the specific reserve price that applies to auctions proposed to be conducted in each circle. It is not just to have one reserve price across all the circles because of the variations in demographic characteristics, income levels, and telecom subscribership across the country. Consequently, the Authority had to fix a sound method on which to decide the reserve prices in different circles.

4.72 The Authority believes that most, if not all, 3G subscribers will be 2G subscribers who choose to upgrade their service. Hence, the current subscriber base in the different circles will indicate the potential market for 3G services, and hence the value of the resources that support this market, including spectrum. Thus, the subscriber base of each circle is a criterion of this value. The contribution of each circle to the national mobile subscriber base is:

| **Circle** | **Mobile subscriber base as of 31.7.2006** | **% circle subs of national** |
|---|---|---|
| Delhi | 9,871,571 | 9% |
| Mumbai | 8,767,225 | 8% |
| Chennai | 3,548,003 | 3% |
| Kolkata | 3,974,091 | 3% |
| Maharashtra | 8,565,194 | 8% |
| Gujarat | 7,936,922 | 7% |
| Andhra Pradesh | 8,897,364 | 8% |
| Karnataka | 7,969,866 | 7% |
| Tamil Nadu | 7,057,368 | 6% |
| Kerala | 5,440,043 | 5% |
| Punjab | 5,980,122 | 5% |
| Haryana | 2,468,739 | 2% |
| UP (West) | 5,205,627 | 5% |

| Circle | Mobile subscriber base as of 31.7.2006 | % circle subs of national |
|---|---|---|
| UP (East) | 6,334,477 | 6% |
| Rajasthan | 4,644,431 | 4% |
| Madhya Pradesh | 4,388,234 | 4% |
| West Bengal & | 3,082,006 | 3% |
| Himachal Pradesh | 820,958 | 1% |
| Bihar | 3,955,154 | 3% |
| Orissa | 1,933,652 | 2% |
| Assam | 1,196,332 | 1% |
| North East | 640,469 | 1% |
| Jammu and Kashmir | 975,186 | 1% |
| **National mobile subscriber base** | **113,653,034** | **100%** |

4.73 It can be seen from the above table the ratio of average percent of subscribers of Metros barring Chennai and Kolkatta and Category A vis-à-vis Category B circle including Chennai and Kolkatta, and C circles is about 15 : 8 : 3. Given that the total reserve price across the country should be approximately Rs. 1100 Crores, the Authority arrived at the reserve prices per 2 x 5 MHz in the 2.1 GHz band.

4.74 **The Authority recommends that the reserve price for spectrum auctions in the 2.1 GHz band for 2 x 5 MHz blocks of spectrum should be:**

| Circle | Reserve price (Rs. Crore) |
|---|---|
| Mumbai, Delhi, Category A | 80.00 |
| Chennai, Kolkatta, Category B | 40.00 |
| Category C | 15.00 |

4.75 The total base price at a national level including Metro, and Category A, B, and C circles would be approximately Rs. 1,050 Crores. Some of the recent examples in international spectrum allocations have an average price equivalent to Rs. 68 Crores for 2 x 5 MHz. The total revenue at a national level if all the circles are put at the same level will be approximately Rs. 1,500 Crores. The total license fee indicated by the 4th cellular entry fee was also about Rs. 1,600 Crores. Therefore, the base price determination for spectrum alone after accounting for Metros, and Category A, B, and C circles in the range of Rs. 1,050-1,100 Crores was considered fair and just by the Authority.

4.76 **The Authority recommends that:**

(1) The reserve price for the spectrum auction in different circles for each different spectrum block be set as follows:

| Reserve price in Rs. crores | Categories of circles Delhi, Mumbai, and Category A | Chennai, Kolkatta, and Category B | Category C |
|---|---|---|---|
| 2 x 5 MHz in 2.1 GHz | 80.00 | 40.00 | 15.00 |

(2) The reserve price form the minimum bidding level for the auction process. Details are provided in Annex N.

## Pricing 800 MHz spectrum

4.77 As noted earlier (¶4.42), the Authority is recommending that the spectrum allocated for 3G in the 800 MHz band should also be priced upon assignment to the desiring UASL CDMA operators. The Authority is proposing that each UASL CDMA operator should get one carrier in the 800 MHz band if it agrees to the conditions imposed. Hence, the price of this spectrum cannot be set based on some competitive process such as an auction or beauty contest.

**4.78 To overcome this problem, and to set a reasonable price for the 800 MHz band 3G carriers, the Authority recommends that the second-highest winning bid in the 2.1 GHz auction should be pro-rated to a per-2 x 1.25 MHz price. This pro-rated price should be charged as a one-time spectrum acquisition fee to each of the UASL CDMA operators who opt to be allocated one carrier in the 800 MHz band. After paying the price, the CDMA operators should be immediately assigned the carrier.**

**4.79 It should be noted here that an additional allocation on one carrier in the 800 MHz band should not be linked to the subscriber base criteria for 2G operations. This is a stand alone allocation and should not influence the allocation of carriers for voice-centric 2G services as and when operators qualify for additional carriers.**

## Pricing 450 MHz spectrum

4.80 Deployments in the 450 MHz band are especially suited for rural areas. The Authority is committed to encouraging rural roll out of 3G networks, and in the process, would ensure enhancing the financial viability and the affordability of these services in rural areas. Consequently, the Authority would like to set the price of the spectrum in 450 MHz low.

4.81 However, it is difficult to make a case to restrict 450 MHz deployments only to rural areas. Not only is this possibly damaging to the operator's business case, but will also be difficult to enforce. Therefore, the Authority cannot price this spectrum so low that urban deployments will be effectively subsidized for a subset of operators.

4.82 **In order to balance these two objectives, the Authority recommends that the spectrum in the 450 MHz band be priced at half the reserve price of the 2.1 GHz band.**

## Other spectrum fees

4.83 The auction will set the spectrum acquisition fee for the different blocks of spectrum. In addition, there are two other fees that could be levied on service providers who acquire this spectrum:

(i) A usage charge: In India, this has taken the form of an annual spectrum charge that is a percentage share of an operator's revenues. The annual charge is stepped - acquiring additional spectrum increases the percentage charge - which encourages operators to invest in infrastructure up to the point where the marginal capital expenditure is higher than the marginal annual spectrum charge. The Authority believes that this mechanism should continue, albeit with some modifications.

(ii) A hoarding cess: This cess is charged to ensure that a scarce resource like spectrum is not hoarded. Given the constraints on the availability of spectrum, it is imperative that the DoT exerts pressure on the operators to roll out services rapidly, and use the allocated spectrum to the fullest extent.

**Annual spectrum charges**

4.84 Operators pay an annual spectrum charge that depends of the quantum of spectrum assigned to them in the 800, 900, and 1800 MHz bands. In case of GSM operators, the annual charge varies from 2 to 6 per cent and in case of CDMA services, the annual charge varies from 2 to 4 per cent. The revenues of the mobile sector are increasing at a very fast pace and even with these current annual fees, the spectrum charges collected from the operators on annual basis could be substantial.

4.85 Many respondents have suggested that the Government should consider modifying the revenue share-based annual spectrum-charging scheme. For example, some comments suggested having an auction based on the annual charge,[37] reducing the AGR share to cover the costs of administration and monitoring spectrum use,[38] or reducing or setting a cap on the fee.[39] Some comments suggested continuing with the AGR-based fee.[40]

4.86 The overall response suggests that most stakeholders are in favour of some type of AGR-based revenue sharing arrangement for annual spectrum charges. However, there is also a feeling that there should be some modification or reduction in the current scheme.

4.87 In its draft strategy paper on the telecom sector, the Union Ministry of Finance emphasized the need of reducing the licensing fees burden from the present level. The paper mentioned that telecom services face multiple taxes and levies and these levies and duties on the sector are one of the highest in the world. A reduction in the absolute amount of these duties and levies will allow telecom service providers to plough-back profits into enhancement of networks and services.

4.88 The Authority believes that it is necessary to reduce the WPC fees based on AGR for all operators, irrespective of the band of spectrum in which they operate. The Authority thus recommends that the annual spectrum

[37] Comments of Rekha Jain, TTSL, VSNL, Zee Network

[38] Comments of UMTS Forum, Siddharth Sinha, Reliance, Nokia, ITU-APT

[39] Comments of MTNL, Shyam Telelink, IDEA, COAI

[40] Comments of Mahesh Uppal, India Manufacturing Foundation, Defence, BSNL, Bharti

fee should be reduced to allow operators to reinvest a larger portion of their revenue in infrastructure development, and yet allowing the licensor to cover the costs of spectrum management and administration. This will be especially useful if there will be a substantial up front fee for acquisition of 3G spectrum.

4.89 It is important to note that there is still some uncertainty about the possible penetration of 3G services in India. Even globally, the 3G subscriber base is below 5 per cent of the total mobile phone subscriber population. A high annual spectrum fee might lead to a situation where 3G operators run into losses. Another argument against charging an annual fee is that allocating spectrum via an auction will realize the full value of the resource, and hence an additional tax will only act as a drag on the sector.

4.90 However, the Authority also notes that it will be difficult to charge two different annual spectrum fees for 2G and 3G operations because it opens the possibility of arbitrage between two possibly indistinguishable revenue streams. Hence, the annual fee should remain as a percentage of the total AGR of the operator.

4.91 **Keeping these factors in mind, the Authority recommends that the DoT should have a one year moratorium on incremental annual spectrum fees for 3G spectrum from the time of spectrum assignment. After this one year, the DoT should charge operators an additional annual spectrum charge of 1 per cent of the operator's total adjusted gross revenue (AGR).**

**Spectrum hoarding cess/use incentives**

4.92 Given that spectrum is a valuable and scarce natural resource, it is important that any spectrum allocated should be used efficiently. In the cases where operators acquire spectrum but do not use it, which can be effectively labeled as hoarding, the Authority recommends a steep penalty and a 'use-it-or-lose-it' condition in the license.

4.93 It is important to recognize that any possible conniving operators might only proceed with a limited rollout in order to avoid a hoarding fine, but there are multiple ways to prevent this. For example, a minimum roll out condition can be specified in the license condition, or the issue can be resolved by including roll out plans which must be followed in the pre-qualification stage for either beauty contests or auctions. As shown in

Annex P, roll out obligations for 3G networks have been set in many countries to date. Operators who do not adhere to these roll out conditions should be fined for their non-compliance, with the fines set steep enough that they discourage the possibility of hoarding.

4.94 For example, in South Korea in July 2006, the Ministry of Communication and Information has indicated it might fine LG Telecom, which had not rolled out their proposed 3G network even five years after allocation, to the tune of 100 billion Won (US$ 105 million) in addition to forcing their CEO to resign and cancelling their 3G license.[41]

4.95 While the Government can impose fines and penalties for an operator's non-compliance with license terms and conditions, the Authority also recommends some incentives to encourage quick roll out, or even rural penetration if an operator feels it viable. One possibility is to include roll out targets in pre-qualification stages of the allocation process, and possibly refund part of the spectrum acquisition fee or reduce the level of revenue shared if an operator meets these targets. These incentives act as a self-subsidy and allow an operator to recover some of the costs associated with their roll out.

4.96 Given the aims to encourage roll out and discourage hoarding, the Authority recommends that the DoT set minimum roll out obligations for operators who acquire spectrum for 3G services. The 3G roll out criteria is addressed subsequently. **If operators do not achieve their roll out obligations, they should be given one year within which to fulfill their roll out obligations. Within this one year, the operators should be fined a spectrum hoarding cess of 2.5 per cent of their winning auction bid (i.e. their spectrum acquisition price) per quarter. If operators do not complete their roll out obligations even within this one year, their spectrum assignment should be cancelled and the spectrum allocated via an auction to a new operator.** No entity related to the defaulting operator should be permitted to participate in this auction.

[41] The Standard (Hong Kong), LG Telecom loses license, July 20, 2006, available at http://www.thestandard.com.hk news_detail.asp?pp_cat=17&art_id=23212&sid=8922469&con_type=1;
Telegeography Commsupdate, LGT abandons IMT-2000 spectrum; regulator mulls licence revocation, July 6, 2006, available at http://www.telegeography.com/cu/ article.php?article_id=13345

**Roll out obligations**

4.97 Annex P provides some examples of the roll out obligations internationally. Typically, roll out obligations are either in terms of the population coverage or area coverage. For example, an operator might be obliged to cover at least 50 per cent of all urban areas in a service area, or alternately, they might have to cover at least 25 per cent of the population of that area. In either case, the intention is to force an operator to deploy a working network and use spectrum.

4.98 In order to allow the 3G operators the opportunity to grow their networks along with their subscriber base, but yet ensuring that spectrum is used efficiently, the Authority believes that the roll out obligations should require specific minimum levels of coverage in the license areas that an operator provides 3G service using the identified spectrum bands.

4.99 From the study of worldwide 3G penetration, the Authority finds that about 5 per cent of the world's subscriber base uses 3G services. Keeping with this worldwide trend, the Authority believes that it is reasonable for Indian 3G operators to be able to attract about 5 per cent of the subscriber base within the first two years of operation. At current mobile penetration, this figure will be in the region of 3 to 5 million nationwide.

4.100 In order to allow simple monitoring of the roll out obligations, and to ensure that operators have the time to deploy their networks, especially in the initial stages, the Authority feels that roll out obligations in the 2.1 GHz band, should be as follows:

| Category of circle | At the end of 3 years | At the end of 5 years |
|---|---|---|
| Metros | - | 90% of metro area |
| A, B, and C | 30% of the DHQs or cities in the circle out of which at least 10% should be rural SDCAs | 50% of the DHQs or cities in the circle out of which 15% should be rural SDCAs |

4.101 Since spectrum in the 450 MHz band is allocated mainly for rural deployments, the roll out obligations in this band could include specific conditions to ensure that rural areas are covered by the operators. For the operators in the 450 MHz band, the roll out obligations should be as follows:

| Category of circle | At the end of 2 years | At the end of 5 years |
|---|---|---|
| Metros | - | 90% of metro area |
| A, B, and C | 20% of the rural SDCAs | 50% of the rural SDCAs |

4.102 **In the matter of roll out obligations and spectrum hoarding cess the Authority recommends that:**

(1) **Rollout obligations should be set in order to encourage operators to deploy networks and provide service quickly. These obligations should be set as given in 4.99. Specific rural area roll out obligations can be set for operators in the 450 MHz band as in 4.101.**

(2) **Operators who do not fulfill their rollout obligations should be fined 2.5 per cent of their spectrum acquisition fee as determined by their auction winning bid per quarter, until they fulfill their rollout obligations.**

(3) **If an operator does not fulfill their rollout obligation within a year of its deadline, their spectrum assignment should be cancelled.**

## License issues

4.103 The Authority recommends that the UASL and CMSP licenses should be suitably amended to reflect the roll out obligations, spectrum bands allocated, fees, and other terms and conditions relevant to 3G service provision.

# CHAPTER 5. SPECTRUM FOR BWA TECHNOLOGIES

## Background

5.1 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.

5.2 The Authority attaches high importance to the policy of allocation and pricing of spectrum for BWA technologies because:

i) BWA technologies offer a media for faster diffusion of broadband services, which wireline media is unable to match. The broadband subscriber base in the country as of August 2006 was 1.72 million, with a year-on-year growth of 180 per cent. The Broadband Policy 2004 has set a target of 20 million broadband subscribers in the country by 2010. Reaching the target will require an annual growth of about 300 per cent per year, which will in turn need a significant increase in the penetration of broadband in both urban and rural areas. Just as growth in telephony is being driven by wireless technology, the Authority expects that broadband wireless technologies will fuel a similar kind of growth.

ii) 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. Therefore, the recommendations on spectrum for 3G services should also consider the possibilities and needs of BWA systems. This would enable the telecom service provider to make well informed choice of technology.

iii) IMT-2000 technology also could meet the data speed requirements of broadband connectivity in some situations. In addition, some of the spectrum bands that are 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 holds great potential for use by BWA technologies as well.[42] There are also other IMT-2000 bands which can be used by 'beyond 3G' technologies. Consequently, spectrum allocations either to 3G or to BWA systems influence the other's growth potential and therefore, should be considered simultaneously to provide a long-term, future oriented technology neutral strategy.

5.3 The recommendations on BWA spectrum allocation and pricing focus on:

i) Identifying spectrum for use by BWA technologies;

ii) Devising a band plan that allows use by different technologies;

iii) Devising a scheme to permit both small and large scale operators to deploy BWA networks throughout the country;

iv) Price determination;

v) Technology neutral and a level playing field for different technologies, while simultaneously encouraging efficiency in spectrum use.

## Broadband in India

5.4 The penetration of Internet and broadband in India has remained relatively low despite proactive measures taken by the Government. Country has 7 million Internet subscribers as on 30.08.2006. Of these, only 1.72 million, or about 0.17 per cent of India's population, has broadband connections.

5.5 At the current growth rate, there will be about 4 million broadband subscribers by mid-2007 (Figure 10), and only about 7 million by 2010. Therefore, to achieve the target of 20 million broadband subscribers by 2010,

[42] "Specifically, we are adding a mobile allocation to the 2500-2690 MHz band to provide additional near-term and long-term flexibility for use of this spectrum, thereby making this band potentially available for advanced mobile and fixed terrestrial wireless services, including third generation ("3G") and future generations of wireless systems." See FCC, *Amendment of Part 2 of the Commission's Rules to Allocate Spectrum Below 3 GHz for Mobile and Fixed Services to Support the Introduction of New Advanced Wireless Services, including Third Generation Wireless Systems; Amendment of the U.S. Table of Frequency Allocations to Designate the 2500-2520/2670-2690 MHz Frequency Bands for the Mobile-Satellite Service*, September 24, 2001, available at http://www.fcc.gov/Bureaus/Wireless/Orders/2001/fcc01256.pdf

there is an urgent need to accelerate the growth of broadband through encouragement of emerging technologies and forward-looking policies.

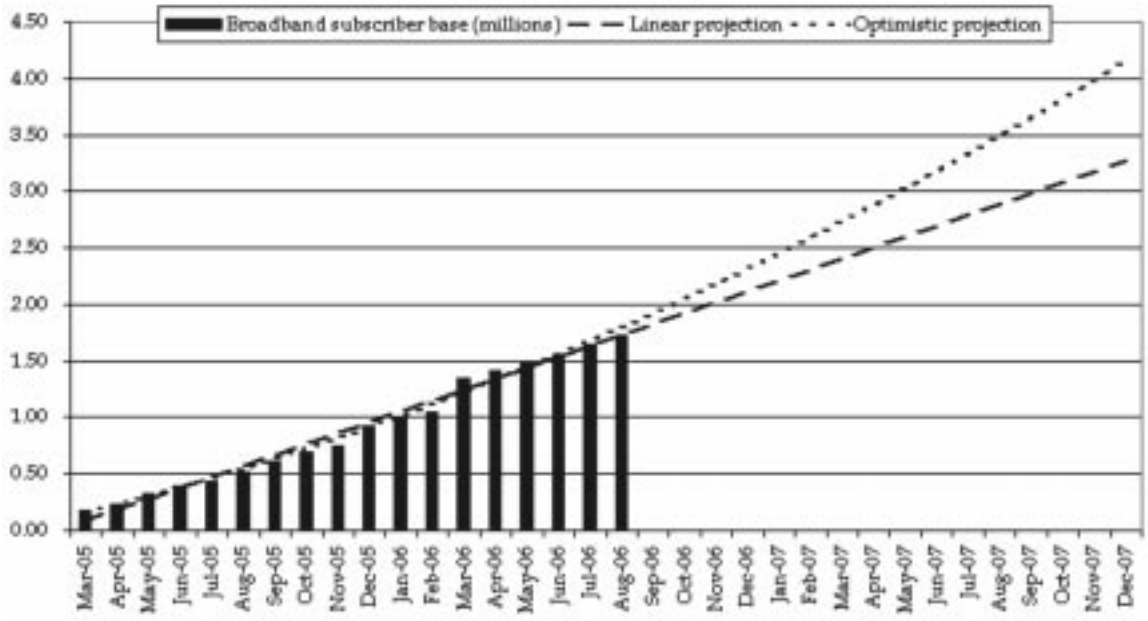


**Figure 10: Growth trend for broadband in India[43]**

5.6 Broadband subscribership around the world has been increasing over the past few years - by 2005, the worldwide broadband subscriber base was more than 150 million, up from about 15 million in 2000 - a growth of 1000 per cent in five years (Figure 11).

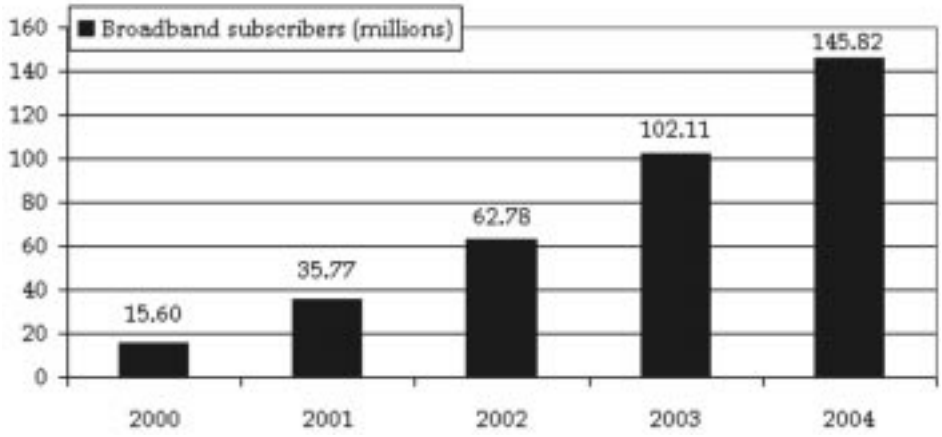


**Figure 11: Worldwide broadband subscriber growth[44]**

[43] TRAI data

[44] World Bank, World Development Indicators Database

5.7 Some of the impressive growth in the broadband space is around wireless broadband systems, which are becoming increasingly relevant in data communication. The use of wireless technologies to access the Internet has also grown, and one of the developments in wireless Internet access has been WLAN technology, especially those based on the IEEE 802.11 standards. The most popular of this family is IEEE 802.11b, better known as Wi-Fi.[45] Since its development in 1999, users have deployed more than 80,000 Wi-Fi hotspots, or public coverage areas.[46] In 2005, the European Commission has noted that there were about 120 million Wi-Fi users around the world.[47] Latest estimates suggest that more than a billion people around the world use the Internet,[48] and this means that 12 per cent of Internet users access the 'net using wireless. The European Commission has also noted that by 2008, there would be 500 million Wi-Fi users worldwide. The wireless will lead the next wave in data communication.

5.8 Given these market growth trends, the Authority is of the opinion that wireless data technologies can help boost the deployment of broadband services in India especially in rural and remote areas where wireline base has not spread. As the ITU notes, "One barrier to the growth of broadband in developing nations is the lack of the necessary underlying wired infrastructure, such as copper telephone lines and coaxial television cable. Wireless seems the most feasible short-term solution to spreading broadband in developing nations."[49] This will be similar to how the rapid growth of the telephony sector was concomitant with the introduction and growth of wireless services in India - both in the mobile and fixed segments (Figure 12).

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[45] Sandvig, C., An initial assessment of cooperative action in Wi-Fi networking, Telecommunications Policy Vol. 28, 2004, p. 579–602; Bar, F. & Galperin, H., Building the Wireless Internet Infrastructure: From Cordless Ethernet Archipelagos to Wireless Grids, Communications & Strategies, No. 54, 2004, p. 45-68

[46] http://www.researchandmarkets.com/reports/c33422

[47] http://europa.eu.int/rapid/pressReleasesAction.do?reference=IP/05/929&format=HTML&aged=1&language=EN&guiLanguage=en

[48] http://www.internetworldstats.com/stats.htm

[49] ITU, *Measuring the Information Society, World Information Society Report, 2006*, available at http://www.itu.int/osg/spu/publications/worldinformationsociety/2006/report.html

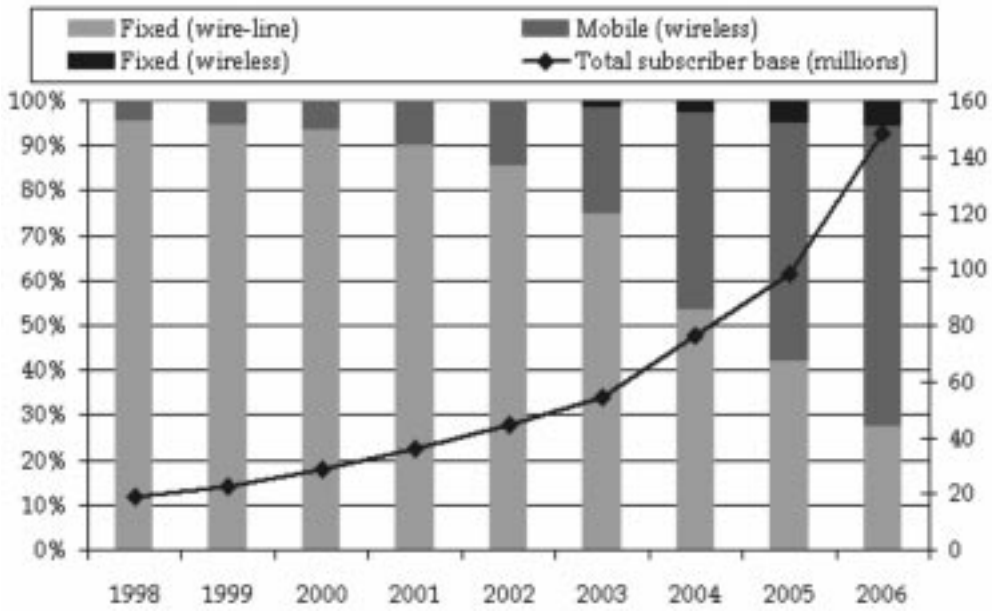


**Figure 12: Growth in telephony is dominated by wireless in both fixed and mobile[50]**

5.9 Thus, in addition to 3G technologies, the Authority believed that it should also look into other wireless data communication systems, and specifically broadband wireless access (BWA) technologies to accelerate the growth of telephony and data services in India. Given its significance, the Authority has decided its powers to make recommendations suo moto, on spectrum issues related to BWA technologies as per provisions of Sec 11 (1) (a) (viii) of TRAI Act.

## Broadband Wireless Access (BWA) technologies

5.10 India's Broadband Policy of 2004 defines broadband services as "an 'always-on' data connection that is able to support interactive services including Internet access and has the capability of the minimum download speed of 256 kilo bits per second (kbps) to an individual subscriber from the Point Of Presence (POP) of the service provider."

5.11 There are a number of BWA technologies. This includes the IEEE standards families of 802.16 and IEEE 802.20, and mobile technologies such as HSPA, WCDMA, and EV-DO.[51] Within these IEEE standards families, there are number of different technologies in development or currently existing, including WiMax, WiBro, Flarion, iBurst, RipWave, and IPWireless, with

[50] TRAI data

[51] Comments of Mahesh Uppal, SIFY, Interconnect Communications, Qualcomm

other potential technologies in the future. These technologies use different modulation techniques and access schemes, and have different bands of operation with different channel width requirements. However, since TRAI is a technology neutral regulator, these recommendations are not technology specific and consider the entire current and future range of BWA technologies.

5.12 During the consultation process, the respondents stated that there are various versions of BWA technology applications. The Authority also recognizes that given the wide range of possible technologies, it is essential that any policy concerned with identification and allocation of spectrum for BWA must be technology-neutral and flexible to permit co-existence of all types of BWA technologies. This approach is similar to that followed by regulators in USA, Australia, UK, Singapore, and Hong Kong. For example, the Wireless Broadband Access Task Force of the Federal Communications Commission (FCC) in the USA has recommended the speedy deployment of BWA services in the US leaving technology decisions to the market.[52] This Authority similarly believes that the market is the best decision maker about the deployment, success, and spread of different technologies.

5.13 During the consultation process, it became clear from respondents' inputs and comments that some globally harmonized bands are especially suited for the deployment of BWA technologies, based on standardization processes, the availability of equipment, planned or operational deployments, and propagation and throughput characteristics. **In addition to these bands, some operators have been already assigned spectrum in 3.3-3.4 GHz band in a number of cities (See Annex Q).** Consequently, the Authority considered the following bands for BWA systems:

- 700 MHz
- 2.3 - 2.4 GHz
- 2.5 - 2.69 GHz
- 3.3 - 3.4 GHz
- 3.4 - 3.6 GHz
- 5.15 GHz - 5.35 GHz
- 5.725 GHz - 5.875 GHz

[52] http://hraunfoss.fcc.gov/edocs_public/attachmatch/DOC-256694A1.pdf

5.14 Before deciding about bands to be recommended for allocation for BWA deployments, it was necessary to estimate the spectrum requirements of eligible operators. Based on this estimate, it will be possible to identify the required spectrum in a combination of these bands.

## Spectrum requirements for BWA

5.15 As an initial exercise, the Authority estimated spectrum requirements for the city of Mumbai for 2007 and 2010 to understand how growth in broadband subscribership might affect the demand for spectrum. The targets for subscribership were based on the DoT's Broadband Policy of 2004, specifically, that nation-wide there would be 9 million broadband subscribers in 2007 and 20 million in 2010.

5.16 The city of Mumbai was chosen because it has the highest population density in the country; therefore, data throughput per unit area will be the highest in this city. Data throughput per user was assumed as 256 kbps, and the other assumptions used for the estimate were:

| Parameter | 2007 | 2010 |
|---|---|---|
| Mumbai population | 16,800,000 | 19,448,100 |
| Mumbai broadband subs (% Indian broadband subs) | 20% | 10% |
| BWA subs (% of broadband subs) | 40% | 50% |
| BWA subs in Mumbai | 720,000 | 1,000,000 |

5.17 The detailed calculations (Annex R) show that in 2007, Mumbai's BWA operators will need a total of 186 MHz to accommodate their subscribers. By 2010, the increase in the number of subscribers will require 258 MHz to be allocated for BWA deployments. The Authority used these figures as approximations, because the precise number of subscribers, the spectral efficiency of technologies, and the deployment strategies are all variables that cannot be accurately predicted. **In order to ensure that sufficient spectrum is available for BWA systems, the Authority recommends that at least 200 MHz of spectrum should be made available for BWA to accommodate growth requirement until 2007, and 300 MHz of spectrum should be earmarked by 2010.**

5.18 Given these requirements, the Authority has identified the bands where the DoT could make allocations in the required timeframe. Of the bands mentioned, some are available now, while some might take time to be vacated from existing users or might not be available for use in the near future.

## Spectrum allocation for BWA use

*A. 700MHz*

5.19 The 700 MHz band is ideal for providing wireless service in low population density regions, such as rural India, due to its better coverage characteristics. This band is gradually becoming a target resource for rural broadband wireless access worldwide. Network deployments in the 700 MHz band will have larger areas of coverage with fewer base stations. This will reduce capital expenditure, which makes deployment in rural or high-cost regions economically viable. In its recommendations on 'Growth of Telecom Services in Rural India,' the Authority has recommended that the DoT should allocate this band for use by advanced wireless technologies for rural connectivity.

5.20 During the consultation process, mobile operators stated that many countries have used the 700 MHz band for enhanced mobile services such as mobile TV. Therefore, they suggested that it would not be desirable to consider this band for any other terrestrial wireless system. Mobile operators further stated that this band was not in use for BWA deployment because equipment was not yet available for operation in this band.

5.21 In India, Doordarshan uses this band for connecting outdoor broadcast vans to their studios. In addition, other users have deployed both fixed and mobile networks in this band. Coordination with or vacating the incumbent users of this band is time consuming. Consequently, this band is not likely for immediate BWA deployments. **However, the Authority recommends that the DoT should coordinate some part of this spectrum for making it available for rural wireless networks in the near future.**

*B. 2.3-2.4 GHz band*

5.22 Many developed countries viz. Australia, Singapore, USA, Canada, and South Korea have allocated the 2.3 GHz band for use by BWA systems. South

Korea has allocated this band to WiBro (Wireless Broadband), which is a portable Internet service with a user data rate of over 1 Mbps for users moving at speeds up to 60 kmph.[53] Since this band is lower than 3 GHz, the propagation characteristics makes for lower capital expenditure associated with network deployment. In addition, lower operating frequencies for the mobile terminal result in lower power requirement for a given propagation distance. As a result, this band is more suitable for mobile broadband wireless access than other higher frequency band, e.g. 2.5 GHz or 3.5 GHz.

5.23 During the consultation process, many stakeholders advocated opening of this band for BWA use because of its suitability, especially for mobile applications. However, a number of captive users like State electricity boards, power utilities, oil companies, the railways, and security organizations have deployed microwave links in this band. As per information provided by the WPC, there are around 100 links operating in this band throughout the country. Keeping in view the large number of existing assignments and deployment in this band, vacation or re-farming of the band may require significant time and financial compensation. It will require coordination with a large number of users, and making this band available for BWA deployments in a short period may not be feasible.

5.24 **Keeping in mind the suitability of this band for BWA applications and the need for additional spectrum later, the Authority recommends that DoT should plan to vacate/re-farm this 100 MHz band from the existing users by end-2007 and allocate it for BWA services.**

*C. 2.5-2.69 GHz band*

5.25 Many countries, including the United States, Brazil, Mexico, Singapore, Japan, Hong Kong, and Canada, have identified and allocated the 2.5 GHz band for all types of wireless systems. The ITU's Radio Regulations identify this band as an extension band for IMT-2000 and beyond.

5.26 The status of existing assignments in this band in India are as follows (Figure 13):

[53] Hong, D., 2.3 GHz Portable Internet (WiBro) for Wireless Broadband Access, ITU-APT Regional Seminar 2004

- 2.500-2.520 GHz paired with 2.670-2.690 GHz is being used for mobile satellite service (MSS),
- 2.520-2.535 GHz paired with 2.655-2.670 GHz is proposed for MSS,
- 2.535-2.550 GHz and 2.630-2.655 GHz are being used for Local Multichannel Distribution system (LMDS) and Microwave multichannel Distribution System (MMDS) applications, and
- 2.550-2.630 GHz is being used for broadcasting satellite service (BSS) in India by DoS.


**Figure 13: Current 2.5 GHz band allocations in India**

5.27 During the consultation, a number of stakeholders commented that the ITU has identified this band as an extension band for IMT-2000. They expect that the next step in evolution of mobile technologies will first be deployed in this band. A number of stakeholders, including mobile operators and equipment vendors requested that the DoT should keep this band reserved for the future growth of IMT-2000 systems since currently available spectrum will not be sufficient for growth.[54] Some stakeholders opined that this band should be technology neutral or that it should be available both for BWA and for IMT-2000 systems.[55] It is pertinent to mention here that the footnote 5.384A of the radio regulations of the ITU, and WRC 2000 Resolution 223 identifies the 2500-2690 MHz band on a non-exclusive basis for IMT-2000.[56] Another respondent

[54] Comments of COAI, UMTS Forum, Bharti, BSNL, CDG, Qualcomm, Nokia, Ericsson, Mr. B K Syngal, and Zee

[55] Comments of Defence forces, ITU-APT, Intel, Mahesh Uppal, SOMA Networks, Interconnect Communications, Professor Arogyaswami Paulraj, ISPAI

[56] Footnote 5.384A states that, "The bands, or portions of the bands… 2500-2690 MHz, are identified for use by administrations wishing to implement International Mobile Telecommunications-2000 (IMT-2000) in accordance with Resolution 223 (WRC-2000). *This identification… does not establish priority in the Radio Regulations*." [Emphasis added]

[57] Comments of Sify

informed us that no 3G equipment was expected in this band for the next few years,[57] although an equipment vendor indicated that they were planning to release equipment in this band by end-2007.

5.28 It is clear that there is significant debate about the future status of this band in India. Both BWA and IMT-2000 systems seek to use it, and the space program has significant allocations in it. All these uses are potentially important, and therefore, the Authority believes that to ensure use of this band in the future, it will be essential to vacate incumbents that are not using this valuable spectrum efficiently and effectively.

5.29 **Consequently, the Authority recommends that the DoT should initiate the process to vacate portions of the 2.5 - 2.69 GHz band that might not be in use at this time, or which have marginal uses limited in nature. Specifically, the Authority recommends that the 40 MHz in use for LMDS and MMDS (2.535-2.550 GHz and 2.630-2.655 GHz) be vacated or re-farmed by end-2007, and that an additional 40 to 80 MHz be coordinated with Department of Space (DoS) in the same timeframe. This spectrum should be earmarked for wireless telecommunications systems, and the Authority will recommend the precise allocation at a later stage depending on technological developments and market demand.**

*D. 3.3-3.4 GHz*

5.30 The Authority believes that the 3.3 GHz band is suitable for providing BWA services. However, it was informed by WPC that this band of 100 MHz has been already assigned to seven ISPs in FDD mode. The WPC has assigned this spectrum on city basis as shown in Annex Q. The annual usage charge for this spectrum is based on the MCW formula, which depends on the bandwidth, number of carriers, and distance, and no roll out obligations or the need for rural coverage was specified while assigning this spectrum. The Authority has already commented in Chapter 2 regarding an urgent need for taking a holistic view of the overall procedure for spectrum allocation, pricing, and subsequent monitoring and management.

5.31 As stated earlier, the Authority views BWA as an efficient means for faster broadband deployment in both urban and rural areas. Urban areas will

gain from the introduction of BWA systems in any case, because cities and major towns will be possibly the first target for BWA deployment. However, the Authority is concerned about the roll out of broadband services in rural areas. As a consequence, it will be necessary to encourage operators to roll out both in urban and rural areas, which can primarily be done via roll out obligations embedded in the relevant license. Further, because of lower wireline tele-density in rural areas in comparison to urban areas, the roll out of BWA technologies in rural areas becomes more significant. These obligations can only be set and be meaningful if allocations are done at the circle-level, which include both rural and urban areas, unlike city-level allocations. Therefore, the Authority strongly is of the view that the allocations for BWA should be at circle level.

5.32 Additionally, circle-level deployments will enable roll out in rural areas because:

(1) Meaningful roll out obligations can be set for rural areas,

(2) The economies of scale due to a larger service area will enable lower costs for operators and business viability due to an increased subscriber base, and

(3) This mixed urban and rural subscriber base would make a better business case than a purely rural subscriber base.

5.33 The present assignments in the 3.3-3.4 GHz band are only for some specific cities. Having both city level and circle level operators will violate the level playing field. In order to maintain the level playing field among all operators for BWA services, the Authority recommends that the operators who have spectrum assignments in the 3.3-3.4 GHz band should be given a choice to migrate to circle based service area. In doing so, these operators will be required to accept a fresh set of conditions relating to rollout and annual spectrum charges, pay an upfront one-time spectrum acquisition fee, and begin operations at circle level. Such scheme for migration and rationalization is discussed subsequently. Here it is important to mention that present allocation of spectrum has been done based on Frequency Division Duplex (FDD) mode whereas all emerging and new technologies are based on Time division duplex (TDD) mode due to better spectral efficiency and flexibility. As such it is expected that most of the operators who have been allocated spectrum for BWA services in FDD mode may like to migrate to TDD based systems.

**5.34 Keeping these factors in mind, the Authority recommends that operators with current spectrum assignments in the 3.3-3.4 GHz band should be given the option to migrate to circle-wide operations by December 2006, and the DoT should then allocate this spectrum for BWA technologies as discussed subsequently.**

*E. 3.4-3.6 GHz band*

5.35 During the consultation process, it became obvious that the 3.5 GHz band was by far the most recommended for broadband wireless deployments. While many stakeholders recommended this band for BWA, only one suggested that allocating this band would be problematic.[58]

5.36 One of the major reasons given in favor of this band was that there was sufficient economy of scale in equipment availability around the world. For example, Canada has made allocations in this band, and more than 70 per cent of Europe's and Central and Latin America's BWA licenses are in this band.[59]

5.37 The DoS has informed the Authority that the lower extended C band from 3.4 to 3.7 GHz is being used for INSAT satellite for television reception. As per the DoS, "use of these bands for terrestrial application... has to be technically coordinated after detailed space-terrestrial system interference analysis." They have undertaken a study of these aspects and findings are expected shortly.

5.38 The DoS has 300 MHz of spectrum from 3.4 to 3.7 GHz. The Authority firmly believes that 100 MHz in the 3.4-3.6 GHz band can be coordinated for broadband wireless deployments around the country to assist in the national communication infrastructure growth.

5.39 **The Authority recommends that the DoT should get 100 MHz for broadband wireless applications in the 3.4 - 3.6 GHz band, coordinated with DoS urgently and make appropriate allocations.**

[58] Comments of Satellite Association

[59] Comments of Maravedis

### *F. 5.15-5.35 GHz and 5.725-5.875 GHz bands*

5.40 Various countries around the world have recognized the 5.150-5.350 GHz and 5.725-5.875 GHz bands as delicensed bands, allowing the use of these bands by terrestrial wireless systems on non-interference, non-protected, and non-exclusive basis.

5.41 India has also delicensed the 5.15-5.35 GHz and 5.725-5.875 GHz bands for indoor use and the Authority has already recommended de-licensing of these bands for outdoor usage also. De-licensing these bands for out door usage will help in increasing the penetration of wireless technologies with little or no regulatory burden. It will also allow small-scale entrepreneurs to deploy wireless networks at a significantly low cost. It is important to note here that the use of unlicensed spectrum in the 2.4 and 5 GHz bands is one of the major reasons for the success of Wi-Fi around the world. The availability of delicensed bands will also provide a space for innovation in wireless systems, spurring indigenous R&D.

5.42 **The Authority recommends allowing use of the 5.15-5.35 GHz and 5.725-5.875 GHz bands on a technology neutral, non-protected, non-exclusive basis as delicensed bands in also the outdoor deployments of terrestrial wireless technologies.**

**Recommended spectrum allocations for BWA**

5.43 Based on the foregoing, the Authority recommends that the DoT should:

(1) **Coordinate some part of 700 MHz spectrum for making it available for rural BWA networks in the near future.**

(2) **Plan to vacate/re-farm the 2.3 GHz band from the existing users by end-2007 and allocate it for BWA services.**

(3) **Initiate the process to vacate portions of the 2.5 - 2.69 GHz band that might not be in use at this time, or which have marginal uses limited in nature. Specifically, the Authority recommends that the 40 MHz in use for LMDS and MMDS (2.535-2.550 GHz and 2.630-2.655 GHz) be vacated or re-farmed by end-2007, and that an additional 40 to 80 MHz be coordinated with Department of Space (DoS) in the same timeframe. This spectrum should be earmarked**

**for wireless telecommunications systems, and the Authority will recommend the precise allocation at a later stage depending on technological developments and market demand.**

(4) **Operators with current spectrum assignments in the 3.3-3.4 GHz band should be given the option to migrate to circle-wide operations by December 2006, and the DoT should then allocate this spectrum for BWA technologies as discussed subsequently.**

(5) **Get 100 MHz for broadband wireless applications in the 3.4 - 3.6 GHz band, coordinated with DoS urgently and make appropriate allocations.**

(6) **Allow use of the 5.15-5.35 GHz and 5.725-5.875 GHz bands on a technology neutral, non-protected, non-exclusive basis as delicensed bands in also the outdoor deployments of terrestrial wireless technologies.**

(7) **Allocate these specific bands or sub-bands for BWA on a technology neutral basis.**

**The quantum of spectrum to be allocated**

5.44 Based on the foregoing, the Authority recommends immediate measures for allocation of a total of 200 MHz for BWA systems on a technology neutral basis, and an additional future allocation of 100 MHz for these systems.

5.45 The quantum of spectrum allocation to operators should be optimized to ensure efficient utilization of spectrum on one hand and adequate spectrum availability to service providers on the other hand so as to deploy their network efficiently, using the technology of their choice.

5.46 The quantum of spectrum allocated per operator and the number of operators are inter-related because the amount of available spectrum is limited. In order to facilitate the growth of BWA technologies, the Authority is of the view that there should be sufficient number of BWA operators, and each service provider should have adequate spectrum.

5.47 To assess the quantum of spectrum that should be allocated per operator for BWA technologies, the Authority estimated the spectrum requirements for the city of Mumbai, and found that for one operator, 15 MHz would be

sufficient to provide broadband wireless service (Annex R). This calculation was also based on the assumptions outlined in 5.16 for 2010. In other service areas with comparatively low population density, the service providers are expected to be in a more comfortable position with spectrum allocation of 15 MHz per service provider.

5.48 During the consultation, most of the stakeholders suggested through their written comments that around 20 MHz of spectrum is required for efficient network deployment and business viability. In the subsequent discussions during the consultation process, some of the stakeholders opined that at least 15 MHz should be allocated per operator keeping in mind the throughput requirements of possible applications. Taking into consideration above fact, the Authority is of the view that 15 MHz spectrum should be allocated per operator, at this stage.

5.49 It is reasonable to expect that major ISPs and UASLs or CMSPs including PSU operators will be interested in offering wireless broadband services to their customers. There are around five major mobile operators in each service area. For the quarter ending March 2006, 153 Internet Service Providers were operational with subscriber base of 7.00 million as on August 2006. The details of the market shares of top 10 ISPs is shown in Annex S.

5.50 From this, it can be clearly observed that top 10 ISPs have market share of more than 95%. It is also pertinent to note that amongst these top 10 ISPs some of the large ISPs or their parent companies also have UASLs or CMSPs licenses (e.g. Bharti Infotel, Reliance Infocomm, BSNL, etc.) in the same service area. In view of above and keeping in mind the amount of likely available spectrum the Authority is of the view that at present 13 service providers should be allocated BWA spectrum and the quantum of spectrum to each service providers should be 15 MHz.

5.51 In addition to the major players, it is feasible that some smaller ISPs might also seek to provide BWA services in their respective areas of operation. Keeping the above in mind, the Authority feels that allocating BWA spectrum to the licensees having significant business plan and impressive performance record will be positive for competition, assist in diffusion of broadband, and give sufficient opportunity to a variety of operators to offer advanced wireless services.

5.52 Based on the above, the Authority feels that 15 MHz spectrum should be the allocated to an operator for BWA services. This will ensure competitive provision of BWA services, bringing benefits to the Indian market place just as in mobile telephony. This point of view was also echoed by the majority of stakeholders.

5.53 **The Authority therefore recommends allocation of the 200 MHz of spectrum in the 3.3-3.4 GHz and 3.4-3.6 GHz bands to 13 operators in contiguous blocks of 15 MHz each. The Authority will make recommendations about future allocations of spectrum in bands such as 2.3 GHz, 2.5 GHz, or 700 MHz, as and when these bands are made available.**

**Identifying BWA operators and their geographic area of operation**

5.54 In the current licensing regime, unified access service license (UASL) holders, cellular mobile service providers (CMSPs), and internet service providers (ISPs) can offer broadband services.[60] Therefore, all of these types of licensees could potentially qualify as BWA operators.

5.55 As has been discussed in 5.31-5.32, the Authority believes that circle-level deployments of BWA networks will drive rural and urban penetration. Keeping in mind the needed scale, economic ability and the current distribution of internet subscriber base among various operators, the Authority considers that a large part of spectrum may be used by large ISPs but Authority still believes that small ISP should also be able to make their contribution in the growth of BWA. **The Authority recommends that the large part of BWA spectrum as identified should be allocated among UASLs, CMSPs, or Category A and B ISPs for circle level deployments.**

[60] UASL Clause 2.2 (a) (i) or CMSP clause 2.1 (a) "Access Service Provider can also provide Internet Telephony, Internet Services and Broadband Services"; ISP License Definition Schedule C.24 "SERVICES or SERVICE means all types of Internet Access/content services except telephony on Internet."

5.56 Simultaneously, there is some scope for smaller players to deploy BWA networks. Indeed, local operators such as Category C ISPs might drive deployment of BWA networks in much the same way as local cable operators have contributed to the spread of cable television in rural India. The Authority recognizes that some local operators might be interested in offering BWA services. However, the Authority believes that a significant number of the smaller ISPs might not be able to acquire spectrum or deal with the associated regulatory overheads. The Authority is interested in encouraging rural and urban roll out by ISPs, and thus feels that this one block of spectrum should be allocated to ISPs only in SSAs or cities where the population is less than one million. Given the localized nature of these networks, the WPC can coordinate these deployments on a case-by-case basis to ensure interference free operation. **The Authority recommends that one block of spectrum should be allocated to Category A, B, and C ISP licensees in cities or SSAs with population less than one million.**

5.57 **Following the above, the Authority recommends that:**

(1) **The DoT should allocate 12 blocks of 15 MHz each among UASLs, CMSPs, and Category A and B ISPs at the circle level following the allocation mechanism discussed subsequently,**

(2) **One block of 15 MHz spectrum should be allocated to ISPs who may use this block to deploy networks in cities or SSAs with population below one million. The WPC should coordinate these assignments to ensure interference-free operation.**

## Term of the spectrum use rights

5.58 As recommended above, broadband access providers will be UASL and CMSP licensees, or ISPs. Telecom licenses are for a term of twenty years, but the WPC used to issue wireless telegraphy operational licenses (spectrum license), required to use the spectrum on a yearly basis. Only recently, the WPC has changed the duration of the wireless operation license from one year to five years.

5.59 BWA technologies are new in the market, and the Authority's emphasis is on encouraging the quick and cost-effective deployment. A one-time entry

fee for a 20-year spectrum license might be difficult for some operators to pay upfront, and is contrary to the goal of keeping the cost of these services low. Viewing the above, it is recommended that the term of spectrum use rights for BWA should be five years, renewable up to 20 years subject to the fulfillment of the spectrum license terms and conditions.

5.60 **Based on the foregoing, the Authority recommends that BWA spectrum licenses should be for five years duration, renewable up to 20 years upon payment of the spectrum acquisition fee every five years, and satisfaction of the relevant license terms and conditions.**

## Rationalization scheme

5.61 As pointed out in 5.30, the WPC has already assigned the 3.3 GHz band for among some of the major ISPs. The Authority is recommending that allocations in this band should be on a circle-wide basis, and should be charged a one-time entry fee, as well as an annual spectrum charge that will be based on adjusted gross revenue as opposed to the MCW formula.

5.62 To maintain a level-playing field between all operators it is imperative that BWA operations are for the same license area, i.e. circles. This is especially important since the Authority envisions that use of BWA as a way to bridge the digital divide in rural areas, and has recommended roll out obligations to go with the circle level operations. It will be unfair to have one set of operators serving only the high-end or urban subscribers without these roll out obligations, while another set, due to no fault of theirs except that they did not seek spectrum early, should have to follow strict roll out obligations. The only exception to this will be only small ISPs who will operate in areas limited to cities or SSAs.

5.63 In order to level the playing field, the Authority recommends the following, and a diagrammatic representation of the process is in Figure 14:

(1) The operators currently assigned spectrum in the 3.3 GHz band shall be given the option to migrate to circle-level operations and the attendant 15 MHz of spectrum within the 3.3-3.4 GHz band at a fixed acquisition fee as determined. The operators who do not choose to migrate to circle level will have to surrender their spectrum. The

operators who choose to continue operation in this band will not be able to obtain spectrum in the 3.4-3.6 GHz band. This option is important because some of the operators with spectrum assigned in the 3.3 GHz band might have made investments or even begun deployments in this band. It will be unfair to them to ask them to write-off these investments, and hence, the Authority believes that they should have the option to continue with their plans in this band.

(2) Operators in 3.3-3.4 GHz who wish to move to the 3.4-3.6 GHz band will have to surrender their current spectrum and participate in the allocation process.

(3) Other operators who wish to acquire spectrum in the 3.3-3.4 GHz or 3.4-3.6 GHz bands should participate in the allocation process.

(4) If the operators currently assigned spectrum in the 3.3-3.4 GHz bands do not wish to move to the circle-level, they should be asked to vacate the spectrum.

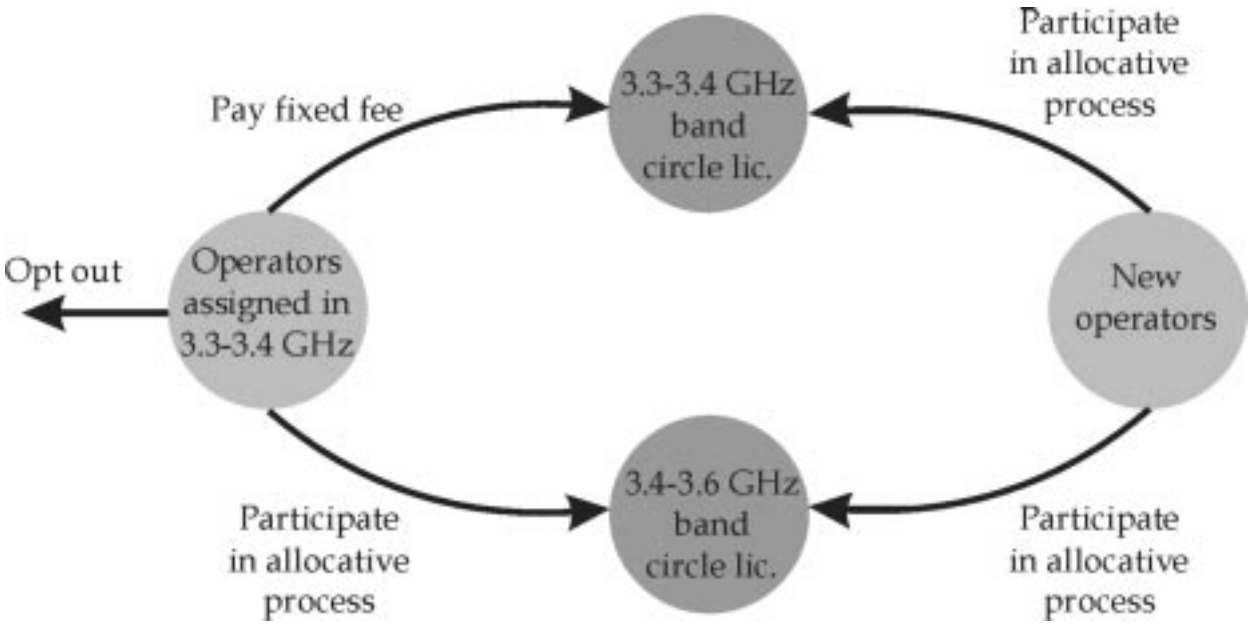


**Figure 14: Possible paths for operators who seek BWA spectrum**

5.64 **The Authority thus recommends that the DoT should allow operators to choose which path they wish to follow as described in 5.63 in order to obtain circle-wide BWA spectrum.**

## Allocation mechanism

5.65 The number of 15 MHz blocks available for circle-wise BWA deployment is 12. The Authority anticipates that for most circles, this should be sufficient to meet demand. To recap, this is because in most circles, there are about 10 to 12 cellular operators /UASLs and major Category A and B ISPs combine together. However, in some circles it is possible that the number of operators who wish to provide BWA service exceeds the number of available slots. In that case, there will be a need for phased allocation to select the operators who should be allocated spectrum in the first slot.

5.66 As explained in detail with respect to allocation of spectrum for 3G services (¶4.47), the Authority believes that if demand is greater than supply, an auction will be the fairest and most transparent allocation method for BWA spectrum.

5.67 As stated earlier, some of the operators currently assigned spectrum in the 3.3 GHz band might choose to continue in that band, and seek to operator circle-wide. These operators should be allocated preferable one contiguous block of 15 MHz spectrum that enables TDD operations at a determined fee, which is equal to the reserve price of the auction. The number of blocks available for the auction will thus be equal to 12 - {number of 3.3 GHz operators who choose to continue in 3.3 GHz}.

5.68 In addition to the circle-wise allocations, one block will be allocated for local use, i.e. for one SSA to Category C ISPs. **The Authority recommends that the DoT use a first-come first-serve allocation mechanism for this one block of spectrum.**

## Auction Process

5.69 The Authority notes that the conditions of allocation of spectrum for circle-wide BWA operations are very similar to the conditions in the Phase II FM radio auctions conducted by the Ministry of Information and Broadcasting recently (¶4.52). **Hence, the Authority recommends that the DoT should organize a one-stage sealed bid auction for every circle to allocate BWA spectrum for circle-wide licensees.**

5.70 The process of this auction can be as follows:

(1) The number of blocks available is n, which is equal to 12 minus the number of 3.3 GHz operators who seek to continue in 3.3 GHz.

(2) All interested parties should submit their bids.

(3) If the number of bids is greater than n, the spectrum should be allocated to the bidders who have offered the top n bids above the reserve price for the circle, at their bid price.

(4) If the number of bids is less than or equal to n, the spectrum should be allocated to all bidders who have offered bids above the reserve price, but at the reserve price only.

(5) The winning bidders should be called in decreasing order of their bids to choose the blocks of spectrum that they wish to acquire.

## Setting the reserve price

5.71 The primary aim of the Authority in recommending a reserve price for BWA spectrum in India is that the spectrum should be affordable to allow all interested and qualified operators to acquire it, while at the same time, dissuade non-serious players and also to encourage efficient use and roll out.

5.72 Internationally, it is seen that except for South Korea, there is not much variation in the entry price paid for BWA spectrum around the world (Annex T).[61] The average price for allocations comes to $0.65 (Rs. 30) per Hz including South Korea, and $0.08 (Rs. 3.75) per Hertz excluding South Korea. Keeping in mind the objective of affordability, the Authority feels that it would be prudent to price spectrum at a reasonable rate, closer to the average excluding South Korea.

5.73 In order to fix a price based on the spectrum charging for LMDS, MMDS, or microwave services, the Authority used the MCW formula to estimate the royalty payments for spectrum. The Authority used the MCW values for a typical deployment and found that the royalty (R) per base station

[61] Comments of Maravedis ¶3.3.3

will be Rs. 288,000 if one excludes the license fee per consumer premises equipment (CPE).

5.74 According to our calculations, the number of base stations in a city like Mumbai come out to at least 60. Thus, the total annual payable royalty is Rs. 175 lakhs. At a discount rate of 5 per cent over 5 years, the net present value of this royalty payment is Rs. 7.6 Crores.

5.75 Given that the intention in charging a spectrum acquisition fee is to dissuade non-serious players and not to extract rent, the Authority was inclined to set the price of spectrum low. In addition, the intention is to encourage rural roll out, and hence, the spectrum acquisition fee could be used as a part of the incentive for completing the roll out. **Consequently, the Authority recommends that the effective spectrum acquisition fee for Metros should be Rs. 10 crore, in addition to a performance bank guarantee of Rs. 5 crore that will be released upon successful completion of the roll out obligations.**

5.76 Keeping the ratio of the price of spectrum in Metros, Category A, B, and C circles the same as in 3G (4.76), the reserve price for 15 MHz of BWA spectrum in different circles will be as follows:

| Circle | Reserve price (Rs. Crores for 15 MHz) | Performance bank guarantee (Rs. Crores) |
|---|---|---|
| Metros & A | 10 | 5 |
| B | 5 | 2.5 |
| C | 2 | 1 |

**Table 10: Recommended reserve price for BWA spectrum**

5.77 **The Authority recommends that the BWA spectrum in the 3.3-3.4 GHz and 3.4-3.6 GHz bands should have a reserve price and performance bank guarantee as noted in ¶5.75.**

5.78 **The Authority recommends that the performance bank guarantee should be collected at time of spectrum allocation and refunded upon fulfillment of the roll out obligations as discussed subsequently.**

5.79 For the networks deployed in SSAs, the Authority would like to price spectrum at a lower cost. This will encourage use in smaller areas. However, the price of spectrum should reflect its value and scarcity, and the Authority wants to prevent non-serious players from acquiring spectrum. **Therefore, for the BWA spectrum block to be assigned to Category C ISPs at the SSA level, the Authority recommends that the price of the 15 MHz should be Rs. 25 lakh per SSA**

## Annual spectrum fees

5.80 In addition to the acquisition fee, the WPC typically charges an annual spectrum fee. For cellular telephony, this annual spectrum fee is calculated based on percentage of adjusted gross revenue (AGR). At present, non-telecom operators have to pay annual spectrum fees in the form of a royalty that is calculated based on the MCW formula, where the distance of a link, number of channels, and the channel separation determine the royalty amount. This royalty is multiplied by the number of transmitters (or BTSs) and is charged annually.

5.81 These recommendations on BWA spectrum are for circle level deployments, and in a circle, the operator will have many BTSs. The number might be in the hundreds, which will increase the royalty per operator per circle to a large sum. Further, the royalty will increase with the deployment and coverage, which burdens operators as they seek to fulfill roll out obligations. **Therefore, in accord with the move to circle-wide operation, the Authority recommends that the annual spectrum fee charged to BWA operators should be based on a percentage of AGR.**

5.82 The Authority has three concerns regarding the setting of the annual spectrum fee for BWA spectrum:

(1) One of the main objectives in keeping the spectrum acquisition fee low was to encourage the deployment and roll out of BWA networks around the country. It is thus logical to set annual spectrum fee low as well, especially since BWA operators will have significant capital investments to make and might not be in a position to pay high annual spectrum fees as soon as they begin service. Hence, the Authority would like to recommend that the annual spectrum fee should be low.

(2) However, if annual fees for BWA spectrum are lower than the slabs defined for cellular telephony spectrum, it opens the possibility for arbitrage. This is a concern because using BWA technologies cellular operators can offer VoIP services on a mobile platform and pay less in spectrum use fees. It will be difficult to segregate the subscribers and consequent AGR within the operation making the collection of AGR on cellular telephony even more complicated than it already is. The Authority recognizes that this possible arbitrage is damaging to the structure of the industry and undermines regulation.

5.83 Keeping these concerns in mind, the Authority could recommend that the BWA operators should pay the same AGR share as the cellular operators. However, this level of annual fee is high and might harm the potential for growth, especially since it may act as an additional burden on subscribers. In order to avoid or overcome this situation, **the Authority recommends that the DoT should not charge an annual spectrum fee for the first year of operation of the BWA network. After this one year, the DoT should charge an annual fee of 1 per cent of AGR, which should be added to current applicable slot of spectrum fee that the operator is currently paying.**

## Roll out obligations

5.84 The DoT has to ensure that operators are using allocated spectrum efficiently, and hence, it is important to impose some minimum obligation to prevent hoarding or inefficient use. In order to encourage quick roll out of BWA networks, the Authority believes that it should have an incentive structure in place that will reward operators who meet their roll out obligations in time. The Authority also feels that it is necessary to impose penalties on those operators who fail the roll out obligations.

5.85 Two of the Authority's main aims in setting roll out obligations are to encourage efficient use of spectrum by weeding out non-serious players, and to encourage rural network deployment. There are three types of BWA operators: those in the Metros, in the Category A, B, C circles, and in the local areas. The roll out obligations will vary because of the differing characteristics of each of these areas. For example, Metros do not have meaningful rural populations, and local area operators do not serve a set population.

5.86 The DoT has classified rural SDCAs. There are 1,685 of these out of a total of 2,645 SDCAs around the country. These rural SDCAs are distributed widely among the different license areas, and hence, will be well-defined geographically to assist in the measurement and monitoring of roll out.

5.87 Consequently, the Authority recommends the following roll out obligations:

| Timeline | License area | Metros | Category A, B & C circles | Local operators/captive networks |
|---|---|---|---|---|
| 2 years | | - | 25% rural SDCAs area coverage | - |
| 5 years | | 90% area coverage | 50% rural SDCAs area coverage | 90% area coverage |

5.88 **The Authority recommends that if a BWA operator in a:**

(1) **Metro or local area fulfills its roll out obligations, their performance bank guarantee should be returned, and they should be permitted to continue their operations.**

(2) **Category A, B, or C circle fulfills its two year roll out obligations, the performance bank guarantee should be returned, and if it fulfills five year roll out obligations, they should be permitted to continue their operations.**

5.89 **If an operator in Category A, B, or C circles fails its two year roll out obligations, its performance bank guarantee should be encashed, and if it fails its five year obligation, measures to cancel the spectrum assignment should be undertaken and no entity related to the operator will be eligible to apply for BWA spectrum again.**

5.90 **If an operator in a Metro or local area fails its five year roll out obligations, its performance bank guarantee should be encashed, and should attract the measures of spectrum assignment cancellation and no entity related to the operator will be eligible to apply for BWA spectrum again.**

## License issues

5.91 A number of issues addressed, and many of the Authority's recommendations on BWA are significantly different from the current UASL, CMSP, and ISP licenses. For example, there are circle wide spectrum allocations, related roll out obligations, annual spectrum charges, and one-time spectrum acquisition fees.

# Annex A: Subscriber base as of July 31, 2006

| | Operator | | Subscribers Base as on 31.7.06 | | | Spectrum Allotted |
|---|---|---|---|---|---|---|
| | GSM | CDMA | Mobile | WLL (F) | Total | |
| Delhi | Bharti | | 2,301,144 | | 2,301,144 | 10 MHz |
| | Hutch | | 1,985,369 | | 1,985,369 | 10 MHz |
| | MTNL | | 1,070,370 | | 1,070,370 | 8 MHz |
| | Idea | | 1,007,977 | | 1,007,977 | 8 MHz |
| | | MTNL | 54,789 | 10,232 | 65,021 | 3.75 MHz |
| | | Reliance Infocomm | 1,881,057 | | 1,881,057 | 5 MHz |
| | | Tata Teleservices | 1,570,865 | 57,565 | 1,628,430 | 5 MHz |
| | TOTAL | | 9,871,571 | 67,797 | 9,939,368 | |
| Mumbai | BPL | | 1,284,778 | | 1,284,778 | 10 MHz |
| | Hutch | | 2,151,662 | | 2,151,662 | 10 MHz |
| | MTNL | | 1,167,430 | | 1,167,430 | 8 MHz |
| | Bharti | | 1,439,596 | | 1,439,596 | 9.2MHz |
| | | MTNL | 26,011 | 51,602 | 77,613 | 5 MHz |
| | | Reliance Infocomm | 1,873,640 | | 1,873,640 | 5 MHz |
| | | Tata Teleservices | 824,108 | 94,912 | 919,020 | 5 MHz |
| | TOTAL | | 8,767,225 | 146,514 | 8,913,739 | |
| Chennai | Aircel Cellular | | 813,269 | | 813,269 | 8 MHz |
| | Bharti | | 816,381 | | 816,381 | 8 MHz |
| | BSNL | | 576,887 | | 576,887 | 8 MHz |
| | Hutchison | | 519,027 | | 519,027 | 8 MHz |
| | | BSNL | 7,399 | 24,851 | 32,250 | 2.5 MHz |
| | | Reliance Infocomm | 579,105 | | 579,105 | 5 MHz |
| | | Tata Teleservices | 235,935 | 28,905 | 264,840 | 3.75 MHz |
| | TOTAL | | 3,548,003 | 53,756 | 3,601,759 | |
| Kolkata | Bharti | | 700,717 | | 700,717 | 8 MHz |
| | Hutchison East | | 1,082,713 | | 1,082,713 | 8 MHz |
| | BSNL | | 483,136 | | 483,136 | 6.2 MHz |
| | Reliable Internet | | 180,213 | | 180,213 | 6.2 MHz |
| | | BSNL | 21,764 | 7,406 | 29,170 | 2.5 MHz |
| | | Reliance Infocomm | 902,478 | | 902,478 | 5 MHz |
| | | Tata Teleservices | 603,070 | 36,019 | 639,089 | 3.75 MHz |
| | TOTAL | | 3,974,091 | 43,425 | 4,017,516 | |
| Maharashtra | Hutch (BPL) | | 886,786 | | 886,786 | 6.2 MHz |
| | Idea | | 2,112,692 | | 2,112,692 | 10 MHz |
| | BSNL | | 1,331,227 | | 1,331,227 | 8 MHz |
| | Bharti | | 1,648,820 | | 1,648,820 | 6.2 MHz |
| | | BSNL | 41,179 | 185,376 | 226,555 | 2.5 MHz |
| | | Reliance Infocomm | 1,723,566 | | 1,723,566 | 5 MHz |
| | | Tata Teleservices | 820,924 | 182,940 | 1,003,864 | 5 MHz |
| | TOTAL | | 8,565,194 | 368,316 | 8,933,510 | |
| Gujarat | Fascel (Hutch) | | 2,824,502 | | 2,824,502 | 10 MHz |
| | Idea | | 1,300,984 | | 1,300,984 | 6.2 MHz |

| | Operator | | Subscribers Base as on 31.7.06 | | | Spectrum Allotted |
|---|---|---|---|---|---|---|
| | **GSM** | **CDMA** | **Mobile** | **WLL (F)** | **Total** | |
| | BSNL | | 905,895 | | 905,895 | 7.4 MHz |
| | Bharti | | 1,073,318 | | 1,073,318 | 6.2 MHz |
| | | BSNL | 11,373 | 104,192 | 115,565 | 2.5 MHz |
| | | Reliance Infocomm | 1,252,956 | | 1,252,956 | 3.75 MHz |
| | | Tata Teleservices | 567,894 | 91,739 | 659,633 | 3.75 MHz |
| | TOTAL | | 7,936,922 | 195,931 | 8,132,853 | |
| Andhra Pradesh | Idea | | 1,172,662 | | 1,172,662 | 8 MHz |
| | Bharti | | 2,286,945 | | 2,286,945 | 8 MHz |
| | BSNL | | 1,261,707 | | 1,261,707 | 8 MHz |
| | Hutchison | | 1,041,900 | | 1,041,900 | 6.2 MHz |
| | BSNL | | 30,619 | 95,636 | 126,255 | 2.5 MHz |
| | Reliance Infocomm | | 2,094,202 | | 2,094,202 | 5 MHz |
| | Tata Teleservices | | 1,009,329 | 129,111 | 1,138,440 | 5 MHz |
| | TOTAL | | 8,897,364 | 224,747 | 9,122,111 | |
| Karnataka | Bharti | | 2,785,346 | | 2,785,346 | 10 MHz |
| | Spice | | 519,135 | | 519,135 | 6.2 MHz |
| | BSNL | | 1,351,802 | | 1,351,802 | 8 MHz |
| | Hutch | | 1,290,538 | | 1,290,538 | 8 MHz |
| | | BSNL | 11,021 | 128,057 | 139,078 | 2.5 MHz |
| | | Reliance Infocomm | 1,336,812 | | 1,336,812 | 5 MHz |
| | | Tata Teleservices | 675,212 | 92,000 | 767,212 | 3.75 MHz |
| | TOTAL | | 7,969,866 | 220,057 | 8,189,923 | |
| Tamil Nadu | Hutch (BPL) | | 619,139 | | 619,139 | 6.2 MHz |
| | Aircel | | 2,026,256 | | 2,026,256 | 10 MHz |
| | BSNL | | 1,625,020 | | 1,625,020 | 8 MHz |
| | Bharti | | 1,294,684 | | 1,294,684 | 6.2 MHz |
| | | BSNL | 10,698 | 267,396 | 278,094 | 2.5 MHz |
| | | Reliance Infocomm | 1,157,285 | | 1,157,285 | 3.75 MHz |
| | | Tata Teleservices | 324,286 | 58,786 | 383,072 | 2.5 MHz |
| | TOTAL | | 7,057,368 | 326,182 | 7,383,550 | |
| Kerala | Escotel (Idea) | | 989,658 | | 989,658 | 8 MHz |
| | Hutch (BPL) | | 583,714 | | 583,714 | 6.2 MHz |
| | BSNL | | 1,636,737 | | 1,636,737 | 8 MHz |
| | Bharti | | 706,285 | | 706,285 | 6.2 MHz |
| | | BSNL | 49,541 | 253,805 | 303,346 | 2.5 MHz |
| | | Reliance Infocomm | 1,131,987 | | 1,131,987 | 3.75 MHz |
| | | Tata Teleservices | 342,121 | 13,279 | 355,400 | 3.75 MHz |
| | TOTAL | | 5,440,043 | 267,084 | 5,707,127 | |
| Punjab | Spice | | 1,575,565 | | 1,575,565 | 8 MHz |
| | Bharti | | 2,062,312 | | 2,062,312 | 8 MHz |
| | BSNL | | 400,583 | | 400,583 | 6.2 MHz |
| | Hutchison | | 782,608 | | 782,608 | 6.2 MHz |
| | | BSNL | 8,048 | 87,862 | 95,910 | 2.5 MHz |
| | | Reliance Infocomm | 700,985 | | 700,985 | 3.75 MHz |
| | | HFCL Infocom | 57,738 | 93,889 | 151,627 | 5 MHz |

| | Operator | | Subscribers Base as on 31.7.06 | | | Spectrum Allotted |
|---|---|---|---|---|---|---|
| | **GSM** | **CDMA** | **Mobile** | **WLL (F)** | **Total** | |
| | | Tata Teleservices | 392,283 | 54,671 | 446,954 | 3.75 MHz |
| | TOTAL | | 5,980,122 | 236,422 | 6,216,544 | |
| Haryana | Escotel (Idea) | | 443,155 | | 443,155 | 6.2 MHz |
| | Aircel Diglink (Hutch) | | 402,722 | | 402,722 | 6.2 MHz |
| | BSNL | | 484,248 | | 484,248 | 6.2 MHz |
| | Bharti | | 456,727 | | 456,727 | 6.2 MHz |
| | | BSNL | 8,306 | 66,151 | 74,457 | 2.5 MHz |
| | | Reliance Infocomm | 347,997 | | 347,997 | 3.75 MHz |
| | | Tata Teleservices | 325,584 | 24,993 | 350,577 | 2.5 MHz |
| | TOTAL | | 2,468,739 | 91,144 | 2,559,883 | |
| UP (West) | Escotel (Idea) | | 1,131,969 | | 1,131,969 | 8 MHz |
| | Bharti | | 676,571 | | 676,571 | 6.2 MHz |
| | BSNL | | 983,136 | | 983,136 | 8 MHz |
| | | Hutch South | 892,391 | | 892,391 | 6.2 MHz |
| | | BSNL | 12,935 | 96,898 | 109,833 | 2.5 MHz |
| | | Reliance Infocomm | 1,073,147 | | 1,073,147 | 3.75 MHz |
| | | Tata Teleservices | 435,478 | 19,342 | 454,820 | 3.75 MHz |
| | TOTAL | | 5,205,627 | 116,240 | 5,321,867 | |
| UP (East) | Aircel Diglink (Hutch) | | 1,880,387 | | 1,880,387 | 8 MHz |
| | BSNL | | 1,701,345 | | 1,701,345 | 8 MHz |
| | Bharti | | 888,406 | | 888,406 | 6.2 MHz |
| | Escorts Telecommunications | | 1,209 | | 1,209 | 6.2 MHz |
| | | BSNL | 20,451 | 144,500 | 164,951 | 2.5 MHz |
| | | Reliance Infocomm | 1,462,137 | | 1,462,137 | 5 MHz |
| | | Tata Teleservices | 380,542 | 42,559 | 423,101 | 3.75 MHz |
| | TOTAL | | 6,334,477 | 187,059 | 6,521,536 | |
| Rajasthan | Aircel Diglink (Hutch) | | 788,857 | | 788,857 | 6.2 MHz |
| | Hexacom (Bharti) | | 1,107,880 | | 1,107,880 | 6.2 MHz |
| | BSNL | | 1,308,623 | | 1,308,623 | 6.2 MHz |
| | Escorts Telecommunications | | 323 | | 323 | 6.2 MHz |
| | | BSNL | 46,705 | 169,184 | 215,889 | 2.5 MHz |
| | | Reliance Infocomm | 959,194 | | 959,194 | 3.75 MHz |
| | | Shyam Telelink | 26,892 | 39,857 | 66,749 | 5 MHz |
| | | Tata Teleservices | 405,957 | 49,256 | 455,213 | 3.75 MHz |
| | TOTAL | | 4,644,431 | 258,297 | 4,902,728 | |
| Madhya Pradesh | Idea | | 960,784 | | 960,784 | 6.2 MHz |
| | Reliance | | 620,427 | | 620,427 | 6.2 MHz |
| | BSNL | | 641,665 | | 641,665 | 6.2 MHz |
| | Bharti | | 681,129 | | 681,129 | 6.2 MHz |
| | | BSNL | 133,778 | 157,193 | 290,971 | 2.5 MHz |
| | | Reliance Infocomm | 1,061,275 | | 1,061,275 | 3.75 MHz |
| | | Bharti | | 21,187 | 21,187 | 2.5 MHz |
| | | Tata Teleservices | 289,176 | 35,920 | 325,096 | 2.5 MHz |
| | TOTAL | | 4,388,234 | 214,300 | 4,602,534 | |
| West Bengal & | Reliance | | 420,885 | | 420,885 | 6.2 MHz |
| Andaman and | BSNL | | 818,900 | | 818,900 | 6.2 MHz |

| | Operator | | Subscribers Base as on 31.7.06 | | | Spectrum Allotted |
|---|---|---|---|---|---|---|
| | **GSM** | **CDMA** | **Mobile** | **WLL (F)** | **Total** | |
| Nicobar | Bharti | | 392,131 | | 392,131 | 4.4 MHz |
| | Hutch South | | 666,946 | | 666,946 | 4.4 MHz |
| | Dishnet Wireless | | 89,355 | | 89,355 | 4.4 MHz |
| | | BSNL | 5,107 | 91,892 | 96,999 | 2.5 MHz |
| | | Reliance Infocomm | 472,666 | | 472,666 | 3.75 MHz |
| | | Tata Teleservices | 216,016 | 11,824 | 227,840 | 2.5 MHz |
| | TOTAL | | 3,082,006 | 103,716 | 3,185,722 | |
| Himachal Pradesh | | Bharti | | 405,274 | | 405,274 |
| 6.2 | | | | | | MHz |
| | Reliance | | 78,789 | | 78,789 | 6.2 MHz |
| | BSNL | | 254,192 | | 254,192 | 6.2 MHz |
| | Escorts Telecommunications | | 121 | | 121 | 4.4 MHz |
| | Dishnet Wireless | | 0 | | 0 | 4.4 MHz |
| | | BSNL | 354 | 44,592 | 44,946 | 2.5 MHz |
| | | Reliance Infocomm | 35,809 | | 35,809 | 2.5 MHz |
| | | Tata Teleservices | 46,419 | 700 | 47,119 | 2.5 MHz |
| | TOTAL | | 820,958 | 45,292 | 866,250 | |
| Bihar | Reliance | | 592,650 | | 592,650 | 6.2 MHz |
| | BSNL | | 1,027,041 | | 1,027,041 | 6.2 MHz |
| | Bharti | | 1,274,190 | | 1,274,190 | 8 MHz |
| | Dishnet Wireless | | 0 | | 0 | 4.4 MHz |
| | | BSNL | 6,783 | 172,792 | 179,575 | 2.5 MHz |
| | | Reliance Infocomm | 792,129 | | 792,129 | 5 MHz |
| | | Tata Teleservices | 262,361 | 30,330 | 292,691 | 3.75 MHz |
| | TOTAL | | 3,955,154 | 203,122 | 4,158,276 | |
| Orissa | Reliance | | 279,135 | | 279,135 | 6.2 MHz |
| | BSNL | | 580,175 | | 580,175 | 6.2 MHz |
| | Bharti | | 584,477 | | 584,477 | 6.2 MHz |
| | Dishnet Wireless | | 95,420 | | 95,420 | 4.4 MHz |
| | | BSNL | 963 | 91,739 | 92,702 | 2.5 MHz |
| | | Reliance Infocomm | 268,069 | | 268,069 | 3.75 MHz |
| | | Tata Teleservices | 125,413 | 7,090 | 132,503 | 2.5 MHz |
| | TOTAL | | 1,933,652 | 98,829 | 2,032,481 | |
| Assam | Reliance | | 239,753 | | 239,753 | 6.2 MHz |
| | BSNL | | 433,410 | | 433,410 | 6.2 MHz |
| | Bharti | | 316,451 | | 316,451 | 4.4 MHz |
| | Dishnet Wireless | | 197,746 | | 197,746 | 4.4 MHz |
| | | BSNL | 8,972 | 50,964 | 59,936 | 2.5 MHz |
| | TOTAL | | 1,196,332 | 50,964 | 1,247,296 | |
| North East | Reliance | | 104,937 | | 104,937 | 6.2 MHz |
| | Bharti | | 90,923 | | 90,923 | 4.4 MHz |
| | BSNL | | 301,025 | | 301,025 | 6.2 MHz |
| | Dishnet Wireless | | 140,117 | | 140,117 | 4.4 MHz |
| | | BSNL | 3,467 | 31,329 | 34,796 | 2.5 MHz |
| TOTAL | | | 640,469 | 31,329 | 671,798 | |

| Operator | | Subscribers Base as on 31.7.06 | | | Spectrum Allotted |
|---|---|---|---|---|---|
| **GSM** | **CDMA** | **Mobile** | **WLL (F)** | **Total** | |
| Jammu and Kashmir | BSNL | 596,532 | | 596,532 | 8 MHz |
| Bharti | | 348,130 | | 348,130 | 6.2 MHz |
| Dishnet Wireless | | 29,366 | | 29,366 | 4.4 MHz |
| | BSNL | 905 | 40,704 | 41,609 | 2.5 MHz |
| | Reliance Infocomm | 253 | | 253 | 2.5 MHz |
| TOTAL | | 975,186 | 40,704 | 1,015,890 | |
| **Total all-India** | | **113,653,034** | **3,591,227** | **117,244,261** | |

# Annex B: Subscriber-based spectrum allocation criteria

As per WPC Letter Nos. J-14025/200(17)/2004-NT(GSM) and J-14025/200(17)/2004-NT(CDMA) dated 29 March 2006

GSM subscriber base criteria (millions of subscribers)

| Service Area | 2 x 6.2 MHz | 2 x 8 MHz | 2 x 10 MHz | 2 x 12.4 MHz | 2 x 15 MHz |
|---|---|---|---|---|---|
| Delhi/Mumbai | 0.3 | 0.6 | 1 | 1.6 | 2.1 |
| Chennai/Kolkata | 0.2 | 0.4 | 0.6 | 1 | 1.3 |
| A | 0.4 | 0.8 | 1.4 | 2 | 2.6 |
| B | 0.3 | 0.6 | 1 | 1.6 | 2.1 |
| C | 0.2 | 0.4 | 0.6 | 0.9 | 1.2 |

CDMA subscriber base criteria (millions of subscribers)

| Service Area | 3rd carrier (2 x 3.75 MHz) | 4th carrier (2 x 5 MHz) | 5th carrier (2 x 6.25 MHz) | 6th carrier (2 x 7.5 MHz) |
|---|---|---|---|---|
| Delhi/Mumbai | 0.3 | 1 | 1.6 | 2.1 |
| Chennai/Kolkata | 0.2 | 0.6 | 1 | 1.3 |
| A | 0.4 | 1.2 | 2 | 2.6 |
| B | 0.3 | 1 | 1.6 | 2.1 |
| C | 0.15 | 0.5 | 0.9 | 1.2 |

# Annex C: Spectrum bands used for 3G services internationally

| Country | WCDMA | | | CDMA2000 1x EV-DO | | | |
|---|---|---|---|---|---|---|---|
| | 1900 | 2100 | 450 | 800 | 1700 | 1900 | 2100 |
| Australia | | Vodafone, Optus, Telstra, 3 | | Telstra | | | |
| Brazil | | | | Vivo | | Vesper | |
| Canada | | | | Alliant, Bell, SaskTel, Telus | | Bell, MTS | |
| China | | | | | | | China Unicom |
| Guatemala | | | | | | Movistar | |
| Indonesia | | Hutchison | | Bakrie, Mobile8 | | Wireless Indo. | |
| Israel | | Cellcom, Orange | | Pelephone | | | |
| Japan | | | | | | | KDDI |
| S Korea | | KTF, SKT | | SKT | LG, KTF | | |
| Malaysia | | Cellcom, Maxis | | | | | |
| New Zealand | | Vodafone | | TNZ | | | |
| Philippines | | Smart, Globe, Digitel, CURE | | | | MMT | |
| Russia | | | Delta, KCC, Moscow Cellular, UralWest | | | | |
| Singapore | | MobileOne, SingTel, StarHub | | | | | |
| South Africa | Vodacom, MTN | | | | | | |
| USA | Cingular | | | ACS, ALLTEL, Verizon Wireless | | ALLTEL, Sprint-Nextel, Verizon Wireless | |

# Annex D: Resumption of spectrum in the 800 MHz band

## Details of frequency assignment to non telecom users in the frequency band 824-844 / 869-889 MHz

Vacation of spectrum by the following non-telecom users

1. 6 MHz by Indian Oil Corporation Ltd. in Gujarat
2. 2.6 MHz by Rajasthan Atomic Power Station in Kota
3. 3 MHz by Railways in Kolkatta and West Bengal

Details of the proposed carrier to be surrendered by the service providers are given below

| Service Provider | Service Area | No. of Subscribers (in lakhs) | Allocated Spectrum (Number of Carrier) | Growth Trend | WPC norms | Proposal |
|---|---|---|---|---|---|---|
| MTNL | Delhi | 0.65 | 3.75 MHz (3) | Decreasing subscriber base from last one year. Growth rate (-) 11.73% in 2QE of 2006 | -3rd Carrier on the subscriber base of 3 Lakhs | Surrender of 1 Carrier |
| | Mumbai | 0.73 | 5 MHz (4) | Erratic growth and small Subscriber base. Growth rate (-) 10.80% in 2QE of 2006 | -3rd Carrier on the subscriber base of 3 Lakhs-4th Carrier on the subscriber base of 10 Lakhs | Surrender of 2 Carriers |
| Bharti Telenet | MP | 0.21 | 2.5 MHz (2) | Surrendered basic license. Decreasing Subscriber base with very low subscriber base | -2 Carrier initially awarded | Surrender of 2 Carriers |
| Shyam | Rajasthan | 0.64* | 5 MHz (4) | Erratic growth and small Subscriber base | -3rd Carrier on the subscriber base of 3 Lakhs-4th Carrier on the subscriber base of 10 Lakhs | Surrender of 2 Carriers |
| HFCL | Punjab | 1.54* | 5 MHz (4) | Subscriber base increasing with moderate growth rate, | 3rd Carrier on the subscriber base of 3 Lakhs 4th Carrier on the subscriber base of 10 Lakhs | Surrender of 2 Carriers |

*The figure includes the subscriber base of CorDECT as well.

# Annex E: Summary of presentations on the 'mixed band plan'

**1. Gist of AUSPI views on interference issues in mixed band allocation for 3G**

Coexistence of 3G services in 2.1 GHz (1920-1980/2110-2170MHz and PCS band (1850-1910/1930-1990MHz)

- ITU band 1 commonly termed as the " UMTS" band
  - UL: 1920-1980 MHz / DL: 2110-2170 MHz
- ITU band 3, commonly termed as "PCS" band
  - UL: 1850-1910 MHz/ DL: 1930-1990 MHz
  - The non overlapping band UL: 1900-1910 MHz DL: 1980-1990 MHz
- Major interference issues are-
  - PCS band CDMA 2000 EVDO base station transmit affecting UMTS band (WCDMA) Base station (Node B) receive
  - UMTS band (WCDMA) mobile User Equipment (UE)Transmit affecting the PCS band CDMA 2000 Mobile receive
- CDMA BTS (DL) to UMTS BTS (UL) Interference- Analysis Principle
  - Principle -I The received out of band emission at WCDMA Node B from the CDMA BTS transmitter should be 10 dB below the WCDMA Node B receiver noise floor
  - Principle II Carrier TX power of CDMA BTS should satisfy WCDMA Adjacent Channel Selectivity (ACS) requirements
  - 3rd order Inter Modulation Product (IMP) is not a major interference source, especially under enough carrier to carrier spacing.
- CDMA 2000 BTS to WCDMA Node-B Interference:
  - Upto 107 dB of isolation is required to mitigate interference due to CDMA BTS TX affecting WCDMA Node-B RX for both OOB (out of Band) emission and blocking.
  - In normal practice around -50 dB of antenna isolation is quite easy to get with good installation practices, for both co-located and not collocated cases
  - With filters in Both CDMA TX and WCDMA Rx, a minimum carrier to carrier frequency of 3.85 MHz (Guard band 1.3 MHz) is required to take care of the interference issues.

- Band pass filter with 60 dB out-of –band rejection / attenuation in CDMA BTS transmit path is realizable with 3.85 MHz of carrier separation
- Cost of band pass filter will go down with 5 MHz of carrier to carrier separation.

➢ With filters in only CDMA 2000 BTS Tx path, a minimum carrier to carrier separation of 5 MHz (guard band of 2.45 MHz) is required to take of the effect of inter modulation products.

➢ With no filters in both CDMA 2000 BTS Tx and WCDMA BTSs, a minimum carrier to carrier separation of 6.35 MHz (GB=3.8 MHz) and site to site separation of around 800m required.

- Interference due to WCDMA Handset (User Equipment) on CDMA2000 handset. The following observations have been taken into consideration

➢ The interference to occur both WCDMA UE and CDMA 2000 MS must be active

➢ Generally maximum TX power of a class 3 WCDMA UE is around 10 dBm which is 11 dBm below its assigned peak power of 21 dBm.

➢ Interference from UE to MS is relatively small percentage of time

➢ As per the 2 slope path loss model, 47.6 dB of path loss can be achieved within 1 meter distance from the mobile transmitter antenna

➢ Hence from RF blocking point of view, there is no interference problem from WCDMA UE transmit signal to CDMA 2000 MS receive

- Isolation requirement for CDMA 2000 Mobile out– of – band emissions

➢ Therefore, the amount of isolation is required to take care of the OOBE for CDMA 2000 mobile from WCDMA UE Tx is 58.6 dB at 3.85 MHz offset and 57.5 dB with 5 MHz frequency offset

- As per 2 slope path loss model, the 58.6 dB rejection can be obtained with 10 m distance from the mobile transmitter antenna.
- Hence there will be no interference problem to CDMA 200 MS RX from WCDMA if 10 m separation is maintained.

- WCDMA (1920-1980 MHz for Node B reception and CDMA 2000 UL 1900 – 1910 DL 1980-1990 MHz can co-exist in India under the following easy to achieve conditions
  - ❖ An edge to edge guard band of min 1.3 MHz using suitable filters in the CDMA Tx path and WCDMA Rx path.
  - ❖ 60 dB antenna isolation between CDMA and WCDMA BTS.
  - ❖ 10m separation between WCDMA and CDMA 2000 mobile or 10 % DL CDMA 2000 capacity degradation with 3.85 MHz (GB= 1.3 MHz) Carrier to carrier.

Similar views were expressed by M/s Lucent technologies, M/s ZTE and M/s Qualcomm and CDMA operators.

**2. Gist of COAI's views on mixed band allocation for 3G services**

- Use of 2.1 GHz and US PCS 1900 band plans together would cause severe interference between base stations
  - o Multiple Mitigation techniques- Multiple Mitigation techniques will be required
    - ▪ Substantial guard bands resulting in wastage of globally harmonized spectrum
    - ▪ Filters at each and every base station- high cost non-standard filter solution
    - ▪ Extensive site coordination-practical problems
    - ▪ Enforcement issues-CDMA being the interferer will have no incentive to incur additional costs to provide additional filtering
  - o Result in additional costs and increased network complexity – operators denied benefits of economic of scale, wide competition, lower tariffs.
    - Interference between Handsets
  - o Cannot be mitigated, will lead to degraded quality of service, customer issues, non-compliance with license terms, etc.
  - o Mixed band plan would cause interference between WCDMA (or CDMA 2000) & USPCS handsets when handsets are in close proximity (e.g. within same meeting room, in crowded places, etc)
  - o There would be a degradation even in the PCS CDMA service within 1980-1990 MHz in the downlink direction

- Current 3GPP/ 3GPP2 standards for handsets did not take mixed band plan into account and hence no protection was provided for this case.
    - COAI had referred Aegis report on mixed IMT 2000 2GHz & PCS 1900 MHz band where coexistence of WCDMA 2000 in 2.1 GHz band & EVDO in PCS 1900 band has been ruled out due to the following:
- Unwanted spurious emissions from PCS 1900 which cannot be mitigated using guard bands
- WCDMA filters have little attenuation in 1980-1990 MHz
- External filters will degrade receiver noise figure lead to reduced cell range which need more cells and add to network costs
- PCS duplex filter does not provide attenuation in 1930-1990 MHz and thus requires additional filtering.
- Wastage of spectrum due to Guard band requirement
- Coordination of BTS sites between WCDMA and CDMA 2000 operators is necessary for interference free operation.
- Special regulation will be required to limit the effect of harmful interference.
- Core Band WCDMA & PCS user equipments are not specified for operation in the same area under mixed band. User equipment cannot be modified country specifically due to global commitments in manufacturing of standards & due to global roaming
- Quality of Service can only be fulfilled if internationally agreed spectrum designs and standards are kept.

Similar views were expressed by M/s Nokia, M/s Ericsson, GSM service providers and UMTS forum.

# Annex F: Technical Discussion Of 'Mixed Band Plan'

## Types of Interferences considered

Foundation for Innovation and Technology Transfer (FITT) at IIT Delhi had considered the following types of CDMA2000 BTS (Tx) to WCDMA BTS (Rx) interferences (Fig. 1):

(i) In-band Interference: Adjacent Channel Power (ACP)

(ii) In-band Interference: Spurious Emissions

(iii) Out-of-band interference: Adjacent Channel Selectivity (ACS)

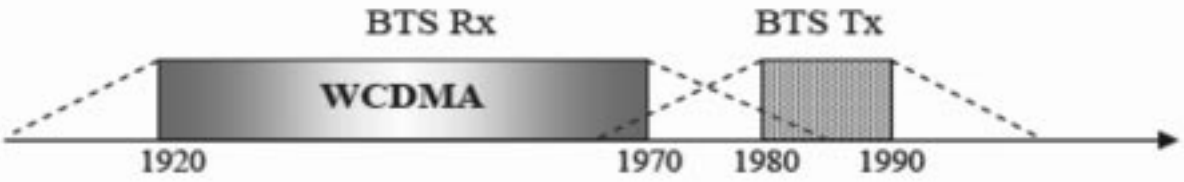


Fig. 1: The different types of BTS – BTS interference.

## Path Loss Model

The path loss model used for simulations is as follows:

Path Loss (dB) = 27.56 - 20log10 (f) - 10nlog10 (d) (1)

where the frequency f is in MHz, the distance d is in meters and n is the path loss exponent. Both theoretical and measurement propagation models indicate that the average received signal power decreases logarithmically with distance.

Typical path loss exponents are: Free space: n = 2, urban area cellular radio: n = 2.7 - 3.5 and shadowed urban cellular radio: n = 3 - 5. Here we have used n = 2 because BTS to BTS interference usually avoids the urban blocking effects because of the location of BTS on top of towers/tall buildings. Besides, n = 2 gives the worst case scenario (free space propagation).

## Antenna Isolation

The formulae used to calculate antenna isolation

$$H = 22 + 20\log_{10}(x/\lambda) - (Gt + Gr) \quad (2)$$

$$V = 28 + 40\log_{10}(y/\lambda) \quad (3)$$

$$\theta = \tan^{-1}(y/x) \quad (4)$$

$$T_{ISO} = (V - H)(2\theta/\pi) + H \quad (5)$$

where H is the isolation due to horizontal antenna separation, V is the isolation due to vertical antenna separation, TISO is the total isolation due to vertical and horizontal antenna separation, Gt and Gr are the Transmit antenna and the Receive antenna gains respectively.

## Simulation Parameters

The various simulation parameters and the corresponding sources (if any) are given in Table 1.

## In-band Interference: Adjacent Channel Power (ACP)

| Parameter | Value | Remarks |
|---|---|---|
| Transmit Power of cdma2000 (interferer) | 42 dBm | Typical |
| Spurious Emission (interferer) | 13 dBm/MHz | From 3GPP2, pg 4-13 |
| Adjacent channel selectivity (WCDMA) | – 40 dBm | From 3GPP, pg 36 |
| Frequency Separation (Guard Band) | 5 MHz and 10 MHz | From TRAI |
| ACLR (5 MHz guard band) | 50 | From 3GPP, pg 20 |
| ACLR (10 MHz guard band) | 45 | From 3GPP, pg 20 |
| WCDMA BTS Receiver sensitivity (for ACS) | – 121 dBm | From 3GPP, Table 7.5.1, page 36 |
| Wanted Signal Mean Power (for ACS) | – 115 dBm | From 3GPP, Table 7.5.1, page 36 |
| Boltzmann Constant | $1.38 \times 10^{-23}$ | Typical |
| Temperature | 300 K | Typical |
| Effective BW of WCDMA | $3.84 \times 10^{6}$ | Typical |
| Noise Figure | 4 | Typical |
| Additional Margin for Noise | 10 dB | Typical |
| Transmitter Antenna Gain | 16 dB | From TRAI |
| Receiver Antenna Gain | 16 dB | From TRAI |
| Minimum Coupling Loss | 30 dB | From 3GPP, page 29 |

The in-band interference due to adjacent channel leakage power is calculated using the following equations:

For co-located antennas: $^{P}_{ACP} = P_T - A_{CLR} - MCL$ (6a)

For spatially separated antennas: $^{P}_{ACP} = P_T - T_{ISO} - A_{CLR}$ (6b)

where $PT$ is the CDMA2000 BTS Transmit Power, $T_{ISO}$ is the total isolation due to vertical and horizontal antenna separation, $A_{CLR}$ is the Adjacent Channel Leakage-power Ratio (from 3GPP standard, pg 20) and $MCL$ is the Minimum Coupling Loss. It is noted that typically $PT$ is specified in dBm, $T_{ISO}$, $A_{CLR}$, $MCL$ are specified in dB, and $^{P}{}_{ACP}$ is specified in dBm. Wherever applicable $MCL$ = 30 dB (from 3GPP, page 29) has been used. It should be noted that $T_{ISO}$ includes the path loss. The WCDMA Noise floor at 300° K is given by

Thermal Noise Floor = $kTB$ (7)

= (1.38×10– 23) (300) (3.84× 106) Watts

= 1.59 ×10– 11 mW = – 108 dBm

Using a Noise Figure of 4 dB, the effective Noise Floor becomes – 104 dBm. Adding a 10 dB margin to the Noise Floor yields the target noise floor level

$NF$ = – 114 dBm. (8)

In-band Interference: Spurious Emission by CDMA2000 BTS Tx

From 3GPP2 standard (pg 4-13), the CDMA2000 Spurious Emission is 13 dBm / MHz. For a 3.84 MHz WCDMA band, the total received Spurious Emission $PS$ = – 7 dBm (If Spurious Emission = 15 dBm / MHz is considered the total received Spurious Emission comes to -9 dBm). The WCDMA Noise floor is at PN = – 104 dBm and adding to that a 10 dB margin yields $NF$ = – 114 dBm.

The in-band interference due to spurious emission is calculated using the following equations:

For co-located antennas: $P_{SP} = P_S - MCL$ (9a)

For spatially separated antennas: $P_{SP} = P_S - T_{ISO}$ (9b)

where $PS$ is the CDMA2000 BTS Spurious Power, $T_{ISO}$ is the total isolation due to vertical and horizontal antenna separation and $MCL$ is the Minimum Coupling Loss. includes the path loss. We note that typically $P_S$ is specified in dBm, $T_{ISO}$, $MCL$ are specified in dB, and $P_{SP}$ is specified in dBm.

Total In-band Interference

The total inband interference is the sum of the two independent interference sources (i) ACP and (ii) Spurious Emission.

Thus, $P_{INB}$ (mW) = $P_{ACP}$ (mW) + $P_{SP}$ (mW) (10)

If $P_{ACP}$ and $P_{SP}$ are specified in dBm. To convert dBm value to mW, then powers are added and then converted back to dBm. Equations (6a,b) and (9a,b) can be used to calculate power in dBm, the total in-band interference (in dBm) is given by

$P_{INB} = 10 \log_{10}[10^{(P_{ACP}/10)} + 10^{(P_{SP}/10)}]$ (11)

Thus, the RF filter to be deployed at the CDMA2000 BTS to mitigate the total in-band interference would have the rejection requirement

$R_{INB} = P_{INB} - NF$ (12)

Out-of-band Interference: Adjacent Channel Selectivity (ACS) / Blocking

From the 3GPP standard (page 36), the WCDMA BTS Receiver sensitivity $P_{RS}$ = – 121 dBm (wide area), – 111 dBm (medium range) and – 107 dBm (local area). Here we have considered the worst case, i.e., *PRS* = – 121 dBm. For ACS, the Wanted Signal Mean Power $P_W$ = – 115 dBm. Thus, there is $P_{NR}$ = 6 dB Noise Rise for – 40 dBm of interfering signal (Source 3GPP standard, Table 7.5.1, page 36). This also requires a guard band of 10 MHz, which is present in the scenario that we are considering. The interfering signal must be blocked such that the resulting interfering signal mean power $P_{ACS}$ = – 40 dBm. For a GB of 5 MHz, we have used $P_{ACS}$ = – 52 dBm (UK WP8F pg 5). Let the CDMA2000 BTS Transmit Power be $P_T$. The received out-of-band power by the WCDMA BTS is given by

For co-located antennas: $P_{OUT} = P_T - MCL$ (13a)

For spatially separated antennas: $P_{OUT} = P_T - T_{ISO}$ (13b)

Typically *PT* is specified in dBm, $T_{ISO}$, *MCL* are specified in dB, and $P_{OUT}$ is specified in dBm. Hence, the Blocking specification required is

$B = P_{OUT} - P_{ACS}$ (14)

However, this forces the WCDMA BTS to perform at $P_{NR}$ = 6 dB above its noise

sensitivity (at – 115 dBm versus – 121 dBm). Thus, the total blocking (rejection) filter requirement at the WCDMA BTS is

$R_{OUT} = P_{OUT} - P_{ACS} - P_{NR}$ (15)

FITT, IIT Delhi have carried out simulation study considering one WCDMA BTS surrounded by 16 non co-sited CDMA BTS (interfering BTS) within a radius of 1 km. These interfering BTSs have been classified into tier 1 (300 m), tier 2 (440 m), tier 3 (600m) and tier 4 (1000 m). for this study guard band of 5 MHz and 10 MHz have been considered. Based on the observations following findings are given

Findings

(i) For co-located Interfering BTS (IBTS), mixed band allocation is not practically viable because of stringent design requirements on RF filters for both CDMA2000 BTS and WCDMA BTS. By 'co-located' we mean that the horizontal and vertical separations between the interfering BTS and the victim BTS are zero, i.e., $?x = 0$ and $?y = 0$. This is possible when the two antennas (interfering BTS and victim BTS) are attached on the same mast, same height, and back-to-back.

(ii) For a realistic scenario (central Delhi) with one IBTS sharing the **same mast** (1 m vertical separation) and 15 other **non co-located** IBTS, the mixed band allocation (MBA) is feasible provided we ensure that there is:

(a) 5 MHz of Guard Band (GB) together with RF filters with rejection greater than 65 dB deployed both at the CDMA2000 BTS and WCDMA BTS.

**OR**

(b) 10 MHz of GB together with RF filters with rejection greater than 62 dB deployedboth at the CDMA2000 BTS and WCDMA BTS.

There are no restrictions on the transmit power but a *minimum vertical separation of 1 m is required between the antennas on the same mast*. Also, the closest non co-sited IBTS is approximately 300 m away from the victim BTS. However, antennas located closer than 0.5 m on the same mast will pose an extraordinarily stringent filter requirement (>65 dB).

(iii) For **non co-sited** IBTS, mixed band allocation (MBA) is practically viable if RF filters are deployed at both CDMA2000 BTS and WCDMA BTS, as well as site coordination is used. MBA is feasible provided we ensure that there is:

(a) 5 MHz GB and a minimum separation of 350 m between base stations (coupled with 60 dB filtering at the IBTS). This assumes 3 simultaneous IBTS are active. The blocking filter required at the victim BTS should have a rejection of 52 dB.

**OR**

(b) 10 MHz GB and a minimum separation of 250 m between base stations (coupled with 60 dB filtering at the IBTS). This assumes 3 simultaneous IBTS are active. The blocking filter required at the victim BTS should have a rejection of 40 dB.

For co-located interfering BTS (IBTS), mixed band allocation is not practically viable because of stringent design requirements on RF filters for both CDMA2000 BTS and WCDMA BTS. By 'co-located' we mean that the horizontal and vertical separations between the interfering BTS and the victim BTS are zero, i.e., $\Delta x = 0$ and $\Delta y = 0$. This is possible when the two antennas (interfering BTS and victim BTS) are attached on the same mast, same height, and back-to-back.

For a realistic scenario (central Delhi) with one IBTS sharing the same mast (1 m vertical separation) and 15 other non co-located IBTS, the MBA is feasible provided we ensure that there is:

(i) 5 MHz of Guard Band (GB) together with RF filters with rejection greater than 65 dB deployed both at the CDMA2000 BTS and WCDMA BTS, or

(ii) 10 MHz of GB together with RF filters with rejection greater than 62 dB deployed both at the CDMA2000 BTS and WCDMA BTS.

There are no restrictions on the transmit power but a minimum vertical separation of 1 m is required between the antennas on the same mast. Also, the closest non co-sited IBTS is approximately 300 m away from the victim BTS. However, antennas located closer than 0.5 m on the same mast will pose an extraordinarily stringent filter requirement (> 65 dB).

For non co-sited IBTS, mixed band allocation is practically viable if RF filters are deployed at both CDMA2000 BTS and WCDMA BTS, as well as site coordination is used. MBA is feasible provided we ensure that there is:

(i) 5 MHz GB and a minimum separation of 350 m between base stations (coupled with 60 dB filtering at the IBTS). This assumes 3 simultaneous IBTS are active. The blocking filter required at the victim BTS should have a rejection of 52 dB, or

(ii) 10 MHz GB and a minimum separation of 250 m between base stations (coupled with 60 dB filtering at the IBTS). This assumes 3 simultaneous IBTS are active. The blocking filter required at the victim BTS should have a rejection of 40 dB.

# Annex G: India's CDMA Operators

| | MTNL | BSNL | Reliance Infocomm | Tata Teleservices | HFCL Infocom | Shyam Telelink |
|---|---|---|---|---|---|---|
| Delhi | ✓ | | ✓ | ✓ | | |
| Mumbai | ✓ | | ✓ | ✓ | | |
| Chennai | | ✓ | ✓ | ✓ | | |
| Kolkata | | ✓ | ✓ | ✓ | | |
| Maharashtra | | ✓ | ✓ | ✓ | | |
| Gujarat | | ✓ | ✓ | ✓ | | |
| Andhra Pradesh | | ✓ | ✓ | ✓ | | |
| Karnataka | | ✓ | ✓ | ✓ | | |
| Tamil Nadu | | ✓ | ✓ | ✓ | | |
| Kerala | | ✓ | ✓ | ✓ | | |
| Punjab | | ✓ | ✓ | ✓ | ✓ | |
| Haryana | | ✓ | ✓ | ✓ | | |
| UP (W) | | ✓ | ✓ | ✓ | | |
| UP (E) | | ✓ | ✓ | ✓ | | |
| Rajasthan | | ✓ | ✓ | ✓ | | ✓ |
| Madhya Pradesh | | ✓ | ✓ | ✓ | | |
| WB & AN | | ✓ | ✓ | ✓ | | |
| Himachal Pradesh | | ✓ | ✓ | ✓ | | |
| Bihar | | ✓ | ✓ | ✓ | | |
| Orissa | | ✓ | ✓ | ✓ | | |
| Assam | | ✓ | | | | |
| North East | | ✓ | | | | |
| Jammu & Kashmir | | ✓ | ✓ | | | |

# Annex H: Proposed 15-carrier plan for 800 MHz band

The proposed 15-carrier plan in Figure 15 is based on the following principles:

1. This plan ensures availability of 7 out of the existing 14 carrier plan adopted and assigned by WPC

2. First and last 6 carriers be allocated to the major operator and three middle carriers may be allocated to third operator

3. Inter-operator carrier spacing is 1.5 MHz and 1.53 MHz, which may lead to some capacity degradations. However, this problem can be overcome if infrastructure is shared and sites are collocated.

4. There is no change in the carrier spacing between last CDMA carrier and fist GSM carrier.

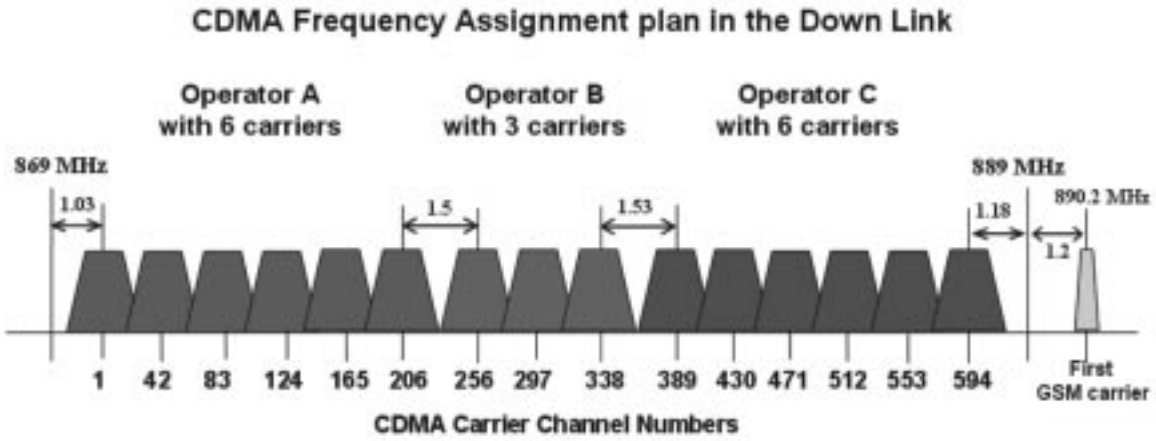


**Figure 15: Proposed 15 carrier plan in the 800 MHz band**

# Annex I: Spectrum requirement In 800 MHz based on present usage, growth, and future subscriber projection

*Disclaimer*: The growth projections of subscriber base have been done only to estimate the 2G spectrum requirements in December 2007. This should not be interpreted as a forecast of market share or growth potential of any CDMA operator.

| | | July 2006 | | December 2007 (estimates) | | |
|---|---|---|---|---|---|---|
| **Circle** | **Operator** | **2G subs (millions)** | **Carriers after normalization** | **2G subs (millions)** | **Carriers needed for 2G** | **Carriers available (est.)** |
| Delhi | MTNL | 0.05 | 2 | 0.05 | 2 | |
| | RIC | 1.88 | 5 | 2.10 | 5 | |
| | Tata | 1.57 | 4 | 2.20 | 6 | **2** |
| Mumbai | MTNL | 0.03 | 2 | 0.03 | 2 | |
| | RIC | 1.87 | 5 | 2.50 | 6 | |
| | Tata | 0.82 | 3 | 1.04 | 4 | **3** |
| Chennai | BSNL | 0.01 | 2 | 0.01 | 2 | |
| | RIC | 0.58 | 3 | 0.62 | 3 | |
| | Tata | 0.24 | 2 | 0.25 | 2 | **8** |
| Kolkatta | BSNL | 0.02 | 2 | 0.02 | 2 | |
| | RIC | 0.90 | 3 | 1.01 | 4 | |
| | Tata | 0.60 | 3 | 0.91 | 3 | **6** |
| Maharashtra | BSNL | 0.04 | 2 | 0.04 | 2 | |
| | RIC | 1.72 | 5 | 2.89 | 6 | |
| | Tata | 0.82 | 3 | 1.31 | 4 | **3** |
| Gujarat | BSNL | 0.01 | 2 | 0.01 | 2 | |
| | RIC | 1.25 | 4 | 2.16 | 6 | |
| | Tata | 0.57 | 3 | 0.75 | 3 | **4** |
| Andhra Pradesh | BSNL | 0.03 | 2 | 0.03 | 2 | |
| | RIC | 2.09 | 5 | 3.40 | 6 | |
| | Tata | 1.01 | 4 | 1.61 | 5 | **2** |
| Karnataka | BSNL | 0.01 | 2 | 0.01 | 2 | |
| | RIC | 1.34 | 4 | 2.18 | 6 | |
| | Tata | 0.68 | 3 | 0.90 | 3 | **4** |
| Tamil Nadu | BSNL | 0.01 | 2 | 0.01 | 2 | |
| | RIC | 1.16 | 4 | 2.29 | 6 | |
| | Tata | 0.32 | 3 | 0.48 | 3 | **4** |
| Kerala | BSNL | 0.05 | 2 | 0.05 | 2 | |
| | RIC | 1.13 | 4 | 1.59 | 4 | |
| | Tata | 0.34 | 3 | 0.54 | 3 | **6** |

| | | July 2006 | | December 2007 (estimates) | | |
|---|---|---|---|---|---|---|
| **Circle** | **Operator** | **2G subs (millions)** | **Carriers after normalization** | **2G subs (millions)** | **Carriers needed for 2G** | **Carriers available (est.)** |
| Punjab | BSNL | 0.01 | 2 | 0.01 | 2 | |
| | RIC | 0.70 | 3 | 0.73 | 3 | |
| | HFCL | 0.06 | 2 | 0.00 | 2 | |
| | Tata | 0.39 | 3 | 0.87 | 3 | **4** |
| Haryana | BSNL | 0.01 | 2 | 0.01 | 2 | |
| | RIC | 0.35 | 3 | 0.46 | 3 | |
| | Tata | 0.33 | 3 | 0.59 | 3 | **7** |
| UP (W) | BSNL | 0.01 | 2 | 0.01 | 2 | |
| | RIC | 1.07 | 4 | 2.09 | 5 | |
| | Tata | 0.44 | 3 | 1.13 | 4 | **4** |
| UP (E) | BSNL | 0.02 | 2 | 0.02 | 2 | |
| | RIC | 1.46 | 4 | 2.56 | 6 | |
| | Tata | 0.38 | 3 | 1.00 | 3 | **4** |
| Rajasthan | BSNL | 0.05 | 2 | 0.05 | 2 | |
| | RIC | 0.96 | 3 | 1.39 | 4 | |
| | Shyam | 0.03 | 2 | 0.03 | 2 | |
| | Tata | 0.41 | 3 | 1.11 | 4 | **2** |
| MP | BSNL | 0.13 | 2 | 0.13 | 2 | |
| | RIC | 1.06 | 4 | 1.78 | 5 | |
| | Tata | 0.29 | 2 | 0.53 | 3 | **5** |
| West Bengal | BSNL | 0.01 | 2 | 0.01 | 2 | |
| | RIC | 0.47 | 3 | 1.07 | 4 | |
| | Tata | 0.22 | 2 | 0.65 | 3 | **6** |
| HP | BSNL | 0.00 | 2 | 0.00 | 2 | |
| | RIC | 0.04 | 2 | 0.14 | 2 | |
| | Tata | 0.05 | 2 | 0.21 | 2 | **9** |
| Bihar | BSNL | 0.01 | 2 | 0.01 | 2 | |
| | RIC | 0.79 | 3 | 1.51 | 4 | |
| | Tata | 0.26 | 2 | 0.90 | 3 | **6** |
| Orissa | BSNL | 0.00 | 2 | 0.00 | 2 | |
| | RIC | 0.27 | 2 | 0.32 | 3 | |
| | Tata | 0.13 | 2 | 0.31 | 3 | **7** |
| Assam | BSNL | | | | N/A | |
| NE | BSNL | | | | N/A | |
| J&K | BSNL | | | | N/A | |
| | RIC | | | | N/A | |

*Note*: Since Assam, North East, and Jammu and Kashmir circles have one or two operators, the question of a spectrum shortage before December 2007 does not come about and hence the projections for these circles are not calculated.

# Annex J: EV-DO Operators in 450 MHz

| Country | Operator | Status | Infrastructure Vendor (s) |
|---|---|---|---|
| Argentina | Telecom Argentina | Trial | Huawei |
| Argentina | Telefonica Argentina | Trial | Huawei |
| Azerbaijan | Aztrank LLC | Launch TBA | |
| Belarus | BelCel JV | Launch TBA | |
| Cameroon | CAMTEL | Launch 1Q 2007 | Huawei |
| Czech Republic | Telefónica O2 Czech Republic | Commercial | Nortel |
| Finland | Nordisk Mobiltelefon Finland | Trial | Ericsson, Lucent, Nortel |
| Kyrgyzstan | AkTel LLC | Launch TBA | |
| Laos | Lao Telecommunications | Launch TBA | |
| Latvia | Telekom Baltija | Commercial | Huawei |
| Madagascar | Telecom Malagasy SA. (Telma) | Launch TBA | Huawei |
| Mali | Sotelma | Commercial | ZTE |
| Namibia | Telecom Namibia | Trial | Huawei |
| Norway | Nordisk Mobiltelefon Norway | Commercial | |
| Norway | Nordisk Mobiltelefon Norway | Launch TBA | |
| Oman | Oman Telecommunications Company | Launch 1Q 2006 | Huawei |
| Pakistan | DVCOM | Launch 4Q 2006 | Huawei |
| Pakistan | Great Bear International Services | Launch 2Q 2006 | |
| Portugal | Radiomovel | Commercial | |
| Romania | Telemobil | Commercial | Huawei, Lucent |
| Russia | Delta Telecom | Commercial | Lucent |
| Russia | JSC Apex | Commercial | Nortel |
| Russia | Kuzbass Cellular Communications (KCC) | Launch TBA | |
| Russia | Moscow Cellular Communications | Trial | |
| Russia | UralWestcom | Commercial | Nortel |
| Uganda | Uganda Telecom | Launch TBA | |
| Vietnam | Vietnam Power Telecom | Launch TBA | Huawei, Lucent, ZTE |
| Zambia | ZAMTEL | Launch 3Q 2006 | ZTE |

# Annex K: Levels Of Competition and number of service providers

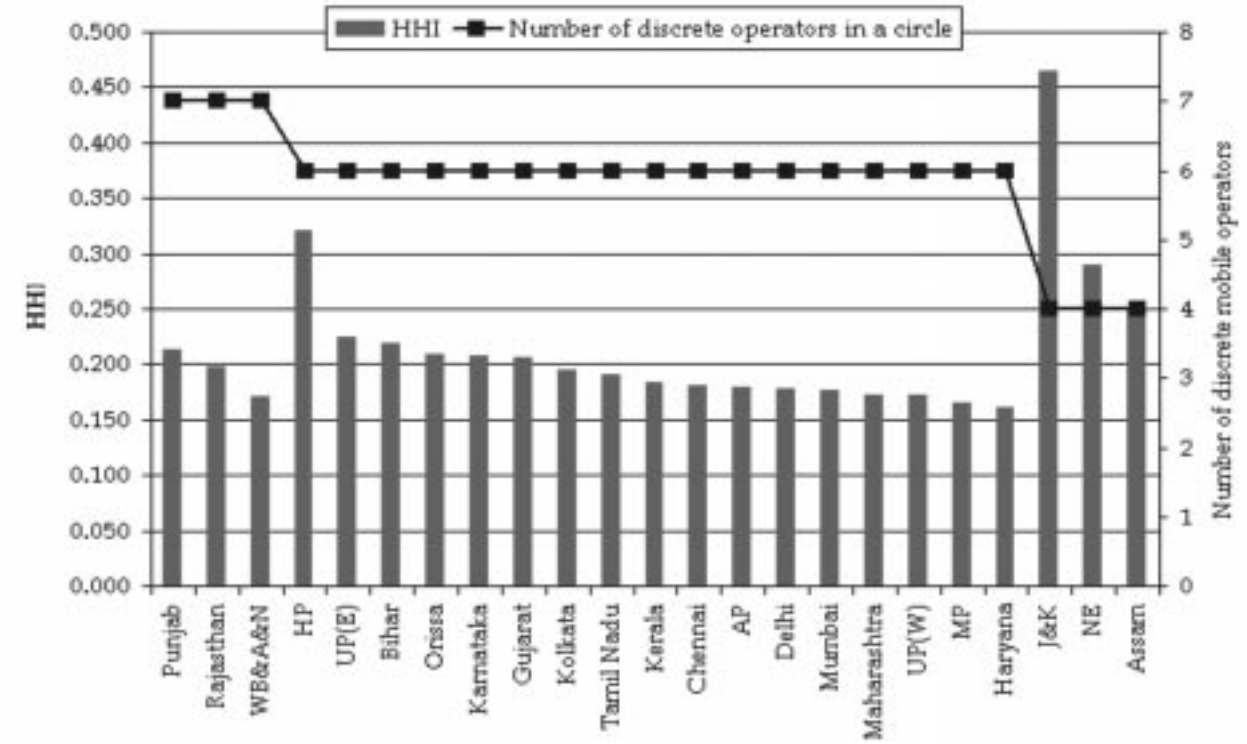


**Figure 16: HHI figures and number of cellular operators in each circle**

Figure 16 shows the HHI figures for each circle in India, and compares them with the number of distinct cellular operators in that circle. An HHI close to 0.0 indicates perfect competition, while HHI close to 1.0 indicates pure monopoly.

Consequently, we find that in the case of mobile telephone service provision the presence of more than five distinct operators ensure HHI of below 0.3 in a circle.

# Annex L: 3G Spectrum allocationmethods internationally

| Auction | Beauty Contest | Fixed Fee |
|---|---|---|
| Australia | Chile | Finland |
| Austria | Croatia | France |
| Belgium | China | Hong Kong |
| Canada | Estonia | Korea |
| Croatia | Finland | Portugal |
| Denmark | France | Spain |
| Germany | Indonesia | |
| Greece | Ireland | |
| Israel | Japan | |
| Italy | Korea | |
| New Zealand | Luxembourg | |
| Poland | Malaysia | |
| Slovenia | Norway | |
| Switzerland | Portugal | |
| Taiwan | Slovakia | |
| The Netherlands | Slovenia | |
| UK | Spain | |
| USA | Sweden | |
| Venezuela | | |

Source: ITU, 3G Licensing In Various Economies, available at: http://www.itu.int/ITU-D/imt-2000/MiscDocuments/new_licensing.PDF

# Annex M: Spectrum allocation methods

There were four methods of allocating exclusive-use spectrum that the Authority considered for 3G spectrum in India:[62]

(i) A multi stage auction
(ii) A one stage auction (or tender process)
(iii) Beauty contest
(iv) Fixed fee

It might also be possible to have a hybrid of these methods, for example, having a fixed one-time spectrum acquisition fee but awarding it to the party that offers the highest revenue share. A number of countries have chosen these different methods to allocate spectrum. Below, we discuss these different options and their consequences. A list of countries that followed auctions, beauty contests, and fixed fee allocation is provided in Annex L.

## Multi-stage Auctions

Auctions are widely considered to be the most transparent and economically efficient method of allocating not only spectrum, but a variety of resources.[63] For any auction, an initial price is set, called the reserve price and the auction either proceeds in an ascending or descending fashion from this starting point. The reserve price can be set in a similar fashion to the spectrum acquisition fee discussed previously. In case the demand exceeds supply, an auction is conducted to select the winner (s). In case the number of operators is less than or equal to the number of blocks available, no auction is required, and the spectrum can be allocated at the reserve price. Such a situation occurred in Hong Kong in 2001, when only four bidders showed up for an auction for four blocks of spectrum.[64]

[62] http://www.itu.int/ITU-D/imt-2000/MiscDocuments/new_licensing.PDF

[63] For an introduction to the idea of allocation of spectrum by auctions, see Coase, R. H., The Federal Communications Commission, Journal of Law and Economics, Vol. 2, p. 1-40, 1959

[64] Financial Times (London), HK awards 3G mobile licences without auction, September 20, 2001

A few stakeholders in their comments have suggested auctions.[65] Some of the respondents were not in favour of auctions, however, especially since they were concerned that auctions would drive the prices of spectrum up and impact the affordability of services.[66] There is evidence that spectrum auctions do not lead to increased price of service.[67] However, auctions have led to high spectrum costs in the past (e.g. Germany and England). This might impact affordability only moderately, but it will certainly have an effect on the viability of operators' business plans.

The Authority is not in favor of organizing an auction to allocate spectrum because given the importance of releasing the spectrum in the 1900 and 2100 bands to operators quickly to ensure continued growth of cellular services, it is essential that operators concentrate their efforts and investments in network infrastructure and not in spectrum acquisition. While an auction will promote efficient allocation and utilization, it might not be the best path given the constraints existing in the Indian environment.

**One stage auction (Tender process)**

In the standard tendering process, the single buyer floats a tender, which requests interested parties to state the least they can offer a service for. This is a monopsony situation with one buyer and multiple sellers. However, in the present case, the situation is reversed and is a monopoly, i.e. there is one seller (the DoT) and multiple buyers (operators). As a result, the winning tender could be the highest bid. Bids could be invited for different parameters, for example the spectrum acquisition amount, or annual spectrum charge revenue share percentage.

Tendering processes have been used for many contract awards, and have been at times successful and at times controversial. A few stakeholders mentioned in their comments to the Authority that a tender bidding process might be useful as an allocation strategy.[68]

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[65] Comments of ASC, IDFC, Mahesh Uppal, Rekha Jain, Sidharth Sinha, TIA, Zee Networks

[66] Comments of Nokia, RRN Prasad

[67] Kwerel, E., Spectrum Auctions Do Not Raise the Price of Wireless Services: Theory and Evidence, Office of Plans and Policy, Federal Communications Commission, October 2000, available at: http://wireless.fcc.gov/auctions/data/papersAndStudies/SpectrumAuctionsDoNotRaisePrices.pdf

[68] Comments of VSNL, DB Sehgal

## Beauty contest

In simple terms, a beauty contest is a process of selection where winners are selected based on how they score on a list of parameters other than the price the contestant is willing to pay for the license. In the case of this spectrum allocation, these parameters could be viability of the business plan, proposed rural coverage, willingness to share infrastructure, or other parameters. For example, in 2002 Malaysia evaluated bids on their proposals for service rollout and coverage, infrastructure sharing, roaming, financial consideration, industry development, and management and technical experience.[69] The operator who scores the highest across these different parameters gets the spectrum.

Beauty contests can be quite open - the criteria for evaluation are known beforehand, as is the price of the resource. However, a drawback is that licenses are awarded typically on the basis of promises about future performance, leading to possible opportunistic behaviour and a credibility problem with beauty contests. In addition, the criteria and selection process in beauty contests might be subjective and open to controversy, especially if the process is opaque.

However, countries still choose the beauty contest method because it allows them to select the specific parameters they want to encourage, and it circumvents the problem of high costs resulting from auctions.[70]

There are two problems with beauty contests:

(1) Since beauty contests seek operators' estimates of future deployments, they might over estimate their potential to deploy their networks. It is possible to incorporate penalties and incentives to ensure that operators stick to their commitments, but the risk of operators being too optimistic and failing, but simultaneously preventing others from deploying is too great.

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[69] Spectrum Allocation For 3G In Malaysia, 2002, available at http://www.3g.co.uk/PR/August2002/3892.htm

[70] Bjuggren, P-O., Allocation of 3G Rights, Credibility and the Rules of the Game Experiences of the Swedish 3G Beauty Contest, The 21st Annual Conference of the European Association of Law and Economics (EALE)/CESIS Electronic Working Paper Series, Paper No. 41

(2) It is difficult to organize an open and transparent process. Although criteria, bids, and evaluation process could be kept in the public domain, it might be difficult to convince prospective operators to disclose their business plans.

## Fixed fee

Some countries have chosen to use a fixed fee approach, where a fixed spectrum acquisition fee is stated, and any interested party can pay that fee and acquire the spectrum. This is not a very commonly employed method because the demand for spectrum typically exceeds supply. In the fixed fee approach, there is no way to discriminate between buyers - anyone who can afford the fee will get spectrum. Sometimes, countries resort to fixed fee allocation when the actual demand does not meet expectations (e.g. Hong Kong). One possible discrimination technique in fixed fee approaches is to set the price of spectrum so high that only very serious and established operators might be able to acquire it. However, this approach is detrimental to the consumer interest because it hinders affordability of the roll out and service provision.

The fixed fee approach can also be construed as meaning that the DoT allocates spectrum at no fee (i.e. fixed fee is zero). Some respondents have suggested that spectrum allocations in the 1900 and/or 2100 bands should be considered as extensions of current allocations and hence should be without an upfront spectrum acquisition fee, just as expansion of 2G spectrum has been handled. The Authority does not agree with this contention because the current license conditions for cellular mobile or unified access service providers clearly specify that only the 800 MHz, 900 MHz and 1800 MHz bands are included in the terms of the license. Further, in the Indian scenario, there are some costs associated with vacating existing users of these spectrum bands and hence, it will not be possible to allocate spectrum in the 1900 and 2100 bands for free.

The fixed fee concept cannot be applied to the Indian scenario because there will be greater demand than supply of spectrum. The fixed fee does not ensure selectivity and it is possible that a number of operators could pay the fee. It is possible to set the fee high enough that only a few operators can acquire spectrum, but this would make 3G services expensive to deploy.

## Hybrid allocation methods

Another possibility that we examine briefly is a hybrid allocation method. It might be possible to combine two of the above methods to derive their individual benefits while reducing their risks. For example, one could have a beauty contest-auction mix, where only pre-qualified bidders will be allowed for the auction. This might be useful in reducing the chance of non-serious or unqualified players entering an auction to drive up spectrum costs; yet, it allows transparency and efficient allocations. Another option might be to set a fixed fee for the spectrum acquisition, but have an auction for the percentage an operator is willing to pay as the annual spectrum fee.

Hong Kong, for example, had a hybrid beauty contest-auction mechanism to "help weed out under-funded, overly ambitious companies who might take on more debt than they can handle... allow the free market to operate, allowing those who value[d] the licenses most to bid as high as their pocketbooks allow[ed]."[71] France has also allocated spectrum using a beauty contest-fixed fee hybrid, "in which licensees are chosen through a beauty contest but charged a high fee."[72]

Different hybrid approaches are possible, as follows:

| | **Beauty contest** | **Fixed fee** |
|---|---|---|
| Auction | Pre-qualification by beauty contest + auction for acquisition | Fixed acquisition fee + auction for annual spectrum charges |
| Beauty contest | | Select operators by beauty contest + charge a fixed acquisition fee |

The Authority believes that an auction will be best suited for the Indian situation because an auction will ensure that spectrum is allocated using a transparent and efficient mechanism. The specific auction mechanism recommended for allocation of 2.1 GHz spectrum in India is discussed in Annex N.

[71] Futch, A., Hard lessons: Guiding America's approach to third generation wireless policy, 2001 Duke Law & Technology Review, Vol. 33, October 2001

[72] Cave, M. & Valletti, T., Are spectrum auctions ruining our grandchildren's future?, info, Volume 2, No. 4, August 2000

# Annex N: Recommended auction mechanism

The Authority has recommended that the auction for the 2.1 GHz spectrum should be a simultaneous ascending auction (SAA). This method was first developed for the U.S. FCC's spectrum auctions and used by them since 1994.[73] The method has been refined with experience, and extended to the sale of divisible goods in electricity, gas, and environmental markets.[74] Keeping in mind the specific circumstances surrounding the allocation of the 2.1 GHz band in India, and the concerns outlined in 4.45, the Authority has recommended an auction mechanism based on the SAA mechanism, and incorporating features that have been successful in previous communication related auctions such as the 4th cellular operator auction and the FM Phase II auction.

The auction's rules should at least include the following:

1. All eligible operators interested in acquiring spectrum in the 2.1 GHz band should be present for the auction.
2. The reserve prices for the auction is set for each license area, and in no case shall any bid go below this reserve price.
3. The bids are to be submitted for in terms of Rupees per 2 x 5 MHz of spectrum.
4. Every bidder should deposit an earnest money guarantee of 25 per cent of the reserve price for the auctions they are participating in.
5. Winning bidders have to deposit 25 per cent of the successful bid amount immediately at the close of the auction, and the balance in seven calendar days.
6. No bidder can withdraw a bid after placing, and no bidder can reduce a bid in subsequent rounds. If a bidder withdraws a bid at any point of time, it will forfeit the earnest money and bid deposit.
7. Bidders should be unconnected from each other in order to prevent collusion and cartelization in the acquisition of spectrum.
8. The auctioneer shall disqualify anyone violating these rules.

[73] http://wireless.fcc.gov/auctions/default.htm?job=about_auctions&page=2

[74] Cramton, P., Simultaneous Ascending Auctions, in Peter Cramton, Yoav Shoham, and Richard Steinberg (eds.), Combinatorial Auctions, Chapter 4, 99-114, MIT Press, 2006

The auction proceeds as follows:

(1) In the first round, all bidders place their bids for 2 x 5 MHz in the 2.1 GHz band

(2) If the number of bids is less than or equal to five, the spectrum should be allocated at the reserve price, but according to the order determined in (9). If the number of bids is greater than five, the auction proceeds as follows.

(3) The lowest bidder is waitlisted for spectrum in the 2.1 GHz band when it is available in the future

(4) The second-lowest bid and the highest bid are made public (only bid amount)

(5) In the next round, bidders can increase their bids or keep them at their older value, with the reserve price as the second-lowest bid of the last round

(6) The lowest bidder is waitlisted for spectrum in the 2.1 GHz band when it is available in the future

(7) If the number of bidders remaining is five, the auction closes, else the steps (3)- (5) continues until only five bidders are left

(8) Allocation price is based on each operator's final bid amount if it is not less than 75 per cent of the highest winning bid. If one of the final remaining bidders' bid is less than 75 per cent of the highest winning bid, then that bidder has an opportunity to, after the auction closes, come up to this level. If the bidder does not wish to do so, it can be waitlisted, and the higher of the previously waitlisted bidders is given a similar opportunity. This process continues until five bidders for blocks in the 2.1 GHz band are chosen

(9) The top five bidders are called in decreasing order of their bids to choose which block of spectrum they wish.

If there is a tie between more than one low bidders, the bidder with the lower subscriber base should be waitlisted while the bidder with the higher subscriber base should be permitted to participate in the next round. If even the subscriber base is tied, then the bidder with higher AGR in the quarter prior to the auction should be allowed to continue, while the other bidder (s) should be waitlisted.

**Example of auction mechanism**

Consider a circle with seven operators who wish to bid for spectrum blocks in the 2.1 GHz band.

In this circle, reserve price is Rs. 100 Crore for one block of spectrum. The table below shows how operators O1 to O7 bid and progress in the auction described.

| | Operators and their bids | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | O1 | O2 | O3 | O4 | O5 | O6 | O7 | Disclosed information |
| Round 1 | 130 | 150 | 120 | 110 | 170 | 105 | 115 | Reserve = 100 (Cr)<br>Second lowest = 110, high = 170 |
| Round 2 | 150 | 165 | 130 | 140 | 180 | | 125 | High = 180, 75% is 135 |
| Bid amount | 150<br>83% | 165<br>92% | 130<br>72% | 140<br>78% | 180<br>100% | | | |
| Final price | 150 | 165 | 135<br>75% | 140 | 180 | | | |

In this auction, O6 and O7 get waitlisted because their bids were the lowest in Rounds 1 and 2 respectively. In Round 3, O3 bids and is at 72% of the highest bid, which is Rs. 180 Crore. Hence, O3 gets the choice of matching 75% of this high bid, i.e. coming to Rs. 135 Crore or getting waitlisted. If it chooses to be waitlisted, O7 is first given a chance to match to Rs. 135 Crore, and if it does not exercise this option, O6 has a chance.

The other bidders (O1, 2, 4, 5) pay their respective bids and are allocated spectrum.

# Annex O: International spectrum prices

| Country | Year of allocation | $/Hz |
|---|---|---|
| Ireland | 2002 | $3.41 |
| Luxemborg | 2002 | $0.01 |
| Malaysia | 2002 | $0.39 |
| Slovakia | 2002 | $1.10 |
| Taiwan | 2002 | $8.99 |
| Estonia | 2003 | $0.16 |
| Norway | 2003 | $0.40 |
| Bulgaria | 2004 | $0.94 |
| Croatia | 2004 | $0.53 |
| Hungary | 2004 | $2.82 |
| Denmark | 2005 | $2.67 |
| Latvia | 2005 | $0.03 |
| Lithuania | 2006 | $0.03 |
| Morocco | 2006 | $1.37 |
| Romania | 2006 | $0.88 |
| Sri Lanka | 2006 | $0.17 |

Average $/Hz internationally since 2002 = $1.49 ≈ Rs. 68

# Annex P: Roll out obligations for 3G networks around the world

| Country | Coverage conditions specified in 3G licenses | | | |
|---|---|---|---|---|
| | Population coverage (%) | Deadline (years from allocation) | Population coverage (%) | Deadline (years from allocation) |
| Denmark | 30 | 1 | 80 | 5 |
| France | 35 | 1 | 58 | 2 |
| Greece | 50 | 1 | - | - |
| Holland | 80 | 3 | - | - |
| Ireland | 53 | 1 | 80 | 3 |
| Italy | 17 | 1 | 30 | 4 |
| Korea | 30 | 1 | - | - |
| Poland | 20 | 3 | - | - |
| Portugal | 40 | 2 | 60 | 4 |
| Switzerland | 50 | 1 | - | - |
| Spain | 50 | 2 | 90 | 5 |
| England | 80 | 5 | - | - |
| Sweden | 99 | 1 | - | - |
| Germany | 50 | 1 | - | - |
| Austria | 25 | 1 | 50 | 2 |

Source: StelaCon, UMTS development: From an international perspective, December 2005

# Annex Q: Assignments in the 3.3-3.4 GHz band

| Spectrum Assigned | OPERATOR | AREA OF LICENCE |
|---|---|---|
| 2x6 MHz | VSNL/TTSL | NAVI MUMBAI, ANDHERI, BHUBANESWAR, NASIK, SURAT, RAIPUR, RAJKOT, BARODA, KOLKATA, INDORE, AHMEDABAD, GANDHINAGAR, BHOPAL, JHANSI, GWALIOR, KANPUR, UDAIPUR, LUCKNOW, JAIPUR, GURGAON, NEW DELHI, DELHI, MOHALI, LUDHIANA, SHIMLA, JALANDHAR, AMRITSAR, CHOTA SHIMLA, NOIDA, TRIVANDRUM, KOLLAM, KOTTAYAM, ERNAKULAM, COCHIN, TRICHY, COIMBATORE, TRIPURA, CALICUT, ERODE, CUDDALORE, KANNUR, MYSORE, BANGALORE, CHENNAI, GOA, HYDERABAD, PONDICHERRY, PUNE, MUMBAI, NAVI MUMBAI, HUBLI, CHANDI |
| 2x5MHz | SPECTRANET | BANGALORE, MUMBAI, FARIDABAD, GURGAON, NEW DELHI, DELHI, GHAZIABAD |
| 2x6 MHz | RCIL | BANGALORE, CHENNAI, HYDERABAD, PUNE, MUMBAI, SURAT, GUJARAT, BARODA, KOLKATA, AHMEDABAD, DELHI, NEW DELHI |
| 2x6 MHz | Dishnet DSL | MADURAI, DINDUGUL, ETTAYAPURAM, RV PURAM, TRIVANDRUM, NAGERCOIL, TRICHY, TANJAVR, NAGAPATTANAM, COIMBATORE, PODANUR, VELLORE, ERODE, COONOOR, OOTY, CHIDAMBARAM, SALEM, CUDDALORE, PONDICHERRY, NYVELI, MYSORE, ARRAKONAM, CHENNAI, TIRUNAVELI, TUTICORIN, HOSUR, BANGALORE, KANCHIPURAM, MANGALORE, VELLORE, RAMESWARAM, SRIPERUMPUDUR, TUMKUR, CHIKAMANGALORE, DEVAN GIRI, UDIPI, KARAIKKAL, CHOLAVARAM, THIRUTHANI, KANYAKUMARI, SIVAKASI, SEVERAL OTHER PLACES IN TN, SHIMOGA, HOSEPET, BIDAR, GADAG, BELGAUM, TIRUMALA, TIRUPATHI, CHITTUR, SRIKALAHSTHI, PUTTUR, HINDUPUR, AANTHAPURAM, CUDDAPAH, GUDUR, NELLORE, BELLARY, KURNOOL, GOA, PRAKASAM, SRISAILAM, AMRAVATI, MACHILIIPATNAM, RAICHUR, KRISHNA DISTRICT, VIJAYWADA, WEST GODAVARI, MAHABOOB NAGAR, NALGONDA, KAKINADA, RAJAHMUNDRY, KHAMMAM, GULBARGA, SECUNDRABAD, HYDERABAD, MEDAK, WARANGAL, RANGA REDDY, VIJAYANAGARAM, NIJAMABAD, ADILABAD, EAST GODAVARI, PUNE, MUMBAI, NASIK, AURANGABAD, NAGPUR, BARODA, AHMEDABAD, VALSAD, BHAVNAGAR, RAJKOT, JUNAGADH, SURENDRANAGAR, GODHRA, NAVSARI, NADIAD, ANKLESHWARI, BHARUCH, BHOPAL, INDORE, SIHOR, LUCKNOW, JAIPUR, CHANDIGADH, DELHI |
| 2x6 MHz | SIFY | KERALA, MADHURAI, COCHIN, COIMBATOR, SALEM, KANNUR, CALICUT, MYSORE, MANGOLORE, BANGALORE, CHENNAI, SHIMOGA, DEVANGIRI, HUBLI, GOA, BELGAUN, GUNTUR, VIJAYAWADA, HYDERABAD, SECUNDRABAD, PUNE, WARANGAL, MUMBAI, THANE, NASIK, BHUVANESHWAR, NAGPUR, SURAT, RAIPUR, JAMNAGAR, KOLKATA, INDORE, BHOPAL, AHMEDABAD, KOTA, PATNA, GUWAHATI, JODHPUR, KANPUR, LUCKNOW, JAIPUR, AGRA, FARIDABAD, NEW DELHI, GHAZIABAD, PANCHKULA, CHANDIGADH, LUDHIANA |

| Spectrum Assigned | OPERATOR | AREA OF LICENCE |
|---|---|---|
| 2x7 MHz | BSNL | ERNAKULAM, BANGALORE, CHENNAI, HYDERABAD, PUNE, NOIDA, MUMBAI, AHMEDABAD, KOLKATA, GURGOAN, AGRA, AHMEDNAGAR, AIZWAL, AJMER, AKOLA, ALIGADH, ALLAHABAD, ALLEPPY, AMBALA, AMRAVATI, AMRITSAR, ANAND, ARIYALUR, ASSANSOLE, AURANGABAD, BANGALORE, BAREILY (UP-W), BEHRAMPUR (ORRISA), BELGAON (KTK), BELLARY (KTK), BHAGALPUR (BIHAR), BHARUCH (GUJARAT), BHATINDA (PUNJAB), BHAVNAGAR (GUJARAT), BHILWARA (RAJ), BHIMAVARAM (AP), BHOPAL (MP), BHUBNESHWAR (ORISSA), BIJAPUR (KTK), BIKANER (RAJ), BILASPUR (C'GARH), BOKARO (JKD), CALICUT (KERALA), CANNANORA (KERALA), CHANDIGARH, CHANDRAPUR (MAH), CHENNAI, COIMBATORE (TN), COLLAM (KERALA), CUDDALORE (TN), CUDDAPH (AP), CUTTAK (ORISSA), DARBHANGA (BIHAR), DEHRADUN (UCHL), DEVANAGERE (KTK), DHANBAD (JKD), DHARAMSHALA (HP), DHARMAPURI (TN), DHARWAD (KTK), DHULE (MAH), DIBRUGARH (ASSAM), DIMAPUR (NE-2), DINDIGUL (TN), DURG (C'GARH), DURGAPUR (WB), ERNAKULAM (KERALA), ERODE (TN), FARIDABAD, FEROZPUR (PUNJAB), GANDHIDHAM (GUJ), GANDHINAGAR (GUJ), GANGTOK (WB), GAYA (BIHAR), GHAZIABAD, GODHARA (GUJ), GORAKHPUR (UP-E), GULBARGA (KTK), GUNTUR (AP), GURGAON (HARYANA), GUWAHATI (ASSAM), GWALIOUR (MP), HALDIA (WB), HARIDWAR (UCHL), HASSAN (KTK), HIMMATNAGAR (GUJ), HISSAR (HARYANA), HOSHIARPUR (PUNJAB), HYDERABAD, IMPHAL (NE-2), INDORE (MP), ITANAGAR (NE-2), JABALPUR (MP), JAIPUR (RAJ), JALANDHAR, JALGAON (MAH), JAMMU (J&K), JAMNAGAR (GUJ), JAMSHEDPUR (JKD), JHANSI (UP-E), JODHPUR (RAJ), JORHAT (ASSAM), JUNAGARH (GUJ), KALYAN (MAH), KANCHIPURAM (TN), KANPUR (UP-E), KANYAKUMARI (TN), KARAIKUDI (TN), KARIMNAGAR (AP), KARNAL (HARYANA), KARRAIKAL (TN), KARUR (TN), KATIHAR (BIHAR), KHAMMAM (AP), KOHIMA (NE-2), KOLHAPUR (MAH), KOLKATA, KORAPUT (ORISSA), KOTA (RAJ), KOTTYAM (KERALA), KUMBAKONAM (TN), KURNOOL (AP), LATUR (MAH), LUCKNOW (UP-E), LUCKNOW (UP-E), LUDHIANA, MADURAI (TN), MALAPURAM (KERALA), MANGALORE (KTK), MATHURA (UP-W), MEERUT (UP-W), MEHBOOBNAGAR (AP), MEHSANA (GUJ), MOGA (PUNJAB), MORADABAD (UP-W), MUMBAI, MUZAFFARPUR (BIHAR), MYSORE (KTK), NAGAPATTINAM (TN), NAGERCOIL (TN), NALGONDA (AP), NAMAKKAL (TN), NANDED (MAH), NANITAL (UCHL), NASIK (MAH), NAVSARI (GUJ), NELLORE (AP), NILGIRIS (TN), NIZAMABAD (AP), NOIDA (UP), ONGOLE (AP), OOTY (TN), PALGHAT (KERALA), PANIPAT (HARYANA), PANJIM (MAH), PATHANKOT (PUNJAB), PATIALA (PUNJAB), PATNA (BIHAR), PERAMBALUR (TN), PONDICHERRY (TN), PORTBLAIR (A&N), PUDDUKOTTAI (TN), PUNE, RAICHUR (KTK), RAIGAD (MAH), RAIPUR (C'GARH), RAJAHMUNDRY (AP), RAJKOT (GUJ), RAMNAD (TN), RANCHI (JKD),RATLAM (MP), RATNAGIRI (MAH), RAURKELA (ORISSA), SAHARANPUR (UP-W), SALEM (TN), SAMBALPUR (ORISSA), SANGLI (MAH), SANGRUR (PUNJAB), SATARA (MAH), SHILLONG (NE-1), SHIMLA (HP), SHIMOGA (KTK), SHIVAGANGA (TN), SILCHAR (ASSAM), SILIGURI (WB), SOLAN (HP), SOLAPUR (MAH), |

| Spectrum Assigned | OPERATOR | AREA OF LICENCE |
|---|---|---|
| | | SRIGANGANAGAR (RAJ), SRINAGAR (J&K), SURAT, SURENDARNAGAR (GUJ), TANJORE (TN), THANJAUR (TN), THENI (TN), THIRUVALLA (KERALA), THIRUVARUR (TN), TINSUKHIYA (ASSAM), TIRUNELVELI (TN), TIRUPATI (AP), TIRUPUR (TN), TIRUVANNAMALAI (TN), TRICHUR (KERALA), TRICHY (TN), TRIVALLUR (TN), TRIVANDRUM (KERALA), TUMKUR (KTK), TUTICORIN (TN), UDAIPUR (RAJ), UDHAMSINGHNAGAR (UCL), UDIPI (KTK), UJJAIN (MP), UTTRAKANNADA (KTK), VADODRA, VALSAD (GUJ), VARANASI (UP-E), VELLORE (TN), VIJAYWADA (AP), VIRUDHUNAGAR (TN), VISHAKHAPATNAM (AP), WARANGAL (AP), YAMUNANAGAR (HARYANA), YEOTMAL (MAH) |
| 2x6 MHz | BHARTI | TRIVANDRUM (KERALA), MADURAI (TN), ERNAKULAM, TRICHY (TN), COIMBATORE (TN), CALICUT, SALEM (TN), PONDICHERRY (TN), MYSORE (KTK), MANGALORE (KTK), VELLORE (TN), CHENNAI, NELLORE (AP), HUBLI, GOA, DALGAON, GUNTUR (AP), VIJAYWADA (AP), GANDHINAGAR (GUJ), HYDERABAD, VISHAKHAPATNAM (AP), WARANGAL (AP), NASIK (MAH), BHUBANESHWAR, SURAT, RAIPUR (C'GARH), BILASPUR (C'GARH), BARODA, KOLKATA, UDAIPUR (RAJ), INDORE (MP), AHMEDABAD, BHOPAL, KOTA (RAJ), VARANASI (UP-E), ALLAHABAD, GWALIOUR (MP), LUCKNOW, AGRA, AMBALA, CHANDIGARH, LUDHIANA, JALANDHAR, AMRITSAR, KAPURTALA, HYDERABAD, BANGALORE, GOREGAON (EAST), FARIDABAD, NOIDA, GURGAON (HARYANA), NEW DELHI, DELHI, GHAZIABAD, MUMBAI |

# Annex R: BWA spectrum requirements in Mumbai

| ***Estimated* BWA spectrum requirement in 2007 in Mumbai** | | |
|---|---|---|
| Population (2006e) | 16,000,000 | |
| **Growth rate** | **5.00%** | |
| Population (2007e) | 16,800,000 | |
| Broadband policy goal (2007) | 9,000,000 | |
| Bombay subs broadband % of policy goal (2007) | 20% | |
| Bombay subs broadband (2007) | 1,800,000 | |
| Bombay BWA subs as % of broadband subs (2007) | 40% | |
| Bombay BWA subs (2007) | 720,000 | |
| **Subs** | **720,000** | **[1636/km$^2$]** |
| Per sub download data rate | 0.25 | mbps |
| | 256 | kbps |
| Duty cycle (what % of time the channel is active) | 25% | |
| Peak time customers | 25% | |
| Max download data throughput needed | 11,250 | mbps |
| Download/Upload traffic channel bandwidth ratio | 3.00 | :1 |
| **Total data throughput needed** | **15,000** | **mbps** |
| Cell radius | 2.00 | km |
| Cell area | 10.39 | km$^2$ |
| Area of Bombay | 440.00 | km$^2$ |
| Number of cells | 42.34 | |
| **Throughput per cell** | **354.27** | **mbps** |
| Spectral efficiency | 2.00 | bps/Hz |
| Spectrum needed per cell | 185,740,939.64 | Hz |
| ***Estimated* spectrum needed per cell** | **185.74** | **MHz** |

| **Estimated BWA Spectrum Requirement In 2010 In Mumbai** | | |
|---|---|---|
| Population (2006e) | 16,000,000 | |
| **Growth rate** | **5%** | |
| Population (2010e) | 19,448,100 | |
| | | |
| Broadband policy goal (2010) | 20,000,000 | |
| Bombay subs broadband % of policy goal (2010) | 10% | |
| Bombay subs broadband (2010) | 2,000,000 | |
| Bombay BWA subs as % of Bband subs (2010) | 50% | |
| Bombay BWA subs (2010) | 1,000,000 | |
| **Subs** | **1,000,000** | **[2273/km$^2$]** |
| Per sub download data rate | 0.25 | Mbps |
| | 256.00 | Kbps |
| Duty cycle (what % of time the channel is active) | 25% | |
| Peak time customers | 25% | |
| Max download data throughput needed | 15,625.00 | Mbps |
| Download/Upload traffic channel bandwidth ratio | 3.00 | :1 |
| **Total data throughput needed** | **20,833.33** | **Mbps** |
| Cell radius | 2.00 | km |
| Cell area | 10.39 | km$^2$ |
| Area of Bombay | 440 | km$^2$ |
| Number of cells | 43 | |
| **Throughput per cell** | **492.05** | **mpb** |
| Spectral efficiency | 2.00 | bps/Hz |
| Spectrum needed per cell | 257,973,527.27 | Hz |
| ***Estimated* spectrum needed per cell** | **257.97** | **MHz** |

| **BWA spectrum requirement per operator in 2010 in Mumbai** | | |
|---|---|---|
| Population (2006e) | 16000000 | |
| Growth rate | 5% | |
| Population (2010e) | 19448100 | |
| | | |
| Broadband policy goal (2010) | 20000000 | |
| Bombay subs broadband % of policy goal (2010) | 10% | |
| Bombay subs broadband (2010) | 2000000 | |
| Bombay BWA subs as % of Bband subs (2010) | 50% | |
| Bombay BWA subs (2010) | 1000000 | |
| Market share of one operator | 10% | |
| **Subs** | **100000** | **[227/km$^2$]** |
| Per sub download data rate | 0.25 | Mbps |
| | 256 | Kbps |
| | | |
| Duty cycle (what % of time the channel is active) | 0.25 | |
| Peak time customers | 0.25 | |
| Max download data throughput needed | 1562.5 | Mbps |
| Download/Upload traffic channel bandwidth ratio | 3.00 | :1 |
| **Total data throughput needed** | **2083.333333** | **Mbps** |
| Cell radius | 1.71 | Km |
| Cell area | 7.55 | Km$^2$ |
| | | |
| Area of Bombay | 440 | Km$^2$ |
| | | |
| Number of cells | 58 | |
| **Throughput per cell** | **35.76278706** | **mbps** |
| Spectral efficiency | 2.5 | bps/Hz |
| Spectrum needed per cell | 15000000 | Hz |
| ***Estimated* Spectrum needed per cell** | **15** | **MHz** |

# Annex S: ISP subscriber base

There were 153 ISPs licensed and operating throughout the country as of March 31, 2006. Of these, only 52 had a subscriber base above 1,000 and only 20 had a subscriber base above 10,000. Given that spectrum is a valuable and scarce resource, it is necessary to ensure that only serious and long-term players have access to it. This is especially true since ISP licenses are only Re. 1, and non-serious players might be able to delay allocation or hoard spectrum. Hence, it is necessary to ensure that only serious and well-established ISPs acquire spectrum, because only they will probably have the capacity to invest in and deploy BWA networks.

As of mid-2006, the top few ISPs together commanded almost 95 per cent of the total Internet subscriber base.

| UASLs/CMSPs | ISPs | Internet subscribers | Broadband subscribers |
|---|---|---|---|
| BSNL | BSNL | 2,929,299 | 734,752 |
| MTNL | MTNL[75] | 984,020 | 280,510 |
| | Sify | 898,708 | 42,237 |
| | VSNL | 556,227 | 113,225 |
| Bharti | Bharti | 392,470 | 235,421 |
| Reliance | Reliance | 359,784 | 15,910 |
| | Data Infosys | 245,908 | 243 |
| | BG Broadband | 116,851 | 108.974 |
| | Hathway | 61,986 | 50,868 |
| | HCL | 42,272 | 39 |

The total Internet subscriber base of these ISPs is 6,587,525, which is 95 per of the total Internet subscriber base of 6.934 million.

[75] MTNL is the only ISP in this table that does not have an all-India footprint because it operates only in Delhi and Mumbai. Subscriber information as of March 2006, TRAI data.

# Annex T: Price of BWA spectrum internationally

| | Entry fee per Hz | Annual fee |
|---|---|---|
| S Korea | $11.40 | |
| Australia | $0.37 | |
| Taiwan | ~$0.00 | |
| Malaysia | ~$0.00 | |
| New Zealand | $0.02 | |
| Singapore | $0.05 | |
| Brazil | $0.33 | |
| Venezuela | $0.13 | |
| China | Free | |
| Greece | $0.08 | |
| Finland | $0.18 | |
| France | $0.16 | |
| UK | $0.14 | |
| Hungary | $0.08 | |
| Spain | ~$0.00 | low annual fee |
| Austria | ~$0.00 | low annual fee |
| Poland | ~$0.00 | low annual fee |
| Ireland | ~$0.00 | low annual fee |
| Denmark | ~$0.00 | low annual fee |
| Sweden | ~$0.00 | low annual fee |
| Average without South Korea | $0.08 | |
| Average with South Korea | $0.65 | |

# TELECOM REGULATORY AUTHORITY OF INDIA

**September 27, 2006**

**PRESS RELEASE NO. 92 /2006**

## TRAI issues Recommendations on 'Allocation and pricing of spectrum for 3G services and Broadband Wireless Access'

- The recommendations are based on the following principles: *Maximization of consumer interest including affordability, Responsible and efficient use of spectrum, Aiding growth of the sector particularly in rural areas, ensure technology and service neutrality/convergence, Recovery of costs and pricing of spectrum, Orient spectrum policy to the future, Competition:, Keeping a level playing field, Sharing of infrastructure.*

- In order to provide long-term vision and planning for spectrum availability and its efficient usage, a National Frequency Management Board may be constituted.

- Spectrum identified for 3G should be treated as a stand-alone allocation and not as an extension of earlier spectrum allocation of 2G.

- Department of Telecom should realize a spectrum acquisition fee from telecom service providers.

- The spectrum for immediate allocation in case of 3G services should be in 450 MHz, 800 MHz and 2.1 GHz. As per present estimates 2X32.5 MHz of spectrum will be available in a time scenario of 6 to 9 months for 3G services.

- Five blocks of 2x5 MHz in 2.1 GHz band, one block of 2x5MHz in 450 MHz band and two blocks of 2X1.25 MHz in 800 MHz band to be made available through a prescribed auction procedure as detailed in the recommendations.

- Rural roll out obligation imposed as part of overall roll out obligation in a time bound manner.

- Base price for acquisition of spectrum for 3G services recommended at Rs. 80 crore for category 'A' circles, Delhi and Mumbai metro, Rs. 40 crore for category 'B' circle and metro Chennai and Kolkata and Rs. 15 crore for category 'C' circle.

- Broadband Wireless Access (BWA) given a high priority. The Authority has identified 200 MHz of spectrum in 3.3-3.4 GHz and 3.4-3.6 GHz bands to about 13 carriers in contiguous blocks of 15 MHz each.

- On grounds of non-availability in a short-term time frame and also on account of technical issues particularly in mixed band plan, the Authority has not immediately taken into account PCS 1900 MHz, 2.3 GHz, 2.5 GHz and 700 MHz for 3G and BWA services.

- Stiff penalty for de-hoarding and non-compliance of roll out obligations.

The Authority has released its recommendations on the allocation and pricing of spectrum for 3G and BWA services. The recommendations focus on level playing field, technological neutrality and affordability while ensuring that spectrum is available to telecom operators wishing to provide 3G and BWA and thus deepening the penetration of telecom services in rural and urban India. The Authority gave a high priority to a forward looking but pragmatic long-term road map identifying bands of spectrum for immediate and future use thus ensuring that the benefits of technology is spread all over the country. Keeping with the broad working guidelines of the Authority, the recommendations fulfill the objectives of healthy competition, sectoral growth, level playing field and maintaining a technologically neutral stance. The key theme of the recommendation is that the consumer must reap the benefits of affordable and varied services.

It is evident to all that the spectrum is a scarce commodity and allocation should be considered in a holistic manner and any piecemeal or ad-hoc solutions should not find place in future planning. Accordingly, the Authority has also made suo-moto suggestions on the wider issue of management spectrum.

The salient features of the recommendations by the Authority are:

(i) The allocation of 3G has to be treated as a stand alone exercise and not as an extension of 2G spectrum. Accordingly allocation criteria has to be specified separately coupled with the basis of spectrum acquisition fee.

(ii) For 3G services 3 bands i.e. 450 MHz, 800 MHz and 2.1 GHz have been identified. The total available spectrum presently is 2x32.5 MHz in a time scenario of 6 to 9 months for 3G services.

(iii) The DoT should take immediate steps for allocation of 5 blocks in 2x25 MHz of spectrum in 2.1 GHz band.

(iv) Allocation for 3G services should also be made in 450 MHz (one block of 2x5 MHz) and 800 MHz (2 carriers of 2x1.25 MHz).

(v) As already requested by TRAI, DoT to verify technical feasibility of co-existence of mixed band allocation. In case found feasible then DoT should work towards refarming of the PCS 1900 bands, specifically 2x10 MHz in the medium-term scenario for allocation to telecom service operators with CDMA technology.

(vi) The allocation and also the waiting list if any of telecom service operators should be determined through a process of auction. Only licensed telecom service operators will have the eligibility for participation in the auction. Reserve price for spectrum in the 2.1 GHz band shall be:

- Rs. 80 Crore for Mumbai, Delhi, Category A circles,

- Rs. 40 Crore for Chennai, Kolkatta, Category B circles and
- Rs. 15 Crore for Category C circles.

(vii) UASL CDMA operators to be given an option of one carrier for EV-DO services in the 800 MHz band and one block of 2x5 MHz in the 450 MHz band subject to specified conditions. If there are more UASL CDMA operators claiming the available spectrum in 450 MHz or 800 MHz band then a one stage bid process will be organized.

(viii) In case UASL CDMA operators bids and succeeds for 450 MHz band, such an operator would not be eligible for participation in the auction of 2.1 GHz band.

(ix) The Authority has requested to DoT for immediate resumption of unused spectrum so that additional spectrum is available in 800 MHz band for the growth of CDMA services. The resumption of unused spectrum should be implemented in a time bound manner in next 3 months. It will be possible to free some carriers in 800 MHz, reallocate them to the fast growing operators, and thus open the possibility to separately earmark two to three carriers for 3G services in the 800 MHz band.

(x) The Authority also examined the option of adding one more carrier to the existing 800 MHz without making major adjustments to increase the total number of carriers available in this band from 14 to 15 . The Authority recommended that DoT may coordinate with the operators in the next three months to modify the existing 800 MHz band plan, adjusting guard bands to add one additional carrier. Hence, at least two carriers, i.e. 2 x 2.5 MHz, can exclusively be dedicated for 3G (EV-DO) services in the 800 MHz band in all circles.

(xi) DoT should take steps for vacating 2 x 5 MHz of spectrum in the 900 MHz band in order to re-farm GSM operations within the band, and then allocate an additional 2 x 5 MHz for CDMA operations in the 800 MHz band.

(xii) DoT should grant a one year moratorium on incremental annual spectrum fees for 3G spectrum from the time of spectrum assignment. After this one year, the DoT should charge operators an additional annual spectrum charge of 1 per cent of the operator's total annual gross revenue (AGR).

(xiii) For operators in 2.1 GHz band, Rollout obligations of covering 90% of area in Metros and in circles 50% of the DHQs or cities in the circle out of which 15% should be rural, at the end of 5 years. At the end of 3 years, 30% of the DHQ or within the circle out of which at least 10% should be rural.

(xiv) At least 200 MHz of spectrum should be made available for BWA to accommodate growth requirement until 2007, and additional 100 MHz of spectrum should be earmarked by 2010.

(xv) Operators with current spectrum assignments in the 3.3-3.4 GHz band should be given the option to migrate to circle-wide operations by December 2006, and the DoT should then allocate this spectrum for BWA technologies.

(xvi) The DoT should get 100 MHz for broadband wireless applications in the 3.4 – 3.6 GHz band, coordinated with Department of Space urgently and make appropriate allocations.

(xvii) 200 MHz of spectrum in the 3.3-3.4 GHz and 3.4-3.6 GHz bands may be allocated to 13 operators in contiguous blocks of 15 MHz each. The majority of BWA spectrum as identified should be allocated among UASLs, CMSPs, or Category A and B ISPs and for circle level deployments. One block of BWA spectrum for allocation among captive networks, which can operate in any Secondary Switching Area (SSA).

(xviii) DoT should organize a one-stage sealed bid auction for every circle to allocate BWA spectrum for circle-wide licensees.

(xix) 5.15-5.35 GHz and 5.725-5.875 GHz bands may be delicensed for outdoor usage.

(xx) Considering the growth and development of wireless technologies and services, a long-term view on overall spectrum management policy including the organizational structure for spectrum management is necessary.

(xxi) In order to ensure availability of additional spectrum, its efficient utilization, planning for future requirement and effective monitoring a National Frequency Management Board (NFMB) may be constituted.

(xxii) A specialized division to study spectrum related issues considering future developments of wireless technology and application to be located in TRAI to assist NFMB.

(xxiii) The revenue estimated from the base price not accounting for final auction bid is around 1500 crores for 3G and BWA services.

(xxiv) If operators do not achieve their roll out obligations, they should be given one year within which to fulfill their roll out obligations. After one year, the operators should be fined a spectrum hoarding cess of 2.5 per cent of their winning auction bid (i.e. their spectrum acquisition price) per quarter in the next year. If the operators do not complete their roll out obligations within this one year, their spectrum assignments should be cancelled and the spectrum be re-allocated to a new operator.