TELECOM REGULATORY AUTHORITY OF INDIA

Recommendations

on

Spectrum related issues

New Delhi

May 13, 2005

List of Abbreviations Used

S.No.	Abbreviation	Full Form
1.	AGR	Adjusted Gross Revenue
2.	AIP	Administrative Incentive Pricing
3.	ARPU	Average Revenue Per User
4.	BS	Base Station
5.	BSO	Basic Service Operator
6.	CBD	Central Business District
7.	CDMA	Code Division Multiple Access
8.	COAI	Cellular Operators Association of India
9.	DHQ	District Headquarters
10.	DoT	Department of Telecommunications
11.	EAP	East Asia and Pacific
12.	ECA	Eastern Europe and Central Asia
13.	EDGE	Enhanced Data Rate for GSM Evolution
14.	ETSI	European Telecommunications Standards Institute
15.	EV DO	Evolution Data Only
16.	FAR	Frequency Allocation Re-use
17.	FDD	Frequency Division Duplex
18.	GDP	Gross Domestic Product
19.	GNI	Gross National Income
20.	GOM	Group of Ministers
21.	GPRS	General Packet Radio Service
22.	GSM	Global System for Mobile
23.	GSM-R	Global System for Mobile – Railways
24.	GST	Goods & Service Tax
25.	HHI	Herfindahl-Hirschman Index
26.	IP	Internet Protocol
27.	IMT	International Mobile Telecommunications
28.	ISD	International Subscriber Dialling
29.	ISP	Internet Service Provider
30.	ITU	International Telecommunication Union
31.	KHz	Kilo Hertz
32.	LAC	Latin America and the Carribbean
33.	MA	Mobile Allocation
34.	MCL	Mean Coupling Loss
35.	MHz	Mega Hertz
36.	M&A	Merger and Acquisition
37.	MENA	Middle East and North Africa
38.	MS	Mobile Station
39.	NTP'99	New Telecom Policy'99
40.	NFAP	National Frequency Allocation Plan
41.	OECD	Organisation for Economic Cooperation and Development
42.	PCS	Personal Communications Service
43.	PMP	Point to Multipoint
44.	POP	Point of Presence
45.	PPP	Purchasing Power Parity

46.	QoS	Quality of Service
47.	RX	Receiver
48.	SAR	South Asia Region
49.	SDCA	Short Distance Charging Area
50.	SSA	Sub-Saharan Africa
51.	SUE	Spectrum Utilisation Efficiency
52.	TDD	Time Division Duplex
53.	TDMA	Time Division Multiple Access
54.	TD-SCDMA	Time Division Synchronous Code Division Multiple Access
55.	TRAI	Telecom Regulatory Authority of India
56.	Tx-Rx	Transmitter-Receiver
57.	TX	Transmitter
58.	UASL	Unified Access Service License
59.	UNDP	United Nations Development Programme
60.	USA	United States of America
61.	USD	United States Dollar
62.	USO	Universal Service Obligation
63.	VAT	Value Added Tax
64.	WARC	World Administrative Radio Conference
65.	WCDMA	Wideband Code Division Multiple Access
66.	WDI	World Development Indicators
67.	WLL	Wireless Local Loop
68.	WPC	Wireless Planning & Coordination Wing under DoT
69.	WRC	World Radio Conference

Index

Executive Summary

Efficient utilisation of spectrum

1. Benchmarking on efficient utilization of spectrum[1]

1.1. The benchmarking criterion for efficient utilisation of spectrum for use as a parameter for determining the need for allocation of additional spectrum may be practically difficult to implement. Since the operators are currently having the spectrum ranging from 2 x 4.4 MHz to 2 x 10 MHz for GSM operators and 2 x 2.5 MHz to 2 x5 MHz for CDMA operators which is far below the international averages for both technology operators, therefore, at this stage application of any such benchmarking criterion as discussed in the consultation paper may not be appropriate. At a later stage, keeping in view technological developments, improvements in availability situation of spectrum and its allocation and also due to development of different type of applications, this concept of benchmarking could be reconsidered.

1.2. Keeping in mind the current constraint in availability of spectrum and pricing (existing revenue share) as a method of ensuring efficient utilisation of spectrum, it is recommended that the existing subscriber base approach for allocation of additional spectrum should continue. However, the present criteria of allocation of additional spectrum is different for GSM and CDMA operators. Originally, when the mobile services were started there was no expectation of the type of growth which has happened lately and there were also limitations in the availability of spectrum. Accordingly, spectrum in small quantities was allocated to these operators in comparison to the international average allocation which are of the order 2x20 MHz for GSM and 2x14 MHz for CDMA. The allocations in India are very limited. As already indicated, the existing allocation criterion for additional spectrum is different for GSM and CDMA operators. The required number of subscribers for allocation of additional spectrum (on per MHz basis) is different for GSM and CDMA operators as per the existing criteria. While finalising this criteria it might have been presumed that these two technologies have different efficiency of utilisation of spectrum. However, it is also well established that this difference diminishes as the traffic grows such as in Central Business Districts (CBD). The criteria for CDMA operators include additional allocation of spectrum even at SDCA level and is service area specific which is not the situation in GSM operators. The Authority, therefore, recommends that the subscriber based spectrum allocation criteria for both GSM and CDMA should be revised. The revised criteria should also keep in mind the expected results from intensive efforts recommended later in this document to get more spectrum released and the resulting availability picture of spectrum. Further, these criteria should be made to gradually move in the direction wherein they become technology neutral. If the Government so desires, TRAI jointly with the Telecom Engineering Centre (TEC) can assist WPC to formulate a revised criteria.

1.3. In framing the recommendations for spectrum allocation while ensuring maximization of efficiency of utilization of the spectrum, the Authority has kept two aspects in mind.

1. In the consultation paper on Spectrum related issues (dated 31.05.2004) based on ITU recommendations SM 1046-1, a methodology for benchmarking for efficient utilisation of spectrum in terms of Erlang/ MHz/ Sq. km. was discussed.

1.3.1. One aspect is to focus Government's objective to make 200 million cellular telephones available by 2007 and the fact that considerable planning period and definitiveness in spectrum allocation is required for quick build up of infrastructure of the operators to meet the above target. The allocation of spectrum to operators in India has been much below international benchmarks leading to inadequate planning and network building by operators. For providing a trigger for another explosive growth, spectrum should not act as a bottleneck and a relatively liberal approach is desirable.

1.3.2. The second aspect which has been kept in mind is that the availability of spectrum is limited and its allocation should be need based. Such an approach results in much longer time for making spectrum available to operators but has the advantage of better control over the limited available spectrum.

1.3.3. The Authority recommends that the spectrum allocation guidelines should be quickly revised both for GSM and CDMA. The Authority further recommends that whatever spectrum is currently available or can be coordinated quickly may be made available to the operators based on the revised allocation procedure. This approach of need based allocation could be adopted till a certain minimum spectrum typically 10 to 15 MHz is made available to each operator. Owing to the constraint in spectrum availability, the Authority recommends that instead of trying to make equal minimum spectrum available to all the operators, the operators should be given additional spectrum based on the needs. For this purpose, the existing subscriber based criteria, should be revised taking into account the "trunking efficiency" principles up to the extent of around 15 MHz and thereafter an alternative criteria could be considered.

2. Spectrum allocation

2.1 Spectrum allocation Procedure

2.1.1 As already discussed earlier, at this point of time the criterion of allocation of additional spectrum is linked to number of subscribers and is different for CDMA and GSM operators. The existing level of allocated spectrum, no. of existing subscribers, the availability of spectrum and licensing terms & conditions, etc. might have been kept in view while deciding these criteria. However, efforts should be made to gradually move in the direction wherein the spectrum allocation criterion is technology neutral. It is, therefore, recommended that the present spectrum allocation criterion may be reviewed such that while retaining the subscriber base approach, the quantum and steps for additional spectrum allocation are technology neutral. The revised spectrum allocation guidelines must keep the spectrum availability, efficiency of utilisation and area of co-ordination in mind.

2.2 Level of competition and entry of new mobile service providers

2.2.1 From the analysis of level of competition it is evident that with 4 to 7 mobile operators in different service areas, there is adequate competition in almost all the service areas. It is, therefore

recommended that before we consider allocating spectrum to new service providers it is necessary to ensure that the existing service providers have adequate spectrum. The adequacy of spectrum has to be seen in the context of short term requirements upto 2007 to meet the government objectives of the sector, the spectrum requirements beyond 2007 and the existing spectrum allocation criterion. On these considerations several locations can be identified in the country where additional spectrum is needed by operators forthwith. Based on these considerations it is recommended that the Government should not keep the available spectrum with themselves in service areas where there is adequate competition i.e. where HHI is 0.35 or below, and allot spectrum to operators, based on the revised spectrum allocation criteria.

2.2.2 New operators should be allowed in areas where spectrum requirements of existing operators have been met and additional spectrum is available. Due to merger and acquisitions policy there is a possibility that in future number of operators in areas with low HHI index are reduced and at that stage also the possibility of entry of new operators in such areas could be considered.

2.2.3 This approach should be followed for allocation of spectrum for even IMT-2000 services for areas where there is adequate competition and constraint on spectrum availability for existing operators in existing 2G/2.5G services.

2.3 Short term and long term spectrum requirement

2.3.1 In annex. 1.5 and 1.6 the requirement of additional spectrum for both GSM and CDMA operators respectively have been worked out till the year 2007 which can be termed as short term requirement. Since such a projection cannot be worked out very accurately due to a large number of factors, a range of values indicating a conservative and a liberal estimate based on the existing spectrum allocation criteria have been worked out. Today only 2 X 1.2 MHz in 900 MHz band & 2 X 4.82 MHz in 1800 MHz band for GSM operations and 2 X 7.5 MHz in 800 MHz for CDMA operations are available for allocation to mobile operators in Delhi (service area with highest number of mobile operators). From a comparison of the spectrum requirement for meeting the 2007 targets and the current level of allocation, it is evident that there is an immediate need for ensuring the availability of additional spectrum. Such a requirement for both GSM and CDMA operators is evident even under most conservative projections. Considering the future growth of mobile services in the country, it is certain that in the long term i.e. beyond 2007 the additional requirement will be such that the entire 1800 MHz (2 X 75 MHz) and entire IMT-2000 band (2 X 60 MHz) will have to be allocated to mobile operators.

2.4 Spectrum allocation to CDMA Operators

2.4.1 It is discussed in Chapter 1 that the spectrum allocation to CDMA operators is inadequate and in comparison to the International

[2] Presently 2 X 15 MHz may be co-ordinated in 1800 MHz in Delhi.

averages of 2 X 14 MHz, the Indian operators have only been allotted 2 X 2.5 to 2 X 5 MHz. This prevents proper planning by operators. Also from the analysis of the requirement of growth till 2007 presented in Annex. 1.6, it is evident that additional carriers would be needed to meet the Government's target of 200 million cellular connections by 2007. In the 800 MHz band, 2x20MHz spectrum is available while the allocated spectrum in Delhi (city with highest number of mobile subscribers) is 2x12.5 MHz. Keeping in view that there is sufficient competition in the mobile market where HHI is ≤ 0.35, it is recommended that in all such areas the Government should allocate the remainder carriers in this frequency band to existing CDMA operators based on revised spectrum allocation criteria. The revised criterion as proposed in para 1.2 , should be finalised in a time bound manner and preferably within one month of acceptance of TRAI's recommendations.

2.4.2 The above recommendations for the allocation of available carriers in the 800 MHz band will provide immediate relief to the CDMA operators. However, as shown in Annex 1.6 the problem of spectrum availability for CDMA operators would persist unless additional bands are identified. In any case, additional spectrum would be required to be identified quickly so that the required equipment can be identified by the operators in advance.

2.4.3 CDMA operators should be allocated additional spectrum in 450 MHz band as and when they request. It is anticipated that in a longer time frame demand and availability for 1800 MHz band for CDMA equipment will also materialize. Therefore, as and when additional spectrum is available in 1800 MHz band and demand and availability of equipment in this band is established, this also should be allocated to CDMA operators at their request. The proposal to make the 1800 MHz band available for CDMA operator is in line with NFAP 2002. At present there is a problem of availability of dual/multi band handsets in 800 MHz/450 MHz/1800 MHz bands. Authority's this recommendation is keeping in view the availability of such handsets in future and also depending upon the requirements of the operators.

2.5 Spectrum allocation to GSM operators

2.5.1 There is a need for immediate time bound action for making more spectrum available for GSM operators also. It is discussed in Chapter 1 that the spectrum allocation to GSM operators is inadequate and in comparison to the International averages of 2 X 20 MHz, the Indian operators have only been allotted 2 X 4.4 to 2 X 10 MHz. This prevents proper planning by operators. Also from the analysis of the requirement of growth till 2007 presented in Annex 1.5, it is evident that additional spectrum would be needed. The bands from which additional spectrum can be considered in this short time frame are 900 MHz in Circles, 1800 MHz and IMT-2000 band. While the IMT-2000 band is not suited for 2G/2.5G type applications due to non-availability of suitable equipment in this band, it is considered possible to evolve strategies to exploit this band towards meeting government targets upto 2007. This band is discussed separately in the next section. Other two bands are discussed below.

2.5.2 As and when 2 x 4.8 MHz spectrum in 900 MHz band is vacated by Defence a part of it should be allocated to those GSM operators in circles who have been allocated only 1800 MHz band. This will assist in improving the coverage in semi-urban and rural areas

2.5.3 A time bound programme has to be drawn up to make available additional spectrum in the 1800 MHz band not later than December 2006. The quantum of spectrum to be vacated in the 1800 MHz band by 2006 has currently been assumed to be up to 2 x 25 MHz.

2.5.4 So far as the long term requirement, i.e. beyond 2007, is concerned, it is quite evident that the entire 1800 MHz band may have to be vacated over a period of time to be reviewed on the basis of evolving technologies, existing usage and other developments to determine the step-by-step vacation procedure.

2.6 Allocation of IMT-2000 spectrum

2.6.1 As indicated in Annexure 1.5, 1.6 and para 3.1, there is a shortage of 2 G spectrum and in the consultation process with various stakeholders including Defence it came out that the release of additional 2 G spectrum in the required time frame so as to meet this shortfall may not be possible. Keeping this in view Authority considered allocation of additional spectrum in IMT-2000 band. While recommending special steps to get additional 2 G spectrum vacated in the desired time frame (i.e. up to 2 X 25 MHz in 1800 MHz by 2006 and the entire 2 X 75 MHz later in a time bound manner), Authority examined whether any other band could be used to supplement the efforts to reach the target of 200 million cellular phones by 2007. Discussions with various users including defence indicated that some frequencies in the IMT-2000 2 GHz could be available more easily and within a shorter time frame. Defence in their comments has also mentioned that it would not be possible to vacate 1900 MHz USPCS band due to existing usage. The Authority is aware that the services offered in IMT-2000 band viz. the so called 3 G services cannot be expected to become popular so fast as to directly help in meeting the Government's targets. However, during discussions with the operators it came out that strategies are 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. Thus, utilization of IMT-2000 band could supplement the primary thrust to get more spectrum vacated in the 1800 MHz band already discussed earlier. Keeping these arguments in mind, the Authority recommends that 3G spectrum allocation to the existing operators should be viewed as extension of 2G spectrum allocations.

2.6.2 It is not desirable to allocate spectrum both in IMT-2000 2 GHz band and 1900 MHz USPCS band in a mixed manner due to non-availability of 1900 MHz USPCS band, Interference issues, spectrum reserved for micro cellular WLL systems based on TDD access techniques, etc.

2.6.3 IMT-2000 2 GHz band should be allocated to mobile operators for offering IMT-2000 services both in GSM & CDMA mainly due to the following reasons:

- Defence in their comments has mentioned that they would not be able to co-ordinate the usage of FDD cellular technologies in 1900 MHz USPCS band
- In addition to 1880-1900 MHz NFAP –2002 has kept 1900-1910 MHz for micro cellular WLL systems based on TDD access techniques, for especially indigenously developed technologies.
- Interference related issues due to mixed band allocations.
- NFAP 2002 has also identified IMT-2000 2 GHz band for IMT-2000 (3G) applications.

Furthermore, each existing operator should be granted 2 x 5 MHz in IMT-2000 2 GHz band, who demands it. The Government should make efforts to make available the required spectrum in each service area so that 2 X 5 MHz may be allocated to each existing mobile service provider who demands it. Efforts to get remaining spectrum in IMT-2000 2 GHz band should be made and policy pertaining to remaining spectrum in this band shall be worked out subsequently, depending upon market developments.

2.6.4 The allocation of IMT-2000 2 GHz spectrum as discussed above, will be subjected to rollout conditions discussed in Chapter-4. The operators who have both GSM and CDMA operations namely, BSNL, MTNL and Reliance would be treated as a single entity for this purpose, and therefore, would only be allocated one chunk of 2 x 5 MHz.

2.6.5 There could be a possibility that initially only one or two carriers (each carrier of 2X5MHz) in IMT-2000 2 GHz band are available, the allocation and pricing of spectrum in such a situation is discussed in Para 3.4.

2.7 Strategy for availability of additional spectrum

2.7.1 Availability of 2 x 25 MHz in 1800 MHz band and the required spectrum in IMT-2000 2 GHz band to provide 2 X 5 MHz to each existing mobile service provider who demands it, within a very short time frame is a must to achieve the target of 200 million mobile subscribers. Efforts to get remaining spectrum in 1800 MHz band and IMT-2000 2 GHz band should be made and policy pertaining to remaining spectrum in this band shall be worked out subsequently, depending upon market developments.

2.7.2 In view of the gravity of the situation in regard to spectrum availability for various operators even in the short term of 2007 to meet the targets set by the Government for cellular telephones and at the same time the nearly insurmountable difficulties faced by Defence in vacating the spectrum in such a short time frame, we strongly recommend immediate constitution of a group at the level of Ministers of the Union Government assisted by professionals from Defence, Department of Telecom and TRAI to draw up a detailed time bound step-by-step programme and monitor its implementation. The mandate of the Group would have to include identification of alternative band, assessing and making available requisite funds and assisting users on procedural aspects of quick procurement and installation of new equipment. This activity has to be taken up on war

footing to be able to meet the Government objectives of growth in telecom services.

2.7.3 This nature of acute shortage of spectrum is not likely to be faced in too many cities and certainly not all over the country. There will, however, be a need to carry out coordination activities even area-wise like district level coordination, etc. and in some cases there may even be a need to carry out these coordination on area-wise basis within a city.

2.7.4 After analysing the spectrum requirements to achieve the target of 200 million mobile subscribers (both GSM & CDMA) in the year 2007, Authority recommends that :-

- While retaining the subscriber base approach, the actual spectrum allocation criterion should be urgently revised.
- Keeping in mind the short time frame available to achieve the 2007 targets, spectrum available or possible to be coordinated but not allocated, e.g. in 800 MHz band for CDMA should be made available immediately based on the revised criterion.
- Efforts should be made to make available remaining 2 X 4.8 MHz spectrum in 900 MHz band in circles for GSM, as per the revised criterion.
- The availability of at least 2 x 25 MHz spectrum in 1800 MHz band is coordinated by Defence by December, 2006.
- The availability of 2 X 5 MHz in IMT-2000 2 GHz band to each existing mobile service provider who demands it, is coordinated within a very short time frame to offer IMT-2000 services.
- The availability of spectrum in 450 MHz band is coordinated.

2.8 In-Band IMT-2000 Services

2.8.1 In-band equipment for providing IMT-2000 services (CDMA 2000 1 x EV-DO) is already available in 450, 800, 1800 and 1900 MHz frequency bands. In fact, most of the operators in other countries are providing EV-DO services with In-Band equipment. But for W-CDMA situation is not same. In Europe operators are now deploying W-CDMA in IMT-2000 2GHz band which is outside 2G/2.5 G frequency bands. Cingular Wireless[3] in US is the first operator in the World to deploy in-band W-CDMA equipment.

2.8.2 When WCDMA equipment is deployed at 900 MHz, it requires much less infrastructure in comparison to higher frequencies (IMT-2000 2GHz band). It provides deeper in-building penetration than do higher frequencies. For these reasons In-band IMT-2000 operations needs serious considerations from spectrum managers and operators point of view.

2.9 Contiguous allocation of spectrum

2.9.1 It is understood that WPC is already making efforts for contiguous allocation of the spectrum, Authority recommends that this process should be expedited.

[3] Source: report on In-band W-CDMA by 'The Shosteck Group'.

2.10 Future spectrum allocation

2.10.1 Government should continue to make efforts for the availability of additional spectrum not only in existing frequency band but also for additional frequency bands which are identified by ITU for mobile services viz. 2500-2690 MHz for IMT 2000 services.

2.11 Authority recommends that the spectrum policy may be reviewed periodically depending upon the development in the market, level of competition, development of technologies and availability of equipments and spectrum.

3. Spectrum Pricing

3.1 As in the existing framework the spectrum charges should continue to have two components: one time spectrum charge and annual spectrum charge.

3.2 One time spectrum charge to existing operators

3.2.1 There will be no one time spectrum charges for allocation of IMT-2000 spectrum to the existing service providers.

3.3 One-time spectrum charge for the new entrants

3.3.1 After implementation of unified license regime as recommended by TRAI and subject to approval by Government of India, authority recommends that the one time spectrum charges would be equal to UASL entry fee in that services area minus the component of registration charge based on the entry fee paid by new BSO (entered in/after 2001), specified by TRAI in its recommendations on Unified licensing regime dated 13th January 2005.

3.3.2 For new UASL operator one time entry fee includes one time spectrum charge also.

3.4 Annual spectrum Charge

3.4.1 Existing method of annual spectrum charge in terms of percentage of revenue share should continue.

3.4.2 Keeping in view the objectives of growth, affordability, penetration of mobile services in semi-urban and rural areas , etc. Authority recommends that existing ceiling on annual spectrum charges of 6% AGR should be brought down to 4% of AGR.

3.4.3 Depending upon the developments in market, availability of spectrum and growth of mobile services in the country, Authority recommends that annual spectrum charges may be periodically reviewed.

3.4.4 Annual spectrum Charges for IMT-2000 spectrum

3.4.4.1 To avoid hoarding of spectrum, a valuable resource, particularly when it has to be given in large chunks of 2 x 5 MHz for IMT-2000 services, it is proposed that a minimum guarantee of spectrum charge be taken for the period till the service provider rolls out IMT-2000 services. For this purpose, the rollout obligations would be as specified in cellular and UASL license agreement for first year of operation, i.e. to offer IMT-2000 services in at least 10% of District Headquarters (D.H.Q.) or any other town in lieu of D.H.Q.

within one year of allocation of spectrum. It means that the annual spectrum charges would have two components, one a percentage of AGR (say X) and the second will be the additional annual IMT-2000 spectrum charge on per MHz basis (Say-Y). The second component, (i.e. Y) will vanish after meeting rollout obligations as mentioned above. However, it should be noted that additional annual spectrum charge for IMT-2000 service would continue unless rollout obligations as mentioned above are completed. The Authority is aware that spectrum is a valuable resource and there could be a possibility that a non-serious operator may not launch IMT-2000 services and prefer to continue to pay additional spectrum charges for IMT-2000 spectrum. Therefore, to safeguard against such eventualities Authority recommends that in case an operator does not roll-out IMT-2000 services within 2 years of allocation of IMT-2000 spectrum, the allocation of IMT-2000 spectrum would be cancelled. It is recommended that necessary amendments in the license conditions for cancelling the allocation of IMT-2000 spectrum should be made such that the spectrum allocation shall be cancelled if the operator does not roll-out the services within 2 years of allocation of IMT-2000 spectrum. This scheme would provide incentive on rollout and disincentive for non-serious players to raise the demand for IMT-2000 spectrum even when they have no inclination to start IMT-2000 services. This methodology would be followed when availability of IMT-2000 spectrum matches with the demand.

3.4.4.2 It is likely that the demand for IMT-2000 spectrum is more than the available spectrum in a particular timeframe. In such a situation, the Government should co-ordinate the availability of IMT-2000 2 GHz spectrum such that all the existing operators in a service area who demand this spectrum may get 2 x 5 MHz in a time bound manner. Further, if due to the reasons beyond control, Government is not able to ensure the availability of adequate IMT-2000 2 GHz spectrum in a time bound manner then Authority recommends that IMT-2000 2 GHz spectrum should not be allocated to any operator unless sufficient spectrum is available for allocation to each existing operator who demand this spectrum. This approach however, would severely constrain further development of the mobile telephony sector and would also delay launching of IMT-2000 services in the country. In case adequate spectrum is not identified despite best efforts, only then the bidding option for 'Y' component as explained in para 3.4.1 will have to be followed. It is once again reiterated that bidding process must be avoided in view of the existing high burden of license fee, service tax, spectrum charges, etc. on service providers and the past experience of the auction process in India and the other countries and the likely undesirable consequences of following the auction route. If adequate IMT-2000 spectrum is made available then bidding process should be avoided. Only such an approach would lead to rapid increase in subscriber numbers and also increase in overall government revenues, as has been seen in the telecom sector, after abandoning the ill-effects of the auction process. As can be seen from annex 2.2, 2.2 (a) and 2.3, the telecom sector is already paying about 25% of the Adjusted Gross Revenue (AGR) in the form of license fee, service tax and spectrum charges. From

annex 2.4 it is also seen that telecom sector is highest payer of service tax and they pay almost 1/3rd of the total service tax collected by Government of India. Keeping this in view, any further increase in spectrum charges would adversely affect the growth of telecom services in the country. Therefore, as recommended in Chapter 3, the Government should make efforts to make available the required spectrum in each service area so that 2 X 5 MHz may be allocated to each existing mobile service provider who demands it. Efforts to get remaining spectrum in IMT-2000 2 GHz band should be made and policy pertaining to remaining spectrum in this band shall be worked out subsequently, depending upon market developments. The bidding process is the last alternative and the bid amount vanishes the moment the service provider meets the rollout obligations specified above.

3.4.5 Calculations for Charge per MHz in situations where demand of IMT-2000 spectrum matches with availability of spectrum

3.4.5.1 The additional per MHz charge (Y component) for IMT-2000 spectrum should be on the basis of highest charge per MHz per annum paid by any operators in different service areas.

3.4.5.2 These charges will be separate for different service areas.

3.4.6 Depending upon availability of spectrum, development in market and the growth of telecom services, the charging mechanism may be reviewed periodically.

4. Spectrum Charging and Allocation for Other Terrestrial Wireless Links

4.1 WiFi Services

4.1.1 Vide Gazette No. D.L.-33004/99 dated 28th January 2005 the Government has de-licensed the 2.4 GHz band for indoor and outdoor usage by any wireless radio equipment meeting certain performance parameters. The 5.150 – 5.350 GHz and 5.725 – 5.875 GHz bands have been de-licensed for indoor usage. The Authority is of the view that demand for such services is already building up and therefore the earlier decisions should be revisited to delicense both 5 GHz bands for outdoor usage.

4.2 Allocation Policy for CorDECT Services

4.2.1 Due to legacy issues in frequency planning and license conditions for UASL operators, allocation of spectrum for micro-cellular based TDD technologies is linked to and limits the allocation of spectrum to UASL operators for usage by their traditional cellular platforms, i.e. CDMA and GSM.

4.2.2 The Authority, recommends that to further promote the reach of internet, broadband and fixed telephony services, and because the platforms are distinct from each other and in different spectrum bands, the allocation of alternative technologies, such as CorDECT, should not affect operators' spectrum allocation otherwise due to them determined from the accepted subscribers-based allocation criteria for traditional cellular technologies like CDMA and GSM. To this end, clause 43.5(iii) of the Unified Access Services License should be

removed, and WPC's order No. J-14025/200(I)/2004-NT dated 20th May, 2004 should be suitably modified.

4.2.3 Furthermore, usage of the CorDECT platform achieves best efficiency when only certain carriers are reserved for exclusive usage and the remainder of the band is shared by all licensed operators. Therefore, to promote the most efficient usage of the CorDECT platform and spectrum reserved for its use by leveraging its core algorithms, spectrum allocation for specific operators should be altered from its current format. Of the total 11 carriers that are available in the 20 MHz reserved for CorDECT, 4 carriers should be reserved uniformly on a national basis as those carriers which will be allocated to specific operators by the WPC for specific geographies, and the remaining 7 should be left open to be shared by all operators with the clearance to operate CorDECT equipment in their service area.

4.3 Policy for Other Terrestrial Wireless Links

4.3.1 Telecom operators including BSO's / UASL's, ISP's and IP-II operators, as well as individual corporate customers had raised concern about the present system for acquiring and pricing of point-to-point and point-to-multi-point wireless links that use technologies other than cellular, i.e., GSM, CDMA, 3G or other related platforms. The overall objectives of the Authority in recommending the pricing and allocation policies for this particular type of spectrum include promoting efficient usage of required allocation, minimizing the quantity of required allocation, usage by multiple parties rather than individual allocation, accounting for the fact that depending on factors like population density the charges should reflect the geography the spectrum is allocated in, and that spectrum outside of the high demand bands should be given more favorable treatment to create incentives for usage. It was also important for the current model to be modified as it uses slabs for determining the pricing multiples for both the distance factor M and the bandwidth factor W. These slabs were too large in certain ranges and the changes between slabs too drastic, therefore not reflecting the full potential of wireless technology and the requirements of operational deployment, and also not encouraging efficient utilization.

4.3.2 The Authority therefore recommended the following pricing model be adopted for purposes of charging for this category of wireless links in point-to-point and point-to-multi-point architecture:

$$R = (\sqrt{M}) * W * C * A * S * P * B$$

Where:

R = the annual rate to be charged for the spectrum allocation (Rs.)

M = the distance in Kilometers between the two farthest transceivers for which the link is being provisioned

W = the bandwidth in Megahertz being allocated

C = the number of RF channels used (twice the number of duplex RF channel pairs)

A = constant multiplier factor, currently set to equal 6,724 for purposes of equalizing the new pricing structure with the previous one

S = the factor for discounting based on spectrum allocated on non-interference, non-protection and non-exclusive basis. When allocation is with these properties, the value should be 0.33 otherwise 1.00
P = the factor for discounting based on population density
B = the factor for discounting based on band of deployment

The values for P and B should be determined based on the following:

$$P = 0.5 \times \left(1 - \frac{population\ density}{2{,}000}\right)$$

where population density is expressed in persons per square kilometer as per the Census of India 2001 for the district in which the link is being deployed

$$B = 0.5 \times \left(\frac{center\ \ frequency\ of\ \ allocation - 3{,}000}{20{,}000}\right)$$

where center frequency of allocation is defined in megahertz (MHz)

The charge for each additional transceiver station required by the operator should be calculated as the minimum of either Rs. 1,000 or 10% of R, where R is the value for the annual spectrum usage fee as calculated above with discounts.

4.3.3 Resulting from this new calculation method, operators utilizing wireless links for shorter distances and lower spectrum bandwidth would get discounts from 50% up to 98%. To further promote usage
of technology that is capable of sharing spectrum, increased penetration into rural areas and usage of higher frequency bands, these discounts would be substantially increased when such parameters are met, making spectrum charges marginal compared to current levels.

4.4. Outstanding Topics to Be Covered in Future

4.4.1 The spectrum policy recommendations should also look ahead to emerging technologies. While India has traditionally been a late mover in deploying or developing the latest telecoms platforms, the industry has today reached a level of maturity and growth that we have the opportunity to influence the direction of future technology development. Therefore, the timely allocation of both TDD and FDD spectrum for such platforms will be of the highest importance, especially if India wants to gain the world leadership in such technologies and leapfrog other countries in developing its telecom infrastructure.

4.4.2 Along with new technologies, new methods for enhancing spectrum efficiency are also being implemented, including smart antennas and software defined radios. With these technologies, co-existence issues are becoming easier to manage, and many spectrum administrators are transitioning to allocating spectrum purely on spectrum usage masks. Many regulators are also transitioning to provide for more “spectrum commons”, bands where spectrum is de-licensed and open to a variety of users for varied purposes, but with certain defined

etiquette standards that are not prevalent in current de-licensed bands.

4.4.3 At this juncture it is not possible for the Authority to provide specific recommendations without gathering much more information on several of these technological developments. The Authority feels that these issues will need to be examined in detail through a consultation process as a follow-up to this set of recommendations.

5. Other relevant issues

5.1 Spectrum Trading

5.1.1 Spectrum trading may not be permitted at this stage. However, depending upon market conditions the issue may be considered at a later stage through a consultation process.

5.2 Mergers and acquisitions

5.2.1 Since the Authority has recommended that the spectrum availability to mobile operators should improve, it is expected that more and more spectrum would be available for mobile services in short and long term. Therefore depending on spectrum availability, allocation and development of market this issue shall be dealt with separately.

5.3 Hostilities and disaster

5.3.1 In the case of hostilities and disaster the defence may be given the authority to use additional spectrum including allocated spectrum to private service providers, as considered appropriate by the Government.

5.4 Spectrum Management

5.4.1 In a multi-operator high wireless growth environment it may not be possible to manually manage the spectrum. This includes SACFA clearance, etc. Any delay in processing the applications for allocation of spectrum including site clearances adversely affects the roll out of services. WPC has commissioned the Automated Spectrum Management System (ASMS) for receiving online applications for frequency assignment as well as for SACFA clearance. It is recommended that the entire spectrum management process including frequency authorisation process should be fully automated in a time bound manner.

Recommendations on Spectrum related issues

As per section 11(1) (a) (i), (ii), (iv), (vii) and (viii) of TRAI (Amendment) Act, 2000 the Authority, after a detailed consultation process, makes the following recommendations.

Chapter 1 – Introduction

"Encouraging the spread of mobile phones is the most sensible and effective response to the digital divide The digital divide that really matters, then, is between those with access to a mobile network and those without."

- ***(The Economist, March 12- 18, 2005)***

"It is precisely in places where no infrastructure exists that wireless can be particularly effective, helping countries to leapfrog generations of telecommunications technology and infrastructure and empower their people."

- (Mr. Kofi Annan, UN Secretary –General)

1.0 For the spread and growth of mobiles services, spectrum is the most vital and scarce input. India with its highest growth rate in mobile services, lowest tariff in the world and huge market potential is in a leading position among the developing countries. To maintain this growth level or rather to increase the growth rate further Government of India has to put a spectrum policy in place which ensures availability of spectrum to this fast growing sector at a reasonable price and also ensures efficient utilisation of this scarce resource.

Spectrum should be free of technology and usage constraints as far as possible. TRAI recognizes that though spectrum policy has to be technology neutral still the availability of equipment in particular frequency band affects this technology neutral approach, but technological developments like Software Defined Radios, different frequency radio transmitters-receivers (Tx-Rx) on a single chip etc and demand in the market will very soon remove this restriction of availability of equipment in specific frequency bands. Ultimately, the equipments using various technologies would be available in all frequency bands where demand exists. These developments would also help in achieving seamless connectivity among various networks. It is also recognised that already the concept of service specific allocation of spectrum is not an accurate reflector of usage. The same equipment using the same spectrum can offer different type of services.

These key aspects and other related issues have been kept in mind while finalising spectrum related recommendations.

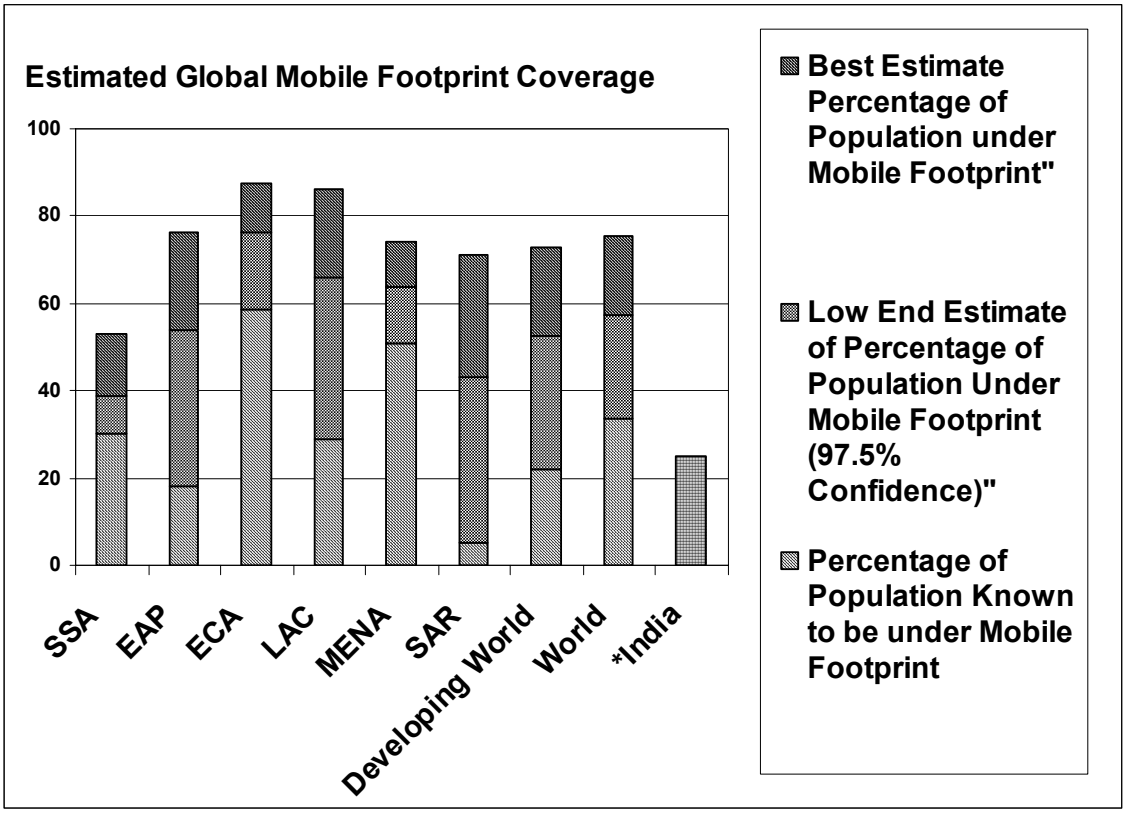
1.1 Growth of Mobile Services in developing and least developed countries

1.1.1. In the past, it has been said that, "Manhattan has more telephones than Africa", but this statistic has been overtaken by events. According to ITU, there were 22 million fixed and 37 million mobile lines in Africa in 2002. Population of Manhattan is about 1.5 million. Unless New Yorkers and their

commuter friends have 12 phones each, Africa now has many more telephones than Manhattan. Within developing countries, rural areas are catching up with urban areas (although gaps remain considerable). This rapid growth in access has been driven by mobile telephony. Fixed telephony was in existence for 113 years before fixed tele-density reached one in ten of global population. Mobile achieved the same penetration level in just 15 years. The mobile revolution has increased the number of mobile subscriber's world wide from 11.2 million in 1990 to around 1.5 billion by end of 2004.

Based on ITU data, estimated global mobile footprint coverage is given in the Figure 1.1.

Figure 1.1: Estimated Global Mobile Footprint Coverage



Source: - World Bank Report

** Source: Information received from service providers.*

From the above it is seen that up to 77% of the world's population is under mobile footprint as against around 25% in India.

1.1.2 **Growth of tele-density in rural areas through mobile services:**

Mobile phones substitute for fixed lines in poor countries. In many African countries mobile phone penetration is far higher than fixed phones. Till 1990, mobile phones were not important: telecom networks were fixed line systems. Today, when we consider telephone networks, the importance of mobiles stand out, especially when we examine the 102 Members of the ITU that had low phone penetration in 1995. Annex. – 1.1 lists these countries (i.e. with less than 8 phones per 100 populations in 1995, when virtually all phones were fixed lines) and the penetration rate in 2003 for both fixed lines and mobile.

1.1.3 Mobile penetration in developing countries has increased dramatically during the past 10 years. The growth of mobile penetration by country grouping for the period 1995-2002 is given in the table 1.1 below.

Table 1.1 Growth in Mobile penetration by country grouping, 1995-2002

	Mobile phones per 1,000 population 1995	**Mobile phones per 1,000 population 2002**	**Average annual growth rate (%) 1995-2002**
Least Developed Countries	0.13	21.88	109%
Sub-Saharan Africa (SSA)	0.74	61.68	90%
Middle Income Countries	5.73	191.29	66%
OECD high income countries	87.33	765.01	37%
Regression Sample	5.28	122.83	58%
India*	Insignificant	10.5	76.52%

(OECD - Organisation for Economic Co-operation & Development)

(Source: WDI (2004), Frontier Economics)
***Source: COAI statistics**

1.1.4 The basic information for developing and high-income countries is given in table 1.2 below: -

Table 1.2: Basic information for developing countries and high income countries

Country	Population (Million)	Percent Urban	Per Capita GDP (USD, PPP)	Fixed Lines Per 1000 People	Mobile Lines Per 1000 People
Egypt	70.7	42.1	3,810	110	67
South Africa	44.8	56.5	10,070	107	304
Tanzania	36.3	34.4	580	5	22
All Developing Countries	4,936.9	41.4	4,054	96	101
High Income Countries	941.2	77.8	28,741	584	653
World	6225.0	47.8	7,804	175	184
India*	1027.0	~ 30	2,570	38	10

(Source: UNDP, Human Development Report 2004. All data are for 2002)
* Census 2001, Information received from service providers
Note: PPP (Purchasing power parity) GDP figures are adjusted to reflect the cost of living, so $1000 of PPP income would yield the same standard of living everywhere)

Empirical evidence in both developed and developing countries shows that an increase in teledensity contributes substantially to GDP growth.

An International comparison shown in the following table 1.3 would reveal that India's per capita holds higher teledensity potential.

Table 1.3: International comparison - India's per capita holds higher teledensity potential

Country	GNI Per Capita PPP 2002, USD**	Teledensity*	
		2002	2003
India	2570	4.8	6.7
Bolivia	2300	17.22	23.81
Georgia	2210	23.35	23.98
Moldova	1560	19.69	23.76
Ecuador	3130	23.08	30.32

Source: * ITU database
** World Development Indicators data, World Bank July 2003

India's teledensity will grow when mobile footprint increases. Current population coverage by mobile is around 25% and the proposed population coverage by 2006, as informed by the operators, is around 75%. Today the ARPU is around $9-$10. As per Morgan Stanley's report dated August 4, 2003 even at monthly ARPU of US $5, Wireless Operators can make money.

1.1.5 Wireless: the new incumbent

In markets worldwide, wireless is replacing fixed lines as the de facto communications service that is perceived as a public utility. Mobile connections have overtaken fixed lines across all regions from emerging markets to developed markets. In developed markets this is driven by fixed to mobile substitution, fixed to mobile number portability, etc. In emerging markets, the weak fixed line infrastructure has created an opportunity for mobile to leap frog over fixed connection. This means that increasingly voice connectivity is being provided via the mobile route which is coming to be perceived as a public utility.

Total number of fixed lines and total mobile subscribers in different parts of the world are given in the table 1.4 below: -

Table 1.4: Total fixed lines and mobile subscribers in different parts of the world

	Total number of fixed line (Fig. In thousand)	Total mobile subscribers (Fig. In thousand)
Asia and Australasia	517,909	651,190
East Europe	82,315	127,169
Latin America	76,563	128,095
Middle east and Africa	24,025	49,304
North America	197,385	183,618
Western Europe	206,005	353,371
World	1,104,202	1,492,747
*India	44,872	48,014

Source: UBS Investment Bank Report January 2005

* India's figures are as on 31st December 2004

1.2 Growth of Mobile Services in India and allocation of Spectrum.

1.2.1 The country is witnessing an unprecedented growth in the mobile sector. As at the end of March 2005 the total mobile subscriber base is around 52.17 million, out of which GSM and CDMA subscriber base is around 41.07 million and 11.10 million respectively. During the year 2004 about 19.50 million mobile subscribers were added. Now we target around 200 million mobile phones by 2007.

1.2.2 In India proper regulatory and policy environment coupled with intense competition led to reduction in tariffs and explosion in growth in the mobile sector. Mobile tariffs reduced from the level of about Rs. 16 per minute in 1995-96 for both incoming and outgoing calls to levels comparable with fixed line tariffs at the calling party end and free for incoming calls in 2005. The Mobile subscriber base crossed the fixed line subscriber base in October 2004. In India too, the growth of telecom services in rural areas is to be achieved through more and more penetration of wireless and mobile services, as has happened in most countries, including least developed countries with high rural population.

1.2.3 All the statistics above indicates that growth of telecom services is synonymous with growth of wireless services. Be it increase in rural tele-density or growth in least developed countries, wireless is giving impetus to future growth. To achieve this growth for a large country with more than 1 billion population and around 10% tele-density (Fixed and Mobile combined), spectrum is an important ingredient and its inadequacy may not only hamper the growth but also adversely affect the quality of service.

1.2.4 While considering the subscriber growth, Authority has to keep the following aspects in mind[4].

i) Weaker demographics: - Table 1.5 presents key data on demographics and the wireless market for various economies. India's GDP per capita is still meaningfully lower than those of other emerging economies. Furthermore, it is believed that a broad GDP per capita comparison alone may not fully reveal the underlying and important differences between various countries.

[4] Source: Goldman Sachs report

Table: 1.5: Key data on demographics and the wireless market for various economies

Key demographics and wireless market data

	Brazil	China	Indonesia	Philippines	Russia	Thailand	India
Country data							
Surface Area (mn sq kms)	8.5	9.6	1.9	0.3	17.1	0.5	3.3
Population end-2004 (mn)	179	1301	222	87	147	65	1094
Estimated 2004 GDP / capita (US$)	**2788**	**1269**	**1164**	**1050**	**3023**	**2540**	**638**
Urban Population (%)	83	40	42	59	73	30	28
Urban Population (mn)	148	521	93	51	107	19	310
Estimated Urban GDP / capita (US$)	NA	2025	NA	NA	NA	NA	1360
Estimated Rural GDP / capita (US$)	**NA**	**765**	**NA**	**NA**	**NA**	**NA**	**352**
Urban to Rural GDP/capita (X)	NA	2.6	NA	NA	NA	NA	3.9
Wireless Market Data							
Wireless Subs, end - 2004 (mn)	66	339	31	32	66	27	48
Current penetration (%)	36.7	26	13.8	36.4	44.7	41.9	4.3
Number of operators (#)	**8**	**2**	**4**	**4**	**6**	**5**	**6**
Market Share of Top 2 (%)	**60**	**100**	**79**	**85**	**70**	**84**	**42**
ARPU of leading operator (US$)	**11.8**	**10.7**	**10.4**	**7.2**	**10.8**	**10.8**	**11.1**
EBITDA margin, average of Top 2 (%)	33(a)	53	64	61	50	46	33(b)

a) Only the top opeartor is included

b) Only Bharti is included

Source:- UNDP, Asian Development Bank, Kotak Institutional Equities, Goldman Sachs Research estimates

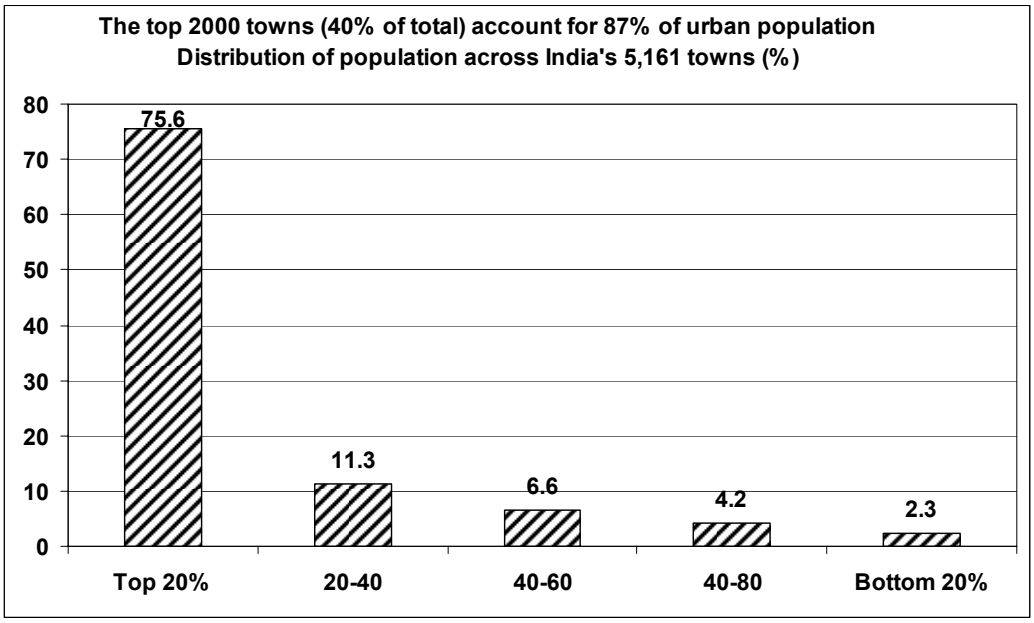
ii) Unfavourable urban-rural population mix and income distribution.: - The proportion of India's population that is rural rather than urban is much higher, at about 72% of the total population. By contrast, 60% of China's population and 58% of Indonesia's is rural. More importantly, India's rural GDP per capita is low, at an estimated US $352, considerably lower than China's US$ 765 and also lower than those of other countries. (Source: Goldman Sachs report).

This would suggest that at some point in time, when urban penetration is reasonably high, India's high rural population and lower rural GDP per capita might act as a barrier to the continued high growth of wireless penetration**. Only if telecom services are offered at an affordable and comparatively low prices then this barrier may be crossed in rural areas and we could achieve a very high growth level.**

iii) We believe that the pattern of distribution of the urban population and reasonable penetration in existing urban mobile markets may make further subscriber additions increasingly challenging. Figure 1.2 below shows that the urban population is

very concentrated; the top 2,000 most populated towns (out of government census-defined total of around 5161) where mobile service is available currently account for 87% of the urban population, or 260 mn out of an urban population of around 300 mn. More importantly, mobile penetration in those 2,000 towns is around-19% indicating huge growth potential.

Figure 1.2: Distribution of population across various towns



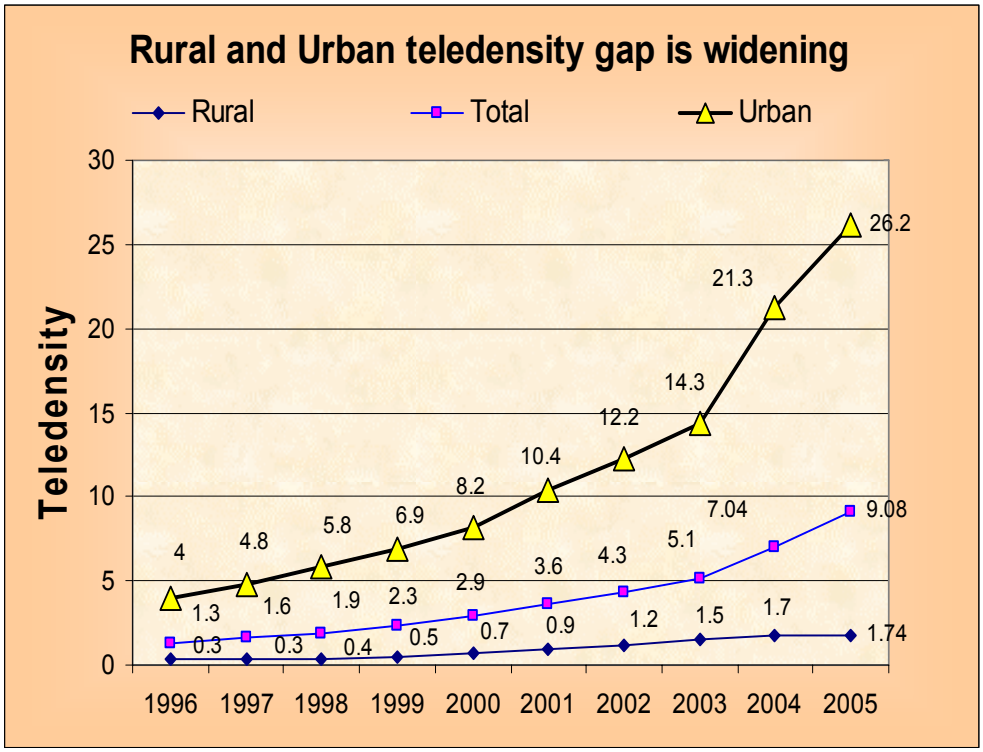
iv) **To achieve higher growth level the operators will have to (1) enter sparsely populated semi-urban/rural markets (2) reduce price points in urban markets.** The former has implications for capex and the latter for ARPUs. As of now, operators are focussing on new markets and extending coverage to new urban/semi-urban and rural markets. However, the limited population in the wireless-dark towns (13% of the total urban population, or 40 mn) may result in a limited addressable population – about 8-10 mn assuming same penetration of around 20% as in the top 2,000 towns –at current price points/demographics.

From the above discussion, it is evident that for maintaining and further increasing the growth rate of the telecom services there is a need to increase the teledensity in the already covered urban areas as well as increased exposure of small towns and rural areas. **In either situation, a reduction in entry cost and tariff is necessary.**

It is evident from the discussions so far that the additional subscribers in urban areas which have already been provided mobile coverage as well as in the uncovered urban and rural areas (both covered and uncovered areas) are likely to be those who could be categorized as relatively marginal subscribers. This is because their ability to spend on telecom facilities is less than the existing subscribers. In price sensitive market like India, it is, therefore, even more important to lower the cost of providing telecom services.

1.2.5 The widening gap of rural and urban tele-density is evident from the following figure 1.3.

Figure 1.3: Widening gap of rural and urban tele-density



The widening gap between urban and rural tele-density is because around 25% of India's population is under mobile footprint as against 77% of world's average. Today the mobile coverage in rural areas is very small and almost incidental. Though there is no spectrum constraint in such areas but mobile coverage is yet to reach such areas. The proposed network plan of the operators indicate 55 ~ 60% of the villages would be covered by 2006 accounting for over 70% of the rural population. **Efforts should be made and our policies should be structured to facilitate penetration in such areas.** Issues pertaining to growth of telecom services in rural areas including

spectrum charges in rural areas would be dealt with separately in the recommendations on Growth of Telecom Services in Rural India.

1.2.6 Operator-wise subscriber base and allocated spectrum is given in Annex.- 1.2. If we compare the spectrum allocations and subscriber base of individual operators 7-8 years back with the present numbers it would be evident that though number of subscribers have increased manifold, the spectrum allocation has not increased to the required extent. Though, there is no linear relationship between these two parameters but definitely they have very strong positive correlation coefficient. Attempt at this stage is not being made to establish the value of this correlation coefficient but only to acknowledge and highlight the fact that the additional allocation of spectrum has not matched with the growth of mobile services in the country. Issues pertaining to present spectrum allocations and future spectrum requirements have been discussed in detail in para 1.4.

1.2.7 When fourth operator licenses were awarded in 2001, there was a constraint of assignment of spectrum to these operators. These licenses were awarded in 1800 MHz band. National Frequency Allocation Plan - 2002 (NFAP-2002) in remark No. IND48 had envisaged that cellular mobile telephone systems may be coordinated for (2 X 10) MHz in the frequency band 1710-1785 MHz paired with 1805-1880 MHz. After allocation of 2 x 4.4 MHz to 2 x 6.2 MHz to the 4th cellular operator in this band, the balance left for other three GSM operators was only 2 x 5.6 MHz to 2 x 3.8 MHz. Probably, even at the time of finalisation of NFAP-2002 such a high growth in mobile services in the country was not anticipated.

1.3 International Practices on spectrum allocation

We now examine the international practices in regard to spectrum allocation. The operator-wise allocated spectrum for GSM and CDMA networks in various countries are given in Annex.-1.3. From this Annex., it is seen that average spectrum allocation per GSM and CDMA operator is approximately 2 X20 MHz and 2 X 14 MHz respectively as against India's highest allocations of 2 x 10 MHz and 2 x 5 MHz for GSM and CDMA operators, respectively.

1.4 Immediate, short term and long-term spectrum requirements in India

1.4.1 Keeping in view the growth of mobile services in the country, it is necessary to assess the immediate spectrum requirement (within one year), short term (upto 2007) and long term (beyond 2007). As discussed in previous paragraphs, theoretically it is very difficult to assess the spectrum requirement because there is no empirical formula which can establish the spectrum requirement of different operators either in short term or in long term. Additional spectrum requirement depends on various parameters like number of subscribers, the density of subscribers, terrain, pattern of traffic (voice, data, etc.), deployment of various technological means to improve the

efficient utilisation of spectrum, the technology itself, etc. In a multi-operator scenario where market forces are in a position to decide the business strategies it is difficult to assess the value of various parameters mentioned above. At the same time, considering the very high growth rate of mobile services, at least an approximate quantification of additional spectrum requirement is desirable. No doubt, due to various factors involved and their uncertain values, this quantification may not be very accurate but it will definitely help in estimation of approximate additional spectrum requirement to some extent. In this exercise, some parameters like current subscriber base, current growth rate, the target of 200 million mobile subscribers by 2007, the required growth rate to achieve the target of 200 million subscribers and the subscriber number based spectrum allocation criterion are known. However, there are several indeterminate factors, which can substantially alter the spectrum requirement estimates. The prominent among them are:-

- Nature of traffic, i.e. extent of voice and data traffic in the network.
- Market share of different operators at a future date for which projections are being made.
- Mergers and acquisitions, which change the total number of players in the market.
- Network design and the deployment of the spectrum optimisation techniques.

Notwithstanding all these associated uncertainties as mentioned above, Authority still considers that approximate estimation of spectrum requirement to achieve a target of 200 million mobile customers by 2007 is necessary. It is also Authority's belief that unless some assessment of requirement of additional spectrum (even if it is approximate and not very accurate) is carried out, it will be very difficult to come out with a specific and objective oriented spectrum policy. Authority is of the view that such an estimation of spectrum requirement, both for short term and long term, is necessary. For the purpose of this exercise it has been assumed that the traffic distribution i.e. type of traffic (voice and data traffic) shall remain the same as at present. If the data traffic grows more rapidly which is the most likely scenario, the estimate arrived at based on the above assumption, will prove to be quite conservative.

1.4.2 List of the service area wise service providers along with the current growth rate and the likely time period for crossing the benchmark for allocation of addition spectrum is given in Annex. 1.4. Presently the criterion for allocation of additional spectrum is linked to the number of subscribers. Even as per this criterion 21 operators, have already exceeded the subscriber base benchmark and 28 more are likely to cross the benchmark for allocation of addition spectrum within next one year. The details of further spectrum allocation to service providers have been discussed in Chapter 3.

1.4.3 For assessment of the spectrum requirement in the year 2007, to achieve a target of 200 million mobile customers, we have to assess the number of subscribers for different operators or different service areas. Doing any operator-wise assessment of number of subscribers may give a wrong signal in the market as if TRAI is trying to suggest what will be market share

of each operator in the year 2007. At the same time, the spectrum requirement has to be assessed on the basis of number of subscribers with each operator in the year 2007. There is also a possibility that in next 2-3 years there could be a major change in the market structure and traffic distribution which may affect the accuracy of this exercise to a large extent. But as mentioned previously the whole purpose of this exercise is to assess the appox spectrum requirement in future so as to judge the urgency of availability of additional spectrum. This in turn may help us in reaching the limited conclusion that unless immediate action is taken by Government of India for availability of additional spectrum this may be the single biggest constraint for growth of telecom services in the country and also for the quality of telecom services using wireless spectrum. For the fear of giving this wrong indication in the market about the market share of each operator, though Authority has worked out the number of subscribers of each operators in the four metropolitan cities, in the year 2007 but these figures are not included in these recommendations and what is included is the projection of number of subscribers in the four metropolitan cities. These estimates do not discuss the additional requirement of Circles, because ultimately it is the requirement in the largest subscriber-base city of a circle which will decide the additional requirement of spectrum. Once again it is mentioned that we are not focusing on the accuracy of this exercise, because even if there is a variation of operator-wise number of subscribers in 2007, it may change operator-wise spectrum requirement but still total spectrum requirement in that service area may not vary to a large extent. At this stage, one could argue that operators may deploy various technological means for efficient utilisation of spectrum and hence the spectrum requirement could be less than what has been estimated. We do not disagree with this assessment but even for deployment of various technological means for improving the efficient utilisation of spectrum, it is necessary that each operator reaches a certain minimum level of allocation of spectrum before such techniques can be used and have impact on reducing the overall requirements.

1.4.4 The next stage is the assessment of spectrum requirement. In the existing subscriber based allocation criteria, for GSM services a service provider becomes eligible to get more than 2 x 6.2 MHz spectrum after he crosses the subscriber base of 5 lakhs and then he gets additional 2 x 1.8 MHz.

1.4.5 In the next stage, he becomes eligible to get additional spectrum beyond this 2 x 8 MHz once he reaches the subscriber base of 10 lakhs. It means for connecting additional 5 lakhs subscribers in his network a service provider gets 2 x 1.8 MHz additional spectrum (from 2 x 6.2 MHz to 2 x 8 MHz). To get additional spectrum from 2 x 8 MHz onwards the service provider has to increase the subscriber base from 8 lakhs to 10 lakhs and then he gets additional 2 x 2 MHz spectrum. It means in the first step, the operator gets 2 x 1.8 MHz spectrum for adding 5 lakhs customers, i.e., 2 x 0.36 MHz spectrum per lakh additional subscribers and in the second step 2 x 2 MHz additional spectrum for adding 2 lakh customers, i.e. 2 x 1 MHz spectrum per lakh additional customers on his network. Based on this, the additional spectrum requirement has been worked out for the four

metropolitan cities. Again though it was worked out on the basis of spectrum requirement for each operator but this information has been disclosed for the four metropolitan cities rather than for different operators. This gives the maximum requirement (2 x 1 MHz per lakh customers) and the minimum requirement of additional spectrum (2 x 0.36 MHz per lakh customers). The maximum and minimum requirement of additional spectrum has been worked out on this basis for GSM operators and then in 4 metro cities and is given in Anne. 1.5. for GSM services

1.4.6 The spectrum requirement for CDMA operators is also based on the subscriber base criteria and has been issued by (DoT's letter No. J14025/200 (12)/2004-NT dated 10.12.2004). As explained earlier, we are in favour of technology neutral spectrum allocation criteria and have already recommended that ultimately we should migrate into that regime. However, we have estimated the additional spectrum requirement for CDMA services based on the existing subscriber base criteria. This subscriber base criterion is different for Delhi and Mumbai and Chennai and Kolkata in Metro cities and also different for category 'A', 'B' and 'C' circles. Initially the CDMA operator is allocated 2 x 2.5 MHz spectrum (two carriers) and the subscriber base allotment of 3rd carrier for different service area is as per the Chart given below:

Spectrum allocation criteria to CDMA Operators

Service Area	**The minimum subscriber base required for allotment of 3rd carrier**
Metro Service Area Delhi & Mumbai Chennai & Kolkata	 3 Lakhs 2 Lakhs
Telecom Circel Service Area Category "A" Circles Category 'B' Circles Category 'C' Circles	 4 Lakhs 3 Lakhs 1.5 Lakhs

Criteria for release of 4th CDMA carrier:

Service Area	**The minimum subscriber base required for allotment of 4th carrier**
Metro Service Area Delhi & Mumbai Chennai & Kolkata	 10 Lakhs 06 Lakhs
Telecom Circel Service Area Category "A" Circles Category 'B' Circles Category 'C' Circles	12 Lakhs 10 Lakhs 05 Lakhs

From this table it is seen that additional spectrum requirement could be worked out on the basis of incremental no. of subscribers for allotment of 3rd carrier and 4th carrier. For Delhi & Mumbai, the 3rd carrier is allotted when subscriber base is 3 lakhs and for Chennai and Kolkatta the subscriber base is 2 lakhs. It means 2 x 2.5 MHz (2 carriers) could cater to this number of subscriber base. Similarly for allotment of 4th carrier, the subscriber base required in Delhi and Mumbai is 10 lakhs and in Chennai and Kolkata is 6 lakhs respectively. The maximum and minimum requirement of additional spectrum has been worked out on this basis for CDMA operators in 4 metro cities and is given in Anne. 1.6.

1.4.7 **After comparing the spectrum requirement for 2007 targets and the current level of allocation of spectrum, one thing which becomes clear is that immediately there is a need of ensuring the availability of additional spectrum for growth of mobile services so as to achieve the target of 200 million mobile customers in the year 2007. In Annex. 1.5, additional spectrum requirement has been worked out. For example, in Delhi, additional spectrum requirement for GSM operations would be in the range of 28-65 MHz. Since the additional spectrum requirement is highest in Delhi, the same has been brought out here. Similarly for CDMA Services in Delhi the additional requirement is in the range of 3.75 – 17.5 MHz. As explained earlier, the allocation criterion should be technological neutral. If GSM criterion for allocation of additional spectrum is applied for CDMA services then additional requirement for Delhi will be in the range of 2 x 8.75 MHz to 2 x 26.25 MHz The additional spectrum requirement for other Metros is also given in Annex. 1.5 for GSM operators and in Annex. 1.6 for CDMA operators.**

1.5 Broad guideline for Spectrum Policy as enunciated in the New Telecom Policy 1999 (NTP'99)

1.5.1 As per the New Telecom Policy 1999 (NTP'99), availability of adequate frequency spectrum is essential not only for providing optimal bandwidth to every operator but also for entry of additional operators. NTP'99 further mentioned that it is proposed to review the spectrum utilisation from time to time keeping in view the emerging scenario of spectrum availability, optimal use of spectrum, requirements of market, competition and other interest of public. It also states that the entry of more operators in a service area shall be based on the recommendation of the TRAI, who will review this as and when required and not later than every two years. NTP'99 also mentioned that with the proliferation of new technologies and the growing demand for telecommunication services, the demand on spectrum has increased manifold. It is therefore, essential that spectrum be utilised efficiently, economically, rationally and optimally. There is a need for a transparent process of allocation of frequency spectrum for use by a service and making it available to various users under specific conditions.

1.6 TRAI's recommendations on Unified Licensing:

1.6.1 TRAI's recommendations on Unified Licensing dated 27th October 2003 envisages the spectrum allocation policy to be separate from licensing of services.

1.7 Government's reference to TRAI on Spectrum related issues:

1.7.1 The Government vide its letter dated 17th November 2003 have sought TRAI's recommendations on:

- efficient utilisation of spectrum;
- spectrum pricing;
- spectrum allocation procedure.

1.8 TRAI's Consultation Process:

1.8.1 It may be recalled that TRAI had issued a consultation paper on Spectrum related issues on 31st May, 2004. The various issues discussed in the consultation paper pertain to:

- Current spectrum availability and requirement.
- Technical efficiency of spectrum utilisation
- Spectrum Pricing
- Spectrum allocation
- Re-farming, Spectrum trading, M&A and Surrender

1.8.2 Written comments were invited on TRAI's above mentioned consultation paper by 30th June 2004. Later the date for receiving comments was extended up to 15th July 2004. The comments received from various stakeholders were put on TRAI's website. Open House Discussions were also held in this regard at Bangalore, Mumbai and Delhi on 20th Aug. 04, 3rd Sept. 04 and 6th September 2004, respectively. A detailed technical meeting was held on Sept. 6, 2004 after the Open House Discussion on spectrum related issues with a number of stakeholders with specific reference to " Interference issues 1900 MHz USPCS band and IMT-2000 2 GHz band plans". A presentation by Indian GSM Industry/COAI was made on this topic and technical discussions were held with the participants to clarify and elucidate the issues concerned. A copy of the above mentioned presentation was put on TRAI's website. Comments of the various stakeholders were also invited. Several other meetings with various stakeholders including service providers, defence and equipment manufacturers, etc. were also held in this regard. In fact, the last comments were received up to 11th May 2005 i.e. just before finalisation of these recommendations. Based on the comments received in the consultation process, international practises and its own analysis TRAI has finalised its recommendations on spectrum related issues.

1.9 Key Objectives of Recommendations:

1.9.1 While finalising these recommendations the following key objectives have been kept in mind: -

- Growth of Telecom Services in the country including rural area.
- Ensuring efficient spectrum use
- Ensuring the availability of spectrum to service providers so that inadequacy of spectrum does not hinder the growth of telecom services in the country.
- Reasonable spectrum price so that the service providers could make available telecom services at affordable price.
- Level playing field among service providers using various technologies in connection with allocation and pricing of spectrum.

1.9.2 Besides the above objectives, certain other important considerations have to be a part of the spectrum policy. These include: -

- Availability of a certain minimum spectrum to each operator for technical efficiency reasons;
- Overall availability of spectrum and steps to ensure its maximisation.
- At what stage new operators should come in under conditions of limited spectrum availability

1.9.2.1. Ensuring a certain minimum spectrum to each operator, helps in better network planning which in turn will imply lesser capex per subscriber and therefore more competitive tariffs. To meet this criterion "in-advance" planning for spectrum availability has to be carried out which may not be always easy especially in a very fast growing market.

1.9.2.2 In such a high growing wireless services market, the requirement of spectrum is high as already discussed in section 1.4. Authority realises that a lot of emphasis has therefore, to be given to availability of spectrum. The other users of spectrum should ensure that the spectrum in which telecom equipment is available and which has been identified for various telecom services, should be vacated at the earliest. Government should make efforts at all levels to ensure the availability of spectrum to telecom services including funding required for refarming of spectrum.

1.9.2.3 A larger number of wireless operators may increase competition but it could adversely affect the efficient utilisation of spectrum. The more fragmented the spectrum is, the more inefficient its use becomes. While finalising the recommendations, it is kept in mind that there is adequate competition in all service areas. There are 4 to 7 mobile operators in different service areas. The issues related to entry of new operators, adequacy of competition and fragmentation of spectrum are discussed in detail later in these recommendations.

1.10 Need for Alternative Approaches in the Spectrum Policy:

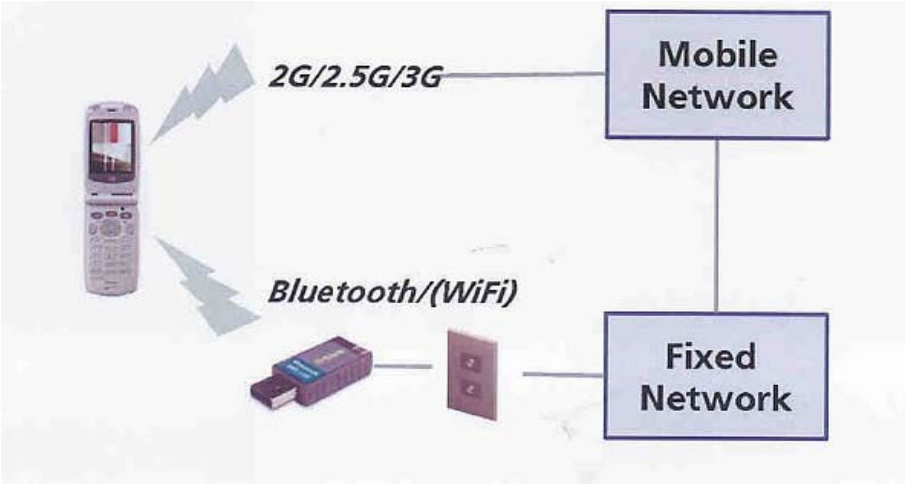
The growth projected for mobile/wireless phones in our country requires spectrum way beyond what is conceivably possible to be made available. Alternative technological scenarios have to be pursued to ensure that the growth is not hampered due to inadequacy of spectrum. This does not imply that vacation of more and more bands should not be pursued. In fact, the highest priority has to be given to time bound vacation of spectrum in which standard mobile equipments are available worldwide. Alternative technological solutions imply increasing the efficiency of utilisation of a given spectrum and/or evolving approaches which are different from the classical approach followed today which in turn results in meeting high requirement of spectrum for the kind of growth projected. Spectrum utilisation efficiency can be increased by the following methods in addition to other technological means to improve spectrum efficiency.

- Fixed-Mobile convergence
- Wi- Fi enabled handsets for data services
- In Building Coverage solutions using alternate spectrum ends

1.10.1 Fixed-Mobile Convergence:

Fixed and Mobile convergence is a reality and the quest is to have a fully integrated IP based network. Based on the industry reports, it is estimated that about 60% of mobile calls are made within a building. With the increased penetration of broadband in the buildings, it could be highly economical if we have a telephone which works on fixed network when the user is inside the building and the same phone works as a cellular phone when outside. British Telecom's 21 CN network concept (Bluephone) is developing such a system which through a Wi-Fi / Bluetooth Wireless Interface base station would be connected to fixed network. With fixed-mobile convergence mobile calls made in buildings would be routed to the fixed network via W*i- Fi/* Bluetooth Wireless Interface. Mobile calls made outside the building will be routed via the traditional mobile network. This is explained in fig. 1.4.

Figure 1.4: Fixed-Mobile Convergence



This arrangement will improve efficiency of mobile network and spectrum requirement of mobile networks would come down as significant traffic shall be routed via fixed network. This will also reduce the number of outdoor cell sites. All these trends are also to be kept in mind while finalising the spectrum management plan. The operators shall also keep this aspect in mind while demanding additional spectrum. A common core platform enables greater functionality, flexibility and lower costs for the industry. This also recognises the fact that convergence is gaining momentum and customer wants more choice, flexibility and control. Simplicity is key.

1.10.2 Wi-Fi enabled handsets

Many mobile operators in various countries have already started offering the handsets which are having the *Wi-Fi* capabilities. When the customer is browsing internet or sending or receiving e-mails then instead of mobile network, *Wi-Fi* network are used in a places where *Wi-Fi* network has a coverage. For example, if a customer with *Wi-Fi* enabled handset is sitting in an airport lounge wherein *Wi-Fi* coverage is there then he can do the browsing of internet, send and receive e-mails through *Wi-Fi* network instead of going through traditional mobile network using the same handset. This reduces the load on mobile network and in a way ensures the more effective utilisation of spectrum for mobile services. In the absence of such an arrangement the mobile network would have been used to meet the requirement of browsing internet, downloading files, sending/receiving mails, etc. This is different from fixed-mobile convergence as discussed in para above, because therein the in-building mobile calls are diverted from mobile network to fixed networks. In the case mentioned above the traffic of mobile network is diverted to Wi-Fi network which through a leased line, etc. connects to ISP node and Internet cloud without joining up either the PSTN or PLMN. In future, there could be a possibility of other technological developments for enabling high-speed wireless data transfer. This saves mobile network resources especially spectrum in large cities where we have spectrum problem.

1.10.3 In building Coverage: -

As mentioned in the preceding paragraphs that 60% mobile calls are made within a building and therefore, if we could do the spectrum planning and network deployment plans separately for in-building and out-door coverage then this also will help in achieving a higher spectral efficiency.

There is an emerging trend world wide to divide the spectrum for indoor and outdoor applications. Countries like Sweden, Switzerland etc. have already planned spectrum for indoor communication. Other countries are also considering this option. This would reduce burden on outdoor spectrum requirements.

1.10.4 To take full advantage of all above technological developments that have been discussed it is necessary that regulatory regime including licensing system has to be service neutral. Unified licensing recommendations have addressed this issue. As discussed earlier in this Chapter, we have to adopt a spectrum policy which is also service neutral.

Chapter 2 – Efficient Utilisation of Spectrum

2.1 Background

2.1.1 Spectral efficiency quantifies the amount of traffic a network can carry for a given spectrum. Furthermore, it is a measure of the radio performance efficiency, thus higher spectral efficiency will imply higher quality of service provided to the end users for a given traffic load. It is pertinent to ensure that the allocated spectrum is being efficiently utilized as spectrum is a scarce resource and also in many areas demand is more than the available spectrum. The performance characterization of efficient utilisation of spectrum of a network is done, in terms of traffic load handled by the network and its quality of service. Network is more spectrally efficient if for a certain benchmarked quality it can carry more traffic, and for a certain traffic load, the Network can offer better quality of service. If certain functionality that increases the spectral efficiency is introduced in Network, the quality will immediately improve and considering the previous quality as the benchmarking quality level, there will be additional traffic load that can be carried by the network. The relative value of this additional traffic load is the capacity increase provided by the introduced functionality.

2.1.2 Even though the most traditional way to express spectral efficiency has been Erlang per megahertz per square kilometre (Erl/MHz/km²), there have been many other ways to quantify the same concept in the wireless industry. Some of the ways to measure it are

- Effective reuse
- Fractional load
- Frequency load
- Effective frequency load (EFL)

All these techniques of measuring the efficient utilisation of spectrum are discussed in details in Annex. 2.1

2.1.3 For increasing the efficiency of spectrum utilisation, there are various methods, such as, synthesised frequency hopping, multilayer architecture of the network, smart antennas, adaptive multi rate speech coding, etc. However, for deployment of these methodologies there is a cost associated and also there is a requirement of a minimum spectrum.

2.1.4 Pricing is also used as a means to promote efficient utilisation of spectrum. However, to achieve high growth of mobile services with their penetration in semi urban and rural areas it is necessary that these services are available at an affordable price. To achieve this, the spectrum price, which is a raw material for wireless services, has to be kept within reasonable limits. It is important to note that lower tax regime does not necessarily imply loss of revenue to Government as has been demonstrated in the introduction of revenue share regime for telecom licensing. (See table in Annex. 2.2, which demonstrates, increased revenues for Government after this regime was introduced - due to higher growth rate). Regulatory levies in some developing countries are enclosed at Annex. 2.3. It is evident from this Annex. that the regulatory levies are not so high in other developing countries. Service tax collections since 2001 are enclosed at

Annex. 2.4. From this Annex. it is seen that telecom Sector is contributing almost 1/3rd of total service tax collections in the year 2004-05, therefore, other levies could potentially be reduced.

2.2 Benchmarking on efficient utilization of spectrum.

2.2.1 In the consultation process, based on ITU recommendations SM 1046-1, a methodology for benchmarking for efficient utilisation of spectrum in terms of Erlang/ MHz/ Sq. km. was discussed. The brief write-up on this methodology is given in Annex. 2.5. In the consultation process, it has emerged that on account of dependence of benchmarking on large number of variables like technology used, the pattern of traffic (voice, data, video, etc.) and various other demographic factors, etc., this methodology is not very practical. All these parameters may have different values in different situations which really increases the size of benchmarking matrix.

2.2.2. Apart from above, many stakeholders were concerned that the methodology in the consultation paper would be used to compare the relative performance of CDMA and GSM technologies. The stakeholders opined that in a technology neutral regime, it is not regulator's concern to define which technology is spectrally more efficient. Different technological options, involving different costs, may be available for different technologies to improve efficient utilisation of spectrum. These technological options would affect different technologies in different ways. In case benchmarking approach is adopted for measuring efficient utilisation it would be very controversial issue as the benchmarked numbers may be different for different technologies.

2.2.3 Further, the operators using different technologies like GSM & CDMA may argue that the benchmarking criteria is favouring one or other technology and may give rise to litigation. Some of the stakeholders opined that TRAI should use market principles and allocation processes to ensure the maximum efficiency of networks and should consider methods of encouraging efficient use of spectrum rather than aiming to measure or determine what is efficient.

2.2.4 There is a perception in the market that amount of spectrum held by an operator increases its valuation. This perception increases the risk of spectrum hoarding. If there is no benchmark criterion for allocation of additional spectrum and spectrum is priced at a very low price due to various considerations discussed in the recommendations then this tendency of spectrum hoarding may increase. Keeping this in view, the alternative approach of defining the criterion for allocation of additional spectrum so as to ensure its efficient utilization needs to be streamlined. The key issue is that the fundamental necessity of ensuring efficient utilisation of spectrum may not be denied.

2.2.5 It is evident from the above discussions that while the concept of efficient utilisation of spectrum is a must, actual implementation through measurements is somewhat impractical. Very considerable effort and analysis will be needed to carry out such measurements and even after doing so, they could easily be questioned.

2.2.6 Existing method of allocation of additional spectrum is based on subscriber base criteria. As already discussed in para 2.1.4, this is one of the methods to ensure efficient utilization of spectrum. As discussed later in Chapter –3 ,

there is a substantial constraint in regard to spectrum availability. The presently used subscriber-base dependent spectrum allocation procedure is useful in situations where there is constraint in the availability of spectrum.

2.3 TRAI's recommendations on benchmarking of efficient utilisation of spectrum

2.3.1 The benchmarking criterion for efficient utilisation of spectrum (in terms of Erlangs/MHz/Sq km) for use as a parameter for determining the need for allocation of additional spectrum may be practically difficult to implement. Since the operators are currently having the spectrum ranging from 2 x 4.4 MHz to 2 x 10 MHz for GSM operators and 2 x 2.5 MHz to 2 x5 MHz for CDMA operators which is far below the international averages for both technology operators, therefore, at this stage application of any such benchmarking criterion as discussed in the consultation paper may not be appropriate.

2.3.2 Keeping in view technological developments, improvements in availability situation of spectrum and its allocation and also due to development of different type of applications, this concept of benchmarking could be reconsidered at a later stage. At this stage, some other methodology of ensuring efficient utilisation of spectrum is to be considered.

2.3.3 Keeping in mind the current constraint in availability of spectrum and pricing (existing revenue share) as a method of ensuring efficient utilisation of spectrum, it is recommended that the existing subscriber base approach for allocation of additional spectrum should continue. However, the present criteria of allocation of additional spectrum is different for GSM and CDMA operators. Originally, when the mobile services were started there was no expectation of the type of growth which has happened lately and there were also limitations in the availability of spectrum. Accordingly, spectrum in small quantities was allocated to these operators in comparison to the international average allocation which are of the order 2x20 MHz for GSM and 2x14 MHz for CDMA. The allocations in India are very limited. As already indicated, the existing allocation criterion for additional spectrum is different for GSM and CDMA operators. The required number of subscribers for allocation of additional spectrum (on per MHz basis) is different for GSM and CDMA operators as per the existing criteria. While finalising this criteria for CDMA operators it might have been presumed that these two technologies have different efficiency of utilisation of spectrum. However, it is also well established that this difference diminishes as the traffic grows such as in Central Business Districts (CBD). The criteria for CDMA operators include additional allocation of spectrum even at SDCA level and is service area specific which is not the situation in GSM operators. **The Authority, therefore, recommends that the subscriber based spectrum allocation criteria for both GSM and CDMA should be revised. The revised criteria should also keep in mind the expected results from intensive efforts recommended later in this document to get more spectrum released and the resulting availability picture of spectrum. Further, these criteria should be made to gradually move in the direction wherein they become technology neutral. If the Government so desires, TRAI jointly with the Telecom Engineering Centre (TEC) can assist WPC to formulate a revised criteria.. Detailed recommendations on the criterion for spectrum allocations are discussed later in Chapter-3.**

2.3.4 If spectrum is available then it should be given to those who need it. A comparison of level of competition in the various circles as compared to some of the Asian markets and various issues related to level of competition and entry of new mobile service providers have been discussed in the subsequent chapter**. From the analysis, a high degree of competition in the Indian Mobile market is evident. With 4 to 7 mobile operators (GSM and CDMA combined) in different service areas, we are convinced that there is adequate competition in Indian Mobile Telecom Market. Since there are 4 to 7 mobile operators in each service area the Government should not keep the spectrum in reserve. Also, before we consider assigning spectrum to new service providers it is pertinent to ensure that the existing service providers have adequate spectrum. Due to merger and acquisitions policy there is a possibility that in future number of operators are reduced and at that stage the possibility of entry of new operators could be considered.**

2.3.5 In framing the recommendations for spectrum allocation while ensuring maximization of efficiency of utilization of the spectrum, the Authority has kept two aspects in mind.

One aspect is to focus Government's objective to make 200 million cellular telephones available by 2007 and the fact that considerable planning period and definitiveness in spectrum allocation is required for quick build up of infrastructure of the operators to meet the above target. The allocation of spectrum to operators in India has been much below international benchmarks leading to inadequate planning and network building by operators. For providing a trigger for another explosive growth, spectrum should not act as a bottleneck and a relatively liberal approach is desirable.

The second aspect which has been kept in mind is that the availability of spectrum is limited and its allocation should be need based. Such an approach results in much longer time for making spectrum available to operators but has the advantage of better control over the limited available spectrum.

The Authority recommends that the spectrum allocation guidelines should be quickly revised both for GSM and CDMA. The Authority further recommends that whatever spectrum is currently available or can be coordinated quickly may be made available to the operators based on the revised allocation procedure. This approach of need based allocation could be adopted till a certain minimum spectrum typically 2X10 to 2X15 MHz is made available to each operator. Owing to the constraint in spectrum availability, the Authority recommends that instead of trying to make equal minimum spectrum available to all the operators, the operators should be given additional spectrum based on the needs. For this purpose, the existing subscriber based criteria, should be revised taking into account the "trunking efficiency" principles up to the extent of around 2X15 MHz and thereafter an alternative criteria could be considered.

Chapter 3 Spectrum allocation

3.1 Background:

Allocated Spectrum

3.1.1 Currently, spectrum varying from 2 X 4.4 MHz to 2x10 MHz has been allocated to service providers using GSM technology, while 2 X 2.5 MHz to 2 X 5 MHz has been allocated to service providers using CDMA technology. Some operators have been allotted mixed 900 and 1800 MHz operations while others have been allotted either in 900 MHz or 1800 MHz frequency band. CDMA operators have been allocated spectrum in 800 MHz band. Currently allocated spectrum to GSM and CDMA operators as on 28.02.2005 is given in Annex. – 1.2.

3.1.2 Most operators have only GSM or only CDMA operations. However, BSNL and MTNL have both GSM and CDMA operations. Reliance Infocomm has CDMA operations almost in all service areas but in addition in Bihar, West Bengal, Orissa, HP and MP, Reliance Telecom has GSM operations.

Bands available for Cellular Mobile Operations

3.1.3 The bands recognized for providing the 2G/2.5G mobile services internationally and in India are given in the table 3.1: -

Table 3.1 - Spectrum allocations for 2 / 2.5 G cellular mobile services

	International allocations*	Indian allocation
450 MHz	Spectrum allocated in some countries***: 452.5-457.475 paired with 462.5-467.475 452 – 456.475 paired with 462-466.475 450-454.8 paired with 460-464.8 411.675 – 415.850 paired with 421.675-425.850 415.5-419.975 paired with 425.5-429.975 479-483.48 paired with 498-493.48 455.23-459.99 paired with 465.230-469.99 451.310-455.730 paired with 461.31-465.73 Details are given in table 3.3	Not allocated
800 MHz	824 – 849 MHz paired with 869 –894 MHz	824 – 844 paired with 869 – 889 MHz *(Used to provide WLL (M) & CDMA based mobile services)*
900 MHz	890 – 915 MHz paired with 935 – 960 MHz	890 – 915 paired with 935 –960 MHz** *(Used by 1st, 2nd and 3rd*

	(880 – 890 MHz paired with 925 – 935 MHz E-GSM band)	*Cellular Mobile Service Providers for GSM)*
1800 MHz	1710 – 1785 MHz paired with 1805 – 1880 MHz	1710 – 1785 paired with 1805 – 1880 MHz *(Used by 4th CMSP and for additional allocations to 1st, 2nd and 3rd CMSPs.)*
1900 MHz	1850 – 1910 MHz paired with 1930 – 1990 MHz *(North American PCS band)*	1880–1900 MHz is earmarked for Micro cellular technologies based on TDD

* SOURCE: ITU-R Recommendation M.1073-1 & NFAP 2002. The above table does not reflect allocations where these technologies co-exist.
** Out of 2 X 25 MHz, 2 X 1.6 MHz is with the Railways
***Source: IA 450 Presentation, 3GPP2 CDMA 450 Seminar, Warsaw, Poland dated 15.6.04

From the above table it is clear that 800 MHz band has been earmarked for CDMA based systems, while 900 MHz is for GSM based cellular systems. The 1880-1900 MHz band has been earmarked for micro-cellular technology based on TDD mode. So far as the 1800 MHz band is concerned, the NFAP-2002 states that up to 2 x 10 MHz could be coordinated on case by case basis for WLL systems based on FDD access mode after the full utilization of allocated spectrum in 800 MHz band. This band can and has been used for GSM operators. The WLL system introduced in the country have used CDMA technology (in the 800 MHz band) and in the year 2003 when the concept of Unified Access Service licensing was introduced, these systems in the FDD access mode were used to provide cellular mobile services. Thus, so far as the 1800 MHz band is concerned, as per NFAP 2002 it is possible to use both GSM and CDMA based FDD access mode systems.

For IMT-2000 services, various WARCs have identified different frequency arrangements in the bands 1710-2200 MHz. These are given in table 3.2 below:

Table 3.2: Frequency arrangements in the band 1 710-2 200 MHz
Frequency arrangements in the band 1 710-2 200 MHz

Frequency arrangements	***Mobile station transmitter (MHz)***	***Centre gap (MHz)***	***Base station transmitter (MHz)***	***Duplex separation (MHz)***	***Un-paired spectrum (e.g. for TDD) (MHz)***
B1	*1 920-1 980*	*130*	*2 110-2 170*	*190*	*1 880-1 920; 2 010-2 025*
B2	*1 710-1 785*	*20*	*1 805-1 880*	*95*	*None*
B3	*1 850-1 910*	*20*	*1 930-1 990*	*80*	*1 910-1 930*
B4 (harmonized with B1 and B2)	*1 710-1 785* *1 920-1 980*	*20* *130*	*1 805-1 880* *2 110-2 170*	*95* *190*	*1 900-1 920; 2 010-2 025*
B5* *(harmonized with B3 and parts of B1 and B2)*	*1 850-1 910* *1 710-1 755* *1 755-1 805*	*20* *50* *305*	*1 930-1 990* *1 805-1 850* *2 110-2 160*	*80* *95* *355*	*1 910-1 930*
B6 (harmonized with B3 and parts of B1 and B2)	*1 850-1 910* *1 710-1 770*	*20* *340*	*1 930-1 990* *2 110-2 170*	*80* *400*	*1 910-1 930*

*It is understood that frequency arrangement B5 has been dropped due to interference problems.

NOTE 1 – Administrations can implement all or parts of these frequency arrangements.

NOTE 2 – In the band 1 710-2 025 and 2 110-2 200 MHz three basic frequency arrangements (B1, B2 and B3) are already in use by public mobile cellular systems including IMT-2000. Based on these three arrangements, different combinations of arrangements are recommended as described in B4, B5 and B6. The B1 arrangement and the B2 arrangement are fully complementary, whereas the B3 arrangement partly overlaps with the B1 and B2 arrangements.

For countries having implemented the B1 arrangement, B4 enables optimization of the use of spectrum for paired IMT-2000 operation.

For countries having implemented the B3 arrangement, the B1 arrangement can be combined with the B2 arrangement. Two different arrangements (B5 and B6) are therefore recommended to optimize the use of the spectrum:

- *B5 would implement the B2 arrangement to harmonize parts of the extension bands globally. B5 enables the use of spectrum to be maximized for paired IMT-2000 operation in countries where B3 is implemented and where the whole band 1 710-1 850 MHz is available.*
- *B6 enables the use of spectrum to be maximized for IMT-2000 in countries where B3 is implemented and where the band 1 770-1 850 MHz is not available in the initial phase of deployment of IMT-2000 in this frequency band.*

NOTE 3 – TDD may be introduced in unpaired bands and also under certain conditions in the uplink bands of paired frequency arrangements and/or in the centre gap between paired bands.

NOTE 4 – If selectable/variable duplex technology is implemented within terminals as the most efficient way to manage different frequency arrangements, the fact that neighbouring countries could select either option B5 or B6 will have no impact on the complexity of the terminal. Further studies are necessary.

Spectrum allocation Procedure

3.1.4 At this point of time the criterion of allocation of additional spectrum is linked to number of subscribers. This spectrum allocation procedure could be one of the criterions to ensure efficient utilization of spectrum. DOT recently (WPC Wing) vide its order No. J-14025/200(17)/2004-MT dated 10th December 2004 has issued a criterion for allocation of additional spectrum to CDMA operators. The existing spectrum allocation procedure for GSM and CDMA operators are enclosed at Annex. 3.1. As per the criterion specified for GSM operators for over 10 lakhs subscriber base GSM operator could get beyond 2 X 8 MHz spectrum while CDMA operators would get 2x5 MHz (in Delhi and Mumbai). In category 'A' circles, the minimum subscriber base required for allotment of 2X5MHz in CDMA (4th carrier) is 12 lakhs. Authority has noted that this criterion is different for CDMA and GSM operators. One could argue that this criterion assumes that CDMA technology is more spectrally efficient, therefore, even with a lower (just half in this illustration) spectrum in comparison to GSM operator the CDMA operator could handle the same number of subscribers as GSM operators. However, another view point is that in Central Business District (CBD) area this advantage, if at all it exists for a particular technology, may not be available to the extent as in comparatively thin subscriber density area. The maximum spectrum requirement is in CBD areas and from this point of view to have different subscriber number based criterion for different technologies may not be desirable. Further additional spectrum allocation criteria for CDMA operators is service area specific and is also defined at SDCA level which is not the case with GSM operator's criteria. DOT vide its letter No. 20-232/2004-BS-III dated 17th March 2004 (enclosed at Annex. 3.2) in connection with M&A guidelines had clarified that the spectrum charges shall be calculated for the total spectrum held by the merged entity as Government has already decided that spectrum charges shall be same for CDMA and GSM. It means that for spectrum pricing purpose, Government is currently following technology neutral approach. However, it is very well understood that these steps of number of subscribers for allocation of additional spectrum are being put because there is constraint on the availability of additional spectrum. The existing level of allocated spectrum, no. of existing subscribers, the availability of spectrum and licensing terms & conditions, etc. might have been kept in view while deciding these criteria. **However, we are of the opinion that efforts should be made to gradually move in the direction wherein the spectrum allocation criterion is technology neutral. It is, therefore, recommended that the present spectrum allocation criterion may be reviewed such that while retaining the subscriber base approach, the quantum and steps for additional spectrum allocation are technology neutral. The revised spectrum allocation guidelines must keep the spectrum availability, efficiency of utilisation and area of co-ordination in mind.**

Provisions of NFAP2002

3.1.5 IND 48 of NFAP 2002 indicates as follows:

"IND 48- Requirements of cellular and WLL systems in the frequency band 1700-2000 MHz may be coordinated on a case by case basis. Cellular mobile telephone systems may be coordinated for (10 + 10) MHz in the frequency band 1710-1785 MHz paired with 1805-1880 MHz and on full utilization of allocated spectrum in 800 MHz band, an additional (10 + 10) MHz of spectrum may be coordinated for the WLL systems in the frequency bands 1710-1785 paired with 1805-1880 MHz on a case-by-case basis.

This additional spectrum could be in chunks of (2 x 5) MHz if possible, otherwise smaller chunks in multiples of 1.25 MHz could be considered for allocation on case-by-case basis. These allocations may not be contiguous. However, efforts would be made to make the spectrum width as large as possible".

As per NFAP 2002, 1880-1900 MHz has been reserved for micro cellular WLL systems based on TDD access techniques. Additional requirements of micro cellular WLL systems based on TDD may be considered in 1900-1910 MHz. NFAP 2002 further indicates that the requirements of IMT-2000 (3G) applications in the frequency bands 1885-2025MHz paired with 2110-2200 MHz may be coordinated with existing users initially for 1920-1980 MHz paired with 2110-2170 MHz (FDD mode) and 2010-2025 MHz (TDD mode) depending on the market needs and availability, as far as possible.

3.1.6 The total spectrum for GSM 900 and GSM 1800 frequency bands is 2x100 MHz (2 X 25 MHz of GSM 900 + 2 X 75 MHz of GSM 1800). Most of GSM 900 spectrum has already been allocated including allocation of 2 x 1.6 MHz to Railways for GSM-R systems but in GSM 1800 most of it is still being used by other users like Defence etc. Efforts are being made for allocation of additional spectrum in GSM 1800 band (1710-1785 MHz paired with 1805-1880 MHz band). The maximum allocated spectrum in a service area at present in 1800 MHz band is 2 x 12 MHz (varies from region to region). During TRAI consultation process Defence informed TRAI that the frequency band 1710-1785 MHz paired with 1805-1880 MHz is extensively utilized by Air Force and Army and a maximum of 2 X 25 MHz spectrum, as agreed by GoM be considered for coordination, subject to readjustment of systems in a time frame of 4-6 years and re-farming Defence in suitable alternate bands. Even in GSM 900 MHz band spectrum around 2 X 4.8 MHz is being used by Defence in all the circles except Delhi and Mumbai.

3.1.7 Currently, operators are adding around 2 million mobile customers (both GSM & CDMA) every month. To achieve the target of 200 million mobile customers in 2007, this growth rate has to increase from existing 2 million mobile subscribers to around 4 million mobile customers every month. To achieve this enhanced growth rate the pressure on availability of spectrum will further go up. In fact, availability of additional spectrum has to be ensured not only to achieve higher growth rates but also even to sustain the current growth rate of around 2 million mobile customers per month. Issues pertaining

to present spectrum allocations and future spectrum requirements have already been discussed in detail in Chapter-1

Availability of equipment and handsets in different frequency bands

3.1.8 In the 450 MHz band CDMA equipment is available and has been deployed in many countries though at least eight different bands sub-classes have been used (details given in table 3.3). So far as the handsets are concerned, dual/triple band with 450 MHz along with 800 MHz or any other band are not available in the market presently. The usage of 450 MHz equipment especially in semi-urban and rural areas would be advantageous from coverage point of view because of propagation characteristics at such frequencies. On the other hand, the deployment of equipment in this frequency band may increase the multi band handset price. The operators would have to weigh various advantages and disadvantages in deployment of 450 MHz frequency band. Authority believes that instead of making judgment ourselves, we should focus on availability of spectrum in various frequency bands including 450 MHz band and rest should be left to market forces. No GSM equipment is currently available in this band, but allocation of this band for GSM and other technology usage should not be ruled out.

3.1.9 In the 1800 MHz band, equipment is available and is already being used by GSM operators in many countries including India. Dual band handsets are also available in GSM 900 and GSM 1800 MHz frequency bands. So far as the CDMA equipment is concerned, equipment in this band has been deployed in South Korea but they have chosen different duplexer spacing of 90 MHz instead of 95 MHz as specified in this band. In other words, standard band equipment is not available in this band for CDMA technology. As a consequence, handsets in this band whether dual band, i.e. CDMA 800 and CDMA 1800 MHz or triple band, viz. CDMA 450 MHz/CDMA 800 MHz/CDMA 1800 MHz are not available. During consultation process, some stakeholders opined that in view of the growth potential of mobile services in our country, the equipment vendors would develop the equipment in this band and the same will be the situation for handsets.

3.1.10 In the IMT-2000 2 GHz band (1920-1980 MHz paired with 2110-2170 MHz), both WCDMA and CDMA 2000 1X EVDO equipment is available. Dual band handsets are available for WCDMA, in this and 900 MHz band as also triple band handsets (2 GHz/1800 MHz/900 MHz) are also available. However, so far as CDMA 2000 1X EVDO is concerned, dual or triple band handsets are not available. As far as availability of the equipment is concerned, CDMA 2000 1 X EVDO equipment is available in this band. For example, KDDI Japan is using CDMA 2000 1 X EVDO equipment in IMT-2000 2 GHz band. It is also expected that KDDI, Japan may start offering dual band handsets for offering CDMA services in 800 MHz and 2 GHz bands. Further, extensive trials for WCDMA, CDMA 2000 1 X EVDO and TD-SCDMA technologies in IMT-2000 2 GHz band have been conducted in China. It is understood that apart from others, dual band CDMA 2000 1 X EV-DO handsets had been used in these trials. In fact, one of the handset

developers has written to TRAI that such handsets can be made available within six months.

3.1.11 So far as the 1900 MHz USPCS band is concerned, both GSM and CDMA IMT 2000 equipment (both WCDMA & CDMA 2000 1x EV DO) and multiple band handsets are available in this band.

3.1.12 Authority notes that as far as IMT 2000(both WCDMA and CDMA 2000 1X EVDO) is concerned, the equipments are available in both 2GHz as well as 1.9 GHz band. Authority also notes that the economy of scale of equipment in different technologies GSM, CDMA and IMT 2000 and also in different frequency bands could be different. The position of availability of multi band handsets has also been explained. Authority has considered these aspects while finalizing these recommendations.

3.2 International Practices:-

3.2.1 As already discussed in para 1.3, internationally the average spectrum allocation is approximately 2 X20 MHz and 2 X 14 MHz for GSM and CDMA operators respectively as against maximum allocation of 2 x 10 MHz and 2 x 5 MHz for GSM and CDMA operators respectively in India.

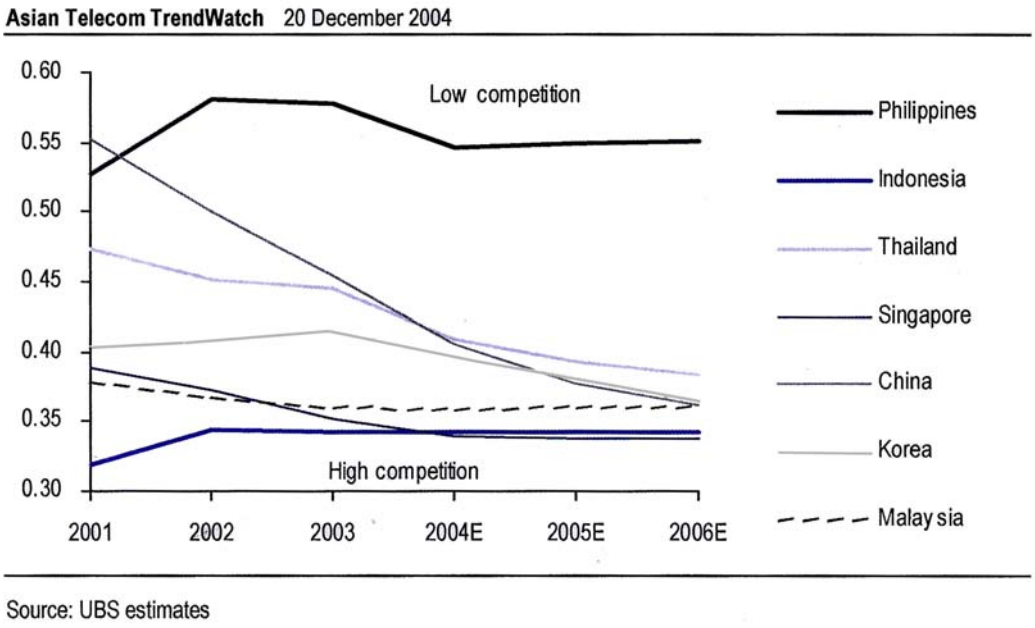
3.2.2 India is in a unique situation in terms of current teledensity, very high growth rate, high growth potential, the level of competition (large number of access providers) and operators using both GSM and CDMA technologies. All these aspects coupled with constraint in additional spectrum availability make the spectrum management task very complex and very different from other countries.

3.3 Level of competition and entry of new mobile service Providers

3.3.1 Before examining the entry of new mobile operators, let us consider the existing level of competition. We can measure the level of competition by looking at the Herfindahl-Hirschman Index (HHI), which is sum of square of the market share of all the operators in the market. Thus HHI = 1 represents monopoly and HHI = 0 represents perfect competition.

3.3.2 HHI Index for some Asian markets is given in the fig. 3.1. It is believed that this is a good gauge for measuring the level of competition in each market.

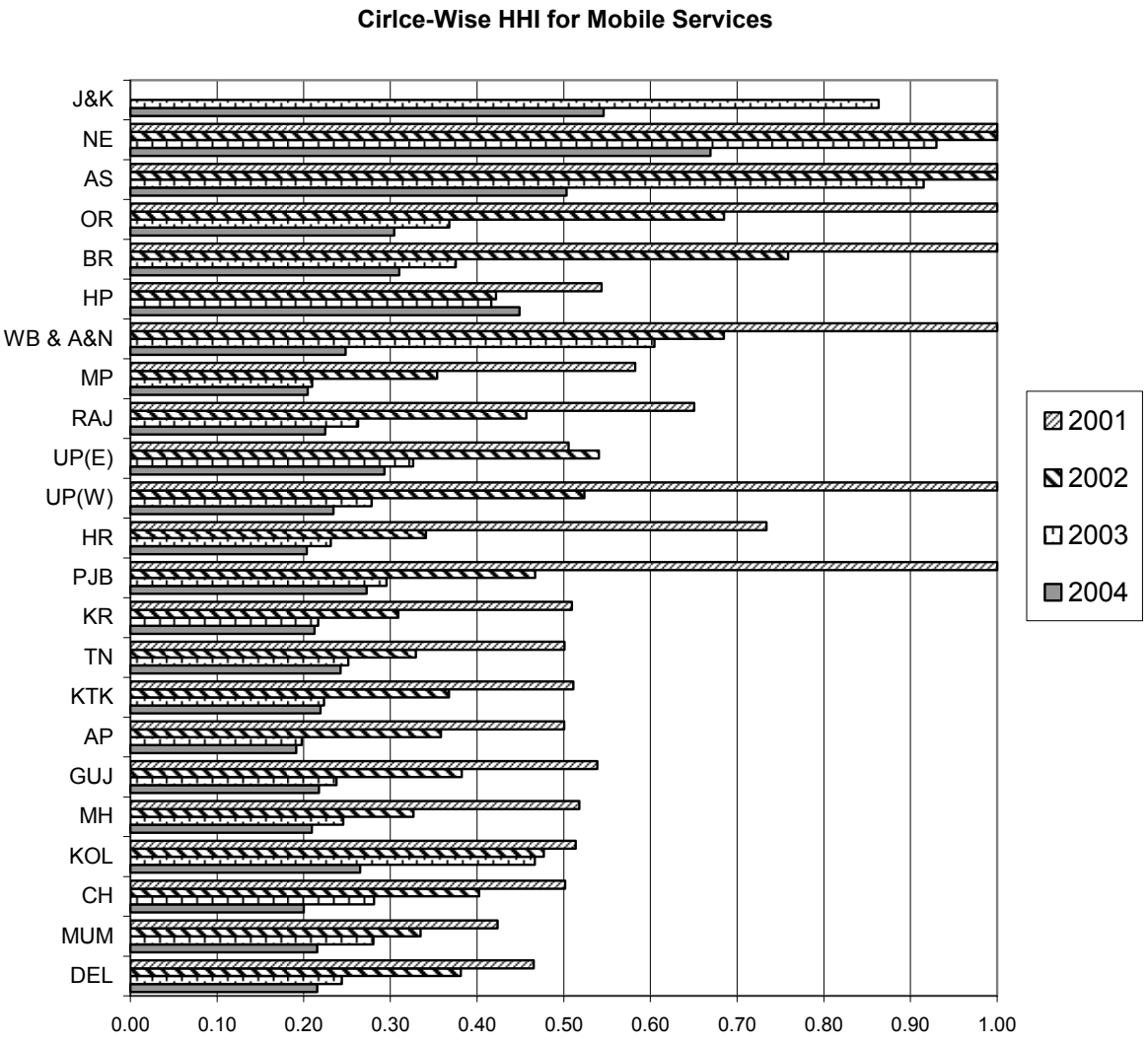
Fig 3.1: - Measuring the level of competition with the HHI in some Asian Markets



Source: UBS estimates

3.3.3 In India, licenses are given circle-wise. The level of competition in terms of HHI Index for various circles from the year 2001 to 2004 is given in the fig. 3.2. An HHI Index calculation for different service areas is enclosed at Annex. 3.3.

Fig. 3.2 Level of competition in terms of HHI Index for various circles from the year 2001 to 2004.



As mentioned earlier, as per the International Standard, a zero (0) value of HHI denotes Perfect Competition and one (1) denote Monopoly. Detailed analysis of circle-wise HHI of the mobile market of India for 4 consecutive years i.e. 2001-04, is enclosed in Annex. 3.4.

3.3.4 Analyzing the circle-wise HHI of the mobile market of India in comparison to the International data, it is observed that the HHI for the countries studied revolves around 0.35. In India, however, we have HHI averaging to 0.33, which denotes quite a high degree of competition in the Indian Mobile Market. In fact in the year 2004, HHI for Metros, Cat 'A' & 'B' circles is within 0.24.

3.3.5 The HHI analysis has been done to show the level of competition in different service areas. The HHI for various developing countries have been plotted in the graph shown in figure 3.1. This would help in consideration of entry of new operators which has linkage to adequate spectrum availability to existing operators and efficient utilisation of spectrum. It should also be noted that maximum spectrum requirement is in Metros, Cat 'A' and 'B' circles wherein as already mentioned the level of competition is very high because HHI in these service area is below 0.24.

3.3.6 **From the analysis of level of competition it is evident that with 4 to 7 mobile operators in different service areas, there is adequate competition in almost all the service areas. It is, therefore recommended that before we consider allocating spectrum to new service providers it is necessary to ensure that the existing service providers have adequate spectrum. The adequacy of spectrum has to be seen in the context of short term requirements upto 2007 to meet the government objectives of the sector, the spectrum requirements beyond 2007 and the existing spectrum allocation criterion. On these considerations several locations can be identified in the country where additional spectrum is needed by operators forthwith. Based on these considerations it is recommended that the Government should not keep the available spectrum with themselves in service areas where there is adequate competition i.e. where HHI is 0.35 or below, and allot spectrum to operators, based on the revised spectrum allocation criteria.**

3.3.7 We are in favour of open competition in the different segments of Indian telecommunication market and have recommended accordingly to the Government in respect of the different services. **TRAI's specific recommendation is that new operators should be allowed if spectrum requirements of existing operators have been met and additional spectrum is available.**

3.3.8 Due to merger and acquisitions policy there is a possibility that in future number of operators in areas with low HHI index are reduced and at that stage also the possibility of entry of new operators in such areas could be considered.

3.3.9 We are of the view that this approach should be followed for allocation of spectrum for even IMT-2000 services for areas where there is adequate competition and constraint on spectrum availability for existing operators in existing 2G/2.5G services.

3.4 Spectrum allocation to CDMA Operators

3.4.1 From the previous discussions it is seen that CDMA operators can be given 2 x 20 MHz in 800 MHz band. When more than one operator operates in the same band there is a requirement of 600 KHz guard band between two operators. Thus, when there are three operators in a given service area a total of 15 carriers become available and when there are four operators, a total of 14 carriers become available.

3.4.2 The allocation of carriers at this juncture is different for different service areas. However, it is clear that the commitment in the Unified Access Service License is for an allocation of 2x5 MHz for each CDMA operator (subject to ensuring the optimal and efficient utilization of the already allocated spectrum). This implies that there is a commitment to allocate at least four carriers for each operator subject to the specified conditions. In service areas, where there are three existing CDMA operators, three carriers will remain to be allocated after meeting the commitment in the license, while in services areas where there are four operators we will not have adequate carriers even to meet the above commitment of four carriers to each operator.

3.4.3 We have to determine an appropriate method of allocation of these additional carriers. One method could be to allocate equal number of carriers to each CDMA operator. This is possible only in the service areas where there are only three operators. However, if one looks at the subscriber base of the three operators in such areas, there are wide differences between the various operators and the criteria for allocation of even the fourth carrier is not met by several operators. Even if a more liberal criterion were to be adopted to match with the GSM criterion, the position is unlikely to change. Therefore, this approach is not feasible. This approach is in any case not feasible in those service areas where there are four operators.

3.4.4 The next aspect to consider is whether the existing criteria for allocation of additional carriers can be extended and we provide the criteria for the allocation of the fifth and sixth carriers based on some defined projected subscriber base. TRAI is of the view that the present criteria for the allocation of the third and the fourth carriers for CDMA when compared to the criteria for allocation of frequencies to GSM, is not equitable. It has been argued time and again that CDMA is capable of handling more subscribers than GSM for a given spectrum. However, this parameter is not a fixed parameter and as the traffic load increases, the difference appears to diminish. There is no agreement on what this difference should be. The present criteria is also based on the assumption of some difference between the efficiency of CDMA and GSM systems but it is felt that this assumed or implied improvement factor is too drastic. As already stated, since there is no agreement available internationally on what this factor should be, there would always be questions, no matter what subscriber base is defined as the criteria.

3.4.5 It is discussed in Chapter 1 that the spectrum allocation to CDMA operators is inadequate and in comparison to the International averages of 2 X 14 MHz, the Indian operators have only been allotted 2 X 2.5 to 2 X 5 MHz. This prevents proper planning by operators. Also from the analysis of the requirement of growth till 2007 presented in Annex. 1.6, it is evident that additional carriers would be needed to meet the Government's target of 200 million cellular connections by 2007. In the 800 MHz band, 2x20MHz spectrum is available while the allocated spectrum in Delhi (city with highest number of mobile subscribers) is 2x12.5 MHz. Keeping in view that there is sufficient competition in the mobile market where HHI is ≤ 0.35, it is recommended that in all such areas the Government should allocate the

remainder carriers in this frequency band to existing CDMA operators based on revised spectrum allocation criteria. The revised criterion should be finalised in a time bound manner and preferably within one month of acceptance of TRAI's recommendations.

3.4.6 **From the analysis, it is seen that there is a need of additional spectrum requirement for CDMA services. This requirement may go up in case CDMA growth rate picks up in future. In addition, the spectrum requirement may also increase if data usage becomes more than the existing level. The above recommendations for the allocation of available carriers in the 800 MHz band will provide immediate relief to the CDMA operators. However, as shown in Annex 1.6 the problem of spectrum availability for CDMA operators would persist unless additional bands are identified. In any case, additional spectrum would be required to be identified quickly so that the required equipment can be identified by the operators in advance.**

There are two possible candidate bands besides the IMT-2000 band. These are 450 MHz and 1800 MHz. (The IMT-2000 band is discussed separately in this chapter later).

3.4.7 It is a well-known fact that lower frequencies like 450 MHz are useful to provide larger coverage in semi-urban and rural areas due to their higher coverage range. Considering the benefits of deployment of 450 MHz frequencies especially to cover these uncovered areas the Authority considers that their allocation and usage should be promoted. Though there will be no restriction on the usage of 450 MHz frequency even in urban areas but as mentioned above it will offer benefits not only to increase the coverage in semi urban and rural areas but also lessen the burden on other bands in urban areas. As already mentioned, as per the available information dual/triple band handsets that work in 450 MHz alongwith 800 MHz or any other band are not available in the market. However, keeping in mind the size of the Indian market the availability of such handsets at affordable price should not be a major issue. Issues pertaining to allocation of band in which currently equipment and/or handsets are not available are discussed in separate paragraph. The details of the spectrum allocated in 450 MHz in some countries is shown in the table 3.3:

Table3.3: Allocation of spectrum in 450 MHz in some countries

Band subclass	Mobile station	*Base Station Freq.	Countries
A (Preferred Band subclass	452.5-457.475	462.5-467.475	Bulgaria, China (Daging), Denmark, Estonia, Finland, Iceland, Indonesia, Latvia, Lithuania, Moldova, Norway, Poland, Portugal, Romania, Spain, Sweden, Tunisia, Ukraine
B	452-456.475	462-466.475	Malaysia
C	450-454.8	460-464.8	France
D	411.675-415.850	421.675-425.850	Croatia, Slovenia
E	415.5-419.975	425.5-429.975	Turkey
F	479-483.48	489-493.48	Thailand
G	455.23-459.99	465.230-469.99	Hungary
H	451.310-455.730	461.31-465.73	Austria, Belgium, Czech Republic, Netherlands, Slovakia

*** Source: IA 450 Presentation, 3GPP2 CDMA 450 Seminar, Warsaw, Poland dated 15.6.04**

So far as 1800 MHz band is concerned, the availability of additional spectrum as well as CDMA equipment of standard configuration (Korean band is non-standard) is a problem. The issue of spectrum availability in 1800 MHz band has already been discussed in section 3.1.6. Further, the need for additional spectrum allocation in this band is discussed later in section 3.5. As mentioned above, there is a problem of availability of standard CDMA equipments to match with Indian specifications in 1800 MHz band. NFAP-2002 had mentioned regarding allocation of 2 x 10 MHz to CDMA operators in 1800 MHz band. NFAP-2002 was finalised in consultation with all operators, so they must have kept in view the availability of CDMA equipment in 1800 MHz at the time of its finalisation. Secondly, WRC-2000 has already finalised 1800 MHz band for IMT-2000 services also. It means, the equipment would be available in 1800 MHz bands also for both W-CDMA and CDMA-2000 1 x EV DO services. **Keeping this aspects in mind, Authority is keeping the option open for allocation of additional spectrum in 1800 MHz bands to both GSM and CDMA operators. It is appreciated that while the 1800 MHz band is of immediate utility to GSM operators, the exploitation of this band by CDMA operators will take longer due to equipment availability status. However, it is anticipated that considering the expected demand in India and several other major countries and the steps taken by WRC-2000, this band should be able to contribute to the requirements in India beyond 2007. Keeping in view the above, Authority recommends that CDMA operators should be allocated additional spectrum in 450 MHz band as and when they request. It is anticipated that in a longer time frame demand and availability for 1800 MHz band for CDMA equipment will also materialize. Therefore, as and when additional spectrum is available in 1800 MHz band and demand and availability of equipment in this band is established, this also should be allocated to CDMA**

operators at their request. The proposal to make the 1800 MHz band available for CDMA operator is in line with NFAP 2002.

3.5 Spectrum allocation to GSM operators:-

3.5.1 As already discussed in Chapter-1, the projected requirement of spectrum for the GSM operators in the four metropolitan cities is given at Annex.-1.5. This projection is with the objective of reaching a target of 200 million phones (GSM and CDMA combined) all over the country. From these projections it is evident that additional spectrum is required in all the four metropolitan cities. This Annex. does not discuss the additional requirement of Circles, because ultimately it is the requirement in the largest subscriber-base city of a circle which will put the upper cap on the additional requirement of spectrum. It is to be noted that no city in the country has more than four GSM operators. This requirement is expected to be less than that of Delhi and Mumbai and therefore, the analysis of additional requirement of spectrum for GSM operators has been carried out by examining the case of Delhi in more detail. It may be mentioned that in some of the border States, the problem could be peculiar due to certain limitations which may not exist in non-border area Circles.

3.5.2 It is seen that on the basis of the average additional requirement of spectrum in Delhi that beyond 2 x 32.4 MHz already allocated, an additional spectrum in the range of 28-65 MHz has to be found for GSM operators if they have to meet their share of expansion to achieve the target of 200 million mobile telephones by 2007. It is further evident that the actual additional requirement of spectrum will be different from this number due to a number of factors such as assumption of present trend to continue, non-inclusion of data traffic, etc. The figures may range between about 2 x 28 MHz to 2 x 65 MHz; if the existing criterion of subscriber base linked spectrum allocation is simply extrapolated.

3.5.3 As stated in para 3.1.6, 2 x 25 MHz in the 900 MHz band and 2 x 15 MHz in the 1800 MHz band is available for use of GSM operators. Even out of the 2 x 25 MHz in the 900 MHz band, 2 x 1.6 MHz has been allocated to Railways for GSM-R systems so that only a further 2 x 1.2 MHz is available for allocation. Likewise, in 1800 MHz band, only 2 x 4.8 MHz (2 x 15 minus 2 x 10.2 MHz) is available for further allocation. Thus, in theory at the moment only a maximum of 2 x 6 MHz (2 x 4.8 in 1800 MHz band and 2 x 1.2 MHz in 900 MHz band) more can be given to the GSM operators against a requirement of about 2 x 28 to 2X65 MHz. There are co-ordination problems in 2X1.2 MHz in 900 MHz band.

3.5.4 In Circles, GSM 900 MHz band 2x4.8 MHz has not been allocated so far because it is being used by Defence. Since the mobile network operators would have to roll out their networks in semi-urban / rural areas, therefore, from coverage point of view the availability of this additional spectrum to GSM operators would be very useful. This is because in comparison to 1800 MHz band 900 MHz band can cover a larger distance. The 4th GSM operator has the allocation only in 1800 MHz band and even

additional IMT-2000 spectrum will be allocated in higher frequency, therefore, the 4th cellular operator would be required to invest higher CAPEX for rolling out its network in semi – urban and rural areas. Keeping this in view, **Authority recommends that as and when 2 x 4.8 MHz spectrum in 900 MHz band is vacated by Defence a part of it should be allocated to those GSM operators in circles who have been allocated only 1800 MHz band. This will assist in improving the coverage in semi-urban and rural areas**

3.5.5 So far as Delhi is concerned, the spectrum allocation status for the existing four GSM operators is as follows:

- 1st and 2nd largest GSM operators 2 x 10 MHz (2 x 8 MHz in 900 MHz band and 2 x 2 MHz in 1800 MHz band)
- MTNL 2 x 6.2 MHz (900 MHz band)
- 4th GSM operator 2 x 6.2 MHz (1800 MHz band)

3.5.6 Out of these operators three have already crossed the subscriber base limit prescribed for their present allocation qualifying them for the requirement of additional allocation. Even the fourth operator has lately shown a spurt in the growth rate indicating that even this operator would require additional spectrum soon.

3.5.7 **The above analysis clearly points to the gravity of the situation and the need for immediate time bound action for making more spectrum available for GSM operators also. It is discussed in Chapter 1 that the spectrum allocation to GSM operators is inadequate and in comparison to the International averages of 2 X 20 MHz, the Indian operators have only been allotted 2 X 4.4 to 2 X 10 MHz. This prevents proper planning by operators. Also from the analysis of the requirement of growth till 2007 presented in Annex 1.5, it is evident that additional spectrum would be needed. The bands from which additional spectrum can be considered in this short time frame are 900 MHz in Circles, 1800 MHz and IMT-2000 band. While the IMT-2000 band is not suited for 2G/2.5G type applications due to non-availability of suitable equipment in this band, it is considered possible to evolve strategies to exploit this band towards meeting government targets upto 2007. This band is discussed separately in the next section.**

3.5.8 Some quick and temporary fixes can be provided through means such as technical initiatives to increase the efficiency of utilization of the existing spectrum. This aspect has already been discussed in Chapter 2. It is necessary to examine where this additional spectrum can be obtained from.

3.5.9 The 1800 MHz band provides for a total of 2X75 MHz out of which currently only 2X15 MHz may be coordinated. There is a commitment from the Defence that an additional 2X10 MHz (a total of 2X25 MHz) can be made available in 4 to 6 years time frame subject to certain conditions. In addition, some bandwidth can be provided in the IMT-2000 band, which has been discussed separately in the following paragraphs. However, unless the

entire IMT-2000 band is made available, the requirement of GSM operators up to the year 2007 and that of both GSM and CDMA operators beyond 2007 cannot be fully met.

3.5.10 The Authority, therefore, has come to the conclusion that a city-wise analysis needs to be carried out for the requirement of additional spectrum for GSM operators on the lines of the analysis carried out for metropolitan cities given in Annex. 1.5. The projected subscriber base and the additional spectrum requirement has been indicated in Annex.- 1.5 for GSM operators. For example, in Delhi the additional spectrum requirement for GSM operators is in the range of 28-65 MHz. **Based on this analysis a time bound programme has to be drawn up to make available additional spectrum in the 1800 MHz band not later than December 2006. Similar requirements in the IMT-2000 band have been commented upon in the next Section. The quantum of spectrum to be vacated in the 1800 MHz band by 2006 has currently been assumed to be up to 2 x 25 MHz on the assumption that a strategy can be evolved in which IMT-2000 band is also available and can be utilized to meet the short term requirements.** This is discussed in more detail in the Section 3.6.

3.5.11 So far as the long term requirement, i.e. beyond 2007, is concerned, it is quite evident that the entire 1800 MHz band may have to be vacated over a period of time to be reviewed on the basis of evolving technologies, existing usage and other developments to determine the step-by-step vacation procedure.

3.5.12 The Authority has held extensive discussions with Defence and fully understands what appear to be nearly insurmountable difficulties in regard to vacation of this band due to:

i) Need for identification and availability of alternative frequency bands
ii) Need for availability of equipment in alternative frequency bands.
iii) Long drawn procedures for procurement of equipment.
iv) Implementation time needed for the projects.
v) Training of officials to use the equipment.
vi) Funds required for refarming.

3.6 Allocation of IMT-2000 spectrum

3.6.1 ITU has identified various frequency bands for IMT-2000 services. WARC-92 identified the bands:

-1885-2025 MHz
-2110-2200 MHz

And WRC-2000 identified the bands:

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

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

One of the key objectives of IMT 2000 services was inter-operability of various mobile systems while selecting the frequency band for IMT-2000 services it is to be ensured that the frequency bands should be such that it helps in achieving the international roaming objective and also inter-operability among various systems.

3.6.2 Since vacation of spectrum in existing bands (GSM –900 and GSM 1800) may take some time as mentioned above, the new frequency bands which are immediately available and in which the equipment is also available in the market are to be identified. Allocation of spectrum in IMT-2000 bands is being considered not only for 3G services but also because there is a problem of additional spectrum availability to existing mobile operators.

3.6.3 For additional allocation of spectrum while considering the availability of new frequency band and also availability of equipment, one has to look into the spectrum identified for 3G services. While considering additional allocation of spectrum, Authority has to consider whether for 3G services spectrum allocation is to be considered an extension of 2G spectrum or it is to be dealt separately.

3.7 IMT-2000 spectrum allocation to the existing operators should be viewed as extension of 2G spectrum allocations

3.7.1 The necessity of allocation of additional spectrum in which IMT-2000 equipment is available may arise in the following situations.

1) It is expected there shall be a need of high-speed data services in the market which cannot be fulfilled by existing service available through EDGE. (As per an article in financial times dated 7th April 2005, the mobile phones will replace TV as most important medium for advertisers to reach technology-savy consumers. The article mentioned that the spread of digital video recorders are giving consumers the ability to avoid TV commercials and therefore the way forward for advertisers to reach consumers would be to use wireless devices).

2) The voice traffic increases to a limit that the existing 2G spectrum may not cater to this requirement and since the IMT 2000 technology is more spectrally efficient for voice services, therefore, operator may feel the need of allocation of IMT-2000 spectrum even for voice traffic.

3) Where 2G spectrum is not available in the time frame in which it is required and the possibility of getting additional spectrum in IMT-2000 band are better in the same time frame.

In European Union countries, it was the increasing data services demand which dictated the introduction of 3G services, i.e. the first condition mentioned above was the one which was applicable. Accordingly, 3G spectrum and 3G licenses were taken as an entirely independent situation when compared to the existing voice and low data rate services provided till that date through 2G/2.5G equipment. In the case of India, the applicability of the first condition, viz. requirement of high speed data services is not the predominant reason for the introduction of IMT-2000 services since there is clearly a debate on the extent to which there is such a demand. However, conditions two and three above, i.e. the need to increase the traffic handling capacity per MHz for voice traffic as also to overcome the severe shortage of the spectrum for voice and low speed data services, are evident. Our discussion with the users indicate very limited availability of increased spectrum in this range.

Under the situations explained above, a policy decision regarding allocation of IMT-2000 spectrum has to be taken whether this spectrum should be allocated to existing operators just like allocation of additional 2G spectrum. **Since allocation of IMT-2000 spectrum to one operator may give a competitive edge in terms of the type of offered services, therefore, it has to be ensured that whenever IMT-2000 spectrum is allocated it should be allocated to all the existing operators who need it and a minimum chunk of 2X5MHz should be allocated to all the existing operators who are demanding it. In case of constraint of availability of IMT-2000 spectrum Government should make efforts to make available the required spectrum in each service area so that 2 X 5 MHz may be allocated to each existing mobile service provider who demands it.**

3.7.2 This issue of allocation of 3 G spectrum whether it should be in continuum of 2G spectrum or separately was discussed in the consultation process also. Regarding this there was divided opinion in the consultation process. Further, during the consultation process some of the stakeholders were of the opinion that 3G spectrum should be allocated for 3G services while others opined that the type of services to be offered using a spectrum should be left to market forces. The Authority in its recommendations on Unified Licensing has already recommended that the license should be technology and service neutral. If a service provider can get the equipment in a particular spectrum for offering 2G or 3G or 4G kind of services then Regulator or Policy maker should not come in its way. Authority is aware of the fact that almost all the countries in the world have treated allocation of 3G spectrum separately compared to the 2G spectrum through either auction or beauty contest or combination of both. Authority has also noted that WRC 2002 has already identified the existing 2G spectrum for IMT 2000 services. This means that ultimately this boundary of 2G or 3G spectrum will vanish. Further, the existing spectrum allocation for 2G services in India is much below world average and there is a constraint in the immediate availability of 2G spectrum. Authority considers that our responsibility is to ensure the availability of additional spectrum to the service providers so that shortage of spectrum does not come in the way of growth of telecom services in the

country. While considering this aspect the level of competition in the market is also to be kept in mind. As already brought out in these recommendations that in major cities where spectrum requirement is maximum, there are 4 to 7 mobile operators. Even from increasing the level of competition point of view it is not advisable at this stage that a separate 3G-spectrum policy should be brought out. Further, our intention is not to earn the revenue by sale of the spectrum to service providers and ultimately the Government may get more revenue in the form of Service Tax and other levies, etc. Since these service providers have to focus their capital investments on penetrating their services in semi-urban and rural areas so as to achieve further growth of telecom services in the country, therefore, at this stage if 3G spectrum allocation to the existing operators is not viewed as extension of 2G spectrum allocations, then this may put extra burden on service providers.

As indicated in Annexure 1.5 & 1.6 and para 3.7.1 & 3.9.1, there is a shortage of 2 G spectrum and in the consultation process with various stakeholders including Defence it came out that the release of additional 2 G spectrum in the required time frame so as to meet this shortfall may not be possible. Keeping this in view Authority considered allocation of additional spectrum in IMT-2000 band. While recommending special steps to get additional 2 G spectrum vacated in the desired time frame (i.e. up to 2 X 25 MHz in 1800 MHz by 2006 and the entire 2 X 75 MHz later in a time bound manner), Authority examined whether any other band could be used to supplement the efforts to reach the target of 200 million cellular phones by 2007. Discussions with various users including defence indicated that some frequencies in the IMT-2000 2 GHz could be available more easily and within a shorter time frame. Defence in their comments has also mentioned that they would not be able to co-ordinate the usage of FDD cellular technologies in 1900 MHz USPCS band. The Authority is aware that the services offered in IMT-2000 band viz. the so called 3 G services cannot be expected to become popular so fast as to directly help in meeting the Government's targets. However, during discussions with the operators it came out that strategies are 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. Thus, utilization of IMT-2000 band could supplement the primary thrust to get more spectrum vacated in the 1800 MHz band already discussed earlier. **Keeping these arguments in mind, the Authority recommends that 3G spectrum allocation to the existing operators should be viewed as extension of 2G spectrum allocations. Furthermore, each existing operator should be granted 2 x 5 MHz in IMT-2000 2 GHz band, who demands it. The Government should make efforts to make available the required spectrum in each service area so that 2 X 5 MHz may be allocated to each existing mobile service provider who demands it. Efforts to get remaining spectrum in IMT-2000 2 GHz band should be made and policy pertaining to remaining spectrum in this band shall be worked out subsequently, depending upon spectrum availability in various bands including 1800 MHz, IMT-2000 2 GHz, etc. and evolution of services, market developments, etc. The annual spectrum charges for IMT-2000 spectrum will, however be different and this and other details of spectrum pricing are discussed in the next chapter. At this stage, a question comes that some of the**

operators may either do spectrum hoarding or they may not utilize the spectrum efficiently. The issue of spectrum hoarding, especially, for IMT-2000 spectrum has been dealt separately and to address this issue the pricing of this spectrum will also be done in a different way than 2G spectrum. The details are discussed in Chapter-4 dealing with spectrum pricing

3.7.3 Availability of In-Band equipment for IMT-2000 services (for CDMA 2000 1X EV-DO available in 450, 800, 1800 and 1900 MHz and WCDMA in 900, 1800 MHz) further strengthens the argument that 3G spectrum allocation to the existing operators should be viewed as extension of 2G spectrum allocations. Details pertaining to In-band equipment are discussed in para. 3.10.

3.7.4 Allocation of 3G spectrum to any service provider shall provide competitive advantage to this service provider as 3G spectrum shall enable the service provider to offer wide variety of different services. Therefore, while allocating additional spectrum in frequency bands which have been identified for 3G services the issue of level playing field among various service providers is to be kept in view.

3.8 IMT-2000 allocation in 2GHz vs 1900 MHz USPCS Band

3.8.1 In the Consultation Paper, various options for additional allocation of spectrum utilizing the IMT-2000 band were discussed. These included the following:

1. Allocation of IMT-2000 2 GHz band (1920-1980 MHz paired with 2110-2170 MHz) only.
2. Allocation of 1900 MHz USPCS band (1850-1910 MHz paired with 1930-1990 MHz) only.
3. Mixed band allocation in which part of the portion was in 2 GHz band and part in the USPCS band.

These options have been examined in the following paragraphs.

No problem of interference is expected if spectrum is allocated for IMT-2000 services either only in the 2 GHz band (1920-1980 MHz paired with 2110-2170 MHz) or in the 1900 MHz USPCS band (1850-1910 MHz paired with 1930-1990 MHz) only.

In the case of mixed band allocation, shown in Fig.3.3, a detailed analysis of the interference problem based on presentations from various agencies have been examined in the following paragraphs and boxes.

Box1:

BOX-I*: - Mixed IMT – 2000 2GHz and PCS 1900 bands

The main problem in using the IMT 2000 2GHz band (1920-1980/2110-2170 MHz) and the PCS 1900 band (1850-1910/1930-1990 MHz) is that the WCDMA base receiver is:

- Adjacent or co-channel to the PCS 1900 base transmitter band. Unwanted spurious and wide band noise from the PCS 1900 transmitter falls in the WCDMA receiver band and cannot be mitigated by using guard bands.
- Standard WCDMA base equipment may be blocked by high-powered PCS base transmitters.

Blocking of the WCDMA base receiver

WCDMA filters have little attenuation in the band 1980 – 1990 MHz. The calculated isolation required is 96 dB. Without site co-ordination, a 30 dB mean coupling loss (MCL) between base transmitter and base receiver is assumed in the standards bodies. Thus, external filters on the WCDMA receiver must provide 66 dB attenuation.

External filters will degrade the receiver noise figure by around 1 to 1.5 dB leading to reduced cell range resulting in 15% to 20% more cells needed. This will add to the network costs.

Spurious emissions from the PCS 1900 transmitter

CDMA 2000 transmitter spurious emissions are specified to be < -13 dBm/1 MHz for offsets from the carrier centre frequency > 2.25 MHz. The PCS 1900 duplex filter does not provide attenuation in the band (1930 – 1990 MHz) which overlaps most of the WCDMA base site receive band. Thus, additional filtering at the transmitter output is necessary to reduce the spurious emission levels. Isolation of 103 dB is required. With an MCL of 30 dB, 73 dB filter attenuation is needed.

Practical considerations

- The external filter requirement on the transmitters and receivers is very demanding. Filters of very high precision and high performance are necessary; these will represent additional cost and will degrade system performance.

- Guard bands are necessary to provide a transition band for the transmitter filters. This represents a waste of spectrum.

- Coordination between all users of the effected bands would be necessary, imposing a significant administrative burden. It should be noted that the trend in setting equipment standards and in spectrum management is away from the need to coordinate between users if at all possible. The standards are developed specifically to facilitate sharing without the need for coordination.

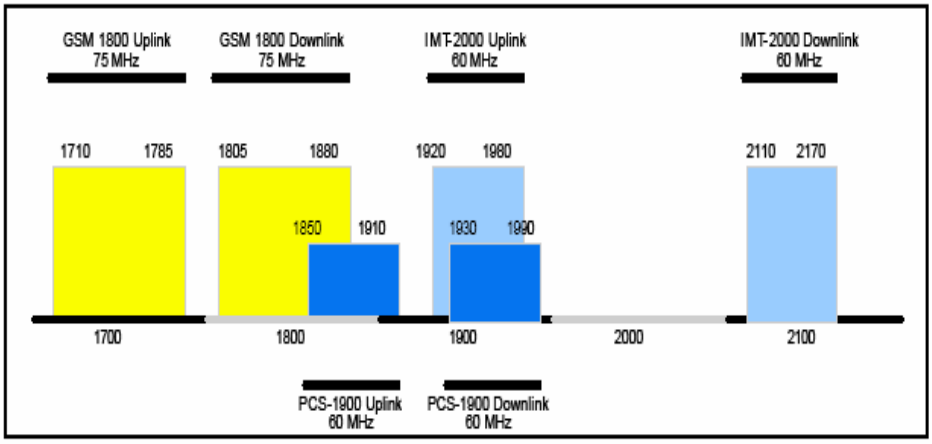
- Under the suggestion to use mixed bands in India, the PCS 1900 equipment that would be used in India would be that designed for the North American market. This equipment is incompatible with IMT 2000 2GHz equipment and no specifications have been written for co-existence of North American PCS equipment and IMT 2000 2GHz band equipment. TRAI would need to devise and impose special regulations including significantly tighter limits than specified in 3GPP and 3GPP2 to limit the effects of interference. These would have to be applied not only to the interfering systems but also to the interfered systems.[1] Because of the nature of the interference, TRAI would not be able to guarantee interference free operation and would therefore need to consider if it would be held liable in any way for the impact of interference. TRAI would need to consider who pays for modification of existing systems to mitigate the effects of interference.

* Source: Aegis report

3.8.2 Though the repercussions of allocation of both IMT 2000 2GHz band and 1900 MHz USPCS band including interference issues were discussed in the consultation paper but even then this issue generated a lot of heat in the industry. Various presentations by vendors, operators, Associations, were made to Authority on this issue. GSM technology stakeholders argued that allocation of both IMT-2000 2GHz band (1920-1980 paired with 2110-2170 MHz) and 1900 MHz USPCS band (1850-1910 MHz paired with 1930-1990 MHz) would not be able to work side by side. The main argument was that base station transmitters of CDMA 1900 MHz USPCS band (1930-1990 MHz) partially overlaps with IMT-2000 2GHz base station receiver (1920-1980 MHz). So CDMA base station transmitter may interfere with WCDMA base station receiver. Similarly, WCDMA mobile handset transmitter may interfere with CDMA mobile handset receiver in the USPCS band. In the consultation paper this aspect was brought out clearly. The relevant extracts of Para 2.6.2 of consultation paper as quoted below: -

"Another issue that arises from using both IMT 2000 and PCS 1900 band plan relates to interference. It has been brought to our notice that using both WARC –92 bands (1920-1980 / 2110 – 2170 MHz) and PCS 1990 band plan (1850-1910 / 1930-1990 MHz) may cause interference problems. Prima facie there appears to be possibility of such interference, however, this would need further examination."

Fig 3.3: - Mixed IMT – 2000 2GHz and PCS 1900 bands



BaseStation to Base Station Interference:: CDMA2000 TX will cause interference into the WCDMA RX

Mobile Station to Mobile Station Interference: WCDMA TX will cause interference into CDMA 2000 RX

3.8.3 Various stakeholders supporting the allocation of American PCS band argued that interference problem could be tackled by using suitable filters in American PCS band base station transmitters. They also argued that allocation could be considered in non-overlapping band, i.e., 1900-1910 paired with 1980-1990 MHz band.

All these issues have been examined in detail and the analysis has been presented in Box -II and Box-III.

Further, argument was that even in existing operations CDMA base station transmitter is operating in 869-889 MHz band and GSM base station RX is operating in 890-915 MHz band. If these existing operations with only 1 MHz separation between CDMA base station TX and GSM base station RX may work by installing suitable filters in CDMA base station TX and also in GSM base station RX (if required), then why not in this situation by keeping a suitable gap between CDMA BS TX and GSM BS RX and also by putting the suitable filters.

All these issues have been examined in detail and the analysis has been presented in Box-II and Box-III.

BOX-II*:- **Issues relating to using 1900-1910 MHz paired with 1980-1990 MHz for CDMA 2000 (2 x 10 MHz)**

The proposal has a high probability of being unworkable because:

- Permitting base transmitters to operate so near to base receivers contravenes basic frequency planning principles. In the areas of high cellular traffic interfering transmitters could be either co-sited or located within the nominal radius of small cells (300 to 600 metres separation).

- Coordination between all users of the band will be required which is not desirable for users of the spectrum and TRAI.

- All WCDMA (and CDMA 2000) receivers across the whole IMT 2000 2 GHz uplink band located within several hundred metres of a CDMA base transmitter are likely to need external filters to reducing blocking. It should be noted that typical cell spacing of CDMA sites in towns and cities is 500 metres so the probability of being near an interfering transmitter is high. It will be difficult to impose additional filtering over and above that required in the specifications, particularly on existing users.

- There is no certainty that receiver filtering techniques will be successful in mitigating interference as the levels of blocking interference are likely to be high and beyond the limits of practical filters.

- External filters will be required on CDMA transmitters to reduce the levels of spurious emissions that fall in the WCDMA receiver bands. The attenuation requirements of these filters are high and between 7.5 and 10 MHz guard bands will be required reducing the amount of spectrum available for the users thereby nullifying the purpose of providing 2 x 10 MHz additional spectrum.

TRAI must decide whether to permit this operation on the balance of risk. For an operator the proposal may appear technically manageable and therefore workable provided all the spectrum was under its control. But, for a Regulator, other broader factors must also be considered in addition and the consequences if interference does occur may warrant a more conservative approach.

*Aegis report

BOX-III:- **Comparison of interference issues in the 800/900 MHz bands and in the PCS1900/IMT 2000 2 GHz bands**
Source: Aegis Report

Respondents that proposed a mixed band solution (IMT Bands B1 and B3) claim that it is workable for the same reasons that CDMA 800 works in the same geographical area as GSM 900. In this section we compared the differences based on the relevant standards. As is shown here, the two situations are different because of the differences in the specifications for the different bands and technologies.

Co-existence of CDMA 2000 in the 800 MHz Band and GSM in the 900 MHz Band.

Assume:

- GSM base receiver is at centre frequency 890.20 MHz
- CDMA base transmitter is at centre frequency 888.29 MHz
- Offset = 1.91 MHz
- This the worst case, representing the top CDMA transmit channel in the 800 MHz band and the bottom GSM base receive channel in the 900 MHz band.

GSM Receiver Blocking
The following parameters derive from the specifications:

- CDMA 2000 – 3GPP2 Spec C.S0010
- GSM – ETSI Spec EN 300 910

GSM base receiver sensitivity	-104 dBm
CDMA base transmitter power	43 dBm
The GSM receiver blocking value at 1.6 < | fc | < 3 MHz	-16 dBm
The adjacent channel rejection of the receiver filtering is (-104 dBm – (-16 dBm))	= 88 dBm
Required isolation is 43 dBm – 88 dB – (-104 dBm)	= 59 dBm
Assume Mean Coupling Loss (MCL) between antennae	30 dB
Isolation required becomes 59dB – 30dB	= 29 dB

Table: GSM receiver blocking

Spurious Emissions from CDMA 800 Base Station Transmitter

At an offset of 1.91 MHz, the transmitter spurious is	-45 dBc/30 kHz
This is equivalent to (- 45 dB + 8.2 dB)	-36.8 dBc/200 kHz
Spurious power (43 dBm – 51.8 dB)	-6.2 dBm
The required isolation is (-6.2 dBm/200 kHz – (-104 dBm)	= 97.8 dB
With 30 dB MCL, the additional filtering required is	67.8 dB

Table: Spurious emissions from CDMA 800 base station transmitter

Co-existence of WCDMA in the IMT 2000 2 GHz band and CDMA 2000 in the PCS 1900 Bands

The following parameters derive from the specifications:

- CDMA 2000 – 3GPP2 Spec C.S0010
- UMTS FDD – ETSI TS 125 104

WCDMA Receiver Blocking

GSM base receiver sensitivity	-110 dBm
CDMA base transmitter power	43 dBm
The adjacent channel rejection of the receiver filtering	= 57 dBm
Required isolation is 43 dBm – 57 dB - (-114 dBm)	= 96 dBm
Assume Mean Coupling Loss (MCL) between antennae	30 dB
Isolation required becomes 59 dB – 30 dB	= 66 dB

Table: WCDMA receiver blocking

4.5.1.2 Spurious Emissions from PCS 1900 Base Transmitter

At an offset > 2.25 MHz from the Tx carrier, the transmitter spurious is	- 13 dBm/1 MHz
This is equivalent to (- 13 dB + 5 dB)	-7 dBm/3.84 MHz
The required isolation is (-7 dBm/3.84 MHz - (-110 dBm)	= 103 dB
With 30 dB MCL, the additional filtering required is	73 dB

Table: PCS 1900 Spurious

Summary of interference effects

	Isolation Required (includes 30dB MCL)	
	800/900 MHz CDMA 2000/GSM	1900/2000MHz CDMA 2000/WCDMA
Blocking	29dB	66dB
Spurious	67.8dB	73dB

Table: Comparison of interference levels

CDMA 800/GSM 900

Further evaluation indicates:

- For GSM and CDMA, for channels 3MHz apart blocking improves by 3dB.
- For GSM and CDMA, for channels > 4MHz apart blocking improves by 24dB.

Thus in the 800/900 MHz bands, for CDMA base transmitters that are spaced more than 4 MHz from GSM base receivers blocking is virtually mitigated by the antenna separation of 30 dB MCL. So blocking will be a problem from only those base transmitters operating in the upper 5 MHz of the 800 MHz CDMA band, and are separated by less than around 600 metres from the GSM base receivers.

Transmitter spurious interference is still a problem requiring filtering.

Furthermore, the figures indicates that there is no blocking problem if the normal duplex separations are respected and explains why there are no blocking problems using the US PCS 1900 bands with different technologies. With normal duplex separations, spurious interference is eliminated by the Transmitter / Receiver duplexers.

WCDMA/PCS1900

The situation here is very different from that in the 800/900 MHz bands.

Spurious emissions

The levels of spurious emissions from the PCS 1900 CDMA and the 800 MHz CDMA are both high, but for the 1900 MHz CDMA case 5.2 dB additional filtering is required, making a difficult engineering task even more difficult. Several respondents submitted detailed papers describing the filter requirements to mitigate the effects of the CDMA 2000 transmitter spurious emissions. The transmitter filter requirements are very exacting and to obtain the required band stop attenuation, it is estimated[2] that a guard band of between 7.5 and 10 MHz is required. So, in order to make 2 x 5 MHz of spectrum available in the 1900 MHz band, 7.5 to 10 MHz of spectrum will be lost in either the IMT 2000 2 GHz band or the 1900 MHz band or this total in both bands. This compares with Lucent's estimate of a 2.25 MHz guard band.[3]

Blocking

Isolation of 66 dB is needed to prevent blocking (compare with 29 dB in the 800/900 MHz case). This can only be mitigated by isolation (transmit/receiver separation more than 1.8 km) and/or filtering at the WCDMA receivers. High precision filters would be required and because the WCDMA receivers have little in built protection across the whole band, all the channels in the band are potentially effected (unlike the case at 800/900 MHz).

[2] Nokia submission to TRAI. Based on the required isolation and a 30 dB MCL between antennae.

[3] Lucent assumes MCL of 50 dB requiring lower filter attenuation and representing 130 metres antenna separation.

3.8.4 **Authority after considering various options has come to the conclusion that it is not desirable to allocate spectrum both in IMT-2000 2 GHz band and 1900 MHz USPCS band in a mixed manner. It is of the view that allocation of spectrum in either of the two bands only is the option available before us.** The reasons for these decisions are summarised below:-

i. In addition to 1880-1900 MHz NFAP –2002 has kept 1900-1910 MHz for micro cellular WLL systems based on TDD access techniques, for especially indigenously developed technologies.

ii. Defence in their comments has mentioned that they would not be able to co-ordinate the usage of FDD cellular technologies in 1900 MHz USPCS band. Subsequently, for 1900-1910 MHz it was mentioned that Defence had agreed to co-ordinate allocation in this band only for micro cellular WLL systems based on TDD access techniques on case-by-case basis. Since cellular mobile transmitters will be high power in comparison to micro cellular technology, therefore, they would not be able to coordinate with them. In any case, it is not considered advisable to vacate the spectrum allocated for micro cellular indigenously developed access technologies to other cellular operators.

iii. From interference point of view, also there is no denial to the fact that due to cross coupling of Base Station (BS) transmitter of one band with BS receiver of other band, interference problem would be there. Even in the existing arrangement a lot of coordination and efforts were required to put additional filters in CDMA base station transmitters so that they do not interfere with GSM base station receivers. At this stage, further allocation should not be done so that again the same coordination problem comes.

iv. The interference problem in 2G systems between GSM and CDMA is different than in 3G systems. Interference issues in 800/900 MHz bands and in the PCS 1900/IMT 2000 2 GHz bands have been discussed in preceding paragraphs.

v. NFAP 2002 has also identified IMT-2000 2 GHz band for IMT-2000 (3G) applications.

vi. Above all, this part of spectrum cannot be allocated as it is being used by other users and also due to already existing agreement for its case-by-case allocation to other micro cellular TDD access technologies.

Choice between 2 GHz and USPCS band

3.8.5 From the discussions given above, it is evident that mixed band allocation is not feasible and allocation should be made only in one of the two bands viz. 2 GHz and 1900 MHz USPCS band. In this regard, following aspects of discussions/comments of various stakeholders including Defence during various consultations are crucial:

1. Defence has indicated in their comments vide their letter dated 14th September, 2004 which was replaced vide their letter dated 23rd February, 2005 as follows: -

   "(a) All the coordination by defence is absolutely on case to case basis for mutual co-existence and avoidance of interference.
   (b) During the open house discussion on 03 September 2004 and on 06 September, 2004 at Mumbai and Delhi respectively the issue of US PCS band was brought out. Defence once again wants to emphasize that it would not be possible to vacate the US PCS band (1850-1910 MHz/1930-1990 MHz) due to the existing usage. This usage is not short term and hence the vacation needs to be planned on a long term. However, as brought out in our consultation paper, 1920-1980 MHz paired with 2110-2170 MHz (60 + 60) MHz may be available on case to case basis in a time frame to be worked out in consultation with defence."

   Though as mentioned above, Defence in their written comments as well as in Open House discussions had mentioned that spectrum in 1920-1980 paired with 2110-2170 MHz (2 x 60) MHz is available for mobile services. They had also indicated in their letter dated 23.2.2005 that all the coordination by Defence is absolutely on case-to-case basis for mutual coexistence and avoidance of interference. In the subsequent discussion with the Authority, Defence has indicated that it may not be possible to vacate 60 + 60 MHz immediately. However, initially up to 2 x 10 MHz (2 carriers of 2 x 5 MHz each) could be coordinated, barring border states and Delhi. Authority in the meeting emphasized the importance of additional spectrum for growth of mobile services, which has been discussed in details in the preceding paragraphs.

   2. 1880-1900 MHz as per NFAP 2002 has been earmarked for Micro Cellular TDD operations and 1900-1920 is also earmarked for Micro Cellular TDD operations. Defence has mentioned that they could coordinate on case-by-case basis micro cellular TDD operations because of their low transmitter power and the same coordination with CDMA operators may not be possible because of their high power transmitters.

In addition, as mentioned earlier in para 3.8.4, NFAP 2002 has also identified IMT-2000 2 GHz band for IMT-2000 (3G) applications.

3.8.6 In regard to equipment availability, the position in international market has already been discussed in sections 3.1.10 and 3.1.11. The key conclusions are:

- Both WCDMA and CDMA 2000 1 x EV DO operators have deployed the equipment in IMT-2000 2 GHz band as well as in US PCS 1.9 GHz bands. Economy of scale could be different for different technologies and that in any case is always there when multiple technologies are deployed in a market to offer telecom services.
- For WCDMA and GSM technologies multi-band handset in 2 GHz, 900 MHz and 1800 MHz frequency bands. Similarly for CDMA technology dual band handsets in 800 MHz and US PCS 1.9 GHz frequency bands are available for 2G and 3G services. However, it has been ascertained from the handsets developers that depending upon the requirement in the market the multi-band handset could be developed in about 6 months time and therefore, Authority considers that availability of multi band handset will not be a limitation as far as developing the spectrum management policy is concerned.

3.8.7 Based on the above consideration and also on the availability of additional spectrum, it is recommended that IMT-2000 2 GHz band should be allocated to mobile operators for offering IMT-2000 services.

3.8.8 Authority is aware of the fact that though 3G equipment is more spectrally efficient, especially, for voice application in comparison to 2G equipment, but the existing price of handsets at this stage does not justify that we may achieve the target of 200 million customers by the year 2007 by enhancing the growth in 3G services. The 3G spectrum is mainly being considered for major cities where there is a possibility that the high-end customers may migrate to 3G services and this in term may relieve the pressure on 2G spectrum. It should be very clearly understood that 3G spectrum is not a substitute for 2G spectrum not only from availability of cheaper equipment and handset but also from propagation point of view for improving the coverage in semi-urban and rural areas.

3.8.9 The allocation of IMT-2000 2 GHz spectrum as discussed above, will be subjected to rollout conditions discussed in Chapter-4. The operators who have both GSM and CDMA operations namely, BSNL, MTNL and Reliance would be treated as a single entity for this purpose, and therefore, would only be allocated one chunk of 2 x 5 MHz.

There could be a possibility that initially only one or two carriers (each carrier of 2X5MHz) in IMT-2000 2 GHz band are available for immediate allocation and the demand for additional spectrum is more. The allocation and pricing of spectrum in such a situation is discussed in Chapter-4.

3.9 Strategy for availability of additional spectrum

3.9.1 In annex. 1.5 and 1.6 the requirement of additional spectrum for both GSM and CDMA operators respectively have been worked out till the year 2007 which can be termed as short term requirement. Since such a projection cannot be worked out very accurately due to a large number of factors, a

range of values indicating a conservative and a liberal estimate based on the existing spectrum allocation criteria have been worked out. Today only 2 X 1.2 MHz in 900 MHz band & 2 X 4.8[5] MHz in 1800 MHz band for GSM operations and 2 X 7.5 MHz in 800 MHz for CDMA operations are available for allocation to mobile operators in Delhi (service area with highest number of mobile operators). **From a comparison of the spectrum requirement for meeting the 2007 targets and the current level of allocation, it is evident that there is an immediate need for ensuring the availability of additional spectrum. Such a requirement for both GSM and CDMA operators is evident even under most conservative projections. Considering the future growth of mobile services in the country, it is certain that in the long term i.e. beyond 2007 the additional requirement will be such that the entire 1800 MHz (2 X 75 MHz) and entire IMT-2000 band (2 X 60 MHz) will have to be allocated to mobile operators.**

3.9.2 In Authority's opinion, availability of 2 x 25 MHz in 1800 MHz band and the required spectrum in IMT-2000 2 GHz band to provide 2 X 5 MHz to each existing mobile service provider who demands it, within a very short time frame is a must to achieve the target of 200 million mobile subscribers. Efforts to get remaining spectrum in 1800 MHz band and IMT-2000 2 GHz band should be made and policy pertaining to remaining spectrum in this band shall be worked out in due course of time, depending upon market developments.

3.9.3 In view of the gravity of the situation in regard to spectrum availability for various operators even in the short term of 2007 to meet the targets set by the Government for cellular telephones and at the same time the nearly insurmountable difficulties faced by Defence in vacating the spectrum in such a short time frame, we strongly recommend immediate constitution of a group at the level of Ministers of the Union Government assisted by professionals from Defence, Department of Telecom and TRAI to draw up a detailed time bound step-by-step programme and monitor its implementation. The mandate of the Group would have to include identification of alternative band, assessing and making available requisite funds and assisting users on procedural aspects of quick procurement and installation of new equipment. This activity has to be taken up on war footing to be able to meet the Government objectives of growth in telecom services.

3.9.4 This nature of acute shortage of spectrum is not likely to be faced in too many cities and certainly not all over the country. There will, however, be a need to carry out coordination activities even area-wise like district level coordination, etc. and in some cases there may even be a need to carry out these coordination on area-wise basis within a city.

3.9.5 After analysing the spectrum requirements to achieve the target of 200 million mobile subscribers (both GSM & CDMA) in the year 2007, Authority recommends that :-

[5] 2 X 15 MHz may be co-ordinated in 1800 MHz in Delhi.

- **While retaining the subscriber base approach, the actual spectrum allocation criterion should be urgently revised.**
- **Keeping in mind the short time frame available to achieve the 2007 targets, spectrum available or possible to be coordinated but not allocated, e.g. in 800 MHz band for CDMA should be made available immediately based on the revised criterion.**
- **Efforts should be made to make available remaining 2 X 4.8 MHz spectrum in 900 MHz band in circles for GSM as per the revised criterion.**
- **The availability of at least 2 x 25 MHz spectrum in 1800 MHz band is coordinated by Defence by December, 2006.**
- **The availability of 2 X 5 MHz in IMT-2000 2 GHz band to each existing mobile service provider who demands it, is coordinated within a very short time frame to offer IMT-2000 services.**
- **The availability of spectrum in 450 MHz band is coordinated.**

3.10 In-Band IMT-2000 Services:-

3.10.1 In-band equipment for providing IMT-2000 services (CDMA 2000 1 x EV-DO) is already available in 450, 800, 1800 and 1900 MHz frequency bands. In fact, most of the operators in other countries are providing EV-DO services with In-Band equipment. But for W-CDMA situation is not same. In Europe operators are now deploying W-CDMA in IMT-2000 2 GHz band which is outside 2G/2.5 G frequency bands. Cingular Wireless[6] in US is the first operator in the World to deploy in-band W-CDMA equipment.

3.10.2 In-band W-CDMA enables operators to respond to market needs immediately. It likely precludes auction or other spectrum payments. When WCDMA equipment is deployed at 900 MHz, it requires much less infrastructure in comparison to higher frequencies (IMT-2000 2GHz band). It provides deeper in-building penetration than do higher frequencies. For these reasons In-band IMT-2000 operations needs serious considerations from spectrum managers and operators point of view.

3.10.3 But managing allocation of spectrum in 5 MHz chunk in already crowded 900 and 1800 MHz band without any interference is a challenging task.

3.11 Contiguous allocation of spectrum: -

3.11.1 It is pertinent to ensure that the operators have access to contiguous spectrum to minimise the need for co-ordination. If the spectrum users are allocated contiguous blocks of spectrum it is only necessary to co-ordinate with other users at the edges of the frequency blocks or at the edges of different geographic service areas.

[6] Source: report on In-band W-CDMA by 'The Shosteck Group'.

3.11.2 In response to the TRAI consultation most of the stakeholders opined that the frequency bands should be re-organised. For efficient utilization of spectrum, it is necessary that contiguous spectrum is allocated. **It is understood that WPC is already making efforts for contiguous allocation of the spectrum, Authority recommends that this process should be expedited.** In the award of the IMT 2000 2GHz band it will also be important to ensure that the operators are awarded contiguous blocks as is standard practice in other countries.

3.12 Future spectrum allocation

3.12.1 In addition to the frequency bands discussed above, **Government should continue to make efforts for the availability of additional spectrum not only in existing frequency band but also for additional frequency bands which are identified by ITU for mobile services. In WRC -2000 ITU has already identified 2500-2690 MHz for IMT 2000 services.** Currently this band is mostly used by Department of Space. Some of the portion in this frequency band is also being used for Mobile Satellite Services, ISPs, Broadcasting, disaster warning, etc. Therefore, at this stage itself Government should make efforts for availability of spectrum in this band.

3.13 Authority recommends that the spectrum policy may be reviewed periodically depending upon the development in the market, level of competition, development of technologies and availability of equipments and spectrum.

Chapter 4 Spectrum pricing

4.1 In the existing licensing framework the spectrum charge has two components i.e. an entry fee, which includes (one time spectrum charge) and an annual spectrum charge in terms of percentage of AGR. When the spectrum was originally awarded in India to the existing operators the one-time entry fees paid were based on the expectation that there would also be annual spectrum charges. Authority in its recommendations on Unified Licensing has already recommended that spectrum and licensing are to be de-linked. The one-time entry fee/Registration charges recommended in Unified Licensing does not include spectrum charges.

It is recommended that as in the existing framework the spectrum charges should continue to have two components: one time spectrum charge and annual spectrum charge.

This Chapter would cover the recommendations on one-time spectrum charges and annual spectrum charges for the existing and new mobile operators.

4.2 One time spectrum charge to the existing operators: -

4.2.1 It is desirable that through regulatory measures, the cost of inputs including spectrum, should be reduced so that providing the final product is economically viable at an affordable price which may have to be even lower than the present tariffs to meet expansion requirements in rural areas, TRAI in its recommendations on Unified Licensing Regime had mentioned that the telecom services should not be treated as a source of revenue for the Government. Imposing lower license fee on the service providers would encourage higher growth, further tariff reduction and increased service provider revenues. With increased growth, it would be a win- win situation for the industry and the Government. Presently, in addition to license fee(which varies from 0%-15%), spectrum charges (2-6% - wherever applicable) the telecom service providers pay Service Tax of 10%. Since for the services being offered, the service providers are charged service taxes of 10% it would make economic sense to lower spectrum and license fees.

4.2.2 In Russia, as per the available information[7], the Government isn't expected to make operators pay for the 3G licences, but will instead issue licences to those prepared to invest more in the network. The approach proposed in the previous paragraph is in line with this approach and is expected to facilitate growth and penetration of telecom services. Russia is another market where like China and India, very high growth rates have been recorded.

[7] Source: Lucent Technologies – 3G solutions for operators: issue18, Feb 2005

4.2.3 The existing service providers have already been allocated spectrum beyond 2 x 6.2 MHz as specified in the license agreements without charging any extra one-time spectrum charges. While considering one-time spectrum charges for IMT-2000 spectrum the Authority has to consider the following: -

- As explained in Chapter-3, 3G spectrum allocation to the existing operators should be viewed as extension of 2G spectrum allocations.
- Service neutral approach as recommended in TRAI's recommendations on Unified Licensing.
- WRC-2000 has already identified the existing 2G frequency bands for IMT-2000 services.
- The key objective is not to earn revenue through sale of spectrum but to achieve higher growth in wireless services. (which in turn gives higher revenues to Government through service tax on the finished products)

Keeping in view all the above considerations the Authority recommends that there will be no one time spectrum charges for allocation of IMT-2000 spectrum to the existing service providers.

4.3 One-time spectrum charge for the new entrants:-

4.3.1 The Authority considered the following pricing options to determine one time spectrum charge for the new operator:

- Auctions
- Administrative Incentive Pricing (AIP)
- Cost Recovery where there is no competition
- Market based benchmarks

4.3.2 The detailed conditions for entry of new operators, adequacy of spectrum and avoidance of fragmentation of spectrum to explore its efficient utilisation have already been discussed in the preceding chapter.

4.3.3. It should be noted that in its recommendations on Unified licensing regime TRAI has recommended that a new Unified licensee shall pay Registration charges which will have two components, i.e. one is Rs. 107 crores and the second component will depend upon the number of service area(s)/circle(s) where the service provider wants to offer access services. In the above mentioned recommendation Authority had also recommended that spectrum charges, initial spectrum charges for entry wherever applicable would be extra. It was also recommended that UASL regime shall continue till two years of implementation of Unified Licensing regime. Therefore, till Unified Licensing regime comes into effect and also till two years of implementation of Unified Licensing regime, the entry fee which includes one-time spectrum charge for new entrants shall be the same as the entry fee under Unified Access Licensing Regime for each service area.

The new operators could enter the market either as UASLs or as unified license operators subject to acceptance of TRAI's recommendations on

unified licensing. In UASL, the one time spectrum charges and entry fee for license have not been separated. In other words, the entry fee includes one time spectrum charge also. If an operator enters the market through UASL route then entry fee paid by him would also include one time spectrum charge**. After implementation of unified license regime as recommended by TRAI and subject to approval by Government of India, Authority recommends that the one time spectrum charges would be equal to UASL entry fee in that services area minus the component of registration charge based on the entry fee paid by new BSO (entered in/after 2001), specified by TRAI in its recommendations on Unified licensing regime dated 13th January 2005.** This recommendation is keeping in view the objectives discussed in the preceding paragraphs and also for maintaining level playing field for existing and new operators, if any. The service area-wise one time spectrum charge based on this principal that the service provider shall pay in case he needs spectrum is given in Annex. 4.1.

4.4 Annual spectrum Charge

4.4.1 As per the existing spectrum policy[8], the annual spectrum charges for GSM service providers are as follows:

- 2% of Adjusted Gross Revenue (AGR) for spectrum usage up to 2 X 4.4 MHz
- 3% of AGR for spectrum usage up to 2 X 6.2 MHz
- 4% of AGR for spectrum usage up to 2 X 10 MHz
- 5% of AGR for spectrum usage up to 2 X 12.5 MHz
- 6% of AGR for spectrum usage up to 2 X 15 MHz.

4.4.2 In addition, charges have to be paid separately in respect of spectrum used for point to point and point to multi-point radio links. Spectrum charges for the same have been dealt separately in these recommendations.

4.4.3 For CDMA operators up to 2 x 5 MHz annual spectrum charges are 2% of AGR. Though Department of Telecom (DoT) has not yet announced the pricing policy for CDMA operators beyond 2 x 5 MHz but DoT vide its letter No 20-232/2004-BS.III dated March 17, 2004 on Guidelines for Mergers & Acquisitions in a service area, has decided that spectrum charges shall be same for CDMA and GSM.

4.4.4 Advantages of the existing annual spectrum charging method:

The current pricing regime is based on revenue rather than the payment of a fixed amount per unit of spectrum licensed. This has the advantage for operators that the amount payable is small in the initial stage of network rollout. Also, the regime is very simple, easily understandable and accountable.

[8] DOT's letter L-14041/06/2000-NTG dated 01-02-2002 specifying charges for GSM spectrum up to 10 MHz in 900/1800 MHz band and DOT's letter L-14047/06/2004-NTG dated 15th April, 2004 specifying charges for spectrum beyond 10 MHz for Mobile services

4.4.5 Disadvantages of the existing annual spectrum charging method:
However, this mechanism poses certain difficulties in the present scenario.

a) The amount increases sharply as the network matures and revenue increases, potentially restricting the scope for infrastructure investment and/or tariff reductions.
b) The low level of fees during the early stages of network rollout does not provide any significant financial incentive to use spectrum more efficiently, hence the level of efficiency is determined by the regulatory limit placed on spectrum assignments. This is currently linked to the number of subscribers, which means that in the initial phase of network rollout service providers may be tempted to adopt a sub-optimal approach to network design.
c) A larger operator in terms of revenue pays higher spectrum charges for the same amount of spectrum as compared to a revenue-wise smaller operator. Further more, since spectrum cost per subscribers does not decrease with more subscribers in the same spectrum allocation, capital investment in increasing efficiency has low incentives.
d) Additional allocation of spectrum is not an incremental cost and does not apply to only new subscribers but is higher percentage value that applies to the whole base.

4.4.6. In the TRAI consultation paper the different approaches that have been used around the World in setting spectrum fees along with the pros and cons of various spectrum pricing options have been discussed. The various approaches discussed include:

- Auctions
- Administrative Incentive Pricing (AIP)
- Recovery of operating costs of the frequency management / regulatory bodies ("cost recovery")
- Payment related to Service Provider's revenue arising from the licensed service and/or use of the radio spectrum (generally referred to as a "levy").
- Based on Market Indicators.

4.4.7 The issue to deliberate upon is whether to continue with the existing revenue share annual spectrum charge as percentage of AGR or use some other methodology to calculate annual spectrum charge. Any methodology adopted should take into account the Government objectives mentioned earlier in these recommendations.

4.4.8 As mentioned in the consultation paper, it is important to decide upon the objectives that the pricing policy should achieve.

These objectives are generally a combination of the following principles.

- Promote spectrum efficiency
- Simplicity and transparency in spectrum charges
- Cost recovery
- Reflecting market value of spectrum
- Promoting competition
- Increasing rural roll-out
- Raising government revenue.

4.4.9 As mentioned earlier, the key objective of the Government is to increase teledensity and as noted earlier the cellular networks are making a major contribution to these objectives. Thus, spectrum charges should be kept low to encourage the network operators to increase their investment in their networks so as to increase the coverage of mobile services in semi-urban and rural areas where the margins will be considerably lower. It is worth mentioning that existing mobile services cover only around 25% of country's population and to achieve the target of 200 million mobile customers by 2007 it is necessary to increase this coverage to at least 70% of country's population.

4.4.10 The Authority is of the opinion that the new spectrum pricing policy should consider the requirements of additional spectrum for the existing operators without creating additional financial burden that would make the service costly. The reduced input costs to the service providers, in a highly competitive environment, are expected to reduce tariffs. At the same time it has to be ensured that the allocated spectrum is utilised effectively. Finally, whatever approach is used for setting the spectrum charges it is essential that they are simple, transparent and easy to implement.

4.4.11 During the consultation process most of the stakeholders opined that the existing revenue share regime of annual spectrum charge may be continued, however, the level of spectrum charge as percent of revenue share may be reduced from the present levels, which varies from 2 to 6%. Some of the stakeholders opined that annual spectrum charge should be 1% of AGR. The Authority is of the opinion that if the spectrum is charged at 1% of AGR irrespective of amount of spectrum, then this would increase the tendency of hoarding the spectrum. While ensuring low input costs to the service provider, it has also to be ensured that the scarce resources are efficiently utilised.

4.4.12 The spectrum charges in terms of percentage of revenue share will go up as growth takes place. Considering the target of 200 million mobile customers in 2007 and also keeping in mind that the operator may have up to 2 x 15 MHz spectrum including IMT-2000 spectrum (allocated as per the criteria explained subsequently in these recommendations) then the annual spectrum charges will be very high. Another method of annual spectrum charge could be in terms of per MHz charge which has been discussed in the following paragraph.

Annual Spectrum Charge on Per MHz basis:-

4.4.13 In view of abovementioned discussions one of the options that was examined was that we should move to per MHz fees that will treat all the technologies ("GSM", "CDMA", "2G" and "3G") on an equivalent basis. For calculating the Per MHz charge the charges paid by various operators in terms of % of AGR and the allocated spectrum could be used. These charges were calculated on the basis of spectrum charges paid by the operators for the quarter ending Dec. 2004. These charges on Per MHz basis would vary from operator to operator, service area to service area depending upon the AGR of the operator and the assigned spectrum. If Charge per MHz criteria is followed then the following questions may arise:

i) Should the Per MHz charge be different for Metros, Category 'A', Category 'B' and Category 'C' circles?
ii) Should Per MHz spectrum charge be fixed on the basis of average value or should it be on the basis of Highest per MHz charge or Lowest per MHz charge for that category of circle?
iii) Some operators who have just started the service, then on the basis of their data spectrum charge on Per MHz basis may be very low.
iv) In some cases on this basis in a Category 'A' circle per MHz charge may be lower than in Category 'C' circle. The reason for this could be comparatively poor growth of the operator as compared to other operators in the category 'A' Circle(s). This may not be practically acceptable situation.

In a situation where some of the operators are in the initial phase of launching of their services, the Per MHz criterion may be too costly in the beginning itself. It is therefore felt that at this stage when the networks are growing, revenue share regime would be beneficial for the operators especially in the initial phase of network roll-out. As the network mature, operators' roll-out and they have some minimum level of spectrum which is sufficiently adequate to plan and operate the network optimally, it would be appropriate to reconsider the annual charge criterion at that stage.

4.5 Recommendations on Annual spectrum charge

4.5.1 Considering all the issues mentioned above, Authority recommends that existing method of annual spectrum charge in terms of percentage of revenue share should continue.

4.5.2 Keeping in view the objectives of growth, affordability, penetration of mobile services in semi-urban and rural areas and also the aspect of spectrum charges brought out in para 4.4.12 above, Authority further recommends that existing ceiling on annual spectrum charges of 6% AGR should be brought down to 4% of AGR.

4.5.3 Depending upon the developments in market, availability of spectrum and growth of mobile services in the country, Authority recommends that annual spectrum charges may be periodically reviewed.

4.6 Annual spectrum charges for IMT-2000 spectrum: -

4.6.1 As already explained in Chapter-3, 3G spectrum allocation to the existing operators should be viewed as extension of 2G spectrum allocations **mainly because additional 2G spectrum is not available in a time frame in which it is required to keep pace with the required growth. From the discussions with various stakeholders it has come out that there could be a possibility of availability of IMT-2000 spectrum in a comparatively shorter timeframe. As far as pricing is concerned, the recommendations are as follows:**

i) **The authority is not in favour of putting any extra annual spectrum charge for IMT-2000 spectrum. However, to avoid hoarding of spectrum, a valuable resource, particularly when it has to be given in large chunks of 2 x 5 MHz for IMT-2000 services, it is proposed that a minimum guarantee of spectrum charge be taken for the period till the service provider rolls out IMT-2000 services.** One of the options could be to levy spectrum charge as a percentage of revenue share or a minimum amount for IMT-2000 services till the spectrum charge in terms of percentage of AGR for IMT services crosses this minimum mark. However, in this approach it would be very difficult to segregate the revenue coming from 3 G services. Therefore, such an approach is not recommended. An alternative approach could be that IMT-2000 spectrum is charged on that IMT-2000 spectrum is charged on per MHz basis. **Since the intention is not to increase the spectrum charges as such but this additional charge is to avoid spectrum hoarding and, therefore, this per MHz additional charge for IMT-2000 spectrum is linked to rollout obligations for IMT-2000 services. For this purpose, the rollout obligations would be as specified in cellular and UASL license agreement for first year of operation, i.e. to offer IMT-2000 services in at least 10% of District Headquarters (D.H.Q.) or any other town in lieu of D.H.Q. within one year of allocation of spectrum. It means that the annual spectrum charges would have two components, one a percentage of AGR (say X) and the second will be the additional annual IMT-2000 spectrum charge on per MHz basis (Say-Y). The detailed methodology for calculation per MHz charge (Y component) has been discussed in subsequent para 4.7. The second component, (i.e. Y) will vanish after meeting rollout obligations as mentioned above. However, it should be noted that additional annual spectrum charge for IMT-2000 service would continue**

unless rollout obligations as mentioned above are completed. The payment methodology for this component of spectrum charge also would be same as for annual spectrum charge. The Authority is aware that spectrum is a valuable resource and there could be a possibility that a non-serious operator may not launch IMT-2000 services and prefer to continue to pay additional spectrum charges for IMT-2000 spectrum. Therefore, to safeguard against such eventualities Authority recommends that in case an operator does not roll-out IMT-2000 services within 2 years of allocation of IMT-2000 spectrum, the allocation of IMT-2000 spectrum would be cancelled. It is recommended that necessary amendments in the license conditions for cancelling the allocation of IMT-2000 spectrum should be made such that the spectrum allocation shall be cancelled if the operator does not roll-out the services after 2 years of allocation of IMT-2000 spectrum. This is being done keeping in mind the twin objectives that we do not want to increase the spectrum charges but also do not want operator to hoard IMT-2000 spectrum. This scheme would provide incentive on rollout and disincentive for non-serious players to raise the demand for IMT-2000 spectrum even when they have no inclination to start IMT-2000 services. This methodology would be followed when availability of IMT-2000 spectrum matches with the demand.

ii) It is likely that the demand for IMT-2000 spectrum is more than the available spectrum in a particular timeframe. In that situation, the Government should make efforts for the availability of additional spectrum so as to meet the demand of spectrum in IMT-2000 band in a time bound manner. In case the Government finds that the additional IMT-2000 spectrum is not available within the desired timeframe then there are following options: -

a) Follow a criterion of giving spectrum first to the service provider with highest no. of subscribers and so on. However, it may not be reasonable to follow a criterion like number of subscribers for allocation of IMT-2000 spectrum because the licenses were awarded to the service providers at different time period. Also, as explained in Chapter 3, the allocation of IMT-2000 spectrum gives a comparative advantage to a service provider**.**

b) The other alternative could be not to allot IMT-2000 spectrum to any operator till the entire demand can be met. This approach, however, would severely constrain further development of the mobile telephony sector and would also delay launching of IMT-2000 services in the country.

c) The 3rd option could be that the available IMT-2000 spectrum is allocated through bidding process. The basic objective is not to charge extra spectrum charges but is mainly to select the eligible service providers wherein the demand of IMT-2000 spectrum is more than the available spectrum and to avoid the spectrum hoarding.

The bidding process will only be for the guaranteed charge i.e. the spectrum charge. The bidders will bid for Y component which has been explained in Para (i) above. The service provider would continue to pay the annual bid amount till he meets the rollout obligations specified above.

4.6.2 Keeping in view, all the issues discussed above, the Authority recommends that the Government should co-ordinate the availability of IMT-2000 2 GHz spectrum such that all the existing operators in a service area who demand this spectrum may get 2 x 5 MHz in a time bound manner. Further, if due to the reasons beyond control, Government is not able to ensure the availability of adequate IMT-2000 2 GHz spectrum in a time bound manner then Authority recommends that IMT-2000 2 GHz spectrum should not be allocated to any operator unless sufficient spectrum is available for allocation to each existing operator who demand this spectrum. It is likely, that due to the reasons mentioned in (b) above, Government may not like to follow this approach. Under these circumstances only the bidding option should be followed. In case adequate spectrum is not identified despite best efforts, only then the bidding option for 'Y' component as explained in 4.6.1, will have to be followed. It should be noted that this may increase the input costs to the service providers and this may increase tariffs. Another issue that could arise is that if initially only one carrier is available and is awarded through bidding process to any operator then should this operator be eligible to again participate in the bidding process for the next carrier, whenever available. This issue could be very controversial. In Mexico, a similar situation led to lot of litigations when an operator was not permitted to participate in auction process. Due to these problems Authority recommends that bidding process should be avoided to the extent possible. It is once again reiterated that bidding process must be avoided in view of the existing high burden of license fee, service tax, spectrum charges, etc. on service providers and the past experience of the auction process in India and the other countries and the likely undesirable consequences of following the auction route. If adequate IMT-2000 spectrum is made available then bidding process should be avoided. Only such an approach would lead to rapid increase in subscriber numbers and also increase in overall government revenues, as has been seen in the telecom sector, after abandoning the ill-effects of the auction process. As can be seen from annex 2.2, 2.2 (a) and 2.3, the telecom sector is already paying about 25% of the Adjusted Gross Revenue (AGR) in the form of license fee, service tax and spectrum charges. From annex 2.4 it

is also seen that telecom sector is highest payer of service tax and they pay almost 1/3rd of the total service tax collected by Government of India. Keeping this in view, any further increase in spectrum charges would adversely affect the growth of telecom services in the country. Therefore, as recommended in Chapter 3, the Government should make efforts to make available the required spectrum in each service area so that 2 X 5 MHz may be allocated to each existing mobile service provider who demands it. Efforts to get remaining spectrum in IMT-2000 2 GHz band should be made and policy pertaining to remaining spectrum in this band shall be worked out subsequently, depending upon market developments. The bidding process is the last alternative and the bid amount vanishes the moment the service provider meets the rollout obligations specified above.

4.7 Calculations for Charge per MHz in situations where demand of IMT-2000 spectrum matches with the availability of spectrum. (Y component of para 4.6 (i))

4.7.1 Before considering per MHz per annum spectrum charges, it is also to be considered whether these charges would vary from service area to service area. Authority considers that since the demand for spectrum would be lower in Category 'B' and 'C' circles due to lower number of subscribers and to promote the growth of services in these areas the spectrum charges should be lower in these areas in comparison to metros and Category 'A' circles.

4.7.2 Another issue for consideration is whether per MHz per annum charges should be incremental steps. For example, beyond 2 X 5MHz the charges could be more than that of 2 X 5MHz spectrum.

4.7.3 Spectrum Charge per MHz per annum could be calculated on the basis of present charges paid by various operators in different service areas. One of the option could be to fix this annual component of spectrum charge for each category of service area, i.e. Metros, Category 'A', 'B' & 'C' Circles, or for each service area. The charge per MHz could then be taken on the basis of :

i) Highest charge paid by the existing operators in each service area, or
ii) Average per MHz charges paid by the existing operators in each service area. This could be the weighted average per MHz charge based on the number of subscribers of each operator.
iii) The 3rd option could be simple average of per MHz charge.
iv) The 4th option is to calculate per MHz charge on the basis of lowest per MHz charge paid by any mobile operator.

4.8 Recommendations on additional annual spectrum charge on IMT-2000 spectrum.

4.8.1 The spectrum charge should not be so high so as to make the operator's business case unviable at the same time it should provide some disincentives for spectrum hoarding. **Considering the various options discussed earlier Authority recommends that the additional per MHz charge (Y component) for IMT-2000 spectrum should be on the basis of highest charge per MHz per annum paid by any operators in different service areas. Authority also considers that these charges will be separate for different service areas.**

4.8.2 However, depending upon availability of spectrum, development in market and the growth of telecom services, this charging mechanism may be reviewed periodically.

Authority while making these recommendations expects that service providers would rollout their networks to cover the uncovered areas and also pass on these benefits to the customers in the form of lower tariffs. In case, Authority finds that industry is not responding accordingly then the spectrum pricing policy would have to be reviewed.

4.8.3 The illustrative per MHz per annum charges on the basis of recommended approach are given in Annex. 4.2. These calculations should be taken as illustrative one. Government while accepting these recommendations may take the figures, for the quarter ending just before accepting these recommendations, for calculating annual charge per MHz for each service area.

Chapter 5 Spectrum Charging and Allocation for Other Terrestrial Wireless Links

5.1 Internet and Broadband access have been widely recognized as catalysts for economic and social development of a country. Significant initiatives have been taken both by the Authority and the Government to pursue initiatives that will boost the growth of the relevant industries in this regard. Further to those initiatives, spectrum policy also needs to be formulated with the growth of future technologies, wireless data services and promotion of competition kept in mind. Just as in telephony, wireless broadband access can lead the way to allow India to leapfrog other countries in achieving widespread connectivity with relatively higher efficiency and lower cost.

5.2 WiFi Services

5.2.1 Broadband wireless access systems using WiFi technology operate in the 5.150 – 5.350 GHz and 5.725 – 5.875 GHz bands. In 2004 Government considered the Authority's recommendations on de-licensing this and decided on 28th January 2005 vide Gazette No. D.L.-33004/99[9] to de-license it for indoor usage only. This notification also de-licensed the 2.4 – 2.4835 GHz band for use both indoors and outdoors by any wireless radio equipment meeting certain operating parameters on a non-interference, non-protection and non-exclusive basis. Since one year has passed from when the Authority had gathered data and made its recommendations, and there has been tremendous response to the Broadband Policy declared by the Government in October 2004, the need for de-licensing in outdoor wireless broadband applications has only increased, **the Authority recommends:**

5.2.2 There is a need to revisit the earlier decision and de-license the 5.150 – 5.350 GHz and 5.725 – 5.875 GHz bands for outdoor usage, as well.

5.3 Allocation Policy for CorDECT Services

5.3.1 CorDECT is another technology which can provide significant support in increasing internet and broadband as well as telephony reach to subscribers in India. Today, many ISP's and traditional telecom operators have deployed this technology in various geographies around the country. It has been particularly useful in helping bridge the access gap in rural areas where large distances are required to be covered, but throughput and capacity requirements are not very high. With the further development of technologies like Cable Wireless, CorDECT can have significant application in

[9] The Gazette of India, Regd. No. D.L.-33004/99, Ministry of Communications & Information Technology (Wireless Planning and Coordination Wing) Notification, 28th January, 2005

urban environment by serving as the uplink channel for a data connection while other high bandwidth unidirectional infrastructure like Cable TV or DTH can serve as the downlink.

5.3.2 Due to legacy policy issues, the allocation of CorDECT spectrum has been tied for UASL operators and BSO's to their CDMA and GSM spectrum allocation. In the Authority's recommendations on driving growth in internet and broadband, this issue was also raised and discussed as a hurdle for growth. Last year, the WPC issued order No. J-14025/200(I)/2004-NT dated 20th May, 2004[10], in which steps were taken to move towards removing the link between spectrum allocation for traditional cellular operations and CorDECT, and as well to indicate a format for optimal usage of the 1880 – 1900 MHz band that has been reserved for usage by CorDECT. Unfortunately, the complete de-linking was not achieved and the policy for usage of the band left a few unresolved issues.

5.3.3 The specific allocation caps cited in the above order are the same as what are present in the Unified Access Services License in clause 43.5(iii). This restriction on the license reads: "In the event, a dedicated carrier for micro-cellular architecture based system is assigned in 1880 – 1900 MHz band, the spectrum not more than 3.75 + 3.75 MHz in respect of CDMA system or 4.4 + 4.4 MHz in respect of TDMA system shall be assigned to any new Unified Access Services Licensee."

5.3.4 Therefore, operators are still restricted to a lower maximum allocation of CDMA or TDMA spectrum if they are allocated a dedicated carrier for micro-cellular architecture based technology (CorDECT) than their peers who may choose not deploy this platform. Since the two technologies are attempting to offer different access services, using different spectrum bands and different platforms, it is therefore justified that the two should be completely independent of each other, and an operator choosing to deploy other technologies, whether CorDECT or otherwise, should not have the maximum cap reduced for deployment of their traditional cellular access technology platforms like CDMA and GSM.

Taking account of the above, it is therefore recommended that:

5.3.5 To further promote the reach of internet, broadband and fixed telephony services, and because the platforms are distinct from each other and in different spectrum bands, the allocation of alternative technologies, such as CorDECT, should not affect operators' spectrum allocation otherwise due to them determined from the accepted subscribers-based allocation criteria for traditional cellular technologies like CDMA and GSM. To this end, clause 43.5(iii) of the Unified Access Services License should be removed, and WPC's order No. J-14025/200(I)/2004-NT dated 20th May, 2004 should be suitably modified.

[10] "De-linking of spectrum for CorDECT based networks in 1880 – 1900 from CDMA based networks in 800 MHz", Ministry of Communication & Information Technology, Department of Telecommunications, WPC Wing, No. J-14025/200(I)/2004-NT, 20th May, 2004

5.3.6 Further to the allocation policies, the CorDECT platform specifically is one which performs at optimal levels when the spectrum is shared amongst multiple service providers. Due to particular algorithms built in to the overall platform, multiple service providers are able to co-exist in the same spectrum, and the spectrum achieves highest utilization levels when multiple service providers are each allowed to use the full 20 MHz band. The gain in spectrum usage efficiency can be 60%.[11] The technologies that enable this are Dynamic Channel Selection (DCS) and Carrier Backoff.

5.3.7 Based on these technologies, CorDECT's efficiency increases as individual users are able to search for the highest quality channel for use at any given time, while taking into account interference and spectrum load. To further assist operators, especially during the roll-out phase when operators can have differing cell sizes and user characteristics, the facility for certain reserved carriers allocated to each operator can be made available. This means that certain minimum level of service can be guaranteed by operators and expected by users, free from potential interference by other operators.

5.3.8 Since CorDECT has a total of 11 carriers, each of 1.728 MHz, in a 20 MHz allocated band, a few of them can be reserved on exclusive basis, while the remaining ones are shared. One can assume that no more than four operators are likely to deploy CorDECT in the same geography, therefore no more than 4 channels out of the total 11 need to be reserved for exclusive allocation. Therefore 7 carriers would be left to be shared by all operators in a given geography, while operators would have to apply for allocation of one of the 4 reserved carriers.

It is therefore recommended that:

5.3.9 To promote the most efficient usage of the CorDECT platform and spectrum reserved for its use by leveraging its core algorithms, spectrum allocation for specific operators should be altered from its current format. Of the total 11 carriers that are available in the 20 MHz reserved for CorDECT, 4 carriers should be reserved uniformly on a national basis as those carriers which will be allocated to specific operators by the WPC for specific geographies, and the remaining 7 should be left open to be shared by all operators with the clearance to operate CorDECT equipment in their service area.

5.4 Allocation Policy for Rural Areas

5.4.1 The spread of telecommunications infrastructure in rural or under-developed areas across the country is another major priority of the Government and the Authority. A consultation paper on "Growth of Telecom Services in Rural India: The Way Forward" was released by the Authority on 27th October, 2004, and the concept of the Niche Operator was proposed in

[11] ETR310, DECT: "Radio Equipment and Systems (RES), Digital Enhanced Cordless Telecommunications (DECT), Traffic capacity and spectrum requirements for multi-system and multi-service DECT applications co-existing in a common frequency band", August 1996, Reference: DTR/RES-03077, European Telecommunications Standards Institute (ETSI)

the recommendations on Unified Licensing released on 13th January, 2005, both initiatives to support the viability of spreading the availability of telecom services.

5.4.2 The Authority will address the issues of reducing cost and promoting the spread of wireless infrastructure in rural areas in its recommendations on "Growth of Telecom Services in Rural India: The Way Forward".

5.5 Policy for Other Terrestrial Wireless Links

5.5.1 All telecom operators including BSO's / UASL's, ISP's and IP-II operators, as well as individual corporate customers had raised concern about the present system for acquiring and pricing of point-to-point and point-to-multi-point wireless links that use technologies other than cellular, i.e., GSM, CDMA, 3G or other related platforms. The issues that were discussed included high spectrum royalty charges, the structure of charge determination, and hurdles in the form of procedural delays for spectrum allocation, siting clearances and other formalities. These topics were explored during the consultation process and input gathered on how to allow for better pricing and, in conjunction, better usage of spectrum allocated for these purposes.

5.5.2 The overall objectives of the Authority in recommending the pricing and allocation policies for this particular spectrum are similar to its overall objectives. This includes promoting efficient usage of required allocation, minimizing the quantity of required allocation, usage by multiple parties rather than individual allocation, accounting for the fact that depending on factors like population density the charges should reflect the geography the spectrum is allocated in, that spectrum outside of the central high demand bands should be given more favorable treatment to create incentives for usage, and finally that even non-cellular technologies operators should be able to acquire and pay for spectrum on a geography-wide basis rather than on per link basis. It is important to achieve these goals to support the quick and cost effective spread of internet and broadband, both for commercial and residential users, and to further assist telecom companies in rolling out voice services. The issues pertaining to hurdles about process and delay have already been addressed by the Authority in its Broadband Recommendations and also acknowledged by the Government in its Broadband Policy 2004. Therefore, only the other issues are addressed below.

5.5.3 Current Pricing Model

5.5.3.1 The current model used for pricing of such spectrum is based on the equation R=MxWxC, where R is the upfront annual payable royalty amount, M is determined by the distance for which the clearance is being sought, W is determined by the amount of frequency being allocated, and C is the number of RF channels used (twice the number of duplex RF channel pairs). Both M and W are determined by range slabs, such that the multiplier increases significantly as soon as the requirements for the operator cross into the next slab. Details can be found in Annex 5.1. In addition to payment for spectrum, there is also an additional Rs. 1,000 annually per additional antenna beyond

the first two within the area of granted clearance, with each new antenna requiring explicit clearance. A sample of the current charges is below in Table 5-1.

Table 5-1 – Charges for Spectrum Under Current Methodology (Rs. 000's)

		M									
		0.25	**0.50**	**1**	**5**	**6**	**10**	**20**	**50**	**100**	**200**
W	**0.25**	36	36	36	36	72	72	72	144	270	450
	0.50	36	36	36	36	72	72	72	144	270	450
	1	36	36	36	36	72	72	72	144	270	450
	2	36	36	36	36	72	72	72	144	270	450
	3	72	72	72	72	144	144	144	288	540	900
	4	72	72	72	72	144	144	144	288	540	900
	5	72	72	72	72	144	144	144	288	540	900
	10	144	144	144	144	288	288	288	576	1,080	1,800
	15	144	144	144	144	288	288	288	576	1,080	1,800
	20	144	144	144	144	288	288	288	576	1,080	1,800
	25	144	144	144	144	288	288	288	576	1,080	1,800
	50	288	288	288	288	576	576	576	1,152	2,160	3,600

Note: C is assumed to be equal to 1 in this calculation.

5.5.3.2 To some operators and for specific frequency bands, spectrum is not allocated on an exclusive and protection basis, rather it is granted on the basis of non-exclusive, non-protection and non-interference. This parameter means that even though users are granted clearance for usage of specific spectrum in a particular geography, they are not guaranteed that they will be the only users, or that they will not experience any interference. This allocation process also allows for accommodating a number of operators within a given frequency, which typically leads to better usage of spectrum resources.

5.5.4 Proposed Pricing Model

5.5.4.1 Extensive feedback was received on the existing model and an analysis was also carried out on its limitations and possible improvements. They key issues which needed to be addressed were:

- The current pricing model uses slabs for determining the pricing multiples for both the distance factor M and the bandwidth factor W. These slabs were too large in certain ranges and the changes between slabs too drastic, therefore not reflecting the full potential of wireless technology and the requirements of operational deployment. Furthermore, this approach also did not encourage efficient utilization of spectrum.
- At times, point-to-point and point-to-multi-point links are allocated on a non-interference, non-protection and non-exclusive basis. This means that at times spectrum is shared between various service providers in the same geography, unlike in certain other situations, e.g., cellular

mobile operators, where spectrum is made available on an exclusive basis. There is a need to differentiate the pricing of spectrum in the two cases by suitably reflecting this aspect in the pricing formula.

- The availability of spectrum is dependent on demand and is therefore also dependent on population density. The higher the demand for spectrum in a given area (i.e. the higher the population density), the greater will be the recoverability on that investment. This aspect should also be reflected in the formula for deriving the cost of spectrum, and will also create incentives for operators to penetrate towns other than the biggest cities by making spectrum cheaper than in areas with less demand.
- All spectrum is not in equal demand and equally viable for usage. Therefore, spectrum which is more vacant will typically be less viable to use, and charging the same cost for such spectrum as that for spectrum that is in high demand would not be logical. This factor is closely tied to the actual band of the spectrum and bands in higher frequencies are less attractive for link deployment than those in lower frequencies. Therefore, this factor, too, needs to be accounted for in the pricing model.

5.5.4.2 The detailed analysis of these various parameters, how the final pricing model was arrived at, and comparison with the existing pricing model have been presented in Annex 5.2. The various parameters listed above have been analyzed and converted into appropriate multiplying factors applied to the original formula. Thus, to smoothen the negative effect of pricing based on large slabs for distance factor M and bandwidth factor W, the treatment of these variables has been altered. For maintaining equality in the median price level between the current and proposed pricing formula, a constant multiplier A has been introduced. To account for the discounting needed on spectrum allotted on non-interference, non-protection and non-exclusive basis, the factor S has been introduced. Finally, the factors P and B incorporate the discounting based on population density and the demand pressure on the specific frequency band of usage. The formula derived for pricing wireless links of this type, resulting from the above approach, is presented below as the Authority's recommendations on spectrum pricing. The details of derivation of the values for these various parameters are available at Annex 5.2.

It is therefore recommended that:

5.5.4.3 To promote the most efficient usage of spectrum for links utilizing technologies other than the traditional cellular platforms, and deployed in point-to-point or point-to-multi-point links, the system of charging for those spectrum allocations should be altered from its current form. For the new system of charging the proposed method is as follows:

$$R = (\sqrt{M}) * W * C * A * S * P * B$$

Where:

R = the annual rate to be charged for the spectrum allocation (Rs.)

M = the distance in Kilometers between the two farthest antennas for which the link is being provisioned
W = the bandwidth in Megahertz being allocated
C = the number of RF channels used (twice the number of duplex RF channel pairs)
A = constant multiplier factor, currently set to equal 6,724 for purposes of equalizing the new pricing structure with the previous one
S = the factor for discounting based on spectrum allocated on non-interference, non-protection and non-exclusive basis. When allocation is with these properties, the value should be 0.33 otherwise 1.00
P = the factor for discounting based on population density
B = the factor for discounting based on band of deployment

5.5.4.4 The values for P and B should be determined based on the following:

$$P = 0.5 \times \left(1 - \frac{population\ density}{2{,}000}\right)$$

where population density is expressed in persons per square kilometer as per the Census of India 2001 for the district in which the link is being deployed

$$B = 0.5 \times \left(\frac{center\ \ frequency\ of\ \ allocation - 3{,}000}{20{,}000}\right)$$

where center frequency of allocation is defined in megahertz (MHz)

5.5.4.5 The charge for each additional transceiver station required by the operator should be calculated as the minimum of either Rs. 1,000 or 10% of R, where R is the value for the annual spectrum usage fee as calculated above with discounts.

5.5.4.6 Resulting from this new calculation method, operators utilizing wireless links for shorter distances and lower spectrum bandwidth would get discounts from 50% up to 98%. To further promote usage of technology that is capable of sharing spectrum, increased penetration into rural areas and usage of higher frequency bands, these discounts would be substantially increased when such parameters are met, making spectrum charges marginal compared to current levels.

5.6 Outstanding Topics to Be Covered in Future

5.6.1 It is part of the intention of TRAI's effort regarding spectrum policy recommendations to also look ahead to emerging technologies. While India has traditionally been a late mover in deploying or developing the latest telecoms platforms, the industry has today reached a level of maturity and growth that we have the opportunity to influence the direction of future technology development.

5.6.2 While today, the primary need for spectrum in customer and civilian services are for traditional technology platforms to provide voice services, emerging technologies like Wi-Max are focusing on providing a unified broadband wireless access platform to deliver all kinds of services. In the effort to create an environment that allows this, one of the key elements is to earmark and reserve spectrum from today for these services to be developed, tested and deployed. Many other countries have already deployed live commercial and test networks based on new technologies that can be classified as pre-Wi-Max or pre-4G. These technologies will also have tremendous impact on various government goals. Therefore, the timely allocation of both TDD and FDD spectrum for such platforms will be of the highest importance, especially if India wants to gain the world leadership in such technologies and leapfrog other countries in developing its telecom infrastructure. At this juncture it is not possible for the Authority to provide specific recommendations without gathering much more information on several of these technological developments. A summary of the current state of international efforts with regards to allocating spectrum for broadband wireless platforms is below in Table 5-2.

Table 5-2 – International Initiatives for Broadband Wireless Frequency Allocation

Frequency	Comments
700 – 800 MHz	• Being considered for future allocations, especially in USA and Philippines
1785 – 1805 MHz	• Being considered for TDD based technologies that do not interfere with neighboring GSM operations, since recognized as the GSM guard band • In many parts of Africa with 5 MHz channel / carrier per operator
1880 – 1920, 2010 – 2025 MHz	• Identified as the TDD bands for IMT-2000 type technologies, therefore traditionally reserved for UMTS-TDD technologies • Many countries, including Australia, UK, US, Singapore have already or are considering making this band technology neutral, therefore allowing other TDD broadband wireless technologies, typically with 5 MHz channel/carrier per operator
2.3 – 2.4 GHz	• Being used in USA, Korea, Malaysia, Singapore for wireless mobile services, including wireless broadband. Typically being viewed on a technology neutral basis
2.5 – 2.69 GHz	• Recommended for expansion of IMT-2000 services, but being considered by some for technology neutral allocation to allow FDD based technologies • USA, Brazil, Mexico, Canada, Australia, New Zealand, Hong Kong, Singapore
3.4 – 3.6 GHz	• Strong support to clear satellite and other users from this band to allow for mixed TDD and FDD allocations for WiMax and other 4G platforms

	• US, UK, France, Malaysia, China, Germany, Hong Kong, Australia, New Zealand, Africa and some parts of Latin America
5.15 – 5.35, 5.725 – 5.85 GHz	• Being considered for unlicensed usage by broadband wireless technologies, especially WiMax

5.6.3 Along with new technologies, new methods for enhancing spectrum efficiency are also being implemented, including smart antennas and software defined radios. With these technologies, co-existence issues are becoming easier to manage, and many spectrum administrators are transitioning to allocating spectrum purely on spectrum usage masks. For example, smart antennas allow more polite usage of allocated spectrum by reducing overall noise levels in the RF environment. They also allow the maximum EIRP to be higher than traditionally allowed limits since it is focused at specific areas or users.

5.6.4 Furthermore, many regulators are also transitioning to provide for more "spectrum commons", bands where spectrum is de-licensed and open to a variety of users for varied purposes, but with certain defined etiquette standards that are not prevalent in current de-licensed bands. This would provide for better inter-technology and inter-platform interference mitigation. In addition to this, certain techniques are being explored that will allow multiple technologies to exist in the same licensed bands by using gaps in spectrum usage or by identifying intermittent white space in spectrum usage by current users that can be used for other communications purposes.

5.6.5 The Authority feels that these issues will need to be examined in detail very quickly, and will issue a consultation paper as a follow-up to this set of recommendations. A study of regulatory practices adopted elsewhere and recommendations by organizations like the ITU that refer to these emerging techniques will need to be conducted. As indicated above in Table 5-2, many countries' regulators including Singapore, Hong Kong, Korea, Australia, New Zealand, United Kingdom, France, Germany, USA, Brazil, Mexico, and China have already released or are in the process of releasing their parameters of usage for broadband wireless and beyond 3G platforms. In India, one significant pre-requisite to this would be unified licensing, so that spectrum allocation does not continue to be service-based.

5.6.6 Likewise, while today only UASL operators have the facility of acquiring spectrum on a circle-wise or geography-wide basis, other licensees who want to provide services under the ambit of their licenses should also be extended such facility. It may be possible to tackle this last issue independent of the other larger issues of emerging technologies and management techniques mentioned above.

Chapter 6 Other relevant issues

6.1. Spectrum Trading

6.1.1. Managing spectrum was a simple and straightforward task when there was sufficiently enough spectrum to accommodate most potential users. With the growth of wireless services and various new applications, which results in increased spectrum demand, spectrum management has become a very difficult and challenging task. Spectrum trading permits service providers to

- Trade part or all of their allocations to others
- Lease spectrum to others on a temporary or longer term basis

6.1.2. Permitting spectrum trading is expected to improve spectrum efficiency over time as it would enable spectrum to be used by those who value it most, and for those uses that offer most value.

6.1.3. Spectrum trading, if properly designed may lead to greater competition in wireless services, provide incentives to innovation, greater certainty to service providers over their rights on spectrum, access to spectrum by those who value it most, greater return to service providers, better/new services being available to consumers at cheaper tariffs, greater choice to consumers, etc.

6.1.4. One of the major disadvantages of spectrum trading could be that service providers of less profitable services would prefer to sell their spectrum instead of continuing to provide services and this would adversely affect the consumers and growth of telecom services in India. If spectrum trading is not designed properly then it may not give the desired results.

6.1.5. As discussed above, to take full advantage of spectrum trading it is necessary that it should be designed properly through a detailed consultation process keeping in view the market situation, legal framework, license conditions and the key objective of growth of telecom services in India.

6.1.6. The issue of spectrum trading was not discussed in details in the consultation paper. In response to the consultation many stakeholders opined that it is premature to consider introducing spectrum trading in India. Opening of trading of spectrum requires lot of technical and legal preparedness and may be considered at a later stage through a consultation process. One of the stakeholder also opined that secondary trading should not be introduced as trading can only be permitted when the spectrum has been auctioned. Few other stakeholders supported the introduction of secondary trading and opined that it increases the efficient use of spectrum and facilitates the deployment of new innovative technologies and services.

6.1.7. The Authority agrees with the viewpoint that the issue of spectrum trading should be addressed as a separate study. Experience can be gained from the

USA, Canada, New Zealand and Australia and also within short timescales from Europe where a number of countries are proposing to introduce spectrum trading. For example in the UK there have already been a number of consultations, available on the Ofcom web-site, that address the issues that would need to be considered before a spectrum trading regime can be introduced. This of course already assumes that the appropriate legislation is already in place.

6.1.8. In view of above, **it is recommended that the current position of not allowing spectrum trading may continue till the issue is considered separately through a consultation process.**

6.2. Mergers and acquisitions

6.2.1. Mergers and acquisitions can currently happen between operators in the same geographic service area subject to Government guidelines on merger of licences in a service area dated 21st February, 2004. As per the guidelines:

"6. Consequent upon the Merger of licences, the merged entity shall be entitled to the total amount of spectrum held by the merging entities, subject to the condition that after merger, the amount of spectrum shall not exceed 15 MHz per operator per service area for Metros and category 'A' Service Areas, and 12.4 MHz per operator per service area in category 'B' and category 'C' Service Areas. Subject to these limits, the merged spectrum will remain with the merged entity and would be treated as a starting point for further allocation and revision, as per the detailed Spectrum Guidelines to be issued separately. The guidelines on efficient utilization of spectrum and its pricing shall be applicable. "

6.2.2 It is considered unlikely that the larger operators will merge as they will be in a position to maximise on their current investments especially as they now have the opportunity to gain access to additional spectrum. It is more likely that a large operator will acquire a smaller operator or that two smaller operators will merge to take advantage of:

- Increased numbers of subscribers and therefore revenue
- Decrease in overheads – for example there will be lower marketing and network costs
- Increased coverage area if geographic roll-out has been different
- Access to additional sites

These should be sufficient reasons for a merger or acquisition to take place even when they are not allowed to retain the complete combined spectrum.

6.2.3 **Since the Authority has recommended that the spectrum availability to mobile operators should improve, it is expected that more and more spectrum would be available for mobile services in short and long term. Therefore depending on spectrum availability, allocation and development of market this issue shall be dealt with separately.**

6.3 Hostilities and disaster

6.3.1 It is recommended that in the case of hostilities and disaster the defence may be given the authority to use additional spectrum including allocated spectrum to private service providers, as considered appropriate by the Government.

6.4 Spectrum Management

6.4.1 In a multi-operator high wireless growth environment it may not be possible to manually manage the spectrum. This includes SACFA clearance, etc. Any delay in processing the applications for allocation of spectrum including site clearances adversely affects the roll out of services. WPC has commissioned the Automated Spectrum Management System (ASMS) for receiving online applications for frequency assignment as well as for SACFA clearance. **It is recommended that the entire spectrum management process including frequency authorisation process should be fully automated.**

Annex. 1.1

The Emergence of Mobile Telephony in 102 Low and Middle Income Nations

Country	Main Lines per 100 population in 1995	Main Lines per 100 population in 2003	Mobile Subscribers per 100 population in 1996	Mobile Subscribers per 100 population in 2003
Afghanistan	0	0	0	1
Albania	1	8	0	36
Algeria	4	7	0	5
Angola	0	1	0	..
Bangladesh	0	1	0	1
Benin	1	1	0	3
Bhutan	1	3	0	1
Bolivia	3	7	0	15
Bosnia and Herzegovina	6	24	0	27
Botswana	4	7	0	30
Burkina Faso	0	1	0	2
Burundi	0	0	0	1
Cambodia	0	0	0	4
Cameroon	0	..	0	7
Cape Verde	6	16	0	12
Central African Rep.	0	..	0	1
Chad	0	..	0	1
China	3	21	0	21
Comoros	1	2	0	0
Congo	1	0	0	9
Congo (Democratic Republic of the)	0	..	0	2
Cote d'Ivoire	1	1	0	8
Cuba	3	..	0	..
Dem. People's Rep. Of Korea	2	4	0	..
Djibouti	1	2	0	3
Dominican Republic	7	12	1	27
Ecuador	6	12	0	19
Egypt	5	13	0	8
El Salvador	5	12	0	18
Equatorial Guinea	1	2	0	8
Eritrea	0	1	0	0
Ethiopia	0	1	0	0

Annex. 1.1 Cont'd

Country	Main Lines per 100 population in 1995	Main Lines per 100 population in 2003	Mobile Subscribers per 100 population in 1996	Mobile Subscribers per 100 population in 2003
Gabon	3	3	0	22
Gambia	2	..	0	..
Ghana	0	1	0	4
Gautemala	3	..	0	..
Guinea	0	0	0	1
Guinea-Bissau	1	1	0	0
Guyana	5	..	0	..
Haiti	1	2	0	4
Honduras	3	..	0	..
India	1	5	0	2
Indonesia	2	4	0	9
Iraq	3	..	0	..
Jordan	7	11	0	24
Kenya	1	1	0	5
Kiribati	3	..	0	1
Kyrgyzstan	8	..	0	..
Lao P.D.R.	0	1	0	2
Lesotho	1	..	0	..
Liberia	0	..	0	..
Libya	6	14	0	2
Madagascar	0	0	0	2
Malawi	0	1	0	1
Maldives	6	..	0	..
Mali	0	..	0	2
Marshall Islands	7	8	1	1
Mauritania	0	1	0	13
Mayotte	4	..	0	22
Micronesia (Fed. States of)	7	10	0	5
Mongolia	4	6	0	13

Annex. 1.1 Cont'd

Country	Main Lines per 100 population in 1995	Main Lines per 100 population in 2003	Mobile Subscribers per 100 population in 1996	Mobile Subscribers per 100 population in 2003
Morocco	4	4	0	24
Mozambique	0	..	0	2
Myanmar	0	1	0	0
Nambia	5	7	0	12
Nepal	0	2	0	0
Nicaragua	2	4	0	9
Niger	0	..	0	0
Nigeria	0	1	0	3
Oman	8	..	0	..
Pakistan	2	3	0	2
Palestine	3	9	1	13
Papua New Guinea	1	..	0	..
Paraguay	3	5	0	30
Peru	5	7	0	11
Phillippines	2	4	1	27
Rwanda	0	..	0	2
Samoa	5	7	0	6
Sao Tome and Principe	2	5	0	3
Senegal	1	2	0	6
Sierra Leone	0	..	0	..
Solomon Islands	2	1	0	0
Somalia	0	..	0	..
Sri Lanka	1	5	0	7
Sudan	0	3	0	2
Swaziland	2	4	0	8
Syria	7	..	0	..
Tajikistan	4	4	0	1
Tanzania	0	0	0	3
Thailand	6	10	2	39

Annex. 1.1 Cont'd

Country	Main Lines per 100 population in 1995	Main Lines per 100 population in 2003	Mobile Subscribers per 100 population in 1996	Mobile Subscribers per 100 population in 2003
Togo	1	1	0	4
Tonga	7	..	0	..
Tunisia	6	12	0	19
Turkmenistan	7	..	0	..
Tuvalu	5	..	0	0
Uganda	0	0	0	3
Uzbekistan	7	7	0	1
Vanuatu	3	3	0	4
Viet Nam	1	5	0	3
Yemen	1	..	0	3
Zambia	1	1	0	2
Zimbabwe	1	3	0	3

Source: The Vodafone Policy Paper Series dated March 2005

Annex. 1.2

Operator Wise Subscriber Base and Allocated Spectrum

SLNO	Service Area	Mobile Operator		Spectrum Alloted*	Subscribers Base as on 28.2.2005
		GSM	CDMA		
1	Delhi	Bharti		10 MHz	1595114
		Hutch		10 MHz	1437846
		MTNL		6.2 MHz	358408
		Idea		6.2 MHz	633541
			MTNL	3.75 MHz	131408
			Reliance Infocomm	5 MHz	1220805
			Tata Teleservices	3.75 MHz	242539
					5619661
2	Mumbai	BPL		10 MHz	1202008
		Hutch		10 MHz	1505201
		MTNL		6.2 MHz	425651
		Bharti		8 MHz	713260
			MTNL	5 MHz	60527
			Reliance Infocomm	5 MHz	994405
			Tata Teleservices	5 MHz	162807
					5063859
3	Chennai	Aircel Cellular		6.2 MHz	519715
		Bharti		6.2 MHz	449098
		BSNL		6.2 MHz	323453
		Hutchison		6.2 MHz	219421
			BSNL	2.5 MHz	9385
			Reliance Infocomm	5 MHz	457438
			Tata Teleservices	3.75 MHz	59635
					2038145
4	Kolkata	Bharti		8 MHz	503064
		Hutchison East		8 MHz	633540
		BSNL		6.2 MHz	249636
		Reliable Internet		6.2 MHz	Service not started
			BSNL	2.5 MHz	23670
			Reliance Infocomm	5 MHz	484941
			Tata Teleservices	2.5 MHz	10363
					1905214
5	MH	BPL		6.2 MHz	528152
		Idea		8 MHz	1262431
		BSNL		8 MHz	690277
		Bharti		6.2 MHz	634260
			BSNL	2.5 MHz	39581
			Reliance Infocomm	3.75 MHz	797796
			Tata Teleservices	5 MHz	88293
					4040790

Annex. 1.2 Cont'd

SLNO	Service Area	Mobile Operator		Spectrum Alloted*	Subscribers Base as on 28.2.2005
		GSM	CDMA		
6	GUJ	Fascel (Hutch)		8 MHz	1230039
		Idea		6.2 MHz	658723
		BSNL		6.2 MHz	521505
		Bharti		6.2 MHz	500792
			BSNL	2.5 MHz	17716
			Reliance Infocomm	3.75 MHz	701769
			Tata Teleservices	2.5 MHz	93106
					3723650
7	AP	Idea		8 MHz	641495
		Bharti		8 MHz	921938
		BSNL		8 MHz	808050
		Hutchison		6.2 MHz	386933
			BSNL	2.5 MHz	51988
			Reliance Infocomm	5 MHz	874484
			Tata Teleservices	5 MHz	190392
					3875280
8	KTK	Bharti		10 MHz	1207379
		Spice		6.2 MHz	324400
		BSNL		8 MHz	701273
		Hutch		8 MHz	545200
			BSNL	2.5 MHz	19404
			Reliance Infocomm	5 MHz	667714
			Tata Teleservices	3.75 MHz	104754
					3570124
9	TN	BPL		6.2 MHz	402628
		Aircel		10 MHz	1196858
		BSNL		8 MHz	853177
		Bharti		6.2 MHz	327968
			BSNL	2.5 MHz	11298
			Reliance Infocomm	3.75 MHz	517161
			Tata Teleservices	2.5 MHz	32615
					3341705
10	Kerala	Escotel (Idea)		8 MHz	560483
		BPL		6.2 MHz	377896
		BSNL		8 MHz	787452
		Bharti		6.2 MHz	339016
			BSNL	2.5 MHz	27825
			Reliance Infocomm	3.75 MHz	461050
			Tata Teleservices	2.5 MHz	Service not started
					2553722

Annex. 1.2 Cont'd

SLNO	Service Area	Mobile Operator		Spectrum Alloted*	Subscribers Base as on 28.2.2005
		GSM	CDMA		
11	Punjab	Spice		8 MHz	1161920
		Bharti		8 MHz	1288283
		BSNL		6.2 MHz	358599
		Hutchison		6.2 MHz	162738
			BSNL	2.5 MHz	12010
			Reliance Infocomm	3.75 MHz	507729
			HFCL Infocom	5 MHz	51383
			Tata Teleservices	2.5 MHz	18551
					3561213
12	Haryana	Escotel (Idea)		6.2 MHz	190241
		Aircel Diglink (Hutch)		6.2 MHz	167681
		BSNL		6.2 MHz	286784
		Bharti		6.2 MHz	255133
			BSNL	2.5 MHz	12173
			Reliance Infocomm	2.5 MHz	216180
			Tata Teleservices	2.5 MHz	10268
					1138460
13	UP-W	Escotel (Idea)		6.2 MHz	622841
		Bharti		6.2 MHz	367748
		BSNL		6.2 MHz	534589
		Hutch South		6.2 MHz	135905
			BSNL	2.5 MHz	15534
			Reliance Infocomm	2.5 MHz	328680
			Tata Teleservices	2.5 MHz	10499
					2015796
14	UP-E	Aircel Diglink (Hutch)		6.2 MHz	796368
		BSNL		6.2 MHz	723776
		Bharti		6.2 MHz	192735
		Escorts communications		4.4 MHz	Service not started
			BSNL	2.5 MHz	20305
			Reliance Infocomm	3.75 MHz	468186
			Tata Teleservices	2.5 MHz	10780
					2212150
15	Raj	Aircel Diglink (Hutch)		6.2 MHz	317171
		Hexacom (Bharti)		6.2 MHz	500470
		BSNL		6.2 MHz	370777
		Escorts communications		4.4 MHz	Service not started
			BSNL	2.5 MHz	63558
			Reliance Infocomm	3.75 MHz	359877
			Shyam Telelink	5 MHz	27443
			Tata Teleservices	2.5 MHz	21675
					1660971

Annex. 1.2 Cont'd

SLNO	Service Area	Mobile Operator		Spectrum Alloted*	Subscribers Base as on 28.2.2005
		GSM	CDMA		
16	MP	Idea		6.2 MHz	500650
		Reliance		6.2 MHz	310003
		BSNL		6.2 MHz	158602
		Bharti		6.2 MHz	235897
			BSNL	2.5 MHz	94648
			Reliance Infocomm	2.5 MHz	358495
			Tata Teleservices	2.5 MHz	6585
			Bharti Telenet	2.5 MHz	Licence Surrendered
					1664880
17	WB&A&N	Reliance		6.2 MHz	151996
		BSNL		6.2 MHz	291918
		Bharti		4.4 MHz	114114
		Hutch South		4.4 MHz	108387
		Dishnet DSL		4.4 MHz	Service not started
			BSNL	2.5 MHz	1781
			Reliance Infocomm	2.5 MHz	121447
			Tata Teleservices	2.5 MHz	33
					789676
18	HP	Bharti		6.2 MHz	191800
		Reliance		4.4 MHz	31771
		BSNL		6.2 MHz	102509
		Escorts communications		4.4 MHz	Service not started
		Dishnet DSL		-	Service not started
			BSNL	2.5 MHz	17
			Reliance Infocomm	2.5 MHz	3713
			Tata Teleservices	2.5 MHz	720
					330530
19	Bihar	Reliance		6.2 MHz	352817
		BSNL		6.2 MHz	404500
		Bharti		6.2 MHz	113300
		Dishnet DSL		-	Service not started
			BSNL	2.5 MHz	8356
			Reliance Infocomm	3.75 MHz	203038
			Tata Teleservices	2.5 MHz	8847
					1090858

Annex. 1.2 Cont'd

SLNO	Service Area	Mobile Operator		Spectrum Alloted*	Subscribers Base as on 28.2.2005
		GSM	CDMA		
20	Orissa	Reliance		6.2 MHz	120681
		BSNL		6.2 MHz	292354
		Bharti		6.2 MHz	124037
		Dishnet DSL		4.4 MHz	Service not started
			BSNL	2.5 MHz	1261
			Reliance Infocomm	3.75 MHz	119193
			Tata Teleservices	2.5 MHz	6623
					664149
21	Assam	Reliance		6.2 MHz	99118
		BSNL		6.2 MHz	151487
		Bharti Televenture		1.8 MHz	Service not started
		Dishnet DSL		4.4 MHz	Service not started
			BSNL	2.5 MHz	6750
					257355
22	NE	Reliance		4.4 MHz	23360
		BSNL		6.2 MHz	86905
		Hexacom India Ltd		4.4 MHz	Service not started
		Dishnet DSL		4.4 MHz	Service not started
			BSNL	2.5 MHz	51
					110316
23	J&K	BSNL		6.2 MHz	149259
		Bharti		4.4 MHz	83313
		Dishnet DSL		4.4 MHz	Service not started
			BSNL	2.5 MHz	3425
			Reliance Infocomm	-	Service not started
					235997
				TOTAL	**51464501**

*Spectrum Alloted for GSM operators as on 27-1-05 and for CDMA operators as on quarter ending Dec 2004.

Annex. 1.3

Licensed Spectrum to GSM Operators in various countries

Country	Network	Spectrum licensed (In MHz)		
		GSM 900	GSM 1800	TOTAL
Belgium	Belgacom (Proximus)	2 x 12	2 x 15	2 x 27
	Mobistar	2 x 12	2 x 15	2 x 27
	KPN Orange	2 x 5	2 x 22	2 x 27
Denmark	TeleDanmark Mobil	2 x 8.8	2 x 26.8	2 x 35.6
	Sonofon	2 x 8.8	2 x 19.6	2 x 28.4
	Telia Denmark	2 x 7.4	2 x 14.4	2 x 21.8
	Mobilix	2 x 7.4	2 x 14.4	2 x 21.8
Germany	T-Mobil	2 x 12.4	2 x 5.0	2 x 17.4
	Mannesman	2 x 12.4	2 x 5.4	2 x 17.8
	E-plus	0	2 x 22.4	2 x 22.4
	Viag Interkom	0	2 x 22.4	2 x 22.4
Greece	Panafon GSM	2 x 15	2 x 15	2 x 30
	Telestet	2 x 10	2 x 15	2 x 25
	Info-Quest	0	2 x 10	2 x 10
	Cosmote	0	2 x 25	2 x 25
Spain	Telefonica Moviles	2 x 12	2 x 15	2 x 27
	Airtel	2 x 12	2 x 15	2 x 27
	Amena	0	2 x 15	2 x 15
France	Itineris	2 x 10.8	2 x 13.2	2 x 24
	SFR	2 x 10.8	2 x 13.2	2 x 24
	Bouyges Telecom	2 x 3.2	2 x 23.2	2 x 26.4
Ireland	Eircell	2 x 7.2	2 x 14.4	2 x 21.6
	Esat Digifone	2 x 7.2	2 x 14.4	2 x 21.6
	Meteor	2 x 7.2	2 x 14.4	2 x 21.6
Italy	Telecom Italia Mobile	2 x 10.2	2 x 9.6	2 x 19.8
	Omnitel	2 x 7.2	2 x 9.6	2 x 16.8
	Wind	2 x 5	2 x 14.4	2 x 19.4
	Blu	0	2 x 15.0	2 x 15
Luxembourg	P+T	2 x 11.6	2 x 9.8	2 x 21.4
	Millicom	2 x 11.6	2 x 9.8	2 x 21.4
Netherlands	KPN Mobile	2 x 12.2	2 x 17.6	2 x 29.8
	Libertel	2 x 12.2	2 x 5.2	2 x 17.4
	Telfort	2 x 5	2 x 17.4	2 x 22.4
	Dutchtone	2 x 5	2 x 15	2 x 20
	Ben	0	2 x 16.8	2 x 16.8
Austria*	Mobilkom Austria	2 x 8	2 x 15	2 x 29.6
	Max Mobil	2 x 8	2 x 8	2 x 16
	Connect Austria (One)	0	2 x 28.8	2 x 32
	Tele.Ring	0	2 x 14.6	2 x 16.8
Portugal	TMN	2 x 8	2 x 6	2 x 14
	Telecel	2 x 8	2 x 6	2 x 14
	Optimus	2 x 7.8	2 x 6	2 x 13.8
Finland	Sonera	2 x 13.6	2 x 11	2 x 24.6
	Radiolinja	2 x 10	2 x 8.2	2 x 18.2
	Telia Finland	0	2 x 8.2	2 x 8.2
	Suomen 3G	2 x 8.6	2 x 7.2	2 x 15.8
	Elisa	0	2 x 7.2	2 x 7.2
Sweden	Telia Mobitel	2 x 7.2	2 x 15	2 x 22.2

Annex. 1.3 Cont'd

Country	Network	Spectrum licensed (In MHz)		
		GSM 900	GSM 1800	TOTAL
	Comviq	2 x 7.2	2 x 8.4	2 x 15.6
	Europolitan	2 x 7.2	2 x 8.4	2 x 15.6
Switzerland	Tele2		2 x 8.6	2 x 8.6
	In&Phone		2 x 5.8	2 x 5.8
	Other 3 operators (each)			2 x 25
UK	O2	2 x 16.8	2 x 5.8	2 x 22.6
	One2one	0	2 x 30.0	2 x 30
	Orange	0	2 x 30.0	2 x 30
	Vodafone	2 x 16.8	2 x 5.8	2 x 22.6
Kenya	(3rd Licence)	2 x 5	2 x 5	2 x 10
Hong Kong	CSL	2 x 7.5	2 x 10	2 x 17.5
	Hutchison	2 x 7.5	2 x 10	2 x 17.5
	New World	0	2 x 10	2 x 10
	SmartTone	2 x 7.5	2 x 10	2 x 17.5
	Peoples		2 x 10	2 x 10
	Mandarin		2 x 10	2 x 10
Australia	Telstra	2 x 8	2 x 12.5	2 x 20.5
	SingTel	2 x 8	2 x 15	2 x 23
	Vodafone	2 x 8	2 x 15	2 x 23
	OneTel (regional operator)		2 x 15	2 x 15
China	Unicom	2 x6	2 x10	2 x16
	China Telecom			2 x 19

The average of the above total allocations for GSM operators is approximately 2 x 20 MHz.

**The total column has been modified to take into account the recent auction for additional GSM spectrum in the summer 2004.*

Source:- Aegis Systems UK

Annex.1.3 Contd…

Licensed spectrum to CDMA operators in various countries*

Country	Bandwidth per Operator (In MHz)
Argentina	2 x 15
Australia	2 x 10
Brazil	2 x 11.5
Canada	2 x 12.5
Chile	2 x 10
China	2 x 10
Dominican Republic	2 x 20
HongKong	2 x 7.5
Indonesia	2 x 10
Japan	2 x 15
Korea	2 x 12
Mexico	2 x 17.5
New Zealand	2 x 20
Philippines	2 x 10
Taiwan	2 x 20
Thailand	2 x 12.5
USA	2 x 18

The average of the above total allocations for CDMA operators is approximately 2 x 14 MHz.

**Source: Reliance Infocomm Ltd. Response to TRAI consultation paper*

Annex. 1.4

Service Area Wise Service Providers along with the growth rate and the likely time period for crossing the benchmark for allocation of additional spectrum based on existing subscriber base criterion

Service Area	Mobile Operator		Spectrum Alloted (In MHz)	Subscribers		Current Annual Growth Rate (In %)	Likely time period for crossing the benchmark for allocation of additional spectrum (in months)
	GSM	CDMA		No. of subscribers possible to cater in lakhs (as per existing benchmark)	Actual no. of subscribers (28.02.2005) in lakhs		
Delhi	Bharti		10.00	12.0	16.0	18.66	Already Crossed
	Hutch		10.00	12.0	14.4	23.42	Already Crossed
	MTNL		6.20	5.0	3.6	120.44	5
	Idea		6.20	5.0	6.3	29.39	Already Crossed
		MTNL	3.75	10.0	1.3	113.58	32
		Reliance Infocomm	5.00		12.2	65.53	No Benchmark Criteria
		Tata Teleservices	3.75	10.0	2.4	59.76	36
Mumbai	BPL		10.00	12.0	12.0	29.38	Reached
	Hutch		10.00	12.0	15.1	38.87	Already Crossed
	MTNL		6.20	5.0	4.3	128.94	2
	Bharti		8.00	10.0	7.1	30.39	15
		MTNL	5.00		0.6	46.86	No Benchmark Criteria
		Reliance Infocomm	5.00		9.9	65.02	No Benchmark Criteria
		Tata Teleservices	5.00		1.6	32.17	No Benchmark Criteria
Chennai	Aircel Cellular		6.20	5.0	5.2	103.82	Already Crossed
	Bharti		6.20	5.0	4.5	24.35	6
	BSNL		6.20	5.0	3.2	185.04	5
	Hutchison		6.20	5.0	2.2	41.06	29
		BSNL	2.50	2.0	0.1	-48.17	Negative Growth Rate in Last Year
		Reliance Infocomm	5.00		4.6	21.71	No Benchmark Criteria
		Tata Teleservices	3.75	6.0	0.6	10.21	285
Kolkata	Bharti		8.00	10.0	5.0	37.56	26
	Hutchison East		8.00	10.0	6.3	32.58	19
	BSNL		6.20	5.0	2.5	834.48	4
	Reliable Internet		6.20	5.0			Service Not Started
		BSNL	2.50	2.0	0.2	38.53	79
		Reliance Infocomm	5.00		4.8	57.10	No Benchmark Criteria
		Tata Teleservices	2.50	2.0	0.1		Recently Started Services
MH	BPL		6.20	5.0	5.3	59.50	Already Crossed
	Idea		8.00	10.0	12.6	33.30	Already Crossed
	BSNL		8.00	10.0	6.9	13.07	36
	Bharti		6.20	5.0	6.3	91.97	Already Crossed
		BSNL	2.50	4.0	0.4	129.89	33
		Reliance Infocomm	3.75	12.0	8.0	70.12	9
		Tata Teleservices	5.00		0.9	195.30	No Benchmark Criteria

Annex. 1.4 Cont'd

Service Area	Mobile Operator		Spectrum Alloted (In MHz)	Subscribers		Current Annual Growth Rate (In %)	Likely time period for crossing the benchmark for allocation of additional spectrum (in months)
	GSM	CDMA		No. of subscribers possible to cater in lakhs (as per existing benchmark)	Actual no. of subscribers (28.02.2005) in lakhs		
GUJ	Fascel(Hutch)		8.00	10.0	12.3	35.81	Already Crossed
	Idea		6.20	5.0	6.6	63.17	Already Crossed
	BSNL		6.20	5.0	5.2	8.30	Already Crossed
	Bharti		6.20	5.0	5.0	158.94	Reached
		BSNL	2.50	4.0	0.2	871.80	16
		Reliance Infocomm	3.75	12.0	7.0	64.00	13
		Tata Teleservices	2.50	4.0	0.9	62.13	36
AP	Idea		8.00	10.0	6.4	40.79	16
	Bharti		8.00	10.0	9.2	57.78	2
	BSNL		8.00	10.0	8.1	55.48	6
	Hutchison		6.20	5.0	3.9	114.85	4
		BSNL	2.50	4.0	0.5	64.55	49
		Reliance Infocomm	5.00		8.7	50.25	No Benchmark Criteria
		Tata Teleservices	5.00		1.9	35.19	No Benchmark Criteria
KTK	Bharti		10.00	12.0	12.1	59.75	Already Crossed
	Spice		6.20	5.0	3.2	5.24	102
	BSNL		8.00	10.0	7.0	117.97	5
	Hutch		8.00	10.0	5.5	84.87	12
		BSNL	2.50	4.0	0.2	135.63	42
		Reliance Infocomm	5.00		6.7	48.65	No Benchmark Criteria
		Tata Teleservices	3.75	12.0	1.0	74.28	53
TN	BPL		6.20	5.0	4.0	57.33	6
	Aircel		10.00	12.0	12.0	102.57	Reached
	BSNL		8.00	10.0	8.5	154.68	2
	Bharti		6.20	5.0	3.3	57.82	11
		BSNL	2.50	4.0	0.1	178.96	42
		Reliance Infocomm	3.75	12.0	5.2	35.08	34
		Tata Teleservices	2.50	4.0	0.3	139.68	34
Kerala	Escotel(Idea)		8.00	10.0	5.6	41.37	20
	BPL		6.20	5.0	3.8	52.01	8
	BSNL		8.00	10.0	7.9	117.85	4
	Bharti		6.20	5.0	3.4	108.50	6
		BSNL	2.50	3.0	0.3	105.96	39
		Reliance Infocomm	3.75	10.0	4.6	55.68	21
		Tata Teleservices	2.50	3.0			Service Not Started
Punjab	Spice		8.00	10.0	11.6	32.62	Already Crossed
	Bharti		8.00	10.0	12.9	55.67	Already Crossed
	BSNL		6.20	5.0	3.6	22.47	20
	Hutchison		6.20	5.0	1.6		Recently Started Services
		BSNL	2.50	3.0	0.1	604.40	20
		Reliance Infocomm	3.75	10.0	5.1	62.98	17
		HFCL Infocom	5.00		0.5	83.88	No Benchmark Criteria
		Tata Teleservices	2.50	3.0	0.2		Recently Started Services

Annex. 1.4 Cont'd

Service Area	Mobile Operator		Spectrum Alloted (In MHz)	Subscribers		Current Annual Growth Rate (In %)	Likely time period for crossing the benchmark for allocation of additional spectrum (in months)
	GSM	CDMA		No. of subscribers possible to cater in lakhs (as per existing benchmark)	Actual no. of subscribers (28.02.2005) in lakhs		
Haryana	Escotel(Idea)		6.20	5.0	1.9	38.82	35
	Aircel Diglink(Hutch)		6.20	5.0	1.7	222.44	11
	BSNL		6.20	5.0	2.9	85.62	11
	Bharti		6.20	5.0	2.6	78.01	14
		BSNL	2.50	3.0	0.1	1199.15	15
		Reliance Infocomm	2.50	3.0	2.2	83.75	6
		Tata Teleservices	2.50	3.0	0.1		Recently Started Services
UP-W	Escotel(Idea)		6.20	5.0	6.2	53.16	Already Crossed
	BSNL		6.20	5.0	5.3	4.59	Already Crossed
	Bharti		6.20	5.0	3.7	176.24	4
	Hutch South(UASL)		6.20	5.0	1.4		Recently Started Services
		BSNL	2.50	3.0	0.2	24.75	161
		Reliance Infocomm	2.50	3.0	3.3	89.90	Already Crossed
		Tata Teleservices	2.50	3.0	0.1		Recently Started Services
UP-E	Aircel Diglink(Hutch)		6.20	5.0	8.0	98.84	Already Crossed
	BSNL		6.20	5.0	7.2	110.82	Already Crossed
	Bharti(UASL)		6.20	5.0	1.9		Recently Started Services
	Escorts Communications		4.40				Service Not Started
		BSNL	2.50	3.0	0.2	11.90	287
		Reliance Infocomm	3.75	10.0	4.7	79.24	16
		Tata Teleservices	2.50	3.0	0.1		Recently Started Services
Raj	Aircel Diglink(Hutch)		6.20	5.0	3.2	186.78	5
	Hexacom(Bharti)		6.20	5.0	5.0	105.11	Reached
	BSNL		6.20	5.0	3.7	80.99	6
	Escorts Communications		4.40				Service Not Started
		BSNL	2.50	3.0	0.6	275.26	14
		Reliance Infocomm	3.75	10.0	3.6	104.30	17
		Shyam Telelink	5.00		0.3	-4.81	No Benchmark Criteria
		Tata Teleservices	2.50	3.0	0.2		Recently Started Services

Annex. 1.4 Cont'd

Service Area	Mobile Operator		Spectrum Alloted (In MHz)	Subscribers		Current Annual Growth Rate (In %)	Likely time period for crossing the benchmark for allocation of additional spectrum (in months)
	GSM	CDMA		No. of subscribers possible to cater in lakhs (as per existing benchmark)	Actual no. of subscribers (28.02.2005) in lakhs		
MP	Idea		6.20	5.0	5.0	73.54	Reached
	Reliance		6.20	5.0	3.1	40.52	17
	BSNL		6.20	5.0	1.6	4.07	345
	Bharti		6.20	5.0	2.4	124.24	11
		BSNL	2.50	3.0	0.9	206.51	12
		Reliance Infocomm	2.50	3.0	3.6	94.47	Already Crossed
		Tata Teleservices	2.50	3.0	0.1		Service Not Started
		Bharti Telenet Ltd (SurenderLicence w.e.f. 1.10.04) allowed to retain two CDMA carriers (2.5+2.5 MHz) for one year on the name M/s Bharti Cellular Limited	2.50	3.0			License Sureendered
WB&A&N	Reliance		6.20	5.0	1.5	46.59	37
	BSNL		6.20	5.0	2.9	76.84	11
	Bharti		4.40		1.1		Recently Started Services
	Hutch South		4.40		1.1		Recently Started Services
	Dishnet DSL		4.40				Service Not Started
		BSNL	2.50	3.0	0.02	14.61	451
		Reliance Infocomm	2.50	3.0	1.2	234.24	9
		Tata Teleservices	2.50	3.0	0.0003		Recently Started Services
HP	Bharti		6.20	5.0	1.9	147.96	13
	Reliance		4.40		0.3	166.27	No Benchmark Criteria
	BSNL		6.20	5.0	1.0	49.59	47
	Escorts Communications		4.40				Service Not Started
	Dishnet DSL		-				Service Not Started
		BSNL	2.50	1.5	0.0002	-59.52	Negative Growth Rate in Last Year
		Reliance Infocomm	2.50	1.5	0.04	121.01	56
		Tata Teleservices	2.50	1.5	0.0072		Recently Started Services
Bihar	Reliance		6.20	5.0	3.5	39.36	13
	BSNL		6.20	5.0	4.0	70.15	5
	Bharti		6.20	5.0	1.1		Recently Started Services
	Dishnet DSL		-				Service Not Started
		BSNL	2.50	1.5	0.08	263.30	27
		Reliance Infocomm	3.75	5.0	2.0	101.05	15
		Tata Teleservices	2.50	1.5	0.1		Recently Started Services

Annex. 1.4 Cont'd

Service Area	Mobile Operator		Spectrum Alloted (In MHz)	Subscribers		Current Annual Growth Rate (In %)	Likely time period for crossing the benchmark for allocation of additional spectrum (in months)
	GSM	CDMA		No. of subscribers possible to cater in lakhs (as per existing benchmark)	Actual no. of subscribers (28.02.2005) in lakhs		
Orissa	Reliance		6.20	5.0	1.2	17.48	106
	BSNL		6.20	5.0	2.9	101.37	9
	Bharti		6.20	5.0	1.2		Recently Started Services
	Dishnet DSL		4.40				Service Not Started
		BSNL	2.50	1.5	0.01	11.10	545
		Reliance Infocomm	3.75	5.0	1.2	68.43	33
		Tata Teleservices	2.50	1.5	0.1		Recently Started Services
Assam	Reliance		6.20	5.0	1.0	82.75	32
	BSNL		6.20	5.0	1.5		Recently Started Services
	Bharti Televenture		1.80				Service Not Started
	Dishnet DSL		4.40				Service Not Started
		BSNL	2.50	1.5	0.1	198.94	34
NE	Reliance		4.40		0.2	132.44	No Benchmark Criteria
	BSNL		6.20	5.0	0.9		Recently Started Services
	Hexacom India Ltd		4.40				Service Not Started
	Dishnet DSL		4.40				Service Not Started
	BSNL				0.0005		No Benchmark Criteria
J&K	BSNL		6.20	5.0	1.5	319.70	30
	Bharti		4.40		0.8		No Benchmark Criteria
	Dishnet DSL		4.40				Service Not Started
		BSNL	2.50	1.5	0.03		Recently Started Services
		Reliance Infocomm	-				No Benchmark Criteria

Annex. 1.5

Projected Subscriber Base and Total Spectrum Requirement in Four Metropolitan Cities for GSM services

Sl.No.	Circle	Spectrum Allotted (In MHz)	Subscriber Base as on 28.2.05 (In Lakhs)	Subscriber Base as on Dec07 (In Lakhs)	Additional Spectrum Req. (In MHz) **MAX**.*	Additional Spectrum Req. (In MHz) **MIN**.**	Total Spectrum Req. (in MHz) **MAX**.	Total Spectrum Req. (in MHz) **MIN.**
1	Delhi	32.40	40.25	104.90	64.60	28.12	97.00	60.52
2	Mumbai	34.20	38.46	87.02	45.80	20.20	80.00	54.76
3	Chennai	24.80	15.15	33.62	8.40	7.76	33.20	32.36
4	Kolkata	28.40	13.86	59.56	26.60	15.72	55.00	44.12

**2x1 MHz for every one lakh additional subscriber*
*** 2x0.36 MHz for every one lakh additional subscriber*

Annex. 1.6

Projected Subscriber Base and Total Spectrum Requirement in Four Metropolitan Cities for CDMA services

SLNO	Circle	Spectrum Alloted (In MHz)	Subscribers Base as on 28.02.05 CDMA (In Lakhs)	Subscribers Base as on Dec. 2007 (In Lakhs)	CDMA additional requirement (In MHz)		Total Spectrum requirement (In MHz)	
					MAX.	MIN.	MAX.	MIN.
1	Delhi	12.50	15.95	41.57	17.50	3.75	30.00	16.25
2	Mumbai	15.00	12.18	27.55	10.00	1.25	25.00	16.25
3	Chennai	11.25	5.31	11.79	5.00	1.25	16.25	12.50
4	Kolkata	10.00	5.27	22.66	12.50	1.25	22.50	12.50

PS:- The present spectrum allocation criteria is different for CDMA and GSM operators. However, we are of the opinion that efforts should be made to gradually move in the direction wherein the spectrum allocation criterion is technology neutral. It is, therefore, recommended that the present spectrum allocation criterion may be reviewed such that while retaining the subscriber base approach, the quantum and steps for additional spectrum allocation are technology neutral. If the GSM spectrum allocation criterion is applied to the projected CDMA subscriber base than the maximum and minimum additional spectrum requirement in Delhi would be in the range of 2x9 MHz and 2x26 MHz.

Annex. 2.1

Techniques of Measuring the Efficient Utilisation of Spectrum

Other ways of expressing spectral efficiency:

- *Effective Reuse* – describes how often the same frequency is re-used in the network. Effective re-use is equal to the total number of frequencies used divided by the average number of TRx per sector. This measure does not indicate if the radio resource is fully loaded.

- *Fractional Load* - measures the efficiency of frequency hopping networks in relation to effective frequency re-use.

- *Frequency Allocation Re-use (FAR)*– indicates how closely the frequencies are actually re-used in a network. FAR equals the total number of frequencies used divided by the average number of frequencies in the Mobile Allocation lists* (MA lists). This measures the ability of hopping networks to implement tight re-use. If fractional loading is not used then frequency allocation re-use is the same as effective re-use.

- *Frequency Load* – indicates how much traffic is carried by the available spectrum. Frequency Load is equal to the busy hour timeslot occupation multiplied by the Fractional Load.

- *Effective Frequency Load* – quantifies the loading of each frequency in the system.

**The frequency-hopping list as per the Mobile Allocation list.*

Annex. 2.2

Increased Revenues for Government after revenue share was introduced due to higher growth rate in mobile services

Statement of Revenue to be received by Central Government							
	All circle and Metro License					(Rs.in Crore)	
		1	2	3	4	5	6
	YEAR	Licence fee under old regime	Licence fee under new regime (post NTP 99)	License Fee as per 2001 Regime	License Fee as per 2003 Regime	service tax(Estimated)*	License Fee+Service Tax
1	1999-00	1603	275	209		110	319
2	2000-01	2270	619	468		248	716
3	2001-02	2734	793	602		317	919
4	2002-03	2455	872	657		349	1006
5	2003-04	2470	1727	1296		1105	2402
6	2004-05	2511	2698		1666	1727	3392
7	2005-06	2591	4586		2831	2935	5766
8	2006-07	2680	7796		4813	4989	9802
		19314	**19366**	**3234**	**9309**	**11780**	**24323**
				12543			

Rate of Service Tax Taken as 5% up to 13.5.2003 & 8% thereafter (Presently 10%)

**Estimated Service Tax (based on estimated Gross Revenue)*

Annex. 2.2 a)

Statement of Estimate of Government Levies from License Fee, Spectrum Fee and Service Tax on Telecom Services

Rs Crores

1	2	3	4	5	6	7	8
Year	**Gross Revenue**	**Pass through**	**Adjusted Gross Revenue**	**License Fee***	**Service Tax #**	**Spectrum Charge &**	**Total Govt. Levies**
2002-03	48000	7200	40800	4080	2040	206	**6326**
2003-04	61000	9150	51850	4770	4148	434	**9353**
2004-05	80000	12000	68000	6256	6800	856	**13912**
2005-06	100000	15000	85000	7820	8500	1530	**17850**

** Weighted Average License fee of Industry is 9.2%and applied on Adjusted Gross revenue. License Fee for Basic Telephone, Cellular Mobile, NLD, ILD, Internet services etc varies from 0% to 15%.*

***#** Service tax applied on Adjusted Gross revenue as it is not charged on Interconnection Usage Charges, etc. Service Tax rate for 2002-03 - 5%, 2003-04-8%, 2004-05 & 2005-06 -10%.*

& Spectrum Fee varies from 2% to 4%, depending on amount of allocated spectrum. Weighted Average Spectrum Fee for years 2002-03 to 2005-06 is estimated as 3%, 3.4%, 3.8% and 4% respectively. Contribution of Adjusted Gross Revenue from wireless services for corresponding period is estimated to be 17%, 25%, 33% and 45% respectively.

Annex. 2.3

Regulatory Levies on mobile services in some developing countries

	Pakistan	Sri Lanka	China	India
Regulatory charges	**%age of revenue**	**%age**	**%age of revenue**	**%age of revenue**
Service Tax, GST	GST	VAT	3%	8%+ GST
License Fee	0.5% + 0.5% R&D	0.3% turnover (t.o.) + 1% of capital invested (inv)	Nil	5~10%
Spectrum Charge	Cost recovery	~ 1.1% of t.o.	~ 0.5%** (China Mobile)	2~6%*
USO	1.5%	Nil (only on ISD calls)	Nil	Incl in license fees
Total Regulatory charges	2.5% +GST+ cost recovery	=1.3% t.o.+1% inv+ VAT	~ 0.5 % + 3% (Tax)	15% ~ 24% + GST

* *Backbone spectrum charges extra*
* * *Estimated from spectrum fees & revenue of China Mobile*

Annex. 2.4

Service Tax Collections since 2001 *(Fig. in Crores)*

Service Tax Collections	Telephone	Insurance	Brokerage	Others	Total Service Tax	Growth	Growth (%)
2001-02	1,712	442	273	1,173	3,600	1,060	42
2002-03	2,129	677	293	1,901	5,000	1,400	39
2003-04	3,024	1,044	378	3,854	8,300	3,300	66
2004-05	4,470	1,399	679	7,602	14,150	5,850	70
2005-06B	5,186	1,623	788	9,903	17,500	3,350	24

B- Budget Target
Source:- The Economic Times dated 4th March 2005

Annex. 2.5

Methodology for benchmarking for efficient utilisation of spectrum in terms of Erlangs/MHz/Sq.Km

ITU-R Recommendations SM.1046-1 on "DEFINITION OF SPECTRUM USE AND EFFICIENCY OF A RADIO SYSTEM" mentions

"Efficient use of spectrum is achieved by (among other things) the isolation obtained from antenna directivity, geographical spacing, frequency sharing, or orthogonal frequency use and time-sharing or time division and these considerations reflected in definition of spectrum utilization. Therefore, the measure of spectrum utilization – spectrum utilization factor, U, is defined to be the product of the frequency bandwidth, the geometric (geographic) space, and the time denied to other potential users:

$$U = B \cdot S \cdot T$$

where:

B : frequency bandwidth

S : geometric space (usually area) and

T : time.".

Also, the recommendation mentions

"*According to the definition of SUE (or spectrum efficiency as a shortened term) of a radio communication system, it can be expressed by:*

$$SUE = \frac{M}{U} = \frac{M}{B \times S \times T} \qquad (2)$$

where:

M : amount of information transferred over a distance"

For cellular mobile systems, it can be expressed as

$$SUE \frac{\text{(Traffic in Erlangs)}}{\text{(Amount of Spectrum in MHz) X (Area in Sq. Kms)}} \Big| \text{For a specified GoS}$$

The time factor can be taken as 1 as the system operates continuously.

This definition takes into account the traffic carrying capacity of a technology per MHz and the capability of the technology to replicate the available spectrum in the unit area for a specified Quality of Service. However, it does not take into account the cost involved in the implementation of individual technologies, and hence does not take into account any economic aspect of spectrum utilisation. Also, this definition presupposes that all the required QoS parameters are met at all times.

Annex. 3.1

1. Procedure for Spectrum allocation to GSM operators

- Service Providers could be considered for allocation beyond 2 X 6.2 MHz on achieving a subscriber base of 5 lakhs;
- Service Providers could be considered for allocation beyond 2 X 8 MHz on achieving a subscriber base of 10 lakhs;
- Service Providers could be considered for allocation beyond 2 X 10 MHz on achieving a subscriber base of 12 lakhs;

2. Spectrum allocation criteria to CDMA operators

Criteria for release of 3rd CDMA carrier:

Service area	**The minimum subscriber base required for allotment of 3rd carrier**
Metro Service Area Delhi & Mumbai Chennai & Kolkata	 3 Lakhs 2 Lakhs
Telecom Circle Service Area Category "A' Circles Category 'B' Circles Category 'C' Circles	 4 Lakhs 3 Lakhs 1.5 Lakhs

Criteria for release of 4th CDMA carrier:

Service area	**The minimum subscriber base required for allotment of 4th carrier**
Metro Service Area Delhi & Mumbai Chennai & Kolkata	 10 Lakhs 6 Lakhs
Telecom Circle Service Area Category "A' Circles Category 'B' Circles Category 'C' Circles	 12 Lakhs 10 Lakhs 5 Lakhs

The SDCA wise assignment of 3rd carrier will continue, in case of any specific operator who may establish technical reasons for not achieving the revised norms but having at least achieve the earlier prescribed norms i.e. 2 lakh subscriber in a SDCA, on the basis of which other operators have been given 3rd CDMA carrier.

Similarly, the SDCA wise assignment of 4th carrier will continue, where customer base has surpassed 3 lakhs. However, in addition to the subscriber base criteria, it shall also be ensured that the density of BTS by the Service Provider should be more than 16 BTS per hundred square Kms. for the largest (area-wise) city of the SDCA where the 4th CDMA carrier is requested.

Source: DOT letter No. J-14025/200(17)/2004-NT dated 10-12-04

Annex.-3.2

DOT vide its letter No. 20-232/2004-BS-III dated 17th March 2004

Government of India
Ministry of Communications and Information Technology
Department of Telecommunications
Sanchar Bhawan, 20 Ashok Road, New Delhi 110 001

No.20-232/2004-BS.III Dated, the 17 March 2004

To

The Director General,
Cellular Operators Association of India,
14,Bhai Veer Singh Marg,
New Delhi – 110 001

Sub: Guidelines for Mergers & Acquisitions in a Service Area.

Sir,

With reference to your letter No. TVR/COAI/024 dated Ist March 2004 addressed to the Secretary, Department of Telecommunications on the above subject, I am directed to state as under:

1. The duration of license of the merged entity will be equal to the duration of License of acquiring company. For example, if license 'B' is merging with License "A", then the duration of License 'A' will be applicable for merged entity.
2. Ceiling of spectrum specified in para 6 of the guidelines dated 21.02.2004 is technology neutral.
3. (i) The operator having a license or token presence in a service area cannot be excluded and is to be counted as one player as
   (ii) Coverage area is not a criteria for determining market share.
4. The spectrum charges shall be calculated for the total spectrum held by the merged entity. The suggestion that post merger, the usage charges could be pegged at the higher percentage of the two being paid by them prior to merger and acquisition, cannot be accepted. TRAI is also seized of the matter regarding spectrum charges and efficient utilization after considering the recommendations of TRAI on the subject, Government may review the spectrum charges.
5. The spectrum charges shall be calculated for the total spectrum held by the merged entity as Govt. has already decided that spectrum charges shall be same for CDMA and GSM.
6. The Guidelines are for merger of license within the same service area, UAS Licensee cannot split its fixed line and mobile services under a single license and merge its mobile business with another operator in same service area. Thus, it is not permitted under the existing Guidelines.

Yours faithfully,

-sd-
(Govind Singhal)
Director (BS.III)

Copy to:
1. Secretary, TRAI New Delhi

Annex. 3.3

HHI Calculations for different service areas

City	Year			
	2001	2002	2003	2004
DELHI	0.47	0.38	0.24	0.22
MUMBAI	0.42	0.33	0.28	0.22
CHENNAI	0.50	0.40	0.28	0.20
KOLKATA	0.51	0.48	0.47	0.26
MH	0.52	0.33	0.25	0.21
GUJ	0.54	0.38	0.24	0.22
AP	0.50	0.36	0.20	0.19
KTK	0.51	0.37	0.22	0.22
TN	0.50	0.33	0.25	0.24
KERALA	0.51	0.31	0.22	0.21
PJB	1.00	0.47	0.30	0.27
HR	0.73	0.34	0.23	0.20
UP(W)	1.00	0.52	0.28	0.23
UP(E)	0.51	0.54	0.33	0.29
RAJ	0.65	0.46	0.26	0.22
MP	0.58	0.35	0.21	0.20
WB&A&N	1.00	0.68	0.60	0.25
HP	0.54	0.42	0.42	0.45
BIHAR	1.00	0.76	0.38	0.31
OR	1.00	0.68	0.37	0.30
ASSAM	1.00	1.00	0.92	0.50
NE	1.00	1.00	0.93	0.67
J&K		0.00	0.86	0.55

Annex. 3.4

Analysis of HHI for various service areas

Detailed analysis for the four consecutive years of Indian Mobile Market may be drawn as follows:

- **2001 - HHI of Mobile market in India saw maximum fluctuations when compared circle-wise**

  - While areas covered under circles 'C' and 'B', like Bihar, Orissa, Assam, North East, Punjab, UP (West), WB&A&N witnessed Monopoly with single operator capturing the entire market, markets of circles like Haryana and Rajasthan had one of the two operators holding a major share in the market;

  - Maximum number of circles, like Chennai, Kolkata, Maharashtra, Gujarat, AP, Karnataka, TN, Kerala, UP (E), MP and HP had two operators sharing almost equal shares of the market. Since the number of operators sharing the market was limited to two or three, the market was in Oligopoly, where the HHI ranged from 0.50 to 0.59.

- **2002 – Circle-wise competition graph continued to fluctuate with the lowest HHI touching 0.31**

  - Areas covered under circle 'C' generally continued to be dominated by a single operator.

  - Circle 'B' witnessed a graph nearing competition where the lowest range touched 0.31 in Kerala that had four operators sharing the market. Other circles covered in circle 'B' had HHI ranging from 0.34 to 0.54 where the market was shared between three operators. The only exception to this trend was WB&A&N where one operator still dominated the market with 80% of the market share.

  - Circle 'A' and 'Metro' witnessed a trend towards competition where the HHI values ranged from 0.33 in Chennai, Maharashtra and TN to 0.48 in Kolkata.

- **2003 – Trend moved towards competition with HHI nearing 0.20 in circles with extensive competition**

  - As in the previous year, 2003 also witnessed operators entering market leading to increase in competition in the mobile market with the HHI touching as low as 0.20.

Annex. 3.4 cont'd

- Circles with low competition also witnessed a trend towards competition, like circle 'C' where HHI witnessed a sharp contrast in values ranging from 0.93 in NE to 0.37 Orissa.

- Circle 'B' also witnessed a trend towards competition with values ranging from 0.21 to 0.33, with the exception of WB&A&N that had HHI of 0.60. Similarly, circle 'A' and 'Metro' also showed almost the same HHI range, i.e. 0.20 to 0.28, with the exception of 0.47 in Kolkata due to two major operators dominating the market.

2004 – HHI approaching 0.33 in all circles

- As per the graph of 2004, except for minor fluctuations in circle 'C' where the values reach a high of 0.67, the HHI primarily revolves around the range 0.22 to 0.33
- As mentioned earlier in Metros, Cat 'A' and 'B' circles. HHI is below 0.24 which indicates a very high level of competition.

Annex. 4.1

One Time Spectrum Charge

Service Area	Entry Fee in UASL Regime	Registration Charge based on the entry fee paid by the new BSO (entered in after 2001)*	Spectrum Charge
Delhi	170.7	8	162.7
Mumbai	203.66	5.82	197.84
Chennai	154	3.22	150.78
Kolkata	78.01	3.57	74.44
MH	189	12.58	176.42
GUJ	109.01	6.4	102.61
AP	103.01	5.6	97.41
KTK	206.83	5.6	201.23
TN	79	4.78	74.22
Kerala	40.54	3.2	37.34
Punjab	151.75	3.2	148.55
Haryana	21.46	1.6	19.86
UP-W	30.55	2.4	28.15
UP-E	45.25	2.4	42.85
Raj	32.25	3.2	29.05
MP	17.45	3.2	14.25
WB&A&N	2.69	0.43	2.26
HP	2	0.32	1.68
Bihar	10	1.6	8.4
Orissa	5	0.8	4.2
Assam	5	0.8	4.2
NE	2	0.32	1.68
J&K	2	0.32	1.68

** As specified by TRAI in Annex.-II in its Unified Licensing Regime dated 13th Jan 2005.*

Annex. 4.2

Annual Charge per MHz on IMT-2000 Spectrum

Circle	Recommended Per MHz Cost (In Crores)	Recommended annual spectrum charge for 5 MHz IMT-2000 2 GHz Spectrum (In Crores)
Delhi	4.73	23.65
Mumbai	3.81	19.05
Chennai	1.28	6.40
Kolkata	2.06	10.30
MH	3.02	15.10
GUJ	3.80	19.00
AP	2.45	12.25
KTK	2.95	14.75
TN	1.76	8.80
Kerala	3.35	16.75
Punjab	3.14	15.70
Haryana	0.46	2.30
UP-W	1.08	5.40
UP-E	1.39	6.95
Raj	1.20	6.00
MP	1.18	5.90
WB&A&N	0.22	1.10
HP	0.37	1.85
Bihar	0.75	3.75
Orissa	0.13	0.65
Assam	0.05	0.25
NE	0.06	0.30
J&K	0.16	0.80

Annex. 5.1

Current Method for Pricing Other Terrestrial Wireless Links

1. The system for calculation of point-to-point and point-to-multi-point wireless links is governed by R=MxWxC, where R is the payable royalty amount, M is determined by the distance the clearance is being sought for, W is determined by the amount of frequency being allocated, and C is the number of RF channels used (twice the number of duplex RF channel pairs). Both M and W are determined by range slabs, such that the multiplier increases significantly as soon as the requirements for the operator cross into the next slab.

2. The most recent definition of the applicable parameters was released by the DOT in Letter No.R-11014/26/2002-LR on April 1, 2003. This letter outlines the parameters as follows:
"5.1 Constant Multiplier M where:
M = 1200 for point to point Microwave Link(s) with end-to-end distance less than or equal to 05 Kms
M = 2400 for point-to-point Microwave Link(s) with end-to-end distance greater than 05 Kms but less than or equal to 25 Kms.
M = 4800 for point-to-point Microwave Link(s) with end-to-end distance greater than 25 Kms but less than or equal to 60 Kms.
M = 9000 for point-to-point Microwave Link(s) with end-to-end distance greater than 60 Kms but less than or equal to 120 Kms.
M = 15000 for point-to-point Microwave Link(s) with end-to-end distance greater than 120 Kms but less than or equal to 500 Kms.
M = 20000 for point-to-point Microwave Link(s) with end-to-end distance greater than 500 Kms.

5.2 Weighting Fact 'W' which is decided by the adjacent channel separation of the R.F. channeling plan deployed where
W = 30 for adjacent channel separation upto 2 MHz
W = 60 for adjacent channel separation greater than 2 MHz, but less than or equal to 7 MHz
W = 120 for adjacent channel separation greater than 7 MHz, but less than or equal to 28 MHz
W = (120) + (30 for each additional 7 MHz Bandwidth or part thereof) for adjacent channel separation greater than 28 MHz"

3. There are a few implications of this overall arrangement. One of these is that the same multiplier would apply to allocations requiring either 8 MHz or 27 MHz. Furthermore, TDD, which uses one channel, is inherently priced lower than FDD, which has one channel each for transmit and receive. For example, an application for TDD spectrum of 20 MHz for a range of 5 km would attract half the royalty payment of an application for FDD spectrum of 2 channels of 10 MHz each for a range of 5 km.

4. For M, the distance factor, implications of the selected slabs effects how operators plan their networks and operations. Today, operators are forcefully limiting their deployments to 5 km radius usage if their technology does not have the ability to reach close to the 25 km mark, as there are no intermediate slabs. Therefore, for a 6 km radius, he would have to pay fees that are the same as that for a 25 km radius.

Annex. 5.2

Proposed Pricing Model for Other Terrestrial Wireless Links

1. One of the substantial points of feedback on the current pricing model was that the slabs used for determining the pricing multiples for both M and W were too drastic and did not reflect the fact that wireless technology is available today that can be tuned to fit the requirements of the end-users. By changing the resulting charge from one large slab to another, users are forced to constrict themselves to artificial performance barriers that may not reflect the most efficient utilization of frequency or the most efficient commercial decisions, either. For example, if a user required a link of 6 km between two locations, his only option was to either pay the full charge for 25 km, thereby creating an incentive for him to ask for more area than he needs, or to take two smaller links under the 5 km ceiling, which in itself also results in paying the same total charge. Likewise, if a user could use more efficient technology that only needed 3 MHz bandwidth of allocation, since the spectrum charges under the current system are the same for 3 MHz and 7 MHz, the user would prefer to pick whichever equipment is cheapest rather than worry about the spectrum utilization efficiency, and thereby occupy a larger portion of the bandwidth than actually required.

2. Referring back to the objectives and goals outlined above, it would imply that a more gradual relationship should exist between the values of M and W required by the user and the related price being charged. The sample of charges presented in Table 5-1 in Chapter 5 demonstrates the major jumps in price at each new slab in the current pricing model.

3. Since M is the distance factor, it would be logical to make it act similar to the way charging is done in wire-line leased circuits. This treatment would also simulate the current slab-based charging system where the higher slabs maintain the same price multiplier for a wider range of values of M. In terms of incentives for efficient usage, having a constant increasing factor encourages users to only apply for what they actually need to minimize cost while not artificially limiting available technology and usage patterns to slab limits. Having a pure linear relationship between M and the price would not produce the above-discussed characteristics. If on the other hand, one uses a square root function, the resulting factor is similar to the above desired pattern. Therefore, for M, it would seem logical that the price should be related to a square root of the actual value of M. This means that there is a higher loading on the initial distances covered with a decreasing change in charge per km as the distance increases.

4. With W representing the amount of spectrum being allocated to the user, the incentive should be to request the least amount of spectrum by using the most efficient technologies. At present, the slab-based system uses the same multiplier for very wide ranges of spectrum usage allowing users to use inefficient communication links and inefficiently occupy bandwidth. Therefore a constantly

increasing function should be applied to W so that there is incentive to only occupy spectrum as needed, and to minimize overall charges by using more efficient equipment for wireless links. An exponential or square function would be too steep as the increasing slope would quickly become drastic, whereas a linear slope is most likely to effectively capture the trade-offs and incentives for efficient usage. Therefore, W should be applied as a linear slope multiplier.

5. The value of C does not require change as it accurately reflects usage pattern and allocated spectrum requirements.

6. The above analysis therefore suggests that the equation for R should take shape along the following lines, where R is described as being proportionate to the factors M, W and C in the following fashion:

$$R \alpha (\sqrt{M}) * W * C$$

where each of M and W represent their actual values in km and MHz, respectively

In the present pricing model, for the charges of M and W the actual values of distance and bandwidth values were not used, but rather a factor was empirically assigned to each slab of M and W. This factor was used in calculating the spectrum charge (please refer to Annex 5.1 for details). Therefore, in the proposed methodology, where actual values of M and W are being used in the calculation, a constant multiplier A would need to be applied to this equation. The objective here would be to bring the proposed equation's levels at par with current levels, while at the same time accomplishing the goal of promoting more efficient usage of resources. Therefore, the equation would be:

$$R = (\sqrt{M}) * W * C * A$$

where each of M and W represent their actual values in km and MHz, respectively, and A is a constant multiplier

7. To arrive at the value of A, one must do a comparison of the new resulting values against the current charging levels. Taking the median of the resulting difference ratios as the constant A then would raise the overall charging levels to equivalent to current prevailing ones. Below is a series of tables demonstrating this methodology. While the tables only display a limited number of sample values for M and W, the analysis to arrive at the Authority's conclusions was done with a much larger sample to ensure that no skewing occurred because of the selected inputs.

Table 1 – Charges for Spectrum Under Proposed Methodology Without Constant Multiplier A (Rs.)

		M									
		0.25	**0.50**	**1**	**5**	**6**	**10**	**20**	**50**	**100**	**200**
W	**0.25**	0.1	0.2	0.3	0.6	0.6	0.8	1.1	1.8	2.5	3.5
	0.50	0.3	0.4	0.5	1.1	1.2	1.6	2.2	3.5	5.0	7.1
	1	0.5	0.7	1.0	2.2	2.4	3.2	4.5	7.1	10.0	14.1
	2	1.0	1.4	2.0	4.5	4.9	6.3	8.9	14.1	20.0	28.3
	3	1.5	2.1	3.0	6.7	7.3	9.5	13.4	21.2	30.0	42.4
	4	2.0	2.8	4.0	8.9	9.8	12.6	17.9	28.3	40.0	56.6
	5	2.5	3.5	5.0	11.2	12.2	15.8	22.4	35.4	50.0	70.7
	10	5.0	7.1	10.0	22.4	24.5	31.6	44.7	70.7	100.0	141.4
	15	7.5	10.6	15.0	33.5	36.7	47.4	67.1	106.1	150.0	212.1
	20	10.0	14.1	20.0	44.7	49.0	63.2	89.4	141.4	200.0	282.8
	25	12.5	17.7	25.0	55.9	61.2	79.1	111.8	176.8	250.0	353.6
	50	25.0	35.4	50.0	111.8	122.5	158.1	223.6	353.6	500.0	707.1

Note: C is assumed to be equal to 1 in this calculation.

Table 2 – Ratio of Charges for Spectrum Between Current and Proposed Methodology Without Constant Multiplier A (000's)

		M									
		0.25	**0.50**	**1**	**5**	**6**	**10**	**20**	**50**	**100**	**200**
W	**0.25**	288	204	144	64	118	91	64	81	108	127
	0.50	144	102	72	32	59	46	32	41	54	64
	1	72	51	36	16	29	23	16	20	27	32
	2	36	25	18	8	15	11	8	10	14	16
	3	48	34	24	11	20	15	11	14	18	21
	4	36	25	18	8	15	11	8	10	14	16
	5	29	20	14	6	12	9	6	8	11	13
	10	29	20	14	6	12	9	6	8	11	13
	15	19	14	10	4	8	6	4	5	7	8
	20	14	10	7	3	6	5	3	4	5	6
	25	12	8	6	3	5	4	3	3	4	5
	50	12	8	6	3	5	4	3	3	4	5

Note: C is assumed to be equal to 1 in this calculation.

8. Prior to calculating the median, an analysis of the resulting values above should be considered. Particularly, the high differences in the lower ranges of M and W are driven primarily due to the fact that the new proposed equation is created purposely to provide incentives for more conservative and efficient usage of spectrum. Furthermore, the previous system of pricing slabs had sharp increases when the value of M crossed over 5 km and the value of W was

greater than 2 MHz. Therefore, using the ratios of differences between the old and proposed pricing system for values of M ≤ 5 km and W ≤ 2 MHz in the calculation for a median ratio would yield a skewed value and would not help in meeting the objectives of the Authority stated above for how this spectrum should be priced. At the same time, for values of M and W on the higher end, one would like to see that the new charges are somewhat higher than the current charging level so that there is a disincentive for inefficient use and that where possible wire-line infrastructure is used to replace the wireless link. Therefore, the median value is calculated based on the values that fall within the region of the shaded box in the bottom right hand corner of Table 2 above. Based on this analysis, the median value is calculated to be 6,724, therefore the constant multiplier A would be set equal to 6,724. A sample of the resulting spectrum charges with this value of A introduced is indicated below in Table 3.

Table 3 – Charges for Spectrum in Proposed Methodology With the Constant Multiplier A (Rs. 000's)

		M									
		0.25	**0.50**	**1**	**5**	**6**	**10**	**20**	**50**	**100**	**200**
W	**0.25**	1	1	2	4	4	5	8	12	17	24
	0.50	2	2	3	8	8	11	15	24	34	48
	1	3	5	7	15	16	21	30	48	67	95
	2	7	10	13	30	33	43	60	95	134	190
	3	10	14	20	45	49	64	90	143	202	285
	4	13	19	27	60	66	85	120	190	269	380
	5	17	24	34	75	82	106	150	238	336	475
	10	34	48	67	150	165	213	301	475	672	951
	15	50	71	101	226	247	319	451	713	1,009	1,426
	20	67	95	134	301	329	425	601	951	1,345	1,902
	25	84	119	168	376	412	532	752	1,189	1,681	2,377
	50	168	238	336	752	824	1,063	1,504	2,377	3,362	4,755

Note: C is assumed to be equal to 1 in this calculation.

9. Table 4 below compares the present charging regime with the proposed scheme, including the constant multiplier. One can see that while there is definitely an advantage given for lower bandwidth and distance circuits because the proposed charge is a small percentage of the charge in the current mode, while in the higher ranges of M and W, the percentage charged in the proposed methodology increases beyond 100% of the current charges. This indicates that the new charging regime provides heavy incentive for more efficient usage of spectrum while increasing the costs of less efficient links, thereby further discouraging their usage. **Furthermore, as expected, when analyzing the ratios of new prices to former prices presented above, the calculated median comes to 100%, demonstrating that overall levels for the former system and the new system are indeed relatively equivalent.**

Table 4 – Proposed Methodology With Constant Multiplier A as a Percentage of Charges for Spectrum in Current Methodology

		M									
		0.25	**0.50**	**1**	**5**	**6**	**10**	**20**	**50**	**100**	**200**
W	**0.25**	2%	3%	5%	10%	6%	7%	10%	8%	6%	5%
	0.50	5%	7%	9%	21%	11%	15%	21%	17%	12%	11%
	1	9%	13%	19%	42%	23%	30%	42%	33%	25%	21%
	2	19%	26%	37%	84%	46%	59%	84%	66%	50%	42%
	3	14%	20%	28%	63%	34%	44%	63%	50%	37%	32%
	4	19%	26%	37%	84%	46%	59%	84%	66%	50%	42%
	5	23%	33%	47%	104%	57%	74%	104%	83%	62%	53%
	10	23%	33%	47%	104%	57%	74%	104%	83%	62%	53%
	15	35%	50%	70%	157%	86%	111%	157%	124%	93%	79%
	20	47%	66%	93%	209%	114%	148%	209%	165%	125%	106%
	25	58%	83%	117%	261%	143%	185%	261%	206%	156%	132%
	50	58%	83%	117%	261%	143%	185%	261%	206%	156%	132%

Note: C is assumed to be equal to 1 in this calculation.

10. Examining the above results in Table 4 further indicates that while the charges under the new regime increase as M and W increase, they do not increase uniformly in comparison to the prices under the current regime. This is because the new system defines a gradual system of pricing, whereas the current pricing model is based on pricing slabs. Therefore, there will be instances when the price change is somewhat discontinuous and even instances where comparative percentage is increasing for some values, but decreasing immediately after that when a certain threshold is crossed. For example, for W = 5 MHz, as the value of M increases in kilometres, the percentage price comparison increases rapidly up to M = 5 km and reaches a level at which it is virtually equivalent to the previous charging scheme. Immediately after M = 5 km, this percentage value drops again and then increases until M = 20 km, and again drops after that. This type of behavior is demonstrated because of the gradual nature of price increase that has been introduced with the proposed equation. It should be noted that M = 5 km and M = 25 km are cutoff points for two of the pricing slabs for M in the current pricing model.

11. Having established the base case, the next set of factors to consider is the protection, availability, demand and viability of usage of spectrum. These factors are influenced by three key drivers which are whether the spectrum is shared, the population density of the geography the wireless link is being used in, and the specific band that has been allocated.

12. For the first driver, sharing of spectrum, a discount should be given on spectrum that is allocated for technologies that allow others to also use the same spectrum in the same geography for their own wireless links. While, in the limit,

this would be de-licensed spectrum, as in the case of WiFi discussed above, there are platforms that are not amenable to de-licensing and abiding by the restrictions typically defined for de-licensed spectrum and the resulting characteristics. On the other hand, these technologies can still support multiple distinct operators and links in shared spectrum. As in the situation of CorDECT, the Authority advocated that an assumption of at maximum four distinct operators in any given area should be assumed. Likewise, for shareable spectrum and technologies a maximum value should be considered, and a proportionate discount given from the applicable charge. In this case one could assume that in more attractive markets, there would be many simultaneous operators in similar geographies using the same spectrum for wireless links. The number could reach well over 4, implying that each should only pay 25% of the actual price. On the other hand, in many instances, even as the market develops, the number is not likely to be above 2. Therefore, taking an average of 3 implies that spectrum usage on a non-interference, non-protection and non-exclusive basis should be priced at 33% of the total applicable spectrum charge. This new factor can be called S, which will be either 1.00 or 0.33.

13. For the second driver, the population density of the geography where the spectrum is being taken, again a discount should be given for deploying infrastructure outside of major districts where density per square km is high. A similar practice is followed by the Brazilian regulator, ANATEL. This is based on a few reasons including that there is typically less demand in areas with less population density, since less population is covered by the same signal it reduces the commercial recoverability, and that this discount would create incentives for further communications infrastructure build-out in those areas, thereby also meeting rural development objectives. According to the 2001 census there are 593 districts in the country, with population density ranging from 2 people per sq. km. (Lahul & Spiti in Himachal Pradesh) to 29,395 people per sq. km. (North East Delhi).

14. When looking at the statistical distribution of population density values, the first major cutoff point comes at 2,000 people per square km. The top 20 districts in the country above this value of 2,000 include all of the metros and a few other major districts. For these geographies, it is the view of the Authority that there should not be any discount as these are the areas that are likely to have the highest demand, and where because of the population covered with a signal, have higher potential recoverability of charges. Table 5 below lists these districts for reference purposes.

Table 5 – Population Density of Top 20 Districts in India as per Census of India 2001

State / Union Territory	District	Pop Density (Persons per Sq. Km.) 1991	2001
West Bengal	North Twenty Four Parganas	1,779	2,181
Pondicherry	Pondicherry	2,098	2,534
West Bengal	Haora	2,542	2,913
Karnataka	Bangalore	2,210	2,979
Pondicherry	Mahe	3,716	4,091
Delhi	South West	2,583	4,165
Delhi	New Delhi	4,791	4,909
Delhi	North West	4,042	6,471
Chandigarh	Chandigarh	5,632	7,903
Delhi	South	6,012	9,033
Delhi	North	11,471	12,996
Delhi	West	11,116	16,431
Andhra Pradesh	Hyderabad	14,497	16,988
Maharashtra	Mumbai (Suburban)	15,137	19,255
Maharashtra	Mumbai	20,222	21,190
Delhi	East	15,986	22,637
Tamil Nadu	Chennai	22,077	24,231
West Bengal	Kolkata	23,783	24,760
Delhi	Central	26,261	25,760
Delhi	North East	18,088	29,395

15. For other districts, a discount should be given to promote telecom operators to quickly deploy telecom infrastructure in those areas by significantly reducing the cost of spectrum. The Authority is of the view that no more than a 50% discount should be given for any district, even the least populous. It is therefore proposed that a linear equation is applied which links the population density inversely to the discount applicable for spectrum charges. This equation would be based on the starting point of 2,000 people per square km, for which there is no discount, and the lowest possible density value approaching 0, for which there should be 50% discount. Therefore, the discount factor P would be calculated as follows:

$$P = 0.5 \times \left(1 - \frac{population\ density}{2{,}000}\right)$$

If more than one district is crossed or covered by the spectrum that has been allocated, the average of the discount factors for the various districts should be taken.

16. Finally, the last driver mentioned above is that of which specific band is allocated for the wireless link. It would be recalled that one of the objectives of the Authority would be to reduce the demand for spectrum in what is considered to be high value and high demand bands where many technology platforms are vying for allocation, and promote usage in high frequency bands that have less demand. For operators, there are actually many disadvantages to use those bands because of less attractive propagation characteristics, typically higher allocation requirement to achieve the same data throughput rates, and sometimes substantially more expensive equipment. To counteract this, spectrum can be priced in such a way that discounts are given as higher frequency bands are used, starting at a base level above 3 GHz. The discounts would start small, but become substantial for very high frequency bands. This factor for the allocated band can be labeled B. As in the case of the discount factor P, the Authority is of the view that no more than a 50% discount should be given for any band, even of the highest frequency. It is therefore proposed that a linear equation is applied which links the band being allocated (in MHz) to the discount applicable for spectrum charges. This equation would be based on the starting point of 3 GHz (3000 MHz), for which there is no discount, and at the high end 23 GHz, for which there should be 50% discount. The value to be taken in the equation should be the center of the frequency being allocated for both TDD and FDD-based allocation, even though the center frequency may fall in the FDD duplex guard, which has not been allocated. Therefore, the discount factor B would be calculated as follows:

$$B = 0.5 \times \left(\frac{center\ \ frequency\ of\ \ allocation - 3{,}000}{20{,}000} \right)$$

17. In addition to the core spectrum charge, there is an additional charge for each transceiver station beyond the first two within the approved coverage area. The feedback received from the industry was that this system can continue if there is an alternative option for acquiring spectrum on a geography-wide basis if the number of subscribers using a particular product / service will be high. The concern of the industry was that to provide an end-customer service even the current level of Rs. 1,000 per year per additional transceiver station (base station or user terminal) would be significant when the number of subscribers (user terminals) reached the thousands and tens of thousands, and it would also increase tariffs paid by customers by approximately Rs. 83 per month. As stated in Section 5.6 of Chapter 5, this aspect will be discussed in a consultation paper to be issued by the Authority on spectrum issues outside the ambit of this recommendation.

18. For the time being, the system of Rs. 1,000 per each additional transceiver station should continue, but with one minor modification. The level of the charge should be revised to a lower level in areas where the overall license fee is very low based on the modifications discussed above. Therefore, this

charge should be capped at no more than 10% of the overall spectrum charges for an area and / or link. This percentage should be calculated after applying the various factors discussed above.