Spectrum Allocation and Spectrum Management

Comments on spectrum strategy for the expansion of cellular mobile networks in India

July 2004

Executive Summary

As India's mobile telecommunications sector continues to experience significant growth, the method of assigning spectrum will be increasingly important in assuring efficient use, equitable distribution among operators of mobile phone services, and capacity to meet teledensity objectives and consumer demand. These imperatives argue for some modification of the current spectrum management process, especially to foster growth of spectrally-efficient and high-capacity mobile services such as CDMA.

Principal improvements to the system include assigning spectrum in sufficient and equal quantities – at least 2 x 15 MHz per operator – in contiguous blocks. Such blocks would provide sufficient bandwidth for network development and would improve overall efficiency. Assignments would best be made in a single step, enabling operators to plan their networks and investments effectively.

Choice of band is also important. CDMA systems are used worldwide in the band 1850 – 1910 MHz / 1930 – 1990 MHz: therefore, existing, cost-effective equipment is readily available for use.

Enacting these changes may require relocation of existing users, but this process can be phased, with minimum impact to the relocated users and with minimal costs covered through license fees. Ultimately, more efficient spectrum management will drive higher-capacity service development and diffusion to all areas of India.

1. Scope and Aims of the Study

Since their introduction, the market for mobile communications in India has experienced huge growth. As seen in many other countries, this growth has exceeded that of fixed line telecommunications by many times. As a result, the limited amounts of spectrum initially identified for such systems is rapidly being exhausted, and may soon constrain further growth.

The introduction of CDMA systems has resulted in a marked increase in both competition and coverage of mobile networks. This technology has been deployed in many other countries, and enjoys the benefits of a wide choice of suppliers and cost-effective equipment. This study examines the deployment of CDMA, and identifies the advantages that it enjoys.

This study also examines the options for increasing the amounts of spectrum available for all mobile systems in India, and identifies the approaches taken in other parts of the world. A series of recommendations is drawn from these approaches, noting the particular requirements of the Indian market.

2. Status of CDMA Around the World

2.1. A Brief History of Cellular Systems and CDMA

The USA and some Nordic countries first introduced mobile phones in around 1982, operating in frequency bands around 800 MHz. In the UK, France and Germany, mobile phone service began several years later, around 1985. These systems used analogue technologies, and all used slightly different technical standards, thereby preventing roaming from one country to another. These systems are commonly known as "first generation".

In 1992, Europe began to introduce a common digital system for mobile phones in standardised frequency bands, called GSM900. By 1994, there were also GSM1800 systems in a higher standardised band. These systems allowed roaming to other countries, and were known as "second generation". GSM has become widely adopted in many parts of the world.

In 1993, the Government of the USA chose to auction spectrum for second-generation systems, but looked for new frequency bands since the bands around 900 MHz were congested with existing applications. The bands chosen were 1850 - 1910 MHz, paired with 1930 - 1990 MHz, and were auctioned in slices of varying bandwidth and for different regional areas of the USA[1]. The auctions permitted the winner to use any technology they wished; as a result, at least four different technologies were deployed including the first commercial CDMA mobile standard called IS-95 (now commonly known as “CDMAone”). It is relevant that some of the auction winners already operated networks at 800 MHz, and they gradually upgraded their old networks to use the newer technologies including CDMA.

The success of these mobile systems can now be seen in terms of customer numbers: In Sweden and Finland, more than 90% of the population has a mobile phone. Across Europe as a whole, approximately 70% of the population subscribes to a mobile phone service. In the USA, about 60% of the population subscribes to the service. Furthermore, in most markets the growth of mobile services has greatly exceeded the growth of fixed telephony, and the numbers of mobile phones now exceed the numbers of fixed lines.

2.2. Standard Frequency Bands for Mobile Systems

When analogue cellular systems were first introduced in the 1980s, the technologies were developed according to locally-defined standards and were established in different bands according to local availability of spectrum. As the success of these systems grew, it became apparent that the spectrum capacity of these networks was insufficient for the demand, and capacity needed to be drastically increased. Moreover, many users desired the flexibility to take their phones with them when they travelled outside of their home city and the lack of wider equipment standardisation prevented this.

As a result, regional and international telecom bodies such as Organization of American States’ CITEL, the International Telecommunication Union (ITU) and the European Conference on Post and Telecommunications (CEPT) began discussions to harmonise frequency bands for cellular systems. However, since every country has a slightly different usage of the radio spectrum, this proved to be a very difficult task. In 1992, the World

[1] These areas were known as “Major Trading Areas” (MTA) and “Basic Trading Areas” (BTA), based upon an assessment of the commercial activity within each.

Administrative Radiocommunication Conference (WARC-92) agreed the identification of harmonised bands for third generation systems[2] around 2 GHz.

Cellular systems still operate in a variety of frequency bands around the world, although as the table below shows, these tend to be in specific groups due to the availability of equipment:

Frequency range	Technology commonly used:
450.4 - 457.6 MHz / 460.4 - 467.6 MHz or 478.8 - 486 MHz / 488.8 - 496 MHz	NMT-450, GSM450
824 - 849 MHz / 869 - 894 MHz	AMPS, D-AMPS, IS-95 (CDMAone)
880 - 915 MHz / 925 - 960 MHz	TACS, GSM900
1710 - 1785 MHz / 1805 - 1880 MHz	GSM1800
1850 - 1910 MHz / 1930 - 1990 MHz	IS-95 (CDMAone), D-AMPS, CDMA2000, GSM1900
1920 - 1980 MHz / 2110 - 2170 MHz	CDMA2000, W-CDMA
2500 – 2690 MHz	*(None at present – identified for future implementation)*

Figure 2.1 Common frequency bands used by cellular systems

2.3. Current Deployment of CDMA Systems

Although CDMA systems have been deployed worldwide, their use has varied across different markets. In the Americas and in some parts of Asia (notably South Korea, Japan and Australia), CDMA technology has been one of the dominant systems for supporting mobile networks. It is less prevalent in Europe, the Middle East and Africa, where GSM has been the principal technology for second-generation networks.

(Annex 1 details the deployment of CDMA technologies in the bands noted above)

2.3.1. The Americas

The Americas boast the highest CDMA subscriber base in the world. CDMA enjoyed an early advantage in the region, though GSM systems are also being adopted for second-generation systems.

CDMA systems are widely in use in the US and Canada. In Latin America and the Caribbean, the following countries have also adopted CDMA systems:

> Argentina, Bermuda, Brazil, Chile, Colombia, Dominican Republic, Ecuador, El Salvador, Guam, Guatemala, Haiti, Honduras, Jamaica, Mexico, Nicaragua, Panama, Peru, Puerto Rico, Uruguay, US Virgin Islands, Venezuela.

[2] At the time, the common term for third-generation (3G) mobile systems was “Future Public Land Mobile Telecommunication System” or FPLMTS. In the ITU, it is now commonly known as “IMT-2000”.

2.3.2. Asia-Pacific

The Asia Pacific region represents the second-largest CDMA subscriber base in the world. In this region, the following countries have adopted CDMA systems:

> Australia, Azerbaijan, Bangladesh, Cambodia, China, Fiji, Hong Kong, India, Indonesia, Japan, Kazakhstan, Kyrgyzstan, Malaysia, Mongolia, Myanmar, New Zealand, Pakistan, Philippines, South Korea, Taiwan, Thailand, Uzbekistan, Vietnam.

The largest market is currently South Korea, although recent aggressive deployment in Japan and in China is increasing the subscriber numbers significantly. Within India, the growth of the CDMA networks has been unprecedented, significantly contributing to the 164% growth in mobile telephony during 2003 (as reported by TRAI).

2.3.3. Europe / Middle East / Africa

Europe, the Middle East and Africa account for the lowest proportion of CDMA subscribers, due to the prevalence of GSM technology. However, as third-generation systems are introduced, it is expected that CDMA subscriber rates will increase. In Russia, for example, CDMA technology has been deployed in parallel with second-generation GSM, and has developed a significant share of subscribers.

Other countries in the region that have adopted CDMA systems are:

> Angola, Belarus, Czech Republic, Democratic Republic of Congo, Egypt, Georgia, Israel, Kuwait, Mauritius, Moldova, Nigeria, Poland, Portugal, Romania, Ukraine, Yemen, Zambia.

2.4. Summary

Since their introduction in 1993, CDMA networks have been adopted across the world. The predominant bands for deployment of CDMA are the 800/1900 MHz bands, as pioneered in the USA.

3. Assigning Mobile Spectrum in India: Technical Precedents and Principles

This section examines precedents that have been set in the assignment of spectrum for mobile services, and the underlying technical principles that may guide future assignments in India. In every country in the world, governments are attempting to make best use of this limited resource to introduce innovative mobile communications services. The lessons learned can provide an important guide to the successful development of a mobile communications industry.

Noting the current situation in India, useful precedents have been identified domestically and elsewhere that may inform the assignment of further radio spectrum.

3.1. The Current Situation in India

The Government of India has licensed the introduction of mobile services under two licence classes: the Cellular Mobile service, and the Unified Access service (formerly known as the Basic licence service). Spectrum for each licence class has been assigned under slightly different conditions.

Under the Unified Access Service (UAS) licensing regime, spectrum is assigned as follows:

- 2 x 4.4 MHz initially, up to a maximum of 2 x 6.2 MHz, may be allocated to a TDMA system, or
- 2 x 2.5 MHz initially, up to a maximum of 2 x 5 MHz, may be allocated to a CDMA system.
  (subject to availability).

All spectrum use under the UAS is subject to an annual fee of 2% of annual gross revenue (AGR). The spectrum can be assigned in the following bands, subject to availability:

- 824-844 MHz paired with 869-889 MHz (CDMA systems)
- 890-915 MHz paired with 935-960 MHz (TDMA systems)
- 1710-1785 MHz paired with 1805-1880 MHz (TDMA systems)

Spectrum assignments under the Cellular Mobile licence regime are as follows:

- 2 x 4.4 MHz initially, up to 2 x 6.2 MHz
- If the subscriber base exceeds 500,000 then further spectrum can be sought up to a maximum of 2 x 10 MHz.

Spectrum use under a Cellular licence is subject to annual fees on the following basis:

- 2% of AGR for spectrum up to 4.4 MHz
- 3% of AGR for spectrum up to 6.2 MHz
- 4% of AGR for spectrum up to 10 MHz
- 5% of AGR for spectrum up to 12.5 MHz

The spectrum is available in the bands 890-915 MHz paired with 935-960 MHz, and 1710-1785 MHz paired with 1805-1880 MHz.

The current assignment process has some important benefits, which provide incentives for the development of mobile networks: fees are payable as a proportion of revenue, which reduces costs in the start-up phase, and additional spectrum can be made available to successful networks, provided that it is available.

However, there are also a number of inherent limitations in this process: spectrum is available in different amounts in each of the bands, but equipment for each technology is not available in each band (see section 3.5). Effectively, this means that only 2 x 20 MHz has been made available for CDMA systems, whereas a total of 2 x 100 MHz has been made available for TDMA/GSM systems. Furthermore, the current system of assignment grants spectrum in non-contiguous blocks, which reduces the efficiency of spectrum use.

These points are considered further in the next sections, noting the approaches taken in other countries.

3.2. The Minimum Bandwidth Requirement

Mobile networks in India are constrained by a lack of spectrum, and require much more than the current assignments permit in order to develop their potential.

Many studies have considered the optimal spectrum (bandwidth) allocation for mobile networks, especially those intended to provide multimedia services. In addition to carrying very high volumes of voice calls, mobile networks can provide very high bandwidth connections for multimedia services, and so require much larger amounts of spectrum than early assignments – which did not foresee this need – permitted.

Many countries have adopted allocations of either 2 x 15 MHz or 2 x 20 MHz per operator, to enable the rapid development of high-capacity networks and wide coverage. In the USA, for example, the first so-called “PCS” bands were assigned in blocks of 2 x 15 MHz[3]. In most of Europe, three or four operators in each country have been assigned 2 x 15 MHz or 2 x 20 MHz each for their networks. The availability of spectrum to be assigned in significant blocks has been one of the driving factors in the rapid development of these networks, which now support more than 60% of the population in the USA and 70% of the population across Europe.

In contrast, the current spectrum situation in India is extremely bandwidth-limited. The maximum spectrum available for any network is 2 x 15 MHz for GSM technology, or 2 x 5 MHz for CDMA technology. Such limitations will constrain the development of the mobile networks until sufficient spectrum has been made available.

It is important to note that the USA and Europe enjoyed high teledensities (typically more than 50 lines per 100 population) through extensive terrestrial wired networks prior to the introduction of mobile systems; the development of mobile networks has therefore supplemented the capacity of terrestrial wired networks. In contrast, teledensity has been much lower in India (7 lines per 100 population), and the demand for wired connectivity has

[3] Blocks A and B of the PCS assignments.

not been satisfied. Mobile networks have been instrumental in increasing teledensity and will continue to do so for the foreseeable future. It is vital therefore that sufficient spectrum is made available to serve this demand for connectivity: as a minimum, 2 x 15 MHz should be made available for each operator.

3.3. Need for Block Assignment of Spectrum

Current spectrum practice in India is to assign mobile network channels on an ad hoc basis, as they are available. Mobile networks, however, require contiguous spectrum channels in order to make most efficient use of channels and minimise wasteful guard-bands.

Radio spectrum for mobile networks is usually assigned in blocks, typically of a few megahertz (MHz) each, which can be sub-divided into channels by an operator. To minimise interference between these channels, a network operator designates a certain *guard band*, or fallow spectrum between each channel. In addition, an operator designs its network to avoid placing high-power channels (for large cells) next to low-power channels (for microcells), to further minimise the size of this guard band. Thus the guard band can be minimised between channels when they are used in a single network.

It is impractical, however, to place constraints on the design of one mobile network due to the architecture of another. When adjacent channels are assigned to different operators, a much larger guard band is required, since the physical separation of channels cannot be assured in use.

If multiple channels are interleaved with the networks of two or more operators, therefore, multiple guard bands are necessary to avoid interference. This both increases the overall amount of spectrum required, and reduces the overall spectral efficiency of both networks.

An example of the effects of assigning non-contiguous spectrum is shown below:

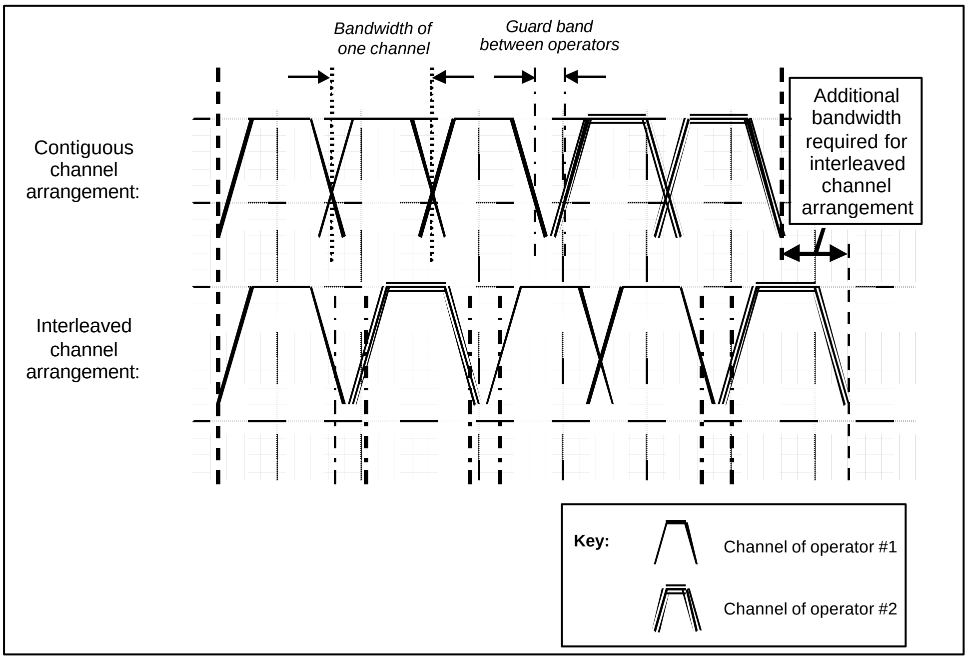

Figure 3.1: Bandwidth required for contiguous and interleaved channel arrangements

The example compares a contiguous channel arrangement with an interleaved arrangement. In both cases, operator #1 is assigned three channels, and operator #2 is assigned two channels. However, with the contiguous assignment, a saving in spectrum equivalent to half of one channel is made compared to the interleaved assignment.

This example illustrates the impact over five channels, where an additional one-half channel is required in the non-contiguous case. When considered over 12 CDMA channels (for example), this saving in spectrum is significant. It is strongly recommended, therefore, that spectrum is assigned in contiguous channels to ensure the most efficient utilisation.

The precedent set in Europe, the USA and Asian countries has been to assign contiguous blocks of 2 x 15 MHz or 2 x 20 MHz, in a single step to each operator. The success of such an approach can be seen in the unprecedented rate of development of the mobile networks in these countries, and the corresponding increases in national teledensities.

By contrast, the current situation in India – assigning spectrum in small volumes at different points in the operators' network planning – has resulted in uncertain spectrum availability and piecemeal assignment, often in non-contiguous blocks. Such method of assignment has had several negative effects:

?? Limited capacity. Network operators are uncertain of obtaining sufficient additional spectrum, and so plan their networks on an incremental basis dependent on the spectrum capacity that they have at a given time. A network built to utilise only 2 x 5 MHz of spectrum will require major modifications to effectively utilise a later assignment of 2 x 10 MHz or 2 x 15 MHz. Increasing the capacity of an existing network is always less effective and more costly than planning such capacity from the beginning.

- ?? Limited coverage. Limited spectrum availability increases the costs of rolling out a network, and so slows down network roll-out and limits coverage. Where suitable amounts of spectrum are guaranteed during the planning stage, a network can be designed to maximise coverage without the risk of depleting capacity in hotspots.
- ?? Reduced functionality. As a consequential effect of limited capacity, network operators will be unable to offer value-added services if there is insufficient capacity to support the basic voice service. This stifles investment in value-added services such as multimedia applications.

To address these problems in a large market such as India, it is vital that spectrum be assigned to each operator in blocks of sufficient size.

3.4. Consideration of Spectrum Efficiency

Cellular technologies offer differing levels of spectrum efficiency. CDMA technology has been proven to offer the best coverage and overall spectrum efficiency of the current mobile technologies.

Spectrum efficiency is a key measure of the effectiveness of mobile technologies. As demand for mobile communications has increased, networks have required greater amounts of spectrum. However, the scarcity of that spectrum has forced network manufacturers to significantly improve the efficiency of the technologies themselves.

Two metrics are generally used to assess spectrum efficiency in the context of mobile networks: the numbers of base stations required to provide coverage of an area, and the amount of spectrum required to support a given level of traffic in that area. These are closely related. It is possible (for example) to use a technology that is less spectrally-efficient, but to re-use the spectrum more frequently (i.e. increase re-use) to achieve the same capacity. Building more cells, for example, can overcome the inefficiency of spectrum use, but greatly increases the capital cost of building a network.

In a study published by Anderson Consulting[4], a simulated network was designed to cover a city with an area of 28 km^2. A traffic level of 3600 E (Erlangs) was assumed for the beginning of service, increasing to 9700 E five years later. TDMA (GSM) and CDMA were compared for the design of the network. The study calculated the amount of infrastructure that would be required to construct the network for the given traffic levels, in terms of "sectors" or individual cells[5]. Where possible, the designs favoured sectored cells as they reduce the number of individual base stations required.

[4] "The GSM-CDMA Economic Study", Anderson Consulting et al, February 1998.

[5] Early cellular systems were designed with a single base station located at the center of each cell. To increase capacity (but avoid the cost of additional antenna sites), operators split their cells by using directive antennas. However, as cell sizes were further reduced to microcells, these antennas could not provide sufficient isolation between sectors: cells must again be planned with individual base stations for each.

The study found that the following number of sectors were required for each design:

Technology	***Year 0***		***Year 5***	
GSM	134 sectors	(*27 E/sector*)	483 sectors	(*20 E/sector*)
CDMA	48 sectors	(*75 E/sector*)	72 sectors	(*135 E/sector*)

Figure 3.2: Number of sectors required to satisfy demand
(average traffic density, Erlangs per sector)

The study showed that the CDMA technology required significantly fewer sectors for the same coverage. Furthermore, the CDMA design permitted three-sector re-use so that the numbers of individual base stations required were as few as 16 (in year 0) and 24 (in year 5) respectively. In contrast, GSM microcells required individual base station locations, greatly increasing the infrastructure cost of the network.

From these results, the study estimated that the roll-out costs of a CDMA solution would be 44% of a GSM solution. In addition, the CDMA solution would require only 84% of the spectrum required by the GSM solution.

Practical deployment of CDMA and GSM networks has supported these findings. CDMA technology is optimised to provide excellent coverage and capacity from a minimum number of base stations. This feature makes CDMA the technology of choice in situations where coverage must be maximised without sacrificing capacity.

In very high-density situations however, such as inner-city “hotspots”, the CDMA advantage is reduced. The technology does not permit base stations to be sited less than about 500m apart, without significant “pilot pollution” or interference with the control signalling. As with all mobile technologies, CDMA systems use a pilot channel in each cell to identify the cell, to assist the mobile handset to gain synchronisation to the network and to measure the signal strength for power control. Unlike GSM, however, a CDMA network must use the same frequency for the pilot channel in every cell. If base stations are located too closely together, the signal strength of a number of pilot channels may not be sufficiently distinguished from each other, and this results in unworkable interference and reduced capacity. Thus in hotspots, CDMA cells cannot be reduced below this threshold radius, and are ultimately limited in their re-use of frequency in such a situation. **CDMA systems therefore require the same amount of spectrum as GSM systems to cater for urban hotspots.**

Overall, CDMA technology can support a much higher traffic capacity, whilst offering a significant advantage in terms of reduced infrastructure. This latter advantage greatly increases the rate of coverage of a network, due to the lower capital requirements.

3.5. Availability of Equipment

Equipment cost and availability is dependent upon technology and band. Suitable bands for the expansion of mobile networks in India should be carefully chosen to avoid disadvantaging the technologies.

An important factor in the choice of network technology is the availability of equipment. The deployment of CDMA and GSM networks in other markets in the world has led to a large selection of equipment manufacturers from which to choose. The effect of competition has also reduced the cost of both network equipment and mobile handsets, making mobile technology both cost-effective and affordable.

However, it must be noted that equipment is not available for all technologies to operate in every frequency band. GSM equipment is manufactured for the 900 MHz[6] and 1800 MHz[7] bands, and for the 1900 MHz[8] band. Multiband handset equipment, capable of operating in all three bands, is widely available. CDMA equipment is manufactured for the 800 MHz[9] and 1900 MHz bands, and dual-band handsets are also widely available. **However, very little equipment exists for GSM to operate in the 800 MHz band, or for CDMA to operate in the 1800 MHz band.**

In facilitating new spectrum for the expansion of existing networks, therefore, it is imperitive to consider equipment availability. Existing networks in India operate in the 800 MHz or 900 MHz bands, depending on technology, and require a suitable migration path to expand their networks with new spectrum. Only the 1900 MHz band offers a practical migration path for all technologies, through the availability of widely available dual band equipment for both 800/1900 MHz (CDMA) and 900/1900 MHz (GSM) networks.

3.6. Summary: Choice of Band for Additional Mobile Spectrum in India

The choice of a suitable band for expansion of the existing mobile networks in India is a very important one. The recent growth in wireless services, and the future potential for expansion of the coverage and capacity of mobile networks will rely upon the provision of suitable spectrum. At least 2 x 15 MHz of spectrum should be available to each operator (including the current assignments).

All spectrum is not equal. Existing mobile networks in India require suitable amounts of spectrum in bands for which equipment is widely (and cheaply) available. Unsuitable spectrum will increase the costs of network expansion and is likely to reduce, or possibly even stall, further development of these networks.

[6] 890-915 MHz, 935-960 MHz
[7] 1710-1785 MHz, 1805-1880 MHz
[8] 1850-1910 MHz, 1930-1990 MHz
[9] 824-844 MHz, 869-889 MHz

The band **1850-1910/1930-1990 MHz** is the most suitable for expansion of the existing networks in India. Dual band equipment is widely available for the current technologies and bands in use, and suitable amounts of spectrum exist for the widescale deployment of competing networks.

4. Procedures for Assigning and Pricing Spectrum

Section 3 of this paper examined the technical precedents for spectrum assignment and usage in India. This section now examines the procedural aspects of assignment, and identifies suitable modifications to the existing process that may greatly assist the extension of coverage by mobile networks in India.

4.1. Current Procedures for Assignment of Spectrum

The current assignment process for mobile spectrum in India has been identified in section 3.1. Spectrum can be assigned to operators for use within the geographical area defined by a telecom "Circle" (a sub-division of the Indian market in broadly equivalent economic areas); it is assigned upon request to holders of cellular or basic licences, provided that such spectrum is available; spectrum fees are levied as a proportion of annual turnover (a basic measure of spectrum usage).

This approach has both benefits and drawbacks. Network operators pay fees only on the amounts of spectrum that they have use of; they can apply for additional spectrum as it is needed; fees are payable as a proportion of the turnover of the network operator. These factors reduce costs for an operator as the network is being built and rolled-out. However, there is a major drawback to this method: spectrum may not be available when a network operator requires it (especially in congested urban markets), or the available spectrum may not be contiguous with the operator's existing assignments. This creates more difficulties for network planning, and reduces the efficiency of spectrum usage.

When planning the assignment of additional spectrum for mobile services, therefore, it is proposed that the procedures for assignment be reviewed, in order to maximise the potential for telecom growth.

4.2. Area of Spectrum Assignment: The Telecom "Circle"

In many countries, cellular licences have been issued for nationwide coverage. This approach ensures, amongst other things, that the networks are of sufficient size to be commercially successful. However, a few countries have chosen to apportion licences based on smaller geographical areas, due to the countries' size. Notable amongst these are the USA, Brazil, China and Russia. This process is not uniform across different countries, since the aim has been to create units that cover a market large enough to support the development of the networks.

To divide telecom networks into manageable geographical areas, the Government of India adopted the principles of telecom Circles and Short-Distance Charging Areas (SDCAs). The twenty-one Circles represent geographical areas with broadly similar levels of economic activity across India. For the purposes of licensing many competitive telecom services, separate licences have been issued for each of 19 of these Circles and four metro areas[10]. The SDCA, on the other hand, identifies call-charging zones for local (short-distance)

[10] The cities of Delhi, Mumbai, Kolcata and Chennai.

telephone calls versus long-distance, and is loosely based upon the structure and arrangement of the existing fixed telephone network.

In conclusion, the smaller divisions of the SDCA model risk fragmenting the network, with some markets being of insufficient size – which in turn may severely limit investment in the new networks**. Therefore, the current concept of the Circle seems to be the most suitable one for the continued assignment of spectrum to mobile networks in India.**

4.3. Assignment of Spectrum: Block Assignment

We have earlier examined the impact of the current piecemeal assignment of spectrum, and the inefficiency that non-contiguous channels can cause (see section 3.3). From a technical perspective, it is clear that the block-assignment of a suitable amount of contiguous spectrum is the preferred method to ensure that spectrum is available for network expansion, and that the spectrum is contiguous with existing assignments as far as possible.

However, block-assignment raises two related issues: how should the blocks be assigned to individual networks? And how should the fees be structured?

4.3.1. Procedures for Assigning Spectrum

The current method of first-come-first-served spectrum assignment has opened the field for many small network operators to attempt to provide wireless services in India. However, this inevitably leads to a surfeit of operators in the urban areas, and much less coverage in the suburbs and beyond. The procedures for assigning new blocks of spectrum should encourage wider coverage by the networks.

The most common procedures for assigning spectrum are administrative pricing, comparative hearings (so-called “beauty contests”) or competitive bidding (auctions).

Administrative Pricing is a process whereby the regulator assigns spectrum on a first-come-first served basis, usually for a fixed geographical area, and priced at a pre-set per-unit bandwidth charge. (This charge may vary from band to band, to encourage operators to deploy systems in less congested spectrum). The current process for assigning mobile spectrum in India is similar to administrative pricing, except that the cost of the spectrum is linked to a percentage of turnover rather than a fixed per-bandwidth fee. The major drawback of administrative pricing is the first-come-first-served basis leads to a fragmentation of the available spectrum, reducing the size of contiguous blocks and increasing spectrum congestion.

Comparative hearings have been used before in India, for example for the granting of the first Cellular Mobile licences. The process involves the development of evaluation criteria by the regulator, for one or more licences; applications are invited, and the regulator evaluates each against the pre-set criteria before awarding the licences and assigning spectrum. Comparative hearings are often used when there are a limited number of licences available, and have been extensively used to assign licences and spectrum for mobile services in most markets. However, the criteria for comparative hearings are generally based upon technical analyses, which are easier to adjudicate but may not accurately reflect other aspects of running a successful mobile network, such as an ability to adapt to changing financial or market conditions.

Auctions have been used in the USA and in some European and Asian countries to distribute licences for mobile services. However, the process has generally been applied to mature markets, where the existing well-developed wireless networks are to be supplemented by additional networks. In India, the existing wireless infrastructure has not yet matured, and both coverage and capacity are still limited. The high entry-cost of spectrum auctions is therefore likely to reduce the investment in network infrastructure and slow down the growth in subscribers and in coverage. (Note the situation in Europe, where very few new networks have been completed even though spectrum auctions were held around the year 2001). For this reason, auctions are unattractive for use in India at this time.

The current practice of administrative pricing is therefore the preferred option for assigning additional mobile spectrum in India, as it facilitates the natural growth of the networks without requiring the regulator to attempt to select “winners”.

4.3.2. Spectrum Fees

As noted, the current fee structure for mobile spectrum in India has been highly beneficial to the development of networks. The sliding scale of fees reduces the regulatory costs during the development phase of the mobile networks, and also links spectrum charges to some measure of spectrum usage (through the percentage of annual turnover). The substitution of a fixed fee at this time risks damaging the growth of the market, and slowing the rate of increase of mobile network coverage.

It is therefore strongly proposed that the current structure of spectrum fees is maintained, to encourage continued network growth.

4.4. Transition of Existing Users

Making new spectrum available for mobile networks will require the transitioning of existing users to higher bands. The preferred bands around 1.9 GHz are currently used by government fixed radio systems, and their transition would be a requirement to ensure successful expansion of the mobile networks. The cost of transitioning the fixed systems is a factor in gaining access to the band, but there are possible options that would ease the impact on the government.

4.4.1. Phased Release of Spectrum

It has been established that the most useful assignment is a block assignment, in order to ensure that networks can be planned with contiguous channels when fully expanded. However, it is not essential that these entire blocks be made available from the very beginning. It is possible that networks can begin with, for example, 2 x 5 MHz of new spectrum, and increase this to 2 x 10 MHz at a later time when the network capacity requires it. This phased release of spectrum to the mobile operators can facilitate a phased relocation of government fixed links to new bands. In this way, the cost of relocation can be spread over time, and the disruption to the fixed network can be minimised.

Such a plan would of course require reference to the channel arrangements of the fixed systems. Below is an example of the band layout, assuming a standard fixed-service channel arrangement[11]:

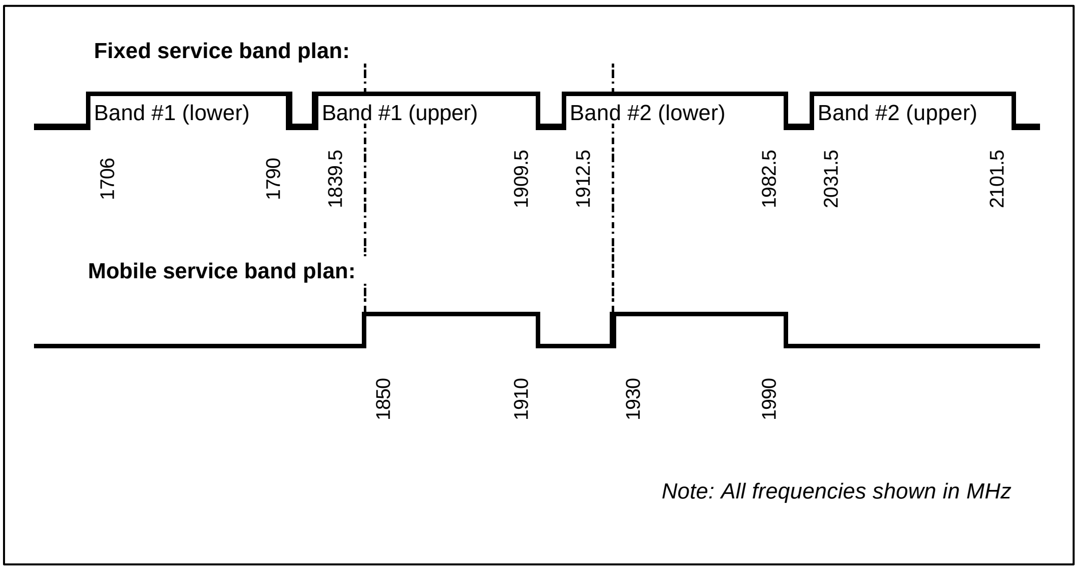

Figure 4.1: Arrangement of mobile spectrum relative to existing fixed link bands

It can be seen that the mobile bands identified fall within two separate sets of fixed-link channel arrangements[12]. A closer examination of the lower mobile band (1850-1910 MHz) shows that the required band for relocation extends over two complete channels and two part channels used by the fixed links:

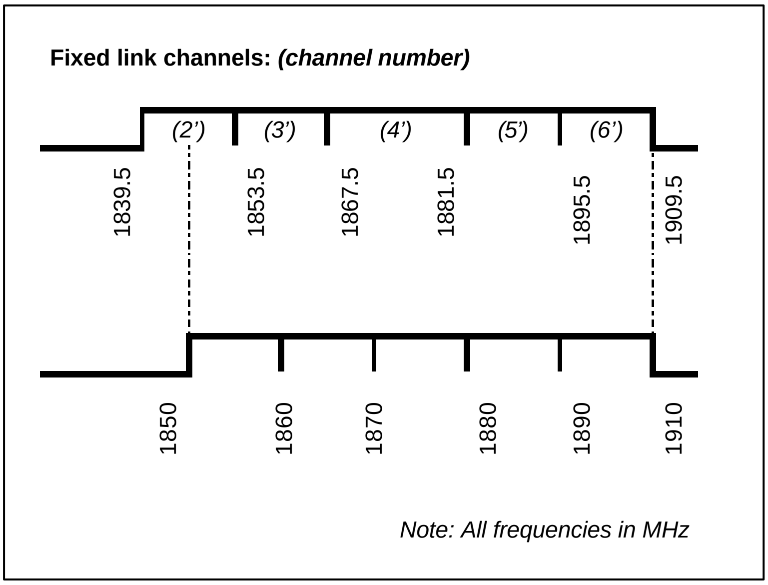

Figure 4.2: Overlap in the range 1850-1910 MHz

[11] ITU-R Recommendation 283-5, channel arrangement for 14 MHz channels.
[12] In the figure band #1 is a duplex band centred on 1808 MHz, band #2 is a duplex band centred on 2000 MHz.

A similar situation exists in the upper mobile band:

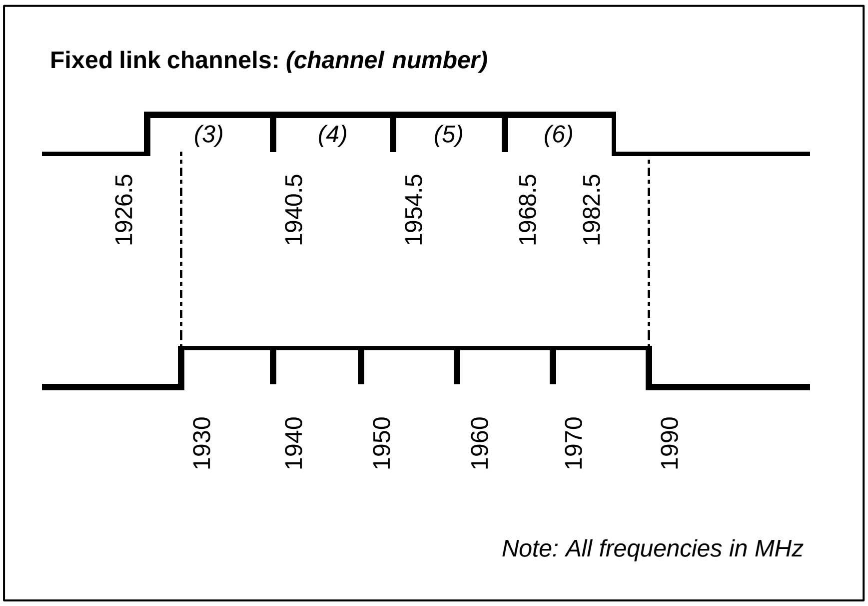

Figure 4.3: Overlap in the range 1930-1990 MHz

By the relocation of, for example, two fixed-link channels in each channel arrangement, it is possible to liberate 2 x 28 MHz of spectrum: channels 3' and 4' (1853.5-1881.5 MHz) and channels 4 and 5 (1940.5-1968.5 MHz). (In practice, the duplex arrangement of the mobile systems may only permit 2 x 21 MHz to be usable, however). This would provide sufficient spectrum for initial expansion of the mobile networks, whilst the remaining overlapping fixed-link channels may be relocated at a later time, when further spectrum is required.

It is therefore feasible that the fixed-link systems be transitioned to new bands in a gradual process, to reduce the cost of relocation.

4.4.2. Equitable Payment for Relocation

It was noted above that the new spectrum sought for mobile networks overlaps the channel arrangements of terrestrial fixed links. However, by transitioning the fixed links to new bands, more spectrum is liberated than that used by the mobile networks. The fixed link systems use blocks of duplex channels, only one-half of which overlap with the wanted mobile bands. Thus by clearing the parts of the band required by the mobile systems, the duplex channels are removed also:

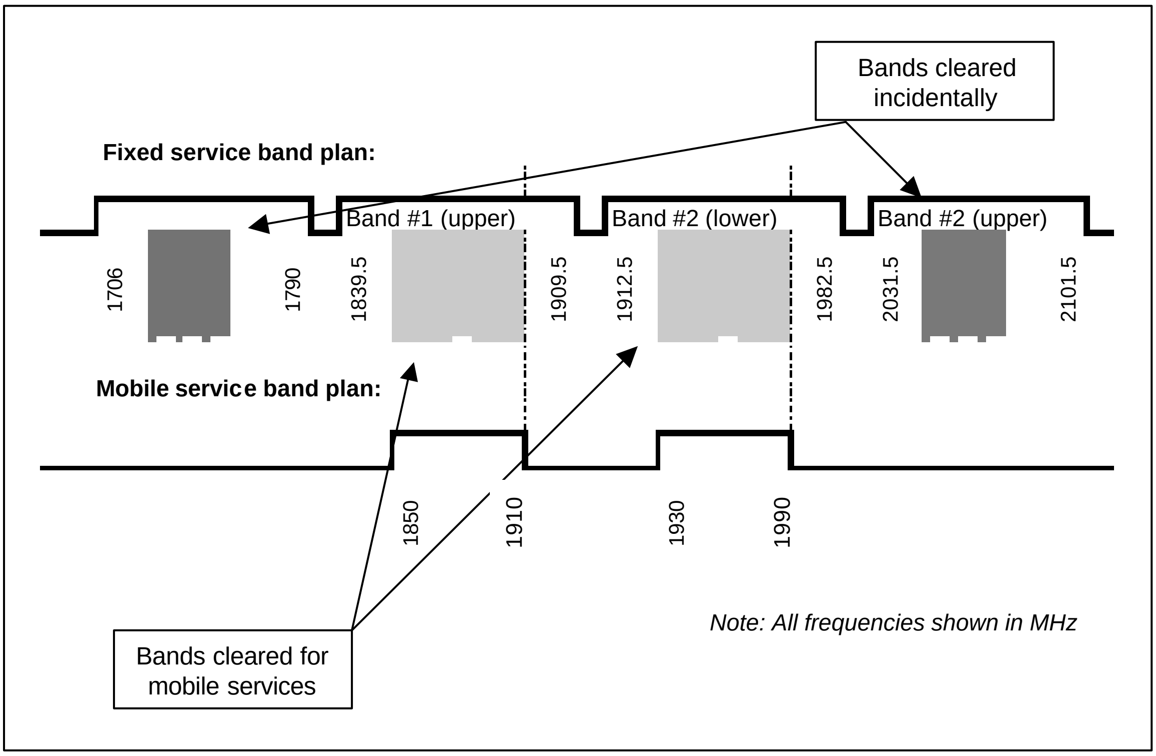

Figure 4.4: Incidental Clearance of the Duplex Bands

This spectrum, totalling 2 x 60 MHz in this example, is not usable by the mobile networks. It is unrealistic, therefore, that the mobile network licensees should be required to pay for the relocation of fixed systems from bands which they are not able to use. Furthermore, these bands may be licensed to other communications systems, which would benefit at the cost of the mobile network licensees.

It is proposed instead that the relocation costs be recovered through the spectrum licence fees, over the lifetime of the mobile networks. In this way, the burden of upfront costs is removed, freeing the mobile network operators to invest in the roll-out of their networks. By design of a suitable transition programme (as outlined above) and fee structure, the cost of the transition process ca n be reduced, and spread over a longer time period. Thus the revenue from licence fees can entirely offset the costs of transitioning, but without the burden of upfront costs.

4.5. Summary: Assigning Spectrum and Relocating Existing Users

The current procedures for assigning mobile spectrum should be retained, with suitable modifications to ensure that sufficient contiguous blocks of spectrum will ultimately be granted to each network operator. The current fee structure is equitable, and does not unduly burden the network operators as they build their networks.

The transitioning of existing users of the spectrum should be planned to take place over a period of time, with the aim to clear at least one or two fixed-link channels at the outset and the remainder as the mobile spectrum is likely to be required. The costs of this transition should be recovered from the spectrum licence fees.

5. Recommendations for Additional Mobile Spectrum Assignments in India

The continued growth of the mobile sector in India will be greatly dependent upon the availability of suitable radio spectrum for increasing capacity. This study has identified practices for obtaining spectrum in other countries, as well as examining the benefits and drawbacks of the current processes in India. In this regard, the following recommendations are made:

- ***A sufficient quantity of additional mobile spectrum should be made available.*** New spectrum should be made available to ensure that each operator has access to at least 2 x 15 MHz. As much as possible, the spectrum should be assigned in a contiguous block to each operator, to facilitate the most efficient deployment of networks and to reduce the possibility for interference. The spectrum should be assigned in one step, and not assigned in a piecemeal fashion that would increase uncertainty and reduce investment in the new networks.
- ***A suitable band must be chosen for additional spectrum***. Noting the mobile technologies currently deployed in India, the band 1850 – 1910 MHz / 1930 – 1990 MHz is the most suitable source for new mobile spectrum. This band is widely used elsewhere in the world for both CDMA and GSM systems, and so suitable equipment is widely available and cost-effective.
- ***The current assignment process should be maintained.*** The current assignment process should not be significantly altered from the current one, except as necessary to ensure contiguous spectrum assignments.
- ***The transition of existing spectrum users from the new bands should be phased, in order to minimise transition costs***. The clearance of the existing government fixed-links should be planned over a suitable transition period, noting the requirements of the mobile network operators. This will ensure that the transition can be achieved in the most cost-efficient manner, liberating spectrum as it is needed by the expanding mobile networks.
- ***The transition of existing spectrum users should be funded from the proceeds of the spectrum licence fees***. Since the transition of fixed links will vacate bands in addition to those required by the mobile services, it would be inequitable to require the mobile networks operators to bear the full cost of relocation. Instead, it is proposed that the transition costs be recovered through the spectrum fees of both the new mobile bands, and of the other bands liberated as a consequence.

Annex 1 CDMA Networks Around the World

Country	Frequency band	CDMA Technology	
		CDMAone (IS-95)	*CDMA2000*
Angola	800 MHz	✍	
Argentina	450 MHz	✍	
	1900 MHz	✍	
	1900 MHz		✍
Australia	800 MHz	✍	
	800 MHz		✍
Azerbaijan	800 MHz		✍
Bangladesh	800 MHz	✍	
Belarus	450 MHz		✍
Bermuda	800 MHz		✍
Brazil	800 MHz	✍	
	800 MHz		✍
	1900 MHz	✍	
	1900 MHz		✍
Cambodia	800 MHz	✍	
Canada	800 MHz	✍	
	800 MHz		✍
	1900 MHz	✍	
	1900 MHz		✍
	800/1900 MHz		✍
Chile	1900 MHz	✍	
	1900 MHz		✍
China	800 MHz	✍	
	800 MHz		✍
Colombia	800 MHz		✍
	1900 MHz	✍	
	1900 MHz		✍
Czech Republic	450 MHz		✍
Dem. Rep. of Congo	800 MHz	✍	
	1900 MHz	✍	
Dominican Republic	800 MHz	✍	
	1900 MHz	✍	
	1900 MHz		✍
Ecuador	800 MHz		✍
	1900 MHz		✍
Egypt	800 MHz	✍	
	800 MHz		✍
	1900 MHz	✍	
El Salvador	800 MHz	✍	
Fiji	800 MHz	✍	
Georgia	450 MHz		✍

Guam	800 MHz	✍	
Guatemala	1900 MHz	✍	
	1900 MHz		✍
Haiti	1900 MHz	✍	
Honduras	800 MHz	✍	
Hong Kong	800 MHz	✍	
India	800 MHz	✍	
Indonesia	800 MHz	✍	
	450 MHz		✍
	1900 MHz	✍	
	1900 MHz		✍
Israel	800 MHz	✍	
	800 MHz		✍
Jamaica	800 MHz	✍	
	800 MHz		✍
Japan	800 MHz	✍	
	800 MHz		✍
Kazakhstan	800 MHz		✍
Kuwait	800 MHz	✍	
Kyrgyzstan	800 MHz		✍
Malaysia	800 MHz	✍	
	800 MHz		✍
Mauritius	800 MHz	✍	
Mexico	800 MHz	✍	
	800 MHz		✍
	1900 MHz	✍	
Moldova	800 MHz	✍	
	800 MHz		✍
Mongolia	800 MHz	✍	
Myanmar	800 MHz	✍	
New Zealand	800 MHz	✍	
	800 MHz		✍
Nicaragua	800 MHz		✍
Nigeria	800 MHz	✍	
	1900 MHz	✍	
	1900 MHz		✍
Pakistan	450 MHz		✍
	1900 MHz	✍	
	1900 MHz		✍
Panama	800 MHz		✍
Peru	800 MHz	✍	
	800 MHz		✍
Philippines	800 MHz		✍
Poland	850 MHz	✍	
	850 MHz		✍
	800 MHz	✍	
	450 MHz		✍
Portugal	450 MHz		✍

Puerto Rico	1900 MHz	✍	
	1900 MHz		✍
Romania	1900 MHz	✍	
	450 MHz		✍
Russia	800 MHz	✍	
	450 MHz		✍
South Korea	800 MHz	✍	
	800 MHz		✍
	1700 MHz	✍	
	1700 MHz		✍
Taiwan	800 MHz		✍
Thailand	800 MHz	✍	
	800 MHz		✍
Ukraine	850 MHz	✍	
	850 MHz		✍
	800 MHz	✍	
Ukraine	800 MHz		✍
United States	800/1900 MHz	✍	
	800/1900 MHz		✍
	800 MHz	✍	
	800 MHz		✍
	1900 MHz	✍	
	1900 MHz		✍
Uruguay	1900 MHz	✍	
US Virgin Islands	1900 MHz	✍	
	1900 MHz		✍
Uzbekistan	450 MHz		✍
	800 MHz	✍	
Venezuela	800 MHz	✍	
	800 MHz		✍
Vietnam	450 MHz		✍
	800 MHz		✍
Yemen	800 MHz	✍	
Zambia	800 MHz	✍	

Annex 2 Responses to Specific Questions in TRAI Consultation Paper on Spectrum Issues (No.11/2004)

Chapter 2: Current spectrum availability and requirement

(i) Should the 450 MHz or any other band be utilized particularly to meet the spectrum requirement of service providers using CDMA technology?

The band at 450 MHz is more suitable for wireless coverage and range in rural and suburban environment because of the lower propagation loss. This frequency can be used for wireless broadband services in rural and inaccessible areas for achieving the government's objectives for e-governance, e-education, telemedicine etc in such areas. The allocation of this band for CDMA operations should be only in addition to the other main bands of 800 and 1900 MHz and not the sole band for the growth of CDMA services in India.

(ii) The consultation paper has discussed ITU method for assessment of spectrum requirement. Based upon the methodology submit your requirement of spectrum, please give various assumptions and its basis.

This submission contains an analysis of the likely requirement for spectrum, based upon experience of other markets. In contract, the ITU method is limited: it was developed in 1997, and is based solely on a theoretical approach. In practice, other factors such as the physical topography of the coverage areas, and the need to interconnect to existing (wired) infrastructure, dictate a flexible approach to spectrum use by an operator when building a network.

(iii) Whether IMT 2000 band should be expanded to cover whole or part of 1710-1785 MHz band paired with 1805-1880 MHz?

In order to ensure parity between GSM and CDMA technologies, the spectrum allocation should be arranged so that both these technologies get an equal opportunity to grow. The ITU-R Recommendation ITU-R M.1036-2 (as given in section 2.3 of the TRAI consultation paper) permits the flexibility for administration to choose any band in 806-960 MHz band or 1710-2200 MHz for IMT2000. The B5 band plan of the ITU-R recommendations can be earmarked for 3G operators in India, allocating equal spectrum for GSM and CDMA in the band 1755-1805 MHz paired with 2110-2160 MHz. This will ensure both a level playing field for GSM and CDMA operators, as well as ensuring adequate bandwidth for the growth of mobile services in the country. The rationale for this band is further explained in section 3 of this response.

(iv) Should IMT 2000 spectrum be considered as extension of 2G mobile services and be treated in the same manner as 2G or should it be considered separately and provided to operators only for providing IMT 2000 services?

In the case of the Indian context, the licenses are technology neutral. All licenses include provision of data services in the scope of services, without specifying the speed at which the data is to be transmitted. Examination of other markets, such as the USA and Europe, shows that there is a gradual evolution of services from 2G to 3G, and not a direct replacement of one network for another. Thus, 3G services should continue to be a part of

the 2G services and no separate license is required. Since the ITU has promoted flexibility for the use of different bands for IMT2000 (3G services), there is no specific core band for such a service. It is suggested that the allocation of spectrum for existing networks should not be linked to considerations of 3G. Network operators will undoubtedly develop 3G services as their customers demand them.

(v) Reorganization of spot frequencies allotted to various service providers so as to ensure the availability of continuous frequency band is desirable feature for efficient utilization of spectrum. Please suggest the ways and means to achieve it.

Reorganization of spot frequencies is essential to allocate contiguous allocation of spectrum, and so to avoid wastage of this natural resource in guard bands. Reorganization should aim to cause the minimum of dislocation to the service providers, and require the least cost in terms of hardware (such as new filters).

Such reorganization would also require that the entire bandwidth be made available. For example, the 20 MHz earmarked for CDMA operators in 800 MHz band and 25 MHz earmarked for GSM operators in 900 MHz band, should be available for use by the service providers. Where the frequencies are being used for other purposes, reorganization is not feasible. Piecemeal reorganization is not recommended.

(vi) Whether the band 1880-1900 MHz be made technology neutral for all BSOs/CMSPs/UASLs and be made available with the par 1970-1990 MHz or should it be kept technology neutral but reserved for TDD operations only.

(This band is believed to be 1960-1980 MHz, not 1970-1990 MHz as shown). Current Government policy has been to embrace technology neutrality, and to permit all access providers to offer services using any technology they choose. For this reason, it seems contradictory to consider reserving bandwidth for a particular technology. Technology neutrality in TDD operations would lead to wastage of the corresponding downlinks in the band 1960-1980 MHz. If used in FDD mode with better utilization, there is no justification for reserving it for the TDD mode. We recommend that this bandwidth need not be reserved for any technology and be made technology neutral for all BSOs/CMSPs/UASLs.

Chapter 3: Technical efficiency of spectrum utilization

(i) Please offer your comments on the methodology outlined in this Chapter for determining the efficient utilization of spectrum. Also provide your comments, if any, on the assumptions made.

We support the TRAI's efforts towards improving the efficiency of spectrum use by service providers. It is important that all wireless networks are efficient and put spectrum to its highest-valued use. We believe that the regulator can ensure high efficiencies of spectrum use by using market-based mechanisms and a considered spectrum allocation policy. We believe that there is not a single standard metric capable of accurately measuring such efficiency, especially noting the different requirements and strengths of the different technologies. Therefore, we do not support the adoption of a single metric to compare spectrum efficiency between services and technologies.

We would point to the experience in other regions, and suggest that TRAI can achieve the efficient use of spectrum through the creation of market incentives and performance

criteria, to discourage the inefficient use of spectrum. Such an approach is both future-proof and flexible, and ensures that operators concentrate more on performance rather than prediction or quantification.

We urge the TRAI to consider the recasting of spectrum as is in progress around the world. Rather than attempting to measure the efficiency of spectrum on a "micro" basis, TRAI would achieve a better result by measuring the efficiency of the networks as a whole.

(ii) Please provide your perception of the likely use of data services on cellular mobile systems and its likely impact on the required spectrum including the timeframe when such requirements would develop?

CDMA technology permits the carriage of voice and data traffic on the same carrier. However, for the best quality and speed transmission data can be achieved only through a dedicated separate carrier. To start with, a minimum of two carriers are needed for the data services. Particularly, in the Indian context, the mobile service providers are facing the issue of declining ARPU, which is stated to have come down to about $ 10.00 per month, the need for provision of data services is very urgent for better utilization, maintenance and sustaining their networks.

Particularly, in the case of CDMA operators in India almost all the handsets are data enabled and hence it can be safely assumed that more than 50% of the subscribers may be using their handsets for data services. Wireless terminals, either fixed wireless or mobile are being used to provide Internet facility for transmission of data at a speed of more than 144 kbps.

With the Regulator having already made recommendations for broadband services using both fixed and wireless technologies the provision of data services is going to be an increasingly more important area for growth of wireless networks.

It is, therefore, essential that adequate and separately dedicated carriers should be allocated to the mobile operators for provision of data services and the time limit has to be ASAP.

Chapter 4: Spectrum Pricing

(i) Is there a necessity to change from the existing revenue share method for determining the annual spectrum charge?

(ii) If yes, what methodology should be used to determine spectrum pricing for existing and new operators? (Please refer table in Section 4.8)

(iii) In the event AIP is adopted as a means to price spectrum, would it be fair to choose GSM as a reference for determining the spectrum price?

(iv) Please provide your comments on the assumptions used in A.I.P.

(v) In case Auction methodology is used for pricing the spectrum, please give suggestions to ensure that spectrum is available to those who need it.

(vi) Should the new pricing methodology, if adopted, be applicable for the entire spectrum or should we continue with revenue share mechanism till 10+10 MHz, and apply the new method only for spectrum beyond this?

(vii) What incentives be introduced through pricing to encourage rural coverage and/or using alternative frequency bands like 450 MHz?

(viii) Does M x C x W formulae for fixed wireless spectrum pricing need a revision? If so, suggest the values for M, C, W?

(ix) Should there be different pricing levels for shared spectrum versus spectrum that is allocated with protection? How should this be determined?

***In response to questions (i) to (ix):* To date, cellular operators in India have not been required to pay an entry fee for spectrum but have paid one time entry fee for getting a license. Thus the consultation paper correctly notes that it is difficult to assess the amount that has been paid by the operators at the time of issue of license for spectrum alone. Furthermore, the current pricing regime is simple, understandable and accountable but has the disadvantage that it does not encourage efficient spectrum use since fees are calculated as a percentage of network revenue. Thus TRAI has proposed that the fee structure be changed to a fee based on amounts of spectrum assigned. We would suggest a change that retains some of the simplicity of the current scheme, whilst increasing the incentives for efficient spectrum use.**

Other countries have used various methods for fixing the spectrum charges. Although these methodologies provide a guide for a policy in India, no single approach can be directly applied due to the ambitious development objectives for communication networks in India.

Since 1994 the government has issued licensees for mobile services. With few exceptions, there are now six or seven mobile operators in each service area, providing mobile services using different technologies (GSM or CDMA). This has created a highly competitive structure, increasing the hurdle for new operators to enter the market. The current operators have made huge investments in the infrastructure (for all technologies) and may need additional spectrum to continue the growth and coverage of their networks. Therefore any new pricing policy should consider the requirements for additional spectrum for the existing operators without creating additional financial burden that would make the service more costly. If not, such a policy would oppose the basic objective laid down in NTP'94 and NTP'99 for providing affordable service to the masses.

***Auctioning Spectrum –Taking the Indian perspective:* Auctioning of the spectrum has been used in different parts of the world, most notably where spectrum which has been licensed for providing some cellular services. Auctions have been recognised as an approach for the allocation of a scarce resource (such as spectrum) where insufficient resource exists for all applicants. In India, however, there are multiple providers of wireless services in every service area. The introduction of auctions at this stage would risk distorting the market and possibly even reducing competition. Thus, the introduction of spectrum auctions in the present Indian context may not be the appropriate at this stage.**

***Administrative Incentive Pricing (AIP)*: As the consultation paper states, AIP is suitable for situations where the demand for spectrum exceeds the supply, and thus seems the appropriate method for pricing wireless spectrum. The more pertinent question, however, may be the determination of the pricing.**

Theoretically speaking, the pricing solution proposed in the consultation paper (that of basing spectrum value on "Second Best" technology) is appropriate since this provides users of the "Second Best" technology with an incentive to use it in the most efficient

manner whilst not penalizing users of the more efficient technology. However, spectrum pricing can only realistically influence spectrum efficiency when the price is set prior to choosing a technology. In the current context in India, this theory is not applicable since technologies have already been chosen, and the networks brought into operation. It is highly unlikely that an operator would choose to switch from one technology to another because of spectrum pricing.

The methodologies proposed in the consultation paper are therefore not applicable in the current scenario. Factors such as the base level of capacity, the number of sites to provide coverage in urban and rural areas, the urban or total population, a reasonable but equal market share etc. are only useful as theoretical metrics. Any pricing formula for spectrum should consider the needs of the existing network infrastructures, and propose future pricing that does not disadvantage the current operators (of any technology) but encourages further development and growth of coverage. The future pricing should ensure a level playing field for the different technologies, as recognized by the TRAI (section 4.5 of the consultation paper).

***A Proposed Pricing Solution*: Reflecting both the theoretical considerations and the current situation in India, the following phased implementation for pricing is proposed, as outlined by TRAI in their consultation paper (section 4.4.1.1.4):**

?? **Spectrum up to 15+15 MHz:**	**The price should be an annual amount to meet the cost of administering spectrum.**
?? **Beyond 15+15 MHz:**	**The price should be fixed in a manner that the operators are not encouraged to make use of the different techniques to use the present allocated spectrum more efficiently, rather than asking for additional spectrum. The cost of additional spectrum should be such that the operators seek additional spectrum only when they find that the cost of additional spectrum is less than the cost of using spectrum more efficiently. For calculating this cost the TRAI can use any appropriate formula.**

This solution addresses the issue of introducing incentives for spectrum efficiency whilst preserving the legacy of existing networks.

***Promoting Coverage in Rural Areas*: Spectrum pricing can be an effective tool for encouraging coverage in rural areas. The TRAI has proposed two options for such a course of action. We support option (ii) in section 4.4.1.1.3, i.e. a discount proportional to infrastructure. We also support the proposal (d) in section 4.5, i.e. discounts for operations in rural areas.**

***Use Of Surplus Generated by Auctions or AIP*: It is proposed that any revenue generated in excess of the cost of administering and managing the spectrum should be utilized to provide compensation to the existing spectrum holders in return for the early release of their spectrum.**

Chapter 5 : Spectrum Allocation

(i) How much minimum spectrum (refer approach (I) and (II) in section 5.4) should each existing operator be provided? Give the basis for your comments.

We would support the TRAI option of Approach II, as described in section 5.4 of the consultation paper. In this paper, we suggest that all mobile service providers in India should have access to a minimum amount of 2 x 15 MHz of spectrum initially irrespective of the technologies and bands used, and that the spectrum allocation should be contiguous where possible.

Approach II ensures a transparent and level playing field and eliminates a case-by-case approach that may be subjective and inconsistent with technology neutrality. Approach II also ensures an equal allocation of spectrum to all operators, which would otherwise promote inefficiency, punish the more efficient service provider or technology, and run contrary to the spirit of the UASL by biasing against possible competitive outcomes and favouring one system over another.

TRAI obviously wishes to maintain a high efficiency of spectrum use, which we would support. It should not, therefore, punish more spectrally efficient technologies by allocating it lesser resources and possibly weakening its market position. All operators have paid the same license fees under the unified license scheme, and so the allocations and benefits granted to them should then be the same, in the interests of fair competition. It is important for the TRAI to allocate an equal amount of spectrum to all operators, and to achieve this aim, we suggest the use of part of the 1900 MHz band (so-called PCS band) for CDMA service providers, and the 450 MHz band for use in rural and high-cost areas. As the allocation currently stands, the amount of spectrum reserved for CDMA operators (up to 2 x 5 MHz) is not sufficient even to support the minimum capacity projections required over the next two years for voice services alone. As TRAI has noted, international practice has been to make 2 x 10 MHz or more spectrum available to service providers. Ideally, TRAI should assign larger blocks of spectrum - at least 2 x 15 MHz or 2 x 20 MHz - to operators, so long as the total allocation of spectrum permits.

(ii) At what stage the amount of spectrum allocation to new entrants be considered in the 800 MHz / 900 MHz/ 1800 MHz frequency bands?

The number of operators for the mobile services is probably large enough to class the Indian mobile service as a competitive market. New entrants may enter the market after meeting the eligibility criteria set out for the Unified access licences, although market entry may be very difficult given the existing competition. Furthermore, new entrants do not immediately increase network coverage as they usually focus their coverage on areas of high population density. Instead of considering assignments for the new entrants, therefore, it is suggested that TRAI should focus on providing sufficient spectrum to the existing operators in order to encourage network growth. The first priority should be to provide adequate spectrum to the existing operators, as per the international standards.

(iii) Should spectrum be allocated in a service and technology neutral manner?

We support the allocation of spectrum on a service and technology neutral basis. However, the other considerations must be observed to ensure true neutrality - the availability of compatible handset and network equipment is not the same in every band for every technology. To ensure that the service providers are free to use any technology for providing mobile services, the choice of frequency band must be made in light of the availability of equipment for all applicable technologies.

(iv) What should be the amount of cap on the spectrum assigned to each operator?

A cap on the spectrum assigned is required in the current situation as spectrum is not readily available. At present, the existing government users of wireless systems, including the defence services, are using the majority of spectrum in every band. The scarcity of bandwidth, combined with multiple operators in each service area, dictates that the spectrum be rationed for use by service providers. However, we suggest that such a cap should not be applied unnecessarily. Under the proposals for spectrum pricing, additional amounts of spectrum above 2x15 MHz could be made progressively more expensive, thus making an administrative cap redundant.

(v) What procedure for spectrum allocation be adopted for areas where there is no scarcity and in areas where there is scarcity?

Currently, all bands available to wireless services suffer from spectrum scarcity. We would suggest, therefore, that the method of allocation should be the same regardless of scarcity. Any method that gives equal spectrum for all service providers and technologies, and a minimum 2x15 MHz assignment per provider (as per international benchmarks), is suitable.

(vi) Which competitive spectrum allocation procedure (auction/ Beauty Contest) be adopted in cases where there is scarcity?

As proposed earlier, the method of assignment for spectrum needs to be considered only when the minimum spectrum of 2x15 MHz has been allocated to all service providers. For assignments beyond 15 + 15 MHz, the allocation method should ensure that operators that require spectrum are not denied, whilst competition is maintained.

(vii) Should we consider giving some spectrum in the 900 MHz band to fourth CMSPs?

It is recognized that spectrum is a scarce resource and needs to be used efficiently. Any spectrum not assigned cannot be considered to be used efficiently. The present license conditions for fourth CMSPs provide for spectrum in 1800 MHz band, and any allocation to the 4^th^ CMSP in the 900 MHz band will be contrary the existing license conditions.

We would therefore suggest that where surplus bandwidth is available in the 900 MHz band, this should be utilized first to increase the present allocation for CDMA from 2x20 MHz to 2x25 MHz[13]

(xiii) Comments of stakeholders are invited on the minimum blocks such as 2 X 2.5 MHz / 2 X 5 MHz of additional spectrum to be allocated to existing service providers in situations where IMT 2000 band is opened as well as in situation where it is not opened. Additionally, comments are also invited on the minimum allocation to new entrants.

In general, we suggest that additional spectrum for existing operators be allocated in minimum blocks of 2 x 5 MHz where feasible (see section 3 of this paper). Larger blocks of contiguous spectrum would provide operators with additional capacity, the ability to plan for long-term growth and greater flexibility to offer a variety of voice and data services.

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[13] I.e. increase the band to 824-849 MHz, paired with 869-894 MHz.

International practice tends to support the allocation of paired spectrum blocks of 5 MHz, 10 MHz, and 15 MHz.

We suggest that TRAI should follow market principles in the allocation of spectrum to new entrants, in order to allow for the creation of a competitive and efficient market. We suggest that TRAI considers a number of different frequency pairing band options and design a fair assignment process that would meet the needs of operators to obtain the spectrum they require to offer a variety of voice and data services, including broadband data access.

Noting the Government desire to encourage network coverage, the spectrum requirements of the existing operators should be met first before consideration of spectrum for new entrants.

(ix) In the event that IMT 2000 spectrum is treated as continuum to 2G, should existing operators using spectrum below the specified benchmark be treated as those eligible for IMT 2000 spectrum?

As proposed earlier, we support Approach II as outlined by TRAI. All operators should have access to 2x15 MHz of spectrum, irrespective of subscribers or technology.

We suggest that the term "IMT-2000 spectrum" may be misleading. As defined in ITU-R Recommendation M.1036-2, IMT-2000 systems can be deployed in any band, and multiple bands have been identified for IMT-2000 systems. If TRAI treats the IMT-2000 bands as a continuum to the 2G bands already allocated, then we support the allocation of additional spectrum to existing operators using spectrum below the specified benchmark in the IMT-2000 bands. Concerns have been expressed by others that the use of such bands may limit the scope for future introduction of 3G services. However, as we have expressed elsewhere, other markets have demonstrated that the introduction of 3G services has been made through an evolution of the existing 2G networks.

Chapter 6: Re-farming, Spectrum Trading, M&A and Surrender

Re-farming of Spectrum

(i) What approach should be adopted to expedite the re-farming of 1800 MHz and IMT – 2000 spectrum from existing users?

The refarming of spectrum has become a necessity in view of the increasing requirements for commercial wireless telecommunication services. Non-telecom users in India, particularly the Ministry of Defence, are presently using large amounts of spectrum in the 1800 MHz and 1900 MHz bands. Redeployment of the spectrum at the expiry of current licence period, or at the end of the equipment's lifetime, are not an effective option since this will take a very long time. Only through planned migration to other frequency bands can the needs of the developing telecommunications industry be served adequately.

To be clear, it is no suggested that the defence requirements be overlooked. However, the opportunities for the commercial use of this spectrum by the telecom service providers should not be ignored. In almost every country in the world today, wireless communications operating in these frequency bands are providing more people with telephony services than through wired connections. Recognising, as indicated in the consultation paper, that this can be technically and economically difficult process to implement, it is the only long term solution to meet the increasing spectrum requirements.

In respect of compensation for redeployment, it is proposed that this be funded from a central resource created by contributing the entire entry fee, and licence fee paid by the service providers for obtaining and using spectrum. The time scale for refarming should be aggressive, noting the economic benefits that accrue with increased coverage and capacity.

(ii) What approach should be adopted for re-farming of spectrum after expiry of license?

After expiry of the existing license of the existing users, the spectrum should be appropriately utilized for the services for which it is most suited.

Surrender of Spectrum

(iii) Should there be any refund for spectrum surrender in principle?

Under the proposals made in this submission, there is no logic for any refund on account of spectrum surrender. The points given by TRAI against the refund in section 6.1.1 are supported.

(iv) Should there be refund for spectrum surrender consequent to unified Access license policy? If yes, what should be the basis?

As stated, there appears to be no rationale for any refund for surrender of spectrum, even in the case of changes in government policy since government policy changes and amendments in the license conditions are done as per the powers given under the license for amending the license. It may be noted that the license conditions (particularly the GSM licenses) have been changed to the benefit of the existing licensees, but they have not been required to make any additional payment for such benefits. The arguments against any refund as given in section 6.1.1 of the consultation document are equally applicable in this case.

(v) How should the amount of refund be estimated?

(Not applicable in view of replies given to the above questions).

Spectrum Trading

(vi) Should we open up the spectrum market for spectrum trading? If yes, what should be the time frame for doing so?
(vii) What are the pre-requisites to adopting spectrum trading?

We suggest that the trading of spectrum is an important topic of discussion, having wide implications for the current and future licensees. The trading of spectrum should be taken up as a separate point of consultation, in order to evolve a long-term strategy and policy rather than making it a part of the present consultation document.

Mergers and Acquisitions

(viii) Whether we should specify a cap higher than 2 x 15 MHz for Metros and Category "A" service area and 2 x 12.4 MHz for Category "B" and "C" service area in case of M&As or should it be retained?

No, the present cap is adequate. Any change in this limit will lead to M&A taking place only on account of the spectrum.

(ix) In case IMT-2000 is considered as a continuum of 2G services, is there a need to have a cap higher than that without IMT 2000 services? Should there be individual caps on 2G and 3G spectrum or a combined cap?

As we propose that 3G be an extension of 2G, we suggest that the cap should be slightly higher than the existing cap. We propose that the cap should be 2x20 MHz. However, it should be ensured that all operators using any type of technology get this minimum of spectrum either by way of allocation from the government or through the process of mergers and acquisitions.

(x) In case of M&As where the merged entity gets spectrum exceeding the spectrum cap, what should be the time frame in which the service provider be required to surrender the additional spectrum?

We propose that the entity be directed to surrender the additional spectrum immediately. In common with practice in other countries, we suggest that the conditions for approval of a merger / acquisition should include the surrender of spectrum in excess of the applicable cap.