Report of Committee to recommend revised subscriber-based criterion for allocation of spectrum

18. 12. 07

11. The Competent Authority constituted the following committee on 7.11. 07 to recommend revised subscriber based spectrum allocation criterion for allocation of spectrum in a scientific and practicable manner.

Composition of the Committee:

01. Shri R. Bandyopadhyay, Addl. Secy(T) Chairman
12. Shri P.K. Garg, Wireless Advisor Member
23. Shri Vijay Madan, ED, C-DOT Member
34. Dr.Bhaskar Ramamurthi, IIT Chennai Member
45. Dr. Ajit Kumar Chaturvedi, IIT Kanpur Member
56. Shri Dilip Sahay, AUSPI Member
67. Shri T. V. Ramachandran, COAI Member
78. Shri A.K. Srivastava,DDG(AS) Member Convener

2The Committee was permitted to co-opt or invite any expert or person who in its opinion would be helpful to formulate revised spectrum allocation criteria. The Committee may also benefit from experts with international experience. The Committee was asked to submit its report within three weeks.

The Committee held its first meeting on 16.11.2007. A Brief was given to the Committee, as attached in Annexure 1. The Committee discussed the way forward and finalized dates for its meetings. It was decided to invite all those who had written expressing a desire to present their views, to make presentations to the Committee. This would help the committee to have practical network related inputs from different operators based on their experience, and their perceptions of the whole issue.

2. In the second meeting of the Committee held on 26th November 2007 presentations were made by the following groups/companies:

M/s. Bharti Airtel Ltd.
M/s. Vodafone
M/s. COAI
M/s. Tata Teleservices Ltd.
M/s. Reliance Communications Ltd.
M/s. HFCL Infotel Ltd.
M/s. Shyam Telelink

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The hard copy and the soft copy of the presentations were circulated to all the members of the Committee by Member-Convener. The Committee requested TEC to make a presentation on their study so that Committee members could seek clarifications to understand their methodology.

4. In the third meeting held on 30th November 2007, following groups/companies presented their views in the forenoon session:

M/s. Spice Communications Ltd.

MTNL

BSNL informed that they have no additional input for the Committee and accordingly they did not make any presentation before the Committee. Efforts were thus made to consider all possible inputs. Various groups brought a number of experts while presenting their views. As the COAI and AUSPI members were present throughout, a lot of post-presentation inputs in the form of counter-arguments were circulated to all the members of the committee. The major issues on which inputs and counter arguments were received are listed in Annexure III. The points mentioned therein are often contradictory, as they were provided by organizations having widely different perspectives and observations.

As requested by the Committee, a detailed presentation on methodology and assumptions for working out the spectral efficiency report was presented by TEC. Committee sought certain clarifications from TEC. The Committee also requested TEC to submit the clarifications in the afternoon at 3 00 pm on 30.11.2007 itself. Based on the TEC presentation, COAI representative-member sought permission of the Chairman for COAI technical team to give their views on the TEC methodology and assumptions. COAI technical team was permitted to present their views at 4:30 pm.

15. After the inputs had been obtained from all the stake-holders, and various claims and counter claims heard, the Chairman requested Profs. Bhaskar Ramamurthi and Ajit Chaturvedi and Mr. Vijay Madan to consolidate the inputs and prepare, if possible, a brief discussion paper for the Committee to deliberate upon further at its next meeting.

26. Committee was supposed to finalise the Report within 3 weeks from the date of constitution (7.11.2007). In view of the complexity involved, it was not possible for the Committee to complete its job within the given time frame. The Committee's request for an additional time of 2 weeks was granted.

17. The Committee met again on 6.12.07. Prof. Bhaskar Ramamurthi made a presentation to the Committee.

28. First, the key issues raised in the earlier presentations to the Committee, along with the counter-arguments submitted, were considered and the following summary was made:

a. Spectrum requirement in a circle is determined by the tele-traffic in dense urban areas. However, the total subscriber base supported in the circle with a given quantum of spectrum depends on the available traffic demand in the rest of the circle.

b. Technology innovations which increase network capacity and improve QoS should be considered when developing the subscriber-based spectrum allocation criteria.

c. Methods other than subscriber-linked criterion for spectrum allocation, such as auction with a cap on maximum allocation are also possible.

d. Operators currently have a subscriber base in each circle significantly higher than the present criterion for all levels of allotted spectrum.

e. Internationally, most countries have only 3-4 operators and the quantum of spectrum allotted to them is higher than what prevails in India

f. When considering the subscriber-linked criterion, all the studies done till date should be examined.

9. Next, the earlier studies for determining the subscriber-linked criterion were discussed. In the WPC and TEC studies, the model used for computing the achievable subscriber base for a given quantum of spectrum is as shown in Annexure 2. (The earlier WPC study too was based on prior work done by TEC.) The TRAI study uses a model which is similar in several respects, though the independent variables defined in their model are not the same. With reference to the parameters described in Annexure II, the maximum cell capacity C depends on the technology employed and on the extent of deployment of innovations that increase capacity. The minimum inter-site distance in dense urban areas, ISD_{DU}, and the practical capacity utilization factor in dense urban areas, U, can be determined from the best practices in real networks world-wide. ISD_{DU} has been reducing over time. The parameters $\{A\}$ and $\{TDR\}$ are independent of technology. These can be determined from analysis of population density data and statistical sample surveys, aided by detailed data from operators at site level, if available. These parameters may vary with time.

This model is based on the premise that when the operator is given an incremental quantum of spectrum to increase the traffic density and subscriber capacity in the dense urban area, the operator is expected to increase the traffic density, and hence the subscriber base, in the remaining areas as well. This increase in the remaining areas is expected

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to be only in proportion to the traffic density ratios obtaining in the areas relative to the dense urban area, by virtue of their lower population densities and demand for mobile telephony. The traffic density ratios are to be estimated independently, as discussed above.

10. The subscriber-base criteria in the studies done till date differ widely due to

0– different values assumed for the minimum inter-site distance in dense urban areas

1– differing values of the technology-independent statistical parameters, based only on limited data obtained from operators.

2– different assumptions about technology advances deployed

3– different values assumed for the factor relating the ideal and realizable cell capacities

211. A calculation was performed by the academic experts in the Committee with data provided by COAI for the parameters for the four metros, including the service area. It was limited to the four metros since the parameter data set was complete only for these. The motivation for doing this calculation was only to explore what happens when the subscriber base is estimated by employing the model of Annexure II, using the values for the parameters as supplied by COAI based on traffic data obtained from operators. One of the technology advances, AMR coding, not considered in studies till date, was assumed to give a capacity gain of 10% as submitted by COAI. It should be pointed out here that higher capacity gains are claimed in the literature. This needs to be examined at a later date. No other advanced capacity enhancement technique was assumed, nor were in-building solutions considered. The subscriber numbers obtained in this study were close to or higher than the corresponding numbers in the TRAI study for some metros, and higher than the corresponding numbers in both the TEC and TRAI studies in others. In all cases, the numbers obtained far exceed those in the WPC study. If all the technology enhancements are taken into account, the numbers will increase further. The reason for the widely varying numbers obtained relative to the earlier studies is the different assumptions about the parameters, as has been pointed out above.

312. COAI and AUSPI member-representatives sought permission for their technical experts to give their inputs on this calculation. This was permitted, and the COAI team interacted with the Committee in the afternoon session of 6.12. 07. The COAI team pointed out their objections to the parameter values assumed in the calculations for the metros. They also questioned how cell capacity increase can be assumed to occur proportionately across the entire circle when incremental spectrum is allotted. The AUSPI team sought additional time

1and was given permission to give their inputs on 10.12.07.

213. In the meantime, the COAI and AUSPI sent in additional inputs on the calculation done for the metros.

314. The COAI member-representative sent a letter dated 7.12.07 formally dissociating himself from the Committee. This was unfortunate. The member had participated in all meetings till then, and had copies of all inputs received by the committee.

415. The Committee met again on 10.12.07. Different members from AUSPI gave their inputs regarding the initial and incremental spectrum allotment, the unsuitability of the subscriber-linked criterion, and the use of In-Building Solutions. While some AUSPI members opposed any reduction in the start-up spectrum allocation for GSM, as well as any reduction in the incremental allocation step size, other members felt both these reductions were justified. Still other members re-iterated the points made in their earlier presentations to the Committee.

516. The Committee resolved to meet again on 18.12.07 to finalize the report.

617. The Committee met on 18.12.07 and submitted the report.

Subscriber-Linked Criterion : the Technical Issues

This section deals with the technical issues regarding the development of a subscriber-base criterion for incremental spectrum allocation. An understanding of these issues will provide the rationale for the recommendations of the Committee.

Background

First, we give some background regarding the link between the quantum of spectrum and subscriber *density (*number of subs/km^2).

Spectrum reuse: A fundamental feature of all cellular mobile telephony systems, is that the same spectrum is re-used in cells spatially across the licensed area of operation. The spatial periodicity of re-use, i.e., the minimum distance between cells that re-use the same spectrum, is determined by the maximum interference level that can be tolerated in any one cell from other cells that use the same spectrum. There are technologies (e.g., CDMA) that re-use the spectrum in every cell. However, it is wrong to conclude automatically that they are superior as a result to technologies that re-use spectrum in cells that are further apart. Only a detailed analysis reveals the true spectral efficiency of any technology.

Cell size: The transmitted power from a cell site determines the size of the cell. In theory, one could make cells smaller and smaller, with subscriber numbers falling in each cell, in turn requiring less spectrum to serve them. Since the transmitted power is also reduced proportionately, the spatial re-use periodicity does not change. Thus, as the cells scale down in size, the same population can be served with less and less spectrum. Cordless phones can be thought of as an extreme example of this – a very small amount of spectrum serves the entire populace (unlike a cell-phone, a cordless phone has only one base station and one cannot go out of range of the base station, but this limitation is not related to the amount of spectrum employed.)

In practice, it is not possible to reduce the spectrum requirement to very small levels in this manner. For one, only the link between the cell-phone and base station is wireless. The base stations are all connected to the network using dedicated links. If one were to make cells very small, one of the key advantages of wireless telephony, namely rapid rollout, is lost. Secondly, there is usually a limit below which cells and transmit power levels cannot be made smaller, while pegging interference to the maximum permissible level *and simultaneously* ensuring full coverage.

Capital cost vs. spectrum cost: Even if the cell size is not reduced to the minimum possible, the capital cost of setting up more and more BTS sites per sq. km goes up as the cell size drops. If spectrum is priced, it is this capital cost with which the unit price of spectrum must be compared. Such a comparison will determine whether to keep cell size unchanged and use more spectrum, or drop cell size and manage with the same spectrum. In many countries, the capital cost of adding sites is very high due to restrictions imposed by civic authorities. An an example, all of London has fewer sites than a typical business center of an Indian metro. This is compensated for by significantly higher spectrum allocation, and by deployment of microcells (with the consequent wiring of base stations) in select areas, where even the higher spectrum allocation is insufficient.

Cell Capacity: The amount of spectrum available in a cell only indirectly determines the cell capacity, i.e, the number of subscribers who can be served in the cell. It is the amount of *teletraffic* that can be carried at any time in the cell that is directly related to the quantum of spectrum available. The number of subscribers supported depends on the teletraffic per subscriber, which is directly related to the minutes of usage during the busy hours. One can get an accurate estimate of this per-subscriber teletraffic level, averaged over all subscribers across the circle. One makes the simplifying assumption that the average per-subscriber traffic level will be valid across all cells in the circle. This is definitely simplistic when one compares, say, rural cells with cells in the heart of a city, and may not be quite valid even across cells within a city. However, with subscribers being mobile by definition, there is no alternative to making this simplification.

Technology vs. cell capacity: The ideal cell capacity (in teletraffic terms) for a given quantum of spectrum is determined by the technology deployed. All technologies are based on international standards, which are constantly being improved upon in a backward-compatible manner, from the time of launch till the next –generation technology replaces it. The capacity thus depends on the advanced techniques deployed in a particular network. Some of these advances are to be deployed on the network side, and cost the operator capital expenditure. Some are advances in the handsets, and while they do not cost the operator anything, they cannot be deployed overnight. The rate of adoption depends on the rate at which subscribers upgrade their handsets.

Circle-Wide Subscriber Base and Spectrum Allocation

We have discussed above the complex factors relating subscriber base and the quantum of spectrum allotted. The subscriber density is not uniform across the circle. While it is highest in the business districts of the cities, it drops as one moves towards the suburbs, and drops even more as one goes into the rural areas. Indeed, in certain uninhabited areas, it is negligible and one may not even
provide coverage there.

Thus the need for the smallest possible cells, maximum available spectrum, and the best technology advances available, is only in the dense urban areas. In the rest of the circle, one needs less spectrum. Or, as we discussed above with regard to capital cost vs. spectrum cost, one can make cells larger in areas where excess spectrum is available, and reduce capital cost. In rural areas, one may also run into the situation where the cell size cannot exceed a maximum limit imposed either by the technology or by coverage.

The quantum of spectrum allotted to an operator is for use in the entire circle. While the operator might be short of spectrum in the most dense areas, there is probably excess spectrum in the rest of the circle. ***An important consequence of the spectrum being in excess in most of the circle, including the metros, is that subscriber base can continue to grow even if there is a scarcity of spectrum in the dense urban areas***. Indeed, the country is adding subscribers at a rate hitherto unknown anywhere else in the world, even as the operators are demanding additional spectrum. And this is happening even before the cellphone revolution hits the rural areas. If we assume for a moment that rural coverage happens overnight and tariffs drop to affordable levels for the rural populace, another 300-400 million subscribers can be added in rural areas without any additional spectrum allocation!

So, how does the subscriber base in the circle relate to the quantum of spectrum allotted? The answer is that the correlation between the two is not high, as we have just seen above. An operator could conceivably run out of spectrum in the dense urban areas, even while the operator has very poor patronage in the

suburban areas. The total subscriber base will be low. Another operator could conceivably be focused on the suburban and rural areas, and achieve a large subscriber base with much less spectrum. Or, the operator might employ the generous (for the less dense areas) spectrum allotted to reduce the number of BTS sites, thus reducing capital expenditure, and presumably reducing the tariffs. Indeed, from the point of view of spectrum being a natural resource meant to be used optimally and efficiently for the public good, one would desire that any spectrum allotted leads to growth in subscriber base across the entire licensed area and is not limited to certain pockets.

A mobile telephone system can identify subscribers only at a circle level. One cannot talk of subscribers limited to the dense urban area within a metro, as the same subscribers are in the suburbs at other parts of the day. It may be possible to distinguish to an extent between rural and urban subscribers, and subscribers in one city from those of another. However, one cannot demarcate the subscriber base in the dense urban areas, which is most crucial from the spectrum point of view, and that in the rest of the city or circle.

Incremental Spectrum Allocation and Subscriber Base Growth

India is the only country in the world that is using a subscriber-linked criterion for incremental spectrum allocation to operators. There is thus no international experience available to the Committee from which lessons can be drawn. If a unit of spectrum is incrementally allotted to an operator, one can expect the subscriber density supported in the dense urban areas to increase proportionately. What about the rest of the circle? If the scope for growth in subscriber base is present across the circle, it is realistic to assume that subscriber base in the rest of the circle will continue to grow till saturation occurs, irrespective of whether additional spectrum is allotted or not. However, additional spectrum allocation is useful even in the less dense areas as it can go towards reducing capital expenditure. The fact that the subscriber base is increasing circle-wide can be used as a correlate of the growth in subscriber density in the dense urban areas. Thus, it is not unreasonable, though it may be difficult, to employ the subscriber-base as one criterion for allotment of *incremental* spectrum.

This can only work till the subscriber base saturates, and as long as there is clear evidence that the subscriber base will grow at feasible tariff levels. If the service is either unaffordable, or not what the customer wants, one cannot expect the subscriber base to grow significantly, whether or not one allots more spectrum.

Methodology for determining the subscriber-base criterion for allotting incremental spectrum

The subscriber base achievable in any of the less dense areas, such as the suburban or rural areas, depends on (a) the population in the area, and (b) the affordability of the service in that area (assuming that the desirability of the cellphone to the average citizen is beyond doubt). The population in different areas of a city is not a readily available figure, though there are ways of estimating it based on property data or satellite pictures of built-up area. Rural populations data are available village–wise, but the question of affordability is harder to address in rural areas. Here too, it is possible to relate potential subscriber base to the tariff and income levels, using data from urban areas.

Estimation of the achievable subscriber base in the less dense areas requires careful data collection and validation. This has to be done circle by circle and separately for the different types of areas ranging from urban to rural. If this has to be done in a reasonably short period, it requires institutional support to collect, analyze and validate the data. It cannot be undertaken by a committee of a few experts working in isolation. Nor can the data be collected reliably by holding consultations with the operators alone. For one, the operators have limited data (at least, that which they can share) and for another, they will understandably be wary about giving data that may unwittingly lead to a situation where they get less spectrum.

Apart from the demography- and economics-related aspects of estimating achievable subscriber base, there is a technology-related part. This is the estimation of the ideal and practically realizable cell capacity as a function of spectrum allotted, in the dense urban areas. This calls for (a) estimation of the minimum feasible cell size, (b) decisions on the technology advances one can realistically assume to be available in the network, and the degree of penetration of each, (c) estimation of the capacity enhancement each such advanced technique brings by itself, and when deployed in combination with others (which is usually less than when deployed alone), and (d) the back-off factor one must assume from the ideal capacity in order to obtain the realizable capacity on the ground.

The cell capacity estimation can be done by a committee of experts. Consultations with operators play an important role. The committee must also have access to the information on the practical performance of the different advanced techniques in networks abroad where they might be already deployed.

Thus, a committee charged with the task of specifying the subscriber-base criterion for incremental spectrum allocation in different circles in the country must have (a) experts on wireless technology with access to data from regulators and network operators elsewhere, (b) experts on data analysis and validation, particularly demographic data and data related to incomes and demand for

telephone services and (c) institutional support for data collection and collation. The committee should hold sufficient consultations with the operators to corroborate the data collected and validate their hypotheses. However, the operators themselves cannot be party to this task. The committee should take up the task simultaneously for all competing technologies and attempt to come up with a criterion that is independent of technology to the extent it is scientifically possible to do this.

Methodology followed till date

Achievable subscriber densities have been estimated based partly on demographic data, and partly on samples of traffic data of BTS sites in the different areas obtained from operators. In this approach, the BTSs of an operator have been used as *sensors* for estimating the demand for cellphones in different areas of the circles. This approach of using the cellular network itself as a tool for estimating the potential subscriber base has its share of problems. For one, it gives an idea only of existing traffic and not the potential traffic. In rural areas, for example, where coverage is sparse, one cannot conclude there is no demand based on the low traffic today supported today by the relatively few rural BTSs. Even in other areas, tariff levels play a role in determining demand. One of the reasons why earlier estimates of subscriber demand (on which the chronologically earlier subscriber-linked criteria were based) have been exceeded significantly is the drop in tariffs and cellphone prices, accompanied by an increase in affordability. Nevertheless, in the absence of any other data, this is a quick and ready approach.

Recommendations

1R1. **It is time to look at other criteria for deciding incremental spectrum allocation, possibly in combination with the subscriber-linked criterion**.

Discussion It is important to draw the obvious conclusions from the fact that the subscriber-base criterion given by the WPC study has been significantly exceeded by the operators. This has happened without additional spectrum being allotted and is a direct result of the high demand created for mobile telephony in the less dense areas of the circles. This shows that there has been sufficient spectrum for the less dense areas and if demand continues to grow in these areas (by a combination of appropriate tariffs and growth in economic activity) subscriber base can continue to grow at a significant pace, possibly even without further allocation of spectrum. Scarcity of spectrum, if any, is felt mostly in the dense urban areas. Deployment of technology advances also plays an important role in improving the spectral efficiency in dense urban areas. In general, the correlation between available spectrum (when above a minimum threshold) and subscriber base in the circle is not high. Nevertheless, the use of the subscriber base as a criterion for incremental spectrum allocation has ensured that when incremental spectrum is allotted due to felt need in the dense urban areas, significant subscriber growth takes place elsewhere in the circle as well. We note, however, that the time has probably come when we need to look at other criteria for deciding incremental spectrum allocation, possibly in combination with the subscriber-linked criterion. The subscriber base can continue to be a necessary criterion, but in the long run, it may not be a robust method by itself for releasing additional spectrum to existing operators. We also note that spectrum is a scarce resource, and if its allocation is not market-driven, at least in part if not in full, its value vis-à-vis capital expenditure on the network infrastructure does not get factored in.

1R2. **A combination of auction and subscriber-linked criterion is worth considering**.

Discussion While it is possible to determine the subscriber-base criterion for different levels of spectrum allocation, it is not a simple

task. Extensive data analysis and collection is needed, and the absence of such an effort till date has led to vastly varying criteria. Further, such data collection and analysis may have to be done at regular intervals, especially in a growing economy like ours where demand for telephony can increase rapidly. Otherwise, the subscriber base criterion runs the risk of becoming outdated.

There are other methods possible for allotting incremental quantities of spectrum. One such method is to first grant a minimum allotment to an operator along with the license, and then auction the remaining spectrum, with a cap on the total spectrum that any operator can have in a circle. Auctions seek to balance the cost of incremental spectrum with the capital expenditure needed to add capacity with the existing spectrum. Auctions have been employed internationally, sometimes with success and at other times, with undesirable consequences. While auction encourages investment in spectrally efficient technologies, it can also lead to spectrum hoarding unless the rules are carefully drawn up. The setting up of auction rules so as to achieve the desirable results is a challenging task.

Yet other methods are possible. For example, one could consider a combination of auction and subscriber-linked criterion. Here, one would periodically auction not large chunks but incremental quanta of spectrum. The eligibility of an operator to participate in the auction and bid for the next incremental quantum of spectrum would depend on whether the operator meets a minimum subscriber base criterion for the amount of spectrum already allotted. Presumably, in such a method, the infirmities of either method when employed alone can be overcome. Careful study is needed before a method is chosen to be employed in future.

1R3. **A technical committee should be set up to specify the method to be followed for allotting incremental spectrum.**

Discussion A technical committee should be set up to specify the method to be followed for allotting incremental spectrum. Apart from the subscriber-linked criterion, other methods such as auction, and combinations of methods such as auction and the subscriber-linked criterion, ought to be evaluated for their suitability. The committee should further conduct the study needed to establish the rules for implementing the method recommended by it. Given that India is innovating in this sphere, the committee should leverage all available

expertise in the country, particularly the academic expertise available from the IITs, IISc, IIMs, and other research bodies. It will need expertise not only about wireless technology, but also regarding auctions, statistical sampling surveys, etc. It will also need institutional support for carrying out its work. The constitution of such a committee has also been recommended by TRAI (Para 2.61) in its Recommendations on "Review of License Terms and Conditions and Capping of Number of Access Providers", dated August 2007.

1R4. **Incremental spectrum allocation for GSM can be reduced to 1 MHz steps.**

Discussion Till date, the incremental quantum of spectrum allotted is in the range 1.8-2.4 MHz for GSM networks, and the minimum possible quantum of 1.25 MHz for CDMA networks. In the case of GSM, this quantum is based on the re-use pattern prevalent in GSM networks in earlier years. However, all networks now employ frequency hopping and several capacity-enhancing advanced techniques. It is now possible to deploy an increment of 1 MHz effectively in the network. The additional subscriber base supported by each extra 1 MHz is also large. The incremental quantum of spectrum allotted for GSM can therefore be reduced to 1 MHz. It is therefore recommended that the subscriber-linked criterion be modified to specify the subscriber base for steps of 1 MHz additional spectrum in the case of GSM.

1R5. **Keeping in view the immediate task at hand, as an interim measure, and till such time as a committee as recommended above is constituted and it completes its work, Profs. Bhaskar Ramamurthi and Ajit Chaturvedi felt that criteria recommended by TRAI, which is the regulatory body, may be considered by government. However, Shri Srivastava was of the view that for GSM systems the TEC criteria may be considered while for CDMA, the TRAI criteria may be considered. In view of the sharp divisions among the members of the Committee regarding this important issue, the Committee felt that this decision is best left to the government.**

2R6. *Discussion* The subscriber-linked criterion of three earlier studies, namely, the WPC, TRAI and TEC studies are available, as described in the Brief given to the Committee, vide Annexure I. As already mentioned above, the numbers in these three studies differ primarily due to the

1different assumptions made regarding the statistical parameters. The subscriber-base criterion given by the WPC study has been exceeded significantly by the operators for all quanta of spectrum allotted, and in most circles. This has happened without additional spectrum being allotted, due to the high demand created for mobile telephony in the less dense areas of the circles. Depending on the parameters assumed, one can get widely varying numbers, including numbers higher than those obtained by TEC. It is not possible for the Committee to arrive at definite numbers for all the circles without the detailed study mentioned above. Hence the Committee is not in a position to recommend any specific numbers/criteria at this time. The government needs to take a decision in this regard. It is also observed that TEC has given criteria for GSM only, whereas TRAI has given criteria for both GSM and CDMA technologies. Keeping in view the immediate task at hand, as an interim measure, and till such time as a committee as recommended above is constituted and it completes its work, Profs. Bhaskar Ramamurthi and Ajit Chaturvedi felt that criteria recommended by TRAI, which is the regulatory body, may be considered by government. However, Shri Srivastava was of the view that for GSM systems the TEC criteria may be considered while for CDMA, the TRAI criteria may be considered. In view of the sharp divisions among the members of the Committee regarding this important issue, the Committee felt that this decision is best left to the government. However, the GSM tables will have to be modified to incorporate the recommendation in Recommendation 4 above, namely, to include the subscriber base criteria for the intermediate spectrum allotments. This can be done either by interpolation, or by re-calculating the subscriber base for these intermediate levels of spectrum allotment.

Dr. Bhaskar Ramamurthi IIT, Madras	Dr. Ajit Kumar Chaturvedi, IIT Kanpur Member
Shri P.K.Garg Wireless Adviser Member	Dr. Vijay Madan ED, C-DoT Member
Shri Dilip Sahay	Shri T.V.Ramachandran

Representative from AUSPI Member	Representative from COAI Member
Shri .A.K.Srivastava DDG (AS Member	Shri R.Bandyopadhyay Additional Secretary Chairman

Annexure I
Brief for the Committee

1. Present Subscriber Linked Spectrum Allocation Criterion for CMTS/UAS Licensees (WPC letter No. 29th March 2006)

The initial spectrum is being allotted to the cellular operators in accordance with the relevant provisions of the Service License Agreement. With growth of service and increased subscriber base, allotment of additional spectrum is considered taking into account the eligibility criteria (subscriber based), justification and subject to availability of spectrum in a telecom service area.

1**A. Existing criteria for allotment of GSM spectrum**:

Service Area	Minimum subscriber base (In Lakh) required for allotment of **different amounts of GSM spectrum ****
4.4 MHz 6.2 MHz 8 MHz 10 MHz 12.4 MHz 15 MHz	
Metro Service Area Delhi & Mumbai Chennai & Kolkata	Initial Allocation* 3 6 10 16 21 Initial Allocation* 2 4 6 10 13
Telecom Circles as Service Area Category 'A' circle Category 'B' circle Category 'C' circle	Initial Allocation* 4 8 14 20 26 Initial Allocation* 3 6 10 16 21 Initial Allocation* 2 4 6 9 12

1**B. Existing criteria for allotment of CDMA spectrum**:

Service Area	Minimum subscriber base (In Lakh) required for allotment of **CDMA carriers of nominal 1.25 MHz** bandwidth each **
1st Carr. 2nd Carr. 3rd Carr. 4th Carr. 5th Carr. 6th Ca	
Metro Service Area Delhi & Mumbai Chennai & Kolkata	Initial Allocation* 3 10 16 21 Initial Allocation* 2 6 10 13
Telecom Circles as Service Area Category 'A' circle	Initial Allocation* 4 12 20 26

Category 'B' circle	Initial Allocation* 3 10 16 21
Category 'C' circle	Initial Allocation* 1.5 5 9 12

* Initial allotment for roll-out of the network

** The active subscribers and peak traffic averaged over a month (for a minimum of 40 mErlangs per subscriber) in the Visitor Locator Register (VLR) would be taken into account for this purpose.

2. <u>TRAI's Recommendation on Spectrum Allocation dt. 28-08-2007:</u> "**The Authority is of the opinion that there is a need to tighten the subscriber criteria for all the service areas so as to make it more efficient form the usage and pricing point of view.** Further, in the category A,B and C service areas the subscribers are widely distributed in the service area and therefore the amount of spectrum required in these areas for the same number of subscriber as in a metro will be comparatively lower".**(para 6. 3 in chapter 6 of TRAI's recommendations)**.

"In order to frame a new spectrum allocation criteria, **a multi-disciplinary committee may be constituted** consisting of representatives from DoT/TEC, TRAI, WPC wing, COAI & AUSPI. The committee may be headed by an eminent scientist/ technologist from a national level scientific institute like Indian Institute of Science, Bangalore. However, **it is necessary to enhance the present subscriber norms as an adhoc measure so that the task of spectrum allocation is not stalled. The suggested revision is given below:-(para 6.4 in chapter 6)**.

GSM subscriber base criteria (millions of subscribers)

Service Area	2 x 6.2 MHz	2 x 8 MHz	2 x 10 MHz	2 x 12.4 MHz	2 x 15 MHz
Delhi/Mumbai	0.5	1.5	2	3.0	5
Chennai/Kolkata	0.5	1.5	2	3.0	5
A	0.8	3	5	8	10
B	0.8	3	5	8	10
C	0.6	2	4	6	8

CDMA subscriber base criteria (millions of subscribers)

Service Area	3rd carrier (2 x 3.75 MHz)	4th carrier (2 x 5 MHz)	5th carrier (2 x 6.25 MHz)	6th carrier (2 x 7.5 MHz)

Delhi/Mumbai	0.5	2	3.0	5
Chennai/Kolkata	0.5	2	3.0	5
A	0.8	5	8	10
B	0.8	5	8	10
C	0.6	4	6	8

Government's Decision: The Government, on 17-10-2007, decided that there is a need to review the subscriber base spectrum allotment criterion and decided that it may be examined by TEC before a final decision is taken.

3. Report of Telecom Engineering Centre(TEC) on Subscriber Linked Spectral Efficiency for GSM Licensees

The report of TEC on Spectral Efficiency was submitted to Hon'ble MOC&IT on 26-10-2007. TEC's report was accepted-in-principle by Hon'ble MOC&IT on 30-10-2007.

The Service Area wise 'Spectral Efficiency Report' suggested by TEC for subscriber linked criterion is as below:

GSM Subscriber Base Criterion (Subscribers in Lakhs) based on Report of Telecom Engineering Centre (TEC) on spectral Efficiency.

S.N	Service Area	Category	Total Mobile subscribers supported by spectrum of				
4.4+4.4 MHz	6.2+6.2 MHz		8.0+8.0 MHz		10.0+10.0 MHz		12.4+12.4 MHz
1	Andhra Pradesh	A	13	42	73	103	133
2	Gujrat	A	12	39	68	96	124
3	Karnataka	A	9	30	52	73	95
4	Maharastra	A	14	42	74	105	136
5	Tamilnadu	A	11	36	64	90	116
6	Haryana	B	4	12	21	30	39
7	Kerala	B	8	25	44	62	80
8	MP	B	13	39	69	97	126
9	Punjab	B	8	25	45	63	82
10	Rajasthan	B	10	32	56	79	102
11	UP (East)	B	13	41	72	101	130

12	UP (West)	B	10	32	57	80	104
13	West Bengal	B	10	31	54	77	99
14	Assam	C	10	33	58	81	105
15	Bihar	C	12	36	64	90	116
16	Himachal Pradesh	C	2	7	12	17	22
17	Jammu & Kasmir	C	2	7	13	19	25
18	North East	C	6	19	34	48	63
19	Orrisa	C	10	31	55	77	100
20	Delhi	A	6	19	34	48	63
21	Mumbai	A	7	23	41	58	75
22	Kolkata	A	6	20	36	50	65
23	Chennai	A	5	17	31	43	56

ALL MOBILE SUBSCRIBER FIGURES ARE IN LAKHS

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1. Licencing Provisions under UAS Licence:

Clause 43.1

A separate specific authorization and licence (hereinafter called WPC licence) shall be required from the WPC wing of the Department of Telecommunications, Ministry of Communications permitting utilization of appropriate frequencies / band for the establishment and possession and operation of Wireless element of the Telecom Service under the Licence Agreement of Unified Access Service under specified terms and conditions including payment for said authorization & WPC licence. Such grant of authorization & WPC licence will be governed by normal rules, procedures and guidelines and will be subject to completion of necessary formalities therein.

Clause 43.5

Subject to availability and as per Guidelines issued from time to time, the ***spectrum allocation*** and frequency bands will be as follows :

43.5.(i) For wireless operations in SUBSCRIBER access network, the frequencies shall be assigned by WPC wing of the Department of Telecom from the frequency bands earmarked in the applicable National Frequency Allocation Plan and in coordination with various users.

Initially a cumulative maximum of upto 4.4 MHz + 4.4 MHz shall be allocated in the case of TDMA based systems @ 200 KHz per carrier or 30 KHz per carrier or a maximum of 2.5 MHz + 2.5 MHz shall be allocated in the case of CDMA based systems @ 1.25 MHz per carrier, ***on case by case basis subject to availability.***

While efforts would be made to make available larger chunks to the extent feasible, the frequencies assigned may not be contiguous and may not be the same in all cases or within the whole Service Area. For making available appropriate frequency spectrum for roll out of services under the licence, the type(s) of Systems to be deployed are to be indicated.

43.5(ii) Additional spectrum beyond the above stipulation ***may also be considered for allocation after ensuring optimal and efficient utilization of the already allocated spectrum taking into account all types of traffic and guidelines / criteria prescribed from time to time.***

However, spectrum not more than 5 + 5 MHz in respect of CDMA system or 6.2 + 6.2 MHz in respect of TDMA based system shall be allocated to any new Unified Access Services Licensee.

The spectrum shall be allocated in 824-844 MHz paired with 869 - 889 MHz, 890 - 915 MHz paired with 935 - 960 MHz, 1710 – 1785 MHz paired with 1805 – 1880 MHz.

43.5(iii) 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.

43.5(iv) ***The Licensor has right to modify and / or amend the procedure of allocation of spectrum including quantum of spectrum at any point of time without assigning any reason.***

Annexure II

The achievable subscriber base *ASB* for a given amount of spectrum depends on the following parameters:

T_s : Erlangs/subs

C : maximum capacity of cell (not sector) for a given quantum of spectrum

U : utilization factor giving realizable capacity

ISD_{DU} : practical minimum site distance in Dense Urban area.

In the above set of parameters, C is directly dependent on technology deployed, and the technology advances assumed.

$\{A_{DU}, A_U, A_{SU}, A_R, A_{UI}\}$: areas of dense-urban, urban, suburban, rural and un-inhabited regions in the circle

$\{TDR_U, TDR_{SU}, TDR_R, TDR_{UI}\}$: traffic density ratios of U, SU, R, and UI areas relative to traffic density of DU area, in Erlangs/km^2.

These parameters are independent of technology. They depend on the statistical distribution of population across the different areas and relative mobile usage in these areas.

As an example, the model employed in the TEC study is:

$$ASB = [1/T_s] \times [(C \times U) / A(ISD_{DU})] \times [A_{DU} + TDR_U \times A_U + TDR_{SU} \times A_{SU} + TDR_R \times A_R + TDR_{UI} \times A_{UI}]$$

Annexure III

The following are the key points made in the presentations of various stake-holders. Many of these are contradictory, since the competing stake-holders often espouse completely opposing views.

1• Claims and counter claims on whether or not the operators had exhausted all spectrum efficiency enhancement techniques.

2• Whether QOS was suffering because of cited congestion due to perceived shortage of spectrum

3• Claims and counter claims on the effectiveness and quantitative values of capacity gain various quality enhancement techniques like AMR, SAIC, disconitinuous transmission, in-building solutions, further reduction in inter site distance, six sectored cells, etc. Also claims and counter claims on provenness of these techniques

4• Whether the short time given was adequate for the committee to generate tables of revised subscriber based criterion on a scientific and practicable basis. Several months of study are needed.

5• How have the operators been able to provide much higher numbers of subscribers than those mentioned in the present criterion without allocation of additional spectrum for more than last one year

6• Claim that the earlier committee of 2003 had done scientific studies and case studies and then only issued criterion in 2006, and nothing has changed since then. Several spectral enhancement techniques were known even at that time

7• Whether maximum site configuration could be applied to all the area categories

8• Whether traffic distribution in Dense urban , urban+ rural was correctly taken by TRAI and TEC

9• Whether TEC numbers are lower or higher due to various reasons

10• TEC numbers are low because many technology advances have not ben taken into account

11• What numbers should be used for Utilization factor to arrive at the efficiency figures

12• Whether global numbers of spectrum allocation and subscribers per MHZ of spectrum are higher or lower than those in India

13• Which of the technologies namely, GSM or CDMA is more efficient

14• How do the in-building solutions contribute to the capacity or coverage

15• What are the interference issues and minimum site distances in some of the world capitals

16• Retrospective or Prospective implementation of changed policy

17• Whether the operators earlier have been allocated spectrum without policy framework

18• Whether QOS has also improved over last few years without additional spectrum

1• Whether correct demographic parameters, cell capacity, site configurations, area have been correctly assumed by earlier studies and the operators themselves

2• Whether while allocating spectrum any other global licensors or regulators had used subscriber based allocation criterion

3• Whether the operators already have extra spectrum allocated more than the eligibility based on the existing criterion, and whether they can manage the number of subscribers within the available or less spectrum. Whether the demand for spectrum is actually justified

4• Why the earlier studies have not taken technology innovations into account

5• Why not the extra spectrum as perceived be returned, surrendered as per past practices

6• Whether fixed charge per additional subscriber could be recommended to avoid over reporting of subscriber base

7• Whether there was a need to move away from subscriber linked criterion

8• What should be the spectrum allocated upfront to make the operators know their limitations or solutions in advance

9• Whether there should be a cap of 10 MHz total for all technologies deployed by an operator

10• Whether there should be separate indoor and outdoor spectrum allocation

11• How much traffic is generated from in-building deployments

12• Whether there are possibilities of deploying in-building solutions

13• What are the ground realities and practicalities as compared to theoretical calculations

14• Whether cities like Bangalore and Hyderabad can be considered as metros

15• Whether Public Sector operators have more difficulties as late entrants, and whether they need more spectrum because of various reasons of security etc.