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July 15, 2004

Dr. H. V. Singh
Secretary, TRAI

Sir,

Lucent Technologies applauds the TRAI for its Consultation on Spectrum Related Issues and appreciates the opportunity to comment on these important matters. There is no question that the forecasted growth of wireless demand in India warrants the allocation of additional spectrum. Lucent believes that spectrum allocations and related spectrum policies should not only support the growing demand, but also provide operators with the flexibility to offer the services their subscribers need and the ability to meet those needs using the technology that best satisfies the operator's business and technical requirements.

Accordingly, Lucent suggests that spectrum allocations be technology neutral and that all operators have equal opportunity to obtain the spectrum necessary to meet their present and future needs. Lucent specifically requests that the TRAI consider the allocation, either in its entirety or in part, of the North American PCS band (1850-1910/1930-1960 MHz) for commercial service in India. Wireless infrastructure for all technologies (GSM/CDMA/UMTS) is available for deployment in this band and its allocation would provide Indian operators with the economies of scale available with this widely used equipment.

Please contact me if you have any questions related to the attached comments.

Respectfully,

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Telecom Regulatory Authority of India
Consultation Paper on Spectrum Related Issues

Comments of Lucent Technologies

Introduction

Lucent Technologies Inc. (Lucent) welcomes the opportunity to respond to the TRAI's consultation on Spectrum Related Issues. Lucent is a major manufacturer of wireless infrastructure and a worldwide leader in the development of spread spectrum technologies. Lucent's research organization, Bell Labs, has been a key contributor to the ever-expanding capabilities and features that characterize the wireless communications industry. Included among these contributions are the initial proposal for high capacity cellular system for mobile phone service in 1971, the first commercial cellular trial in 1978, numerous patents for wireless technologies including CDMA, and recent proposals/patents that describe the use of multiple antenna arrangements for further increased wireless capacity and data rates.

Lucent's comments focus on the need to allocate spectrum on a technology neutral basis, assuring that all operators have an equal opportunity to obtain the necessary spectrum resources to meet their present and future needs. Lucent is particularly concerned that operators who choose CDMA have access to spectrum that will allow them to satisfy the growing subscriber demand for their wireless services.

In addition to addressing the spectrum needs of CDMA operators, Lucent responds directly to a subset of the specific questions asked in the Consultation that are concerned with spectrum availability and spectrum allocation.

Existing Operators Should Have Equitable Near-Term Access to Spectrum

Data reflecting the growth of mobile services in India, as described in the Consultation (Figs. 2.1, 2.2), support the need for the allocation of additional spectrum, and suggest that customer growth and the associated need for additional spectrum is independent of the wireless technology deployed. Accordingly, spectrum should be allocated and available on an equitable basis, with each operator receiving the opportunity to obtain a share of that which is available. Indeed, the TRAI recognizes the need to ensure that both existing GSM and CDMA operators have adequate spectrum and further notes the importance of equipment availability in its allocation decisions (sec. 5.4). An allocation plan for additional spectrum that provides CDMA operators no path for obtaining more than the currently available spectrum – such as those shown in Table 2.3 of the Consultation and further described in Section 2.6.2 of the Consultation – is clearly discriminatory and ultimately not in the public interest.

The PCS Band Should Be Allocated For Use In India

The TRAI properly notes that the possible use of the North American PCS band in India would provide additional spectrum applicable for CDMA use. Available infrastructure and terminal equipment could be used, allowing Indian CDMA operators to take advantage of economies of scale for equipment designed to operate in this band.

The TRAI is correct to raise concerns relative to the potential for interference between the PCS band and the IMT-2000 band that apparently will be implemented in India. Such concerns are understandable as the PCS downlink overlaps the IMT-2000 uplink. However, as the TRAI is no doubt aware, there does exist a 2x10 MHz portion of the PCS band that does not overlap the IMT-2000 band. This band would comprise 1900-1910 MHz for mobile transmit (uplink) paired with 1980-1990 MHz for base station transmit (downlink). Importantly, it appears that the allocation of this band for CDMA use could be accommodated with a minimum burden of interference into systems occupying the IMT 2000 band.

In order to assess the possibility of interference caused by the potential use of the aforementioned portion of the PCS band, Lucent examined the feasibility of deploying a CDMA system in 1980-1990 MHz for Base Station (BS) transmission when IMT-2000 systems operate in the adjacent 1920-1980 MHz band for BS reception (mobile transmit). This study, provided in Appendix A, shows that appropriate frequency assignment, filter design, and antenna engineering can allow the two systems to co-exist with acceptable interference levels. These interference mitigation methods have been common practice in the 850 MHz bands within India and China, where the CDMA 850 MHz BS transmit band is in the proximity of the GSM 900 MHz BS receive band.

The study considers that isolation of the interfering and victim systems is primarily required to mitigate two dominant interference factors – spurious emission power from the interfering transmitter and total interfering carrier power, which can cause victim receiver blocking. Both interference factors can reduce the victim system's capacity and coverage.

Based upon experience gained in the CDMA 850/GSM 900 co-existence studies, Lucent suggests that an affordable BS transmit or receive filter with reasonable physical size and insertion loss can provide a 60 dB rejection if a guard band of 2.25 MHz is utilized. With this 60 dB of transmit filter attenuation, the 107 dB of antenna isolation required to mitigate spurious emissions between an interfering PCS CDMA BS transmitter and a victim IMT-2000 UMTS BS receiver is reduced to 47 dB. It is recognized that the inherent guard band, based upon frequency assignment practices between interferer and victim systems is about 1 MHz, thereby requiring an additional guard band of about 1 MHz to obtain the aforementioned filter attenuation of 60 dB. Lucent suggests that this additional guard band can be realized if the UMTS channel spacing is reduced from 5 MHz to 4.8 MHz, consistent with arrangements permitted in standards. Similarly, if the victim system in the IMT-2000 band was CDMA2000, the additional guard band could be realized by eliminating one (1.25 MHz) carrier.

The required resultant 47 dB isolation can be provided through antenna separation. Measurement data indicates that two PCS BS antennas vertically placed on the same tower with the same orientation can achieve about 49 dB isolation. If the antennas cannot share the same tower, the isolation requirement should be achievable through vertical and horizontal antenna separation the use of appropriate antenna pattern, downtilt, and orientation, and, if necessary, the use of additional filtering.

As described in the Appendix, an analysis of the isolation required to prevent victim receiver blocking, again assuming a 2.25 MHz guard band and the use of a 60 dB filter, demands a similar level of attenuation that is achievable through antenna separation.

The TRAI should be aware that as an alternative to the allocation of the aforementioned portion of the North American PCS band (1900-1910/1980-1990 MHz), it might wish to consider the allocation of the PCS band in its entirety (1850-1910/1930-1990 MHz). Wireless infrastructure and terminals are available in this band to support the use of second generation technologies (cdmaOne (IS 95) and GSM) as well as third generation CDMA2000 and UMTS. Accordingly, this allocation would not reduce 3G spectrum availability. It should also be recognized that although such an allocation would assign spectrum for 3G use that is distinct from the IMT-2000 band, multi-band terminals are either available or planned, and would allow users to easily roam into regions that employ IMT-2000 and possibly other bands.

Lucent Offers Responses To The Following Selected Questions Listed In Chapter 7 Of The Consultation

Question (i)

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

The TRAI Should Allocate The 450 MHz Band For Commercial Service

The TRAI is likely aware of the growing use of the 450 MHz band for commercial wireless services in many areas throughout the world. Propagation loss at this frequency is markedly better (i.e., lower) than that available at higher frequency bands; approximately 1.5 times better than that at 850 MHz, and more than 3.5 times better than that at 1900 MHz. Accordingly, as indicated in the Table shown in Figure 1, below, cell size (i.e., coverage) at 450 MHz could be almost 3 times greater than that achievable at 850 MHz, and more than 13 times greater than at 1900 MHz. The improved propagation performance and the consequent ability to serve sparsely populated areas more economically makes the allocation of the 450 MHz well suited to rural environments.

Figure 1-Coverage Comparisons of IMT-2000 Systems at Various Frequency Ranges[1]

Frequency (MHz)	Cell radius (km)	Cell area (km^2)	Relative Cell Count
450	**48.9**	**7521**	**1**
850	**29.4**	**2712**	**2.8**
950	**26.9**	**2269**	**3.3**
1800	**14.0**	**618**	**12.2**
1900	**13.3**	**553**	**13.6**
2500	**10.0**	**312**	**24.1**

Lucent recognizes that demand for infrastructure and terminals that might be used primarily in rural areas could be limited, and that equipment availability could, therefore, be problematic. However, third generation technology (CDMA2000) is already available for use in the 450 MHz band and it has been successfully deployed in several countries in Eastern Europe as well as in Russia and China. Within these environments, base station coverage areas with a radius of up to 60 km have been reported. The ITU has recognized the potential for the use of 450 MHz wireless technology in developing (i.e., rural) environments and specific equipment requirements have been described in standards.[2] [3] An allocation for commercial services in this band, harmonized with allocations worldwide, would benefit from the economies of scale made available to manufacturers of 450 MHz infrastructure and terminals.

It is further recognized that mobile terminals (handsets) designed for use in the 450 MHz band would have to support the rural subscriber's ability to roam outside the home location, and would therefore require compatibility with the widely used spectrum

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[1] Qualcomm ITU/WP8F submission, June 11, 2001; "Coverage Comparison of IMT-2000 Systems at Various Frequency Ranges, Including 450 MHz"

[2] New Technologies for Rural Applications: Final Report of ITU-D Focus Group 7; February, 2001

[3] ITU-R; M.1457

allocations. Lucent understands that the need to provide such compatibility is well understood by handset manufacturers and that availability of such multi-band terminals is subject to market demand.

In summary, an allocation of spectrum in the 450 MHz band would provide rural carriers the ability to more economically offer to their subscribers state-of-the-art wireless technology and services. To the extent possible, such an allocation should be harmonized with similar allocations worldwide, thereby providing rural operators in India access to 3G technology already available for use in the 450 MHz band.

The TRAI should realize, however, that any allocation of spectrum in the 450 MHz band should be considered primarily as a resource for rural operators and not as a substitute for any other allocations that the TRAI may be contemplating, such as additional spectrum in the 800 MHz band and the use of the 1900 MHz band. Rather, 450 MHz spectrum should be considered in addition to the bands currently being studied or proposed.

Finally, consistent with its view that spectrum allocations should be technology neutral, Lucent suggests that the 450 MHz band, if allocated, need not be dedicated to CDMA technology. Rather, it should be awarded without regard to the operator's choice of technology.

Question (iii)

Whether the IMT 2000 band should be expanded to cover all or part of 1710-1785 MHz band paired with 1805-1880 MHz?

The TRAI Should Permit IMT 2000 Technology To Be Deployed In The 1710-1785/1805-1880 MHz Band

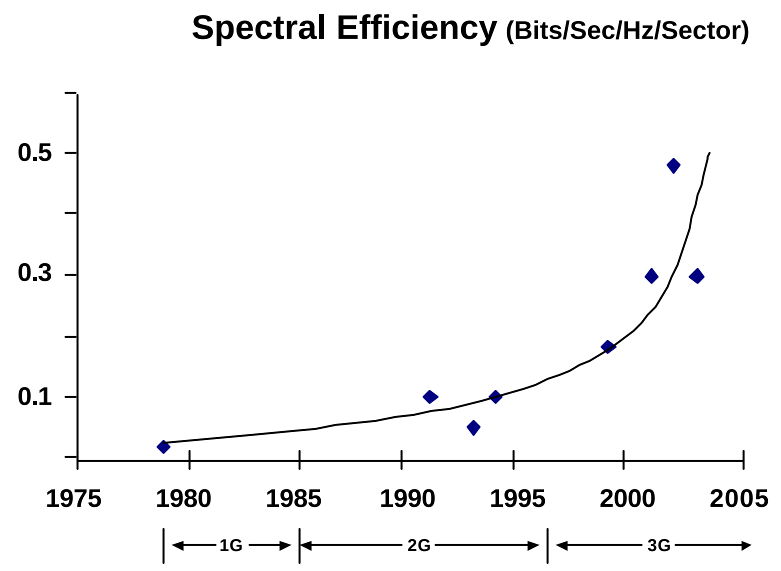
The TRAI is no doubt aware that the 1710-1785/1805-1880 MHz band has been identified, along with other bands, by WRC 2000 as IMT-2000 spectrum. Lucent suggests, however, that the TRAI need not specify any band for exclusive 2G or 3G use and should provide operators the flexibility to use either existing 2G technology or advanced technologies within any of their licensed bands. An operator's choice of technology should not be based upon whether that technology is labeled as 2G or 3G, but rather on whether it meets the operator's business needs and the needs of its subscribers.[4]

It is likely that operators will wish to deploy advanced systems in their licensed bands wherever it is technically possible. The improved spectral efficiency of 3G systems offers increased capacity, higher data rates and the associated ability to provide a broad

[4] To the extent that the TRAI is interested in equipment availability, it should be aware that no CDMA infrastructure is available in the DCS 1800 band. Although the Korean PCS band overlaps, in part, with the DCS 1800 band, the CDMA technology used in Korea cannot be directly adapted to the DCS 1800 band. Specifically, differences in the standard (e.g., different duplex spacing) and the need for software modifications make the use of the technology problematic.

range of feature rich services. The use of this technology should not be denied to operators who seek to deploy such systems but whose licenses lie in spectrum not explicitly designated as IMT 2000. The improvements in spectral efficiency that are available in advanced systems are graphically described in the Figure 2, below.

Figure 2 – Improvement in Spectral Efficiency



As indicated, the spectral efficiency of third generation technology is about 30 times greater than that offered by early analog systems, and importantly, 3G technology is shown to provide up to three times the spectral efficiency available from 2G systems.

Similarly, this level of flexibility should extend to all existing bands, including the 850 MHz (cellular) band. The result may well be that the licensed bands support a mix of 2G and 3G systems, consistent with the operator's need to upgrade their technology and services subject to demand, rather than regulatory mandate.

Question (iv)

Should IMT 2000 spectrum be considered as an 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?

The TRAI Should Allow Licensees In IMT 2000 Spectrum To Deploy Either 2G Or 3G Technology

Lucent firmly believes that market forces will drive operators who receive licenses in bands identified as IMT 2000 spectrum (e.g., 1920-1980/2110-2170 MHz) to deploy state-of-the-art systems that provide the most efficient use of spectrum and offer data rates that support new and innovative services. However, consistent with the above arguments, Lucent suggests that there be no regulatory requirement that any spectrum be used only for 3G technologies, and, therefore, that there should be no exclusive "3G licenses". Indeed, Lucent applauds the TRAI for its efforts on Unified Licensing recommendations. Lucent understands that under this arrangement, the licensee will choose the type of technology (2G or 3G) it wishes to use.

Lucent also agrees with the TRAI's observation that a level playing field demands the allocation of spectrum to be technology neutral.[5] Accordingly, the opportunity to obtain new spectrum (regardless of whether the spectrum is identified as IMT-2000) should be equally available to both CDMA/CDMA2000 operators and GSM/UMTS operators.

Question (vii)

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.

Lucent respectfully suggests that detailed evaluation by the regulatory authority of technology specific spectrum utilization, and the use of that evaluation as input to spectrum allocation decisions that would assign spectrum to operators based upon the technology they use is inappropriate. Rather, spectrum allocations should be technology neutral, with the choice of technology and the associated efficiency of spectrum utilization the decision of the licensee.

Notwithstanding this concern, Lucent offers the following comments on the methodology used in Chapter 3 of the Consultation to determine the efficiency of spectrum utilization.

[5] Consultation, page 16

Lucent believes that the methodology used to evaluate the technical spectrum efficiency of wireless technologies, described in Chapter 3 of the Consultation by the metric Erlangs/MHz/Area, is only appropriate if the goal of the TRAI is to determine the spectrum efficiency associated with the maximum subscriber traffic capacity that can be supported using the absolute minimum cell size. However, if the TRAI seeks to establish a more realistic measure of the relative spectrum efficiency of various technologies, Lucent believes – for the following reason – that cell area should not be included in the determination of the efficiency of spectrum utilization.

Specifically, cells in both CDMA and GSM are not often deployed to an absolute minimum cell radius because technologies capable of supporting large traffic capacities may not require the minimum cell size to meet the traffic demand. This makes the use of a minimum radius in the comparison misleading and not useful when comparing an operator's view of the maximum capacity and coverage supported by various technologies. Further, the advantage provided by a technology that supports a larger cell size (for a given traffic capacity) would not be recognized by the metric described in the Consultation.

Accordingly, Lucent suggests that for purposes of the measure of the spectral efficiency of a given technology, the metric Erlangs/bandwidth be used. This measure provides a comparison of the maximum average capacity that can be supported by a technology in a given bandwidth. During RF deployment planning, other variables, such as cell areas can be considered by operators. The cell area will determine cell count and directly influence the infrastructure cost.

Lucent also notes that it is not clear if a common Quality of Service (QoS) criterion is used to derive the theoretical efficiencies for both GSM and cdma2000. When calculating spectral efficiencies for various technologies, the same channel model distribution (e.g., x% ITU pedestrian A model, y% ITU pedestrian B model, z% ITU vehicular A model) and the same QoS should be used to assess the capacities. For example, for circuit voice service, a common Mean Opinion Score (MOS) can be employed for all technologies to derive the target error rates and the required signal to noise ratios; for packet data services, the same delay/packet error criteria should be considered for all technologies.

Similarly, care must be taken to ensure that all parameters are equally considered for the technologies in question. Lucent particularly notes that although the evaluation includes a loading factor of 0.8 for CDMA, that factor does not appear to be used for GSM.

Question (viii)

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.

The Use Of Mobile Data Services And Its Likely Impact On The Required Spectrum

Although voice communication has and will likely continue, for some time, to be the primary service offered to mobile subscribers, data services are now available as part of the menu of services offered by mobile operators. While voice has been and will always be the most essential, natural, and effective means of human communications, data services add a new and exciting dimension -- providing subscribers with immediate access to timely information and online entertainment, as well as the ability to conduct commercial transactions remotely. Clearly, the applications of wireless data are only limited by the imagination of the industry.

Users who have no wireline access to the Internet from home or from a public facility are obvious beneficiaries of wireless data services. The Internet is, no doubt, the most effective means to disseminate quality information of all types and to facilitate self-learning, research, and electronic correspondence (email, news etc.). It is a highly efficient and cost effective resource that is now widely used by governments, educational establishments, numerous public agencies, medical services, public and private commerce and entertainment providers. The Internet complements public broadcast radio and television in a new way – by providing users with an interactive experience, allowing an Internet user to decide when, where and what kind of information he or she could access and retrieve at any time.

The types of wireless data services are numerous and each has its own different traffic pattern and, therefore, its unique transport requirements. Lean applications such as e-mail or text-based Web pages are the least demanding whereas real-time interactive multimedia (audio-video) applications require advanced broadband wireless networks that are capable of handling huge amount of data and delivering it to end-users consistently with minimal delay. The clear worldwide trend is to build such networks (both wireline and wireless) that are capable of providing users with multimedia data services, simply because it is perceived that such services are a most appealing form of communication and that they will generate significant demand.

Broadband wireless networks require a significant amount of radio spectrum to support the large channel bandwidths necessary to deliver large volumes of data in minimal time. Current (3G) mobile wireless networks require 1.25 MHz (cdma2000) or 5 MHz (UMTS) channels. Accordingly, the TRAI should allocate spectrum blocks that are at least 2x5 MHz with allocations of 2x10 MHz or 2x15 MHz desirable.

Much larger cannel bandwidths are envisioned by the so-called "4G" visionary community. They see a need for ultra wide band channels such as 50 and 100 MHz (see the ITU-R vision document of wireless systems "Beyond IMT-2000"). This vision anticipates that around year 2015, such networks will be in service.

Advanced radio technologies and network architectures are critical in curbing the appetite for larger spectrum. Hence, spectral efficiency and effective frequency reuse are key metrics that should be examined by operators when determining which radio access technology would be best suited for delivering the required services. The TRAI should recognize, however, that the introduction and deployment of advanced radio technologies, although helpful, will not eliminate the ongoing need for additional spectrum.

Question (xx)

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

Spectrum Should Be Allocated In A Technology Neutral Manner

As noted earlier in these comments, Lucent strongly supports the allocation of spectrum on a technology neutral basis. Lucent also believes that service rules should be broad and flexible, allowing operators to provide services defined only under broad categories (e.g., fixed, mobile) and subject only to well defined interference considerations such as transmitter power limits and out-of-band emission limits. This "light regulatory touch" should allow operators to easily provide new and innovative services to their subscribers without the burden of unnecessary controls.

Technological neutrality should be a key factor in the TRAI's spectrum allocation policy. The allocation of spectrum, independent of the technology deployed, will provide operators the flexibility to select the technology that best meets their service needs and the needs of their customers. Importantly, the availability of spectrum on a technology neutral basis should promote the most efficient spectrum use as operators will have the opportunity to acquire desirable spectrum unconstrained by limitations that could offer that spectrum only to a given, but less efficient technology. Further, market forces within the highly competitive wireless industry in India should drive operators to offer innovative services supported by new technology. Rules that restrict the use of technology in any commercial wireless spectrum could delay the deployment of such services, to the detriment of operators and their customers, and ultimately to the Indian economy.

Question (xxv)

Comments of stakeholders are invited on the minimum blocks such as 2x2.5 MHz/2x5 MHz of additional spectrum to be allocated to existing service providers in situations where IMT 2000 band is opened as well as in situations where it is not opened.

Spectrum Should Be Assigned In Blocks That Are At 2x5 MHz Or Larger

The TRAI should attempt to assure that its spectrum allocations provide a level playing field for all operators, regardless of the technology deployed. Any attempt to qualify the allocations based upon estimates of the relative spectral efficiency of the technologies should be avoided, as it appears that the result of this scheme is the possible continued use of a less spectrally efficient system. Moreover, the accuracy of this type of analysis is problematic as ongoing modifications and improvements can change efficiency estimates, potentially impacting the spectrum allocations. Finally, Lucent believes that technical considerations and market forces should dictate technology choices, independent of any regulatory intervention.

Wherever possible, the minimum blocks of spectrum should accommodate the increasing voice capacity needs and the provision of new high-speed data services that can require additional spectrum resources. Lucent believes that these needs demand that blocks be at least 2x5 MHz with larger blocks of 2x10 MHz or 2x15 MHz preferable.

Appendix A – Interference Analysis

Lucent has examined the feasibility of deploying a CDMA system in 1980-1990 MHz for Base Station (BS) transmission when IMT-2000 systems operate in 1920-1980 MHz for BS reception. In the following, it is shown that careful frequency assignment and appropriate filter design and antenna engineering can allow two systems to co-exist with acceptable interference level. These interference mitigation methods have been common practice in the India and China 850 MHz scenarios in which the CDMA 850 BS transmit band is in the proximity of GSM 900 BS receive band.

Because the PCS CDMA BS transmit band is adjacent to the IMT-2000 BS receive band, the potential interference from the PCS CDMA BS transmitter to the 3G BS receiver (including UMTS and cdma2000 operating in the IMT-2000 band) may cause 3G receiver desensitization, overload or/and inter-modulation product (IMP). In order to avoid 3G BS receiver performance degradation, we provide the interference analysis and associated PCS CDMA to 3G BS antenna isolation requirement based on the technical specifications for the PCS CDMA transmitter emission mask and the 3G receiver characteristics. The term "*BS antenna isolation*" refers to the path loss (including the propagation loss through the air and both effective antenna gains) between the PCS CDMA BS antenna connector and the 3G BS antenna connector.

The BS antenna isolation guidelines from interfering transmitters to affected receivers are determined by considering the following four criteria:

1. Isolation used to ensure that the spurious emission power from the interfering transmitter received by the affected system is 10 dB below the receiver noise floor,
2. Isolation used to ensure that the total interfering carrier power received by the affected system is 10 dB below the 1 dB compression point,
3. Isolation used to ensure that each of the 3rd order IMPs generated by the affected receiver and caused by the interfering carriers is 10 dB below the receiver noise floor, and
4. Isolation used to ensure that the total interfering carrier power attenuated by the affected system receive filters is 10 dB below the receiver noise floor to prevent receiver blocking.

The acceptable interference level at the affected BS receive antenna connector is -114.2 dBm/3.84 MHz for UMTS or -119 dBm/1.25 MHz for cdma2000, which is 10 dB below the BS receiver noise floor (assuming a 4 dB receiver noise figure). The typical 3G link budget for RF planning does not take into account external interference from other systems. If the 3G cell layout is designed to the maximum allowable path loss dictated by the link budget, then the maximum path loss in the presence of the acceptable interference level will be reduced by only 0.4 dB (a conservative threshold).

It is found that in most cases, Criteria 1 and 4 are two dominant factors in determining the antenna isolation guidelines. Therefore, we will focus on Criterion 1 and 4 in this study.

Criterion 1:

According to the IS-97E, the PCS CDMA BS out-of-band emissions referenced to the antenna connector shall not exceed -13 dBm/MHz at 1 MHz frequency offset from the frequency block edge. The 1 MHz offset from the band edge corresponds to a PCS CDMA to UMTS center frequency separation of 4.17 MHz or a guard band of 1.625 MHz. It follows that the PCS CDMA BS emission power level falling into the UMTS BS carrier receive bandwidth is -7.2 dBm/3.84 MHz. Therefore, using Criterion 1, the required BS antenna isolation from PCS CDMA to UMTS should be 107 dB [equal to -7.2 - (-114.2)]. The same antenna isolation requirement applies to the PCS CDMA BS and cdma2000 BS co-existence scenario.

Based on our experience with the CDMA 850/GSM 900 co-existence studies, an affordable BS transmit or receive filter with reasonable physical size and insertion loss can provide a 60 dB rejection with a 2.25 MHz guard band, although a sharp filter roll-off may increase the filter size and insertion loss. With the 60 dB PCS CDMA BS transmit filter attenuation, the PCS CDMA to 3G BS isolation requirement is reduced to 47 dB. Because the PCS CDMA has an inherent guard band of 625 kHz from the lower band edge (i.e., 1980 MHz) and the UMTS has an inherent guard band of 580 kHz [equal to (5 MHz - 3.84 MHz)/2] from the upper band edge (i.e., 1980 MHz), an additional guard band of 1.045 MHz is required. One of the possible approaches to achieve this additional guard band is to reduce the UMTS channel spacing from 5 MHz to 4.8 MHz, consistent with 3GPP TS 25.104, which allows the nominal channel spacing of 5 MHz to be adjusted for a specific deployment scenario. For the PCS CDMA and cdma2000 (in the IMT-2000 band) co-existence case, an additional guard band of 1 MHz is needed.

In the real world, the antenna separations associated with the same antenna isolation requirement could be different from site to site because different sites may have various antenna patterns, heights, downtilts, relative positions (to other system antennas) and relative orientations. Measurement data indicate that using certain types of PCS BS antennas, two tip-to-tip antennas that are vertically placed on the same antenna tower with the same orientation can achieve about 49 dB isolation. If two BS antennas cannot share the same tower, a combination of the following schemes can be used to achieve the isolation requirement:

? Using vertical and horizontal antenna separation
? Using appropriate antenna pattern, downtilt and orientation
? Application of a cascade filter in the interfering BS transmitter or/and affected BS receiver, if necessary

Criterion 4:

In order to prevent the UMTS BS receiver blocking, the PCS CDMA BS transmit power of 46.8 dBm (conservatively assuming 3 CDMA carriers each with 16 W or 42 dBm) should be attenuated by the UMTS receive filters to the acceptable level. It can be derived from the 3GPP TS 25.104 Adjacent Channel Selectivity (ACS) that the UMTS BS receiver filtering shall provide an average of 47.4 dB rejection at the adjacent UMTS carrier (which is located at 3.08-6.92 MHz offset from the desired UMTS center frequency). With a 2.25 MHz guard band (used in the calculation for Criterion 1) between the PCS CDMA and UMTS, the PCS CDMA carrier is located at frequency offsets 4.17-5.42 MHz from the UMTS center frequency. Therefore, we consider that the UMTS BS receive filter can attenuate the PCS CDMA BS carrier power by 47.4 dB. Based on Criterion 4, the BS antenna isolation requirement from PCS CDMA to UMTS is about 114 dB [equal to 46.8 - 47.4 - (-114.2)]. The analysis results for all criteria and conservative assumptions indicate that the PCS CDMA to UMTS antenna isolation requirement of 114 dB is dictated by Criterion 4.

When an appropriate UMTS BS receive filter is implemented to provide a 60 dB rejection with a 2.25 MHz guard band and the PCS CDMA BS transmit filter can provide a 53 dB attenuation, the PCS CDMA to UMTS BS isolation requirement is reduced to 54 dB. As discussed above, this requirement can be met by vertically placing two antennas on the same antenna tower with a proper separation; if two BS antennas cannot share the same tower, a combination of several schemes can also be implemented to satisfy the isolation requirement.

For the PCS CDMA and cdma2000 (in the IMT-2000 band) co-existence case, we refer to the 3GPP2 C.S0010 receiver single tone desensitization specification. It can be derived from the C.S0010 that the cdma2000 BS receiver filtering shall provide a 70 dB rejection at 1.25 MHz offset from the cdma2000 carrier center frequency. It follows that based on Criterion 4, the BS antenna isolation requirement from PCS CDMA to cdma2000 is about 96 dB [equal to 46.8 - 70 - (-119)]. The analysis results for all criteria and conservative assumptions show that the PCS CDMA to cdma2000 antenna isolation requirement of 107 dB is dictated by Criterion 1. When an appropriate PCS CDMA BS transmit filter is implemented to provide a 60 dB attenuation with a 2.25 MHz guard band and the cdma2000 BS receive filter can provide a 49 dB rejection, the PCS CDMA to cdma2000 BS isolation requirement is reduced to 47 dB. As mentioned earlier, this requirement can be easily achieved by vertically placing two antennas on the same tower or a combination of several methods.

In sum, it is concluded that with appropriate guard band, BS filters and antenna separation, both PCS CDMA and 3G (UMTS and cdma2000) systems can co-exist with each other for compatible operation, similar to the CDMA 850 and GSM 900 co-existence scenario.