Mobile Broadband, Competition and Spectrum Caps

An independent paper prepared for the GSM Association

Arthur D Little

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Smart Innovation

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KEY FINDINGS

Seven key findings have emerged from analyses and assessments of the past role of and trends in spectrum caps:

- Spectrum caps per operator were introduced in the 1990s in the Americas to ensure competition in the early stages of mobile market development – at that time they typically represented about 30% of total allocated mobile spectrum
- In several countries spectrum caps have either been removed or increased since 2000 as additional spectrum has been allocated and attributed in competitive markets
- Substantial increases in spectrum needs for broadband services are predicted for the next 10-15 years, in some demand scenarios exceeding all spectrum already identified for IMT-2000
- Major European and U.S. operators now hold spectrum well above several Latin American countries' existing caps that range between 40-60 MHz, and have already been reached by several current operators in this region
- Economic, demand, and technical factors are driving operators to seek substantially more spectrum to improve their efficiencies and deploy better and new broadband services to customers, which will be inhibited by the continuation of tight spectrum caps
- As new spectrum is attributed for broadband services, some regulators are imposing high level band-specific caps (40% - 70%+ of the new spectrum on offer)
- In the U.S. and Europe, relaxations of restrictions on spectrum use, such as greater technology- and service-neutrality in licensing and permitted spectrum trading, are increasingly being implemented or evaluated as valuable remedies for dealing with competition problems, in coordination with the application of general principles of Competition Law.

Furthermore it is evident that in future large spectrum blocks (e.g. 2x20 MHz FDD (frequency division duplex)) which do not fit within existing tight, total spectrum caps will be key in some new bands to operators' being able to achieve broadband performance that will enable their mobile customers to enjoy individual user speeds of up to several megabits per second.

INTRODUCTION OF SPECTRUM CAPS

Spectrum caps have been introduced in several countries at various times as one ex ante means to implement competition policy in mobile communications markets. They have been applied to help ensure that no single mobile operator, or a very small number, can acquire all or almost all spectrum on offer either at the time of initial spectrum awards or in subsequent mergers of, or deals between operators. The goal is to prevent operators from gaining positions through large holdings of a scarce resource, i.e. spectrum, which they might then exploit anti-competitively so as to cause market failures with deleterious effects for customers and overall economic welfare. In contrast some countries have relied on other means than spectrum caps to ensure entry into the mobile market by multiple operators, such as issuing multiple separate licenses and setting aside spectrum for entrants in individual spectrum auctions. These other measures have the practical effect of capping the amount of spectrum which various operators can acquire, but in a way that does not fix the same level and form of cap for all operators over an extended period of time.

IMPACT OF MOBILE BROADBAND ON SPECTRUM CAPS

Over time spectrum caps have been substantially modified and even removed in some countries in light of progress in wireless technology, growing demands for mobile services, and the attribution of new spectrum bands for commercial mobile communications. Today the need for, and value and ways of defining and enforcing spectrum caps, if any, are being reconsidered taking account of:

- Emerging demands for mobile broadband services which are most efficiently provided by new broadband wireless technologies using wider channel bandwidths than systems deployed earlier to handle voice-dominated traffic streams,

- Anticipated spectrum requirements that are several times larger than the total amount of spectrum currently allocated to commercial mobile communications in some countries, and

- The opening of new frequency bands, most immediately at 2.6 GHz and the UHF frequencies (the "digital dividend" spectrum (470-862 MHz) within which up to about 100 MHz may be allocated to commercial mobile services as broadcasters switch from analog to digital broadcasting), as well as anticipated and planned auctions or other forms of spectrum attributions in bands that vary by country or region and have already been utilized in some or even many countries, i.e. the PCS (1.8 or 1.9 GHz), AWS (Advanced Wireless Services (1.7/2.1 GHz)), and 1.9/2.1 GHz bands.

Progress in broadband wireless technology and anticipated growth in demand for services are making some current tight spectrum caps – those that are set at a level substantially below 100 MHz per operator – inadequate for operators who wish to provide a comprehensive portfolio of mobile services in the most economic and efficient manner. Continuation of these caps will lead to a large increase in the number of operators – up to ten or more – that are needed to satisfy total likely demand in a geographic service area or country, in comparison to today's typical number of 3-4 major mobile networks in a national market. This number represents a market structure that is unlikely to be economically sustainable. The scenario of a substantial increase in the number of mobile operators beyond the three or four already operating in many countries raises concerns both about techno-economic inefficiencies (e.g. trunking inefficiencies if total traffic in an area is split between increasing numbers of base stations) and about the obstacles any one operator may face in offering a complete portfolio of narrowband and broadband services to its customers if the spectrum it can use is strictly limited. It is very questionable whether the future mobile market can support a number of financially viable operators that comes close to ten, even though it may be larger than three or four. The number of facilities-based operators that can operate profitably in a market is limited by the large capital requirements for deploying a nationwide network, even if these are mitigated by significant facilities sharing among competitors, as well as by the combined impact of market fragmentation on the revenue side and techno-economic inefficiencies on the cost side as this number increases.

Mobile broadband markets (non-voice services) have finally begun to generate significant traffic and revenues in several of the most developed markets in Europe, Asia, and North America. In these countries strict spectrum caps imposed in some of them for an earlier generation of technology and at an earlier stage of mobile market development have either been removed or implemented in much more flexible ways and increased substantially over their earlier levels. Even countries in which mobile broadband services have yet to become a significant factor because suitable spectrum is not yet available and/or consumers' purchasing power is insufficient are considering the conditions under which new spectrum should be made available, and evaluating ways to harmonize these conditions with the application of general competition policy to this important potential market.

SPECTRUM DEMAND AND COMPETITION POLICY

The approaches to harmonizing spectrum demand and competition policy that are being implemented in Europe, the U.S., and Canada include primarily various combinations of:

- Relaxations of restrictions on uses of spectrum,
- Rules to permit spectrum trading, and
- Case-by-case reviews of proposed mergers of, or deals between operators to ensure that they conform to competition policy and do not entail significant risks of future anti-competitive behavior.

In some instances these measures are accompanied by various forms of spectrum caps, that are however much looser and more flexible than the ones applied earlier. Several additional measures to stimulate and sustain a competitive environment in mobile markets are also employed in different countries to varying degrees, and with varied expectations of efficacy, such as:

- Facilitating the entry of MVNOs (Mobile Virtual Network Operators)
- Roll-out and coverage requirements for spectrum winners
- Asymmetric mobile termination rates (higher ones for smaller operators),
- Set-asides of spectrum for entrants, and
- Obligations imposed on established operators to provide roaming and facilities sharing to entrants.

The advent of mobile broadband and the expansion of frequency bands allocated to commercial mobile services are raising a competitive concern that goes beyond the question of whether or not there should be formal restrictions on the amount of bandwidth any operator should be allowed to hold. This concern involves the distribution of an operator's spectrum holdings in various frequency bands, since all frequencies are not equal in terms of their techno-economic implications. Frequencies below 1 GHz which offer significantly superior propagation characteristics compared to higher frequencies close to and above 2GHz, will result in substantially lower network costs[1] in deployment scenarios in which the cell size is coverage-rather than capacity-limited for operators who hold these lower frequencies compared to those who do not..

1. SPECTRUM CAPS POLICIES, OBJECTIVES, AND IMPACT

Overall spectrum caps were introduced in the 1990s in several countries, notably in the Americas, to help ensure the development of effective competition in mobile markets. They limited and in some countries still limit the amount of spectrum any one operator can hold in order to ensure that several operators can enter the market, since no single operator or even a duopoly can acquire all the bandwidth that is made available at the time of awards, thereby precluding entry by other competitors. These caps have also been durable, since entities formed by mergers or resulting from other commercial deals have been prevented from holding spectrum in excess of the cap. "Excess" spectrum has had to be returned, and made available to other operators.

[1] *Emerging Technologies and Their Implications on Regulatory Policy*, Ericsson, ITS Biennial Plenary, Montreal, June 25th. 2008

In Europe, the goal of ensuring that there would be several competitors in mobile markets has been accomplished by means other than formal or quantified spectrum caps. Rather separate licenses have been issued to achieve participation in a mobile market by typically three to four operators. Spectrum set-asides for entrants when additional spectrum is made available are another measure that has been employed to achieve a minimum number of competitors, for example in the original 3G spectrum auctions in the U.K. Roll-out and coverage obligations have also frequently been conditions imposed on spectrum winners to help ensure that competitive services are made available even to customers in areas that are less attractive economically, notably rural regions with lower densities of potential customers. These obligations are also designed to prevent spectrum acquisition and then hoarding by established operators simply to exclude entrants.

Today's mobile markets, whether as a result of spectrum caps and/or other measures, are typically characterized by three or four significant competing networks, although, more often where licenses are structured on a regional and not a national basis, there are sometimes a few regions in which customers are only being served by one or two competitors.

The conditions under which spectrum management and competition problems have been addressed have so far referred to an environment in which mobile use and spectrum demands have been dominated by voice traffic. This environment is now changing under the impact of demands for new mobile broadband services and the advent of new broadband wireless technologies designed to meet these demands as efficiently as possible. These new broadband technologies also offer improvements in meeting demands for voice services. As is shown in subsequent sections of this report, the trend in mobile markets which are advanced in terms of the development of mobile broadband services is to remove spectrum caps altogether, or to introduce much looser and more flexible forms of caps, relying mainly on other measures to resolve potential competition problems in the mobile broadband era.

2. REVIEWS OF COUNTRY EXAMPLES

It is not surprising that current approaches towards the use of spectrum caps in different countries should be diverse given the wide national and regional variations in their: (a) institutional arrangements in the political, legal and commercial spheres, (b) histories of telecommunications development, (c) internal social, cultural and economic pressures, as well as (d) current status of competition, supply, and demand in mobile communications. The following examples cover instances in which:

- Earlier spectrum caps have been effectively removed
- Spectrum caps have been increased over time as additional spectrum has been made available for broadband services
- Spectrum caps established for a pre-broadband or voice dominated market era are still in place.

In North America the major developments that are relevant for the development of mobile broadband, the attribution of spectrum, and issues of competition include:

- The removal of spectrum caps first established in the 1990s since 2000on the grounds that the mobile market had become sufficiently competitive, hence the rationale behind them was no longer valid
- The introduction of screening guidelines for spectrum holdings that can be changed at every auction of new spectrum, and which, if exceeded by an operator, could trigger a review of these holdings for potential competition problems.

In contrast to North America, Europe did not introduce spectrum caps but relied on conditions of mobile licensing, for example the number of licenses that were issued, to ensure competitiveness in the mobile market. More recently the trend in Europe has been to rely on measures such as permitting spectrum trading and relying on "loose' and generous spectrum caps in the new bands being auctioned for broadband services to achieve a reasonable balance between maintaining competition in the mobile market while enabling operators to acquire enough bandwidth to offer broadband services efficiently and economically. Most European regulators[2] believe that relaxation of restrictions on the uses of spectrum, e.g. the introduction of greater technology- and service- neutrality in wireless licenses, is the best remedy for competition problems

It is also noteworthy that both in Europe and North America major operators already have spectrum holdings well in excess of the spectrum caps that prevail in several Latin American countries.

In striking contrast to the two affluent regions of North America and Western Europe, India presents an example of a micromanaged approach to the attribution of spectrum to individual operators that is dependent in various cases upon the operator's choice of technology, its ongoing progress in acquiring customers, and its ownership (i.e. state versus private sector). The implication of the Indian approach, if pursued in future, is that its market for mobile and mobile broadband communications could become characterized by a substantially larger number of competitors than in other countries, perhaps ten or more. The sustainability and value of such a market structure is dubious, given the threshold market share a facilities-based operator most probably requires to remain viable in this very capital-intensive business and the adverse consequences of its inevitable techno-economic inefficiencies for customers as well as for the operators themselves of the substantial fragmentation of spectrum across multiple networks.

2.1 NORTH AMERICA - U.S.A.

In the 21st century spectrum caps introduced in the mid-1990s have been progressively relaxed and then removed as the sector regulator, the Federal Communications Commission (FCC), has concluded that mobile markets have become effectively and increasingly competitive.

Spectrum caps were originally viewed by the FCC as one means to ensure effective competition in early stages of mobile market development. They amounted to 45 MHz in any geographic area within a total of 180 MHz[3] allocated at that time for commercial mobile services, including 10 MHz maximum counted toward the cap from Specialized Mobile Radio (SMR) Spectrum. The justification for imposing these caps that were introduced in 1994 in advance of PCS (1.9GHz) spectrum auctions included the intent to prevent:

- Exclusion of efficient competitors, leading to increased prices and reductions in service to the detriment of consumers
- Artificial withholding of capacity from the market by spectrum hoarding.

Other restrictions imposed by the FCC at that time included limits on:

- The aggregation of broadband PCS spectrum – a cap of 40 MHz, and
- Cellular/PCS cross-ownership – a cap of 10 MHz of PCS spectrum for a cellular operator within its service area

[2] "Spectrum Allocation and bottlenecks/competition problems", European Regulators Group report ERG (06) 45 b

[3] Bandwidth allocations and spectrum caps identified in this paper refer to total bandwidths, i.e. sum of downlink (DL) and uplink (UL) in FDD (frequency division duplex) format plus TDD (time division duplex) if any, e.g. 100 MHz in FDD = 50 MHz DL plus 50 MHz UL

- Cellular cross-interest rule (from 1991) on the ownership interest of one party in both cellular operators in overlapping geographic service areas.

In 1996 the FCC removed the caps on PCS spectrum aggregation and the restrictions on cellular/PCS cross-ownership, in order to rely mainly on the 45 MHz spectrum cap to promote competition while preserving incentives for efficiency and innovation

In its first Biennial Review in 1998 the FCC substantially retained the cellular cross-interest rule and spectrum cap, which however it increased to 55 MHz in Rural Service Areas only. Later in its second Biennial Review in 2000 the FCC decided to:

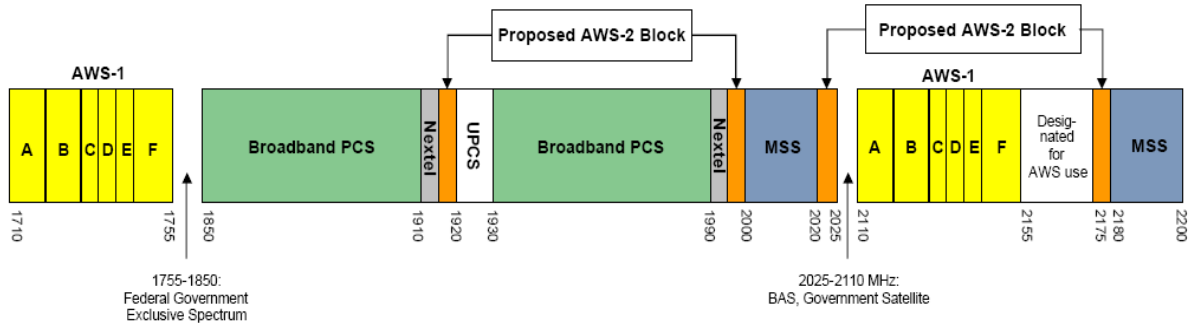
- Eliminate the spectrum caps, effective Jan 1st, 2003
  - During the transition period to 2003 the spectrum cap was increased to 55 MHz in all geographic service areas
- Eliminate the cellular cross-interest rule for Metropolitan Service Areas (MSA)
- Replace spectrum caps with a case-by-case review of spectrum aggregation.

Since 2003 two especially relevant spectrum auctions have been the 2006 AWS (Advanced Wireless Services) auction (1.7/2.1GHz), and the 2008 700 MHz ("digital dividend") auction. The conditions for the AWS auction included:

- No spectrum caps but a screening guideline of 70 MHz at which level an operator's spectrum holdings and situation could be reviewed for potential competition problems
- Bidding credits for specific bidding entities', e.g. small businesses', bids to provide service in federally recognized tribal lands
- Technology neutrality
- Mix of licenses by different geographic groupings.

The following figure shows the band plan for the AWS band – the 2006 auction covered the AWS-1 frequencies.

FIGURE 1: U.S. AWS BAND PLAN



Total winning bids in this auction amounted to about $13.7 billion. The top 5 winners accounted for about 85% of the auction's proceeds including the four largest mobile operators (Verizon Wireless, AT&T Mobility, Sprint, and T-Mobile USA), and a regional operator (Metro PCS). These winning bidders for the new spectrum intend to expand geographic coverage and/or increase capacity elsewhere in the near future (and indeed some

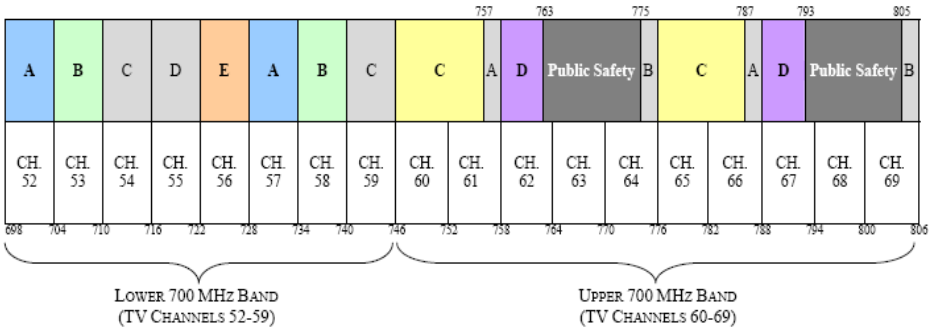
winners have already started doing so, i.e. T-Mobile and Metro PCS), or to deploy future broadband systems, (e.g. LTE) when limits of 3G systems become apparent (Verizon Wireless and AT&T Mobility).

The conditions for the 2008 700 MHz auction (the FCC's Auction 73) were slightly different from the earlier AWS-1 auction:

- No spectrum caps, but a screening guideline of 95 MHz
- Technology neutrality
- Auction procedures to mitigate the risk of bidders' collusion, i.e. anonymous bidding (in contrast to the AWS-1 auction) until completion
- "Open access" requirement for Block C (2x11 MHz in 12 Regional Economic Area Groups) covering "open devices" and "open applications" – it is unclear how these conditions will be applied in practice
- Set-aside of 20 MHz (Block D) for a public/private partnership to deploy a new nationwide broadband network to meet public safety requirements
- Bidding credits for specific bidding entities', e.g. small businesses', bids to provide service in federally recognized tribal lands
- Mix of licenses by different geographic groupings.

The band plan for these frequencies is shown in Figure 2. The winning bids for these 700 MHz licenses totaled about $19 billion. Verizon Wireless and AT&T Mobility accounted for over 80% of this sum (mainly Block C and Block B respectively). Block D was not awarded since the reserve price was not met. The major winners are likely to deploy LTE in this spectrum (AT&T had also earlier acquired some 700 MHz spectrum via trades from a winner in a previous 700 MHz spectrum auction). The 700 MHz frequencies are well suited to providing more cost-effective coverage in rural areas as compared to AWS or even higher frequencies.

FIGURE 2: U.S. 700 MHZ BAND PLAN



Block	Frequencies (MHz)	Bandwidth	Pairing	Area Type	Licenses
A	698-704, 728-734	12 MHz	2 x 6 MHz	EA	176
B	704-710, 734-740	12 MHz	2 x 6 MHz	CMA	734
C	710-716, 740-746	12 MHz	2 x 6 MHz	CMA	734
D	716-722	6 MHz	unpaired	EAG	6
E	722-728	6 MHz	unpaired	EA	176
C	746-757, 776-787	22 MHz	2 x 11 MHz	REAG	12
A	757-758, 787-788	2 MHz	2 x 1 MHz	MEA	52
D	758-763, 788-793	10 MHz	2 x 5 MHz	Nationwide	1 *
B	775-776, 805-806	2 MHz	2 x 1 MHz	MEA	52

* Subject to conditions respecting a public/private partnership.

The blocks shaded above in gray (Lower 700 MHz Band C and D Blocks and Upper 700 MHz Band A and B Blocks) were auctioned prior to Auction 73.

2.2 NORTH AMERICA – CANADA

As in the U.S. spectrum caps introduced in the mid-1990s in Canada have been progressively relaxed and then removed. At the same time other means somewhat different from the U.S. – notably the use of spectrum set-asides – are being employed to sustain and increase competitive intensity within the country's mobile communications market.

In 1995 Industry Canada (IC) introduced a spectrum cap of 40MHz for an initial auction of PCS frequencies. This cap covered the 850 MHz cellular as well as the PCS band and spectrum used for SMR services

Other policy provisions were also introduced to promote competition, such as:

- Issuing national licenses
- Imposing resale and roaming of analog cellular service
- Requiring resale of PCS among carriers
- Establishing a minimum roll-out of services in each region of Canada.

In 1999 the spectrum cap was increased to 55 MHz prior to the auction of the remaining 40 MHz of PCS spectrum, after which a total of 170 MHz of spectrum was licensed for mobile services, excluding SMR.

In 2003 Industry Canada modified the way in which SMR spectrum was counted in the spectrum cap, by limiting it to 10 MHz in line with existing U.S. practice. In 2004 the spectrum cap was removed, on the basis of the finding that a spectrum cap policy to oversee spectrum concentration had become less relevant. The IC argued that spectrum caps had been an effective tool in fostering a competitive mobile market, but the regulatory framework had evolved, including more flexible use of spectrum, and additional spectrum (e.g. 100 MHz in the 1.7/2.1GHz band) planned for release would provide new opportunities for both existing and new operators

In 2008 IC held an AWS spectrum auction. Total spectrum of 105 MHz was on offer, in 5+5 and 10+10 MHz blocks, of which B, C and D (40 MHz) were set aside for new entrants. Block structure was the same as in the 2006 AWS auction in the U.S. "New entrants" were defined as having a national wireless market share of less than 10%, which allowed incumbent regional operators (i.e. the incumbent telephone companies owned by their respective provinces, Manitoba's MTS Allstream and Saskatchewan's SaskTel) to qualify, even though they already enjoyed a larger mobile market share within their respective home provinces. There were no roll-

out obligations (only targets) on new entrants except for "national new entrants" with licenses in the AWS or PCS bands that would cover all of Canada through Tier 2 or Tier 3 service areas or a combination thereof. Conditions for roaming obligations and infrastructure sharing were also imposed upon existing mobile operators.

Winning bidders included 15 entities, from the three existing major operators (Rogers, Bell Mobility, and Telus) who accounted for about 2/3 of the value of winning bids (some $4.2 billion total) to small local operators, and two large cable operators as well as the regional incumbents already mentioned and a new operator with foreign backing (the Egypt-based multinational mobile operator Orascom) which acquired licenses nationwide with the exception of Quebec. The highest average new spectrum holding acquired in a province varied from 20 to 40 MHz.

2.3 U.K.

Competition in the U.K. mobile market has been enabled by the issuance of separate licenses rather than by the imposition of spectrum caps. Most recently the sector regulator Ofcom has pronounced itself in favor of applying general competition policy and relaxing restrictions on spectrum use as the main remedies for resolving or preempting potential competition problems, accompanied by band-specific spectrum caps that are loose and flexible.

Analog cellular service was initially provided by two operators in the 1980s. In 1989 three new applicants for service in the 1800 MHz band (PCN) were awarded licenses out of a number of contenders. Two of the winners subsequently merged. Two GSM licenses were awarded at 900 MHz to the two analog cellular operators, who started digital service in mid-1992 and early 1994 respectively. The two 900 MHz operators were later awarded 1800 MHz spectrum in 1996. Infrastructure sharing was initially allowed for entrants in rural areas recognizing the higher costs of 1800 MHz networks compared to 900 MHz. The requirement on the two original cellular operators to use independent service providers was lifted following the PCN license awards

In 2000 a 2.1GHz 3G auction was held. Five licenses were awarded by auction, with one that involved the greatest amount of spectrum (2x15 MHz plus 5 MHz of unpaired spectrum) being set aside for an entrant. No bidder could acquire more than one license. The other four licenses were won by the existing 2G operators.

The U.K. sector regulator Ofcom is planning an auction of the 2.6GHz band (scheduled earlier for September 2008 but now delayed into 2009), with the following conditions:

- Technology- and service-neutrality
- A "loose" or "safeguard" band-specific spectrum cap of 80 MHz (out of 190 MHz) (but excluding restricted blocks)
    - This cap relates only to the 2.6 GHz band and does not include spectrum held in other bands, which currently averages in excess of 80 MHz (see Table 5 below)
- No rollout or coverage obligations
- Acquired spectrum will be tradable.

Ofcom also envisages an auction of "digital dividend" spectrum (550-630 and 790-854 MHz) with similar conditions, and a band-specific 50 MHz cap (out of 128 MHz). Spectrum trading rules and liberal band-specific caps indicate that Ofcom expects to rely primarily on general competition policy to address potential anti-competitive behavior in the emerging U.K. mobile broadband market. As noted, even before these new spectrum auctions, the average spectrum holding of U.K. mobile operators exceeds 80 MHz.

However, the question of the redistribution of 900 MHz spectrum, which can be re-farmed for broadband services and is now held by only two U.K. operators[4], is delaying the 2.6 GHz auction.

A dispute about this issue has arisen because operators who do not hold spectrum below 1 GHz have pointed out that these frequencies offer significant advantages compared to higher frequencies in terms of lower capex and opex (fewer base stations) in coverage-limited areas (e.g. rural), as well as better in-building penetration. Also they permit a more stretched out program of network investments that better matches revenue growth with increasing investment by requiring fewer base stations while a broadband subscriber base is being built up, when even in suburban or urban areas the number of base stations needed is coverage- rather than capacity-limited.

Hence equitable access to 900 MHz frequencies is being presented as an issue of "fair competition", which until resolved makes accurate valuation of the 2.6GHz spectrum by bidders impossible. The claim of operators with no 900 MHz spectrum is that conditions about how and how much of existing 900 MHz spectrum holdings will be redistributed must be clearly established before the 2.6GHz auction is held.

2.4 Other European examples

2.4.1 Spectrum auctions in the 2.6GHz 3G Extension Band

As of September, 2008 two auctions have been held in Europe for frequencies in the 2.6GHz expansion band, both of them in Scandinavia. Both auctions are evidence of a trend in Europe toward relaxing restrictions on spectrum use as a key remedy for potential competition problems.

2.4.1.1 Norway

Norway held a 2.6GHz spectrum auction in November, 2007. The auction rules included

- Awards of spectrum by region (6 in all)
- Band-specific bidding cap of 90 MHz in 2.5-2.69 GHz (block B,C,D,E) in any region only in Round 1 of auction[5]
- Technology and service neutrality
- No rollout or coverage obligations
- Spectrum is tradable.

The Norwegian Government collected about $42 million from this auction. .Spectrum in the 2.6 GHz band was awarded for 15 years to 5 operators including the two established mobile operators (one acquired 120 MHz in all Regions) and 3 newcomers focused on mobile WiMax (not all bidders acquired licenses for all regions).

2.4.1.2 Sweden

Sweden held its 2.6GHz spectrum auction in 2008. Auction rules included:

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[4] [4]The original cellular operators, although the ownership of one of them has changed since the early 1990s - originally the incumbent BT's mobile arm, it is now branded O2 and is owned by Telefonica)

[5] If high bids in a round are withdrawn, it is possible for a bidder's eligibility to increase in subsequent rounds beyond the Round 1 cap

- A band-specific cap of 140 MHz
- National licenses
- Technology and service neutrality
- Harmonized split between FDD and TDD (frequency and time division duplex respectively – at this writing mobile WiMax is only available in TDD format)
- No rollout coverage obligations.

The Swedish Government collected about $350 million from the auction, and a total of 190 MHz was awarded to five players:

- 14 FDD blocks to existing mobile operators (maximum award was 40 MHz)
- One TDD block of 50 MHz to a newcomer, a WiMax investor (Intel Capital)

2.4.2 European Trends in Spectrum Use

The preceding examples of the two 2.6GHz spectrum auctions in Scandinavia are illustrations of a general trend towards relaxing restrictions on the use of spectrum within the European Union as a remedy for competition problems, following a similar philosophy to that of Ofcom in the U.K.

Only one response in a survey[6] of 22 European national regulators expressed concern about a competition problem arising from concentration of spectrum in a few operators. In this same survey a few regulators identified access to capital as an entry barrier, while most expressed the belief that relaxing spectrum restrictions would be the best remedy for competition problems. Measures envisaged included a higher degree of technology- and service-neutrality in licenses combined with spectrum trading, as already implemented in the preceding examples of the U.K., Sweden, and Norway. Opinions were more mixed about the remedial value of rollout obligations and MVNO (Mobile Virtual Network Operator) access.

2.4.2.1 Spectrum Refarming

In the Americas re-farming of existing 850/900 MHz spectrum originally awarded for voice services for broadband technologies has been freely allowed, but in Europe this possibility has triggered debates about competitive fairness, especially when it involves 2G licenses at 900 MHz close to the end of their current term.

Spectrum below 1 GHz, as noted in the earlier discussion of the U.K., has substantial advantages over AWS and 2.1 GHz and higher frequencies under several deployment scenarios. Propagation losses are lower, so 3G networks can be deployed with much larger cells at 850/900 MHz than at 2GHz, requiring about 1/3 the number of base stations in some coverage-driven, e.g. rural, deployments, or allowing for more gradual investment paths during build-up periods when there may be few customers for broadband services within an area. Furthermore, in-building penetration is greater below 1 GHz, helping coverage and quality for mobile communications that terminate and/or originate indoors, as do 50%+ of mobile voice calls in many countries. It is expected that mobile broadband users may well also frequently use and want to use their devices and services when indoors.

[6] "Spectrum Allocation and bottlenecks/competition problems", European Regulators Group report ERG (06) 45 b, September, 2006

Hence operators not holding spectrum below 1GHz can argue that they are at a significant disadvantage compared to operators who have access to these frequencies, both economically and in terms of the quality of service they may be able to offer indoors[7]. This observation highlights the key potential role that "digital dividend" UHF spectrum can play in stimulating the efficient and cost-effective deployment of mobile broadband networks and services. Hence a key issue for regulators is arising to ensure that sufficient portions of this spectrum are allocated to commercial wireless communications among other applications such as digital terrestrial broadcasting and mobile television as the transition to digital from analog broadcasting is planned and implemented.

2.5 INDIA

India presents an extreme example of detailed spectrum management or micro-management by a regulator. Uniquely additional spectrum in this country is attributed to an operator on the basis of its number of subscribers. Furthermore, the total spectrum which a 2G operator can hold is linked to the technology it uses on the basis of the supposed spectrum efficiency of that technology.

Current 2G spectrum caps are 15 MHz/GSM operator and 7.5MHz/CDMA operator (earlier proposals were 7.2 MHz and 5MHz respectively), on the grounds that CDMA technology is more spectrally efficient than GSM. Additional spectrum within the caps is attributed in 0.8 and 1 MHz "chunks" (previously 1, 2, 2.4, and 2.6 MHz) when specified subscriber thresholds are reached.

The issues of spectrum caps and criteria for attributing additional spectrum have fueled long delays in decision making and intense controversy between and even within the sector regulator, the Telecommunications Regulatory Authority of India (TRAI), and the Department of Telecommunications (DOT), as well as the industry. Traditionally the regulator and the Government (DOT) have not seen eye-to-eye on many key matters affecting the development of the telecommunications sector in India. This sector's environment is also complicated or muddied by competition between state-owned operators and private sector competitors in which the rules of the game are far from symmetric, and the Government has potentially conflicting interests in encouraging competition, while at the same time not wishing to harm the prospects and revenues and profits of businesses which it owns. This situation is apparent in the lead up to long awaited 3G auctions. As of September, 2008 3G auction rules have not been finalized, but indications are that 3G entrants may not be allowed to acquire 2G spectrum, and all 3G bidders will be restricted to one block 0f 5 MHz. Furthermore awards of new spectrum for 3G and Broadband Wireless Access (BWA) include directed allocation of spectrum to state-owned incumbent operators BSNL and MTNL[8], while private operators will have to acquire or compete for their spectrum via auctions.

In mid-2008 both MTNL and its state-owned rival BSNL were each awarded a block of 5MHz spectrum in the 2.1GHz band for 3G services, ahead of the auction for privately-owned operators. However, both state-owned enterprises will eventually be required to pay a license fee equivalent to the highest price paid in the private auction. The auction is scheduled to close by January 2009, but may be delayed further, and could ultimately lead to as many as ten Indian 3G operators. BSNL reportedly became the first Indian mobile operator to switch on 3G services in mid-2008, unveiling a 2Mb/s (megabits per second) free pilot service to 2,000 subscribers in the city of Pune. BSNL plans to launch commercial 3G services by early2009. The other state-owned operator

[7] This issue has been raised in Europe in a region-specific context as the licenses for spectrum at 900 MHz which were awarded at no cost (in contrast to other frequencies which were acquired through auctions) come up for renewal, and it is argued that this spectrum should therefore not remain entirely in the hands of the original 900 MHz licensees.

[8] MTNL is the incumbent in the two major metropolitan areas of Delhi and Mumbai, and BSNL in the rest of the country

MTNL is reportedly test launching a 3G network in New Delhi and may make the service available by early 2009 as well. A second network in Mumbai is scheduled to launch also early in 2009.

Similar detailed management of the spectrum attributed to individual operators is also evident in the case of frequencies for BWA services. The DOT now appears willing to auction off more BWA spectrum per license winner than was previously suggested by either the government or TRAI. A total of 80MHz of spectrum in the 2.3GHz and 2.5GHz frequency bands (40MHz per band) is to be made available for four operators (20MHz each). The state-owned operators BSNL and MTNL have been given set asides of 20MHz at 2.5GHz in their respective regions, while another three operators will be authorized to acquire the remaining 60MHz. Both 2.3GHz and 2.5GHz are standardized frequencies for the 802.16e mobile WiMax system. The 2.5GHz band is also standardized for FDD technologies such as HSPA+ and LTE in option 1 of the International Telecommunications Union's (ITU) planning for this band (2500MHz-2690MHz). In addition, the DOT has announced that spectrum blocks in the 3.3-3.6GHz and 700MHz frequency bands will also be auctioned off as they become available. The DOT has now also proposed that the BWA license holders should be able to offer mobile voice service in addition to mobile data.

India's very detailed prescriptions for spectrum attribution and the asymmetric nature of the way in which Government-owned and private sector operators acquire spectrum raise multiple concerns that will be exacerbated in a future mobile broadband environment that will demand substantially more bandwidth if broadband services are to be provided efficiently and effectively, notably:

- Inappropriate low spectrum caps and parsimonious additional attributions over time may penalize successful operators via congestion, or give them an added competitive advantage via early access to more spectrum on the basis of what might possibly only be a temporary market lead if its competitors had equal amounts of spectrum to exploit

- Operators are motivated to exaggerate subscriber numbers to acquire more spectrum

    - The prices of mobile services in India are very low, and as a consequence the average Minutes of Use (MOU) is very high by international standards (450+ MOU/month, compared to about 150 in Chile for example), which further increases the likelihood that Indian mobile networks will experience congestion unless more spectrum is made available in a timely manner

- Application of tight, detailed prescriptions for spectrum attribution may lead to:

    - An uneconomically large number of entrants,

    - Corresponding inefficiencies (inability to exploit economies of scale) in the services available to customers, and

    - Inflexibility in responding to developments in the market that are inherently unpredictable and may change rapidly.

- Perceived competitive inequalities and obstacles (guaranteed spectrum for state-owned operators, lack of access to 2G spectrum for 3G entrants) may discourage capable firms, e.g. foreign operators, from entering the market

The current Indian approach to allocating and attributing spectrum is fraught with risks to the demand-driven development of mobile broadband services, which will likely be delayed and frustrated unless the underlying policies and the processes for resolving the kinds of disputes it provokes are substantially revised.

2.6 LATIN AMERICAN EXAMPLES

2.6.1 BRAZIL

Brazil is a special case in Latin America by virtue of its sheer size, population, and language. In mobile communications it is also unique in having allocated 850 MHz and, as in Europe, frequencies at 900/1800 MHz plus 1.9/2.1GHz for 3G[9]. In contrast the rest of the region has followed U.S. frequency allocations of 850 and 1900 MHz as well as AWS (1.7/2.1 GHz) for commercial mobile communications.

In January 2008, following a 2.1GHz spectrum auction in December, 2007 the regulator Anatel issued four 3G licenses (one 30 MHz and three 20 MHz) in 9 zones. These zones are not identical to the earlier ten 2G concession areas. They combine poorer, sparsely populated states with wealthier areas. Existing mobile operators won all 3G licenses, which are subject to roll-out and coverage obligations aimed at achieving universal service coverage of mobile communications. Limited 3G services have already been launched in operators' existing frequencies, but additional spectrum was required if these services were to become a major factor in the market. In recognition of this need Anatel increased a previous spectrum cap of 50MHz to 80 MHz per operator for the 3G auction. The earlier cap was applied within a total spectrum allocation of 110 MHz at 850 and 1800 MHz.

Anatel has allocated coverage responsibility for municipalities not yet served by mobile networks among the mobile operators which won the recent 3G spectrum auction. These operators are required to provide mobile coverage to 1,836 unserved municipalities. Anatel requires that service be provided to all these localities by February 2010. Operators must provide coverage to half of their allocated communities by February 2009. The selection of cities to be served in the first phase was made by the winning bidders with the assistance of Anatel. The total population of the areas to be covered is 17.3 million. Coverage will be provided using 2G technologies. The coverage obligations for all operators who received 3G licenses are designed to lead to complete coverage of Brazilian territory, probably eight years after the licenses were issued. Operators are allowed to share network components such as towers as well as spectrum in order to provide services in municipalities with fewer than 30,000 inhabitants. Anatel will likely issue new regulations on the conditions for spectrum sharing as well as sharing of active elements of the network. Spectrum sharing arrangements must be authorized by Anatel.

Anatel has also issued a number of licenses in the 2.6 GHz band and five licensees in the 3.5GHz band for which WiMax technology will be deployed. A new auction for additional 3.5GHz spectrum is planned for 2008. Some of the licensees have already started authorized trials.

The trend in Brazilian telecommunications is manifestly towards the establishment of national operators, in contrast to the largely regional structure that was established in both fixed and mobile communications at the time of privatization in the late 1990s. Mobile operators have been acquiring spectrum in additional regions, while the restriction of a fixed operator to one region only (there are three in all for fixed telecommunications, in contrast to the larger number of zones for mobile communications) is being removed in new legislation which paves the way for the acquisition of Brasil Telecom by Oi. This acquisition would create a Brazilian-owned telecommunications company to compete with the Spanish-owned Telefonica companies and Mexico's America Movil which have become market leaders in Brazil as in many Latin American countries.

[9] Uruguay has also adopted the 1.9/2.1GHz band for 3G services

2.6.2 ARGENTINA

A combined 50 MHz spectrum cap per operator in each region has been effective since 1998. As of 2008 a total of 170 MHz is assigned for mobile communications in the country's three zones (Norte, Sur, and AMBA), including 50 MHz in the 850 MHz band and 120 MHz at 1900 MHz. The mobile operator Movistar (Telefonica) was obliged by the Competition Authority (Comisión de Defensa de la Competencia (CNDC) to agree to return 35MHz of spectrum in the 850MHz band to satisfy the 50 MHz cap after acquiring BellSouth's Movicom unit in 2005. This spectrum return has not been totally completed to date.

In 2008 Nextel, whose trunking services focuses on business users, paid $32 million for this spectrum, despite lobbying from local telephone cooperatives to be awarded this spectrum free of charge so they could enter the mobile market. There are over 300 such cooperatives which offer fixed telephone services in the country, and reportedly two federations of cooperatives had received concessions for mobile services, but lacked any spectrum with which to launch them. Their motivation to enter the mobile markets was inspired by the impact upon their business (loss of market share) of the substitution of fixed by mobile telephony, and by the circumstance in which fixed operators have to pay mobile operators fixed-to-mobile termination rates under the CPP (calling party pays) mobile charging system that has been in place in Argentina for over a decade. However, the government could not award spectrum directly to the cooperatives for mobile telephony because by law spectrum has to be auctioned.

As of September, 2008 the regulator SeCom (Secretaría de Comunicaciones, which is part of the Ministry of Planning) is planning a 3G auction at 1.7/2.1GHz (AWS band) and a TDD auction in the 3.5 GHz band in 2009. The potential of the 700 MHz band ("digital dividend") is also being evaluated. Although the Government has repeatedly delayed a decision on a Digital TV Standard and a date for analog transmission switch off, there is some spectrum that is already available in the 700 MHz which is sparking MNO's (mobile network operators) interest.

In common with many other countries the Argentine mobile market is characterized by three significant players, led in terms of market share by America Movil's Claro, followed closely by Movistar, and including also Telecom's (the other fixed incumbent in addition to Telefonica) Personal business. All these MNO's are currently offering competitive mobile broadband services in a market that surpassed the 100% penetration mark at end-2007.

2.6.3 CHILE

At the turn of the century, the sector regulator Subtel (Subsecretaria de Telecomunicaciones, part of the Ministry of Transport and Telecommunications) became very active regarding mobile telephony. It initiated a process intended to make an additional 30MHz of spectrum in the 1900MHz PCS band available to the mobile market with three 10 MHz licenses. In early 2000, intense competition existed in mobile telephony, with four competitors and penetration that had reached a level that greatly exceeded earlier forecasts. The asymmetry in costs between companies, caused by the allocation of twice the spectrum (60MHz) to one competitor (Entel) was particularly difficult for its rivals, which only had 25MHz or 30 MHz to serve a mixture of analog and digital customers on 850MHz. Subtel established a procedure aimed at directly distributing 30MHz of spectrum in the 1900MHz band among the companies, in accordance with technical and economic efficiency criteria. These rules were halted by the anti-monopoly Commission, which ordered the awarding of these bands by tender, establishing a 60MHz spectrum cap per operator, thereby preventing Entel's participation. The result of the bid was the granting of the 30 MHz to the 850MHz band operators, including at that time BellSouth and Telefonica Movil (which since then has been re-branded as Movistar).

At the beginning of 2005 Telefonica completed the acquisition of BellSouth's properties in Latin America, including BellSouth Chile. The Chilean antitrust court TDLC (Tribunal de Defensa de la Libre Competencia)

approved the merger of mobile operators Telefónica Móviles and BellSouth Chile, subject to nine restrictions or conditions. As one condition involving a spectrum cap, the combined entity (now rebranded Movistar) was required to give back 25MHz of spectrum in the 850 MHz band by means of a public auction organized by Subtel, which was given a period of 18 months to start the auction. At the time of the acquisition Telefónica Móvil held 25MHz in the 850MHz band and 20MHz in the 1,900MHz band, whereas BellSouth held 25MHz in the 850MHz band and 10MHz in the 1,900MHz band. Therefore, the new company held a total of 80MHz, but after the auction it would hold a total of 55MHz in both bands. The companies allowed to take part in the bid should themselves not have more than 60MHz of spectrum, or else they would have to transfer the excess spectrum to a third party by means of another public auction. Both processes were regulated by Subtel and approved by the TDLC. The result of the auction held in early 2006 was the sale of the spectrum by Movistar to another established mobile operator, Smartcom, which has since been rebranded as Claro by its current owner Mexico's America Movil.

After the auction Chile's anti-monopoly tribunal TDLC rejected a request from triple play provider VTR (a cable operator which is also active in fixed telephony and cable modem-based broadband access) to annul this spectrum sale to Claro. VTR had submitted a bid that was US$20 million higher, but was subject to several conditions demanded by VTR. According to VTR, which had withdrawn from the mobile market much earlier (it used to be in a joint venture with the predecessor of Movistar in which it sold its share in 1997), Movistar's decision was an excuse to prevent the entrance of new players into the mobile market. VTR's only other option for undoing the spectrum sale would have been to take its case to Chile's Supreme Court.

Currently (September, 2008) there is ongoing controversy about the rules for an upcoming 3G auction involving paired 45 MHz bandwidth in the AWS band (1.710-1.755)/2.1(2.110-2.155), to add to the total of 140 MHz that is currently assigned for mobile communications services in the 850 and 1900 MHz bands. Subtel initially proposed to reserve the largest block of frequencies for a new operator. It submitted its proposals to the TDLC, asking for a ruling as to whether existing mobile operators should be allowed to bid for this spectrum. Absent a change in the 60 MHz spectrum cap, existing mobile operators would either be excluded from the 3G auction or restricted to acquiring an uneconomically small amount of 3G spectrum. The TDLC issued a ruling in July, 2008 that existing operators should not be excluded from bidding in this auction, for which it also set out the following conditions for Subtel to establish to help prevent existing operators from engaging in anti-competitive activities such as spectrum hoarding:

- Mobile number portability (not yet in force in Chile but just introduced in Brazil in September 2008 for example) should be implemented as soon as possible, taking account of the schedule for the winners of the auction to start operation
- The 3G bandwidth should be divided into the maximum number of blocks that is technically efficient and economically reasonable for offering 3G services, and every bidder should be restricted to bidding on only one block in a first auction. Blocks that are not assigned in a first auction can be acquired by the bidders in a second auction
- Provisions for rollout and time scales for offering service should be imposed upon the auction winners.

Subtel has appealed the TDLC's decision to the Supreme Court. A number of operators including VTR as well as existing mobile operators have also appealed to the Supreme Court against the condition regarding mobile number portability (MNP), on the grounds that this issue is one for Subtel alone to decide, and that in any event it will take a long time to implement (i.e. two years) and its costs, which would be borne by customers, are too high for a small market such as Chile's. They argue that the 3G auction should not be delayed for the sake of MNP.

The TDLC's conclusions with respect to not excluding existing mobile operators from the 3G auction are based on a number of its findings of which the most relevant are:

- There is no evidence that the existing mobile operators are enjoying monopoly or "extra-normal" rents, which undercuts the argument that they will use the new 3G spectrum to prolong or defend this situation
- While 3G services can be offered in some of the frequencies the existing operators currently hold (and such services already are to a limited extent), this would be inefficient technically and economically
- There are potential benefits to be gained from an increase in competitive intensity that the entry of a fourth (or more) mobile operators into the Chilean market could generate, but steps need to be taken to reduce barriers to entry (which are formidable given the current high penetration of mobile telephony in Chile) and allow a new operator to compete on a more equal basis with the incumbents. The latter can take advantage of their existing facilities to reduce the time and total investment needed to deploy a 3G network in the 1.7/2.1GHz band compared to what a greenfield operator will face on its own.

The finding that 3G services offered in incumbents' existing frequencies would suffer from techno-economic disadvantages compared to use of the new 3G spectrum, which the TDLC noted would soon be able to take advantage of products developed for this band in the very large U.S. market, is an implicit recognition, as is the decision not to exclude incumbents from the 3G auction, of the benefits of removing or at least increasing significantly the spectrum cap of 60MHz that had been applied earlier.

2.6.4 MEXICO

The regulator Cofetel established a spectrum cap for mobile operators as a rule for the auction of broadband PCS spectrum held in early 2005. The spectrum offered comprised four 2x5 paired MHz blocks in each of the 9 regions covering the national territory and one 2x15 paired MHz block in two of them. The auction rules imposed a 65 MHz spectrum cap in any one of Mexico's nine regions on the combined cellular (824-849/869-894 MHz) and PCS (1850- 1910/1939-1990 MHz) frequencies held by each licensee (new or incumbent).

As required by the Federal Telecommunications Law the auction call required prospective bidders to obtain a favorable opinion from the Competition Commission CFC, as a necessary condition for Cofetel to accept their bids. The CFC assessed 7 different economic agents, including four incumbents and three entrants. Based on the attributes of broadband PCS, the CFC defined the relevant service as that of mobile telephony services, which also included cellular and digital trunking (push-to-talk over cellular). The geographic dimension it considered corresponded to the footprint of each of the 9 regions in Mexico. In practice, mobile carriers seek to create nationwide footprints via spectrum trading in secondary markets and, to a limited extent, by establishing roaming agreements with other carriers.

The CFC concluded that the market was highly concentrated in terms of subscribers and operators' revenues, both nationally and regionally. Only four carriers (or three in terms of ownership) provided mobile telephony services: Telcel, Telefonica, Unefon and Iusacell. The last two operators both belong to Grupo Salinas. The first two operators had a nationwide spectrum network in both cellular and PCS bands. Unefon had licenses for PCS in all regions, whereas Iusacell had cellular and PCS licenses in all but regions 2 and 3.

The sum of intended spectrum acquisitions revealed by the prospective bidders exceeded the available spectrum. Moreover, the intended spectrum acquisitions of the incumbents, adhering to the spectrum cap of 65 MHz, exceeded the spectrum auctioned. Therefore, according to the auction rules, incumbent operators could acquire all the bandwidth on offer and theoretically use their resources to deter entrants by pushing up prices at the auction.

Hence in order to encourage entry the CFC introduced the additional requirement that prospective bidders in this auction should hold no more than a total of 35 MHz (including any existing holdings in this band) in the 1.9 GHz band in all regions. This decision was intended to make more spectrum frequencies available to new entrants, and to increase competitive pressure on incumbents. The spectrum caps imposed by the CFC would have had the following effects: (a) Telefonica and Grupo Salinas would be blocked from bidding for spectrum in several regions; (b) Telcel, the market leader by far, would be able to acquire a maximum of 10 MHz in all regions; and (c) at least 210 MHz would be available for new entrants, independent of any bids by incumbents.

This 1.9GHz-specific spectrum cap was challenged by the incumbents in the courts on the grounds of unconstitutionality, and the auction was carried out under the original combined 65 MHz spectrum cap. No new entrants participated in the auction, although some had initially expressed interest and presented the information requested. However, they withdrew before the auction, so that only the three incumbents Telcel, Telefonica, and Grupo Salinas acquired spectrum, which was the outcome the CFC was trying to prevent. In three regions (1, 2, and 4) one or two of the 2x5MHz paired blocks were not awarded.

Subsequently in 2007 the courts supported the CFC's rule concerning a band-specific cap of 35MHz, so the result is that Cofetel cannot issue licenses for between 20-30 MHz of PCS spectrum in seven of the regions, including 20 MHz that covers Mexico City. It is now up to Cofetel to decide what to do with this spectrum. At this writing (September, 2008) Cofetel is also engaged in establishing bidding rules and reference terms for AWS and 3.5GHz spectrum auctions.

The CFC believes that spectrum auction rules in Mexico have been anti-competitive by facilitating behavior by incumbent operators to successfully deter entry and thereby keep monopoly rents in the mobile or wireless communications market[10]. It is trying to find ways to design spectrum auctions to minimize the potential for anti-competitive behavior and to encourage entry. Spectrum caps of the kind the CFC introduced into the 2005 PCS spectrum auction are one, but by no means the only, and not necessarily the best way to achieve these goals.

The development of effective competition in mobile broadband services in Mexico is dependent upon additional spectrum being made available to existing operators, such as Movistar (Telefonica) in the very important Federal District (Ciudad de Mexico), with or without a new entrant. The consequence of the sequence of events involving the 2005 PCS auction in Mexico has been that no one, whether incumbent or entrant, is yet in a position to exploit some potentially valuable spectrum in Mexico, which may be regarded as a "lose-lose" outcome from the perspective of overall market development and the value of additional mobile communications capacity for customers

One or more of the following other approaches may be considered, such as:

- Specific spectrum set asides for entrants (example: Canada's recent AWS spectrum auction)
  - This approach can be enhanced in practice by the attribution as rapidly as possible of new frequencies to mobile communications services, so that among other consequences overall rather than band-specific spectrum caps can be more effective in limiting the potential for incumbents to crowd out entrants completely

[10] This paper does not take a position as to whether or not incumbent mobile operators in Mexico or anywhere else are acting anti-competitively and enjoying monopoly or excessive rents. Rather it is concerned with polices and actions that can be pursued by Competition Authorities and regulators to change and/or pre-empt these outcomes if they believe that they represent either the current situation or pose a significant risk for the future in order to apply competition law in a manner that is compatible with the increasing demand for spectrum for mobile broadband access.

- Introduction of Universal i.e. technology- and service-neutral (as far as possible) Licenses, so operators with suitable frequencies in which mobile services are not yet authorized can enter this major telecommunications market segment

- Encouragement of additional powerful foreign operators to enter the Mexican market (the 49% limit on foreign ownership can be increased in specific cases by a decision of the National Commission of Foreign Investment).

However, a series of other actions will also be needed to persuade additional foreign investors that the telecommunications market in Mexico is in practice open to them under acceptable competitive conditions, e.g. enforcement of:

- Reasonable and timely interconnection agreements (possibly asymmetric in some aspects, e.g asymmetric mobile termination rates for some period of time) with incumbents (fixed and mobile), and

- Roaming and facilities sharing obligations on existing operators with respect to entrants under reasonable and non-discriminatory arrangements.

The outcome of the 2005 PCS auction illustrates how important it is for a Competition Authority and a telecommunications sector regulator to coordinate their rules for spectrum auctions ahead of the auction, so that once spectrum is attributed its commercial deployment exploitation can begin for the benefit of customers and the economy as soon as possible without being subject to delays of several years while legal disputes between government entities are being resolved. Current and potential operators will be the source of more than enough claims and disputes on their own.

2.6.5 COLOMBIA

In late 2004 the Ministry of Communications introduced in Decree 4234 an overall spectrum cap of 40MHz per operator. This cap is even tighter than those in other countries in Latin America. In 2005 Comcel, the mobile operator with the highest market share, and Movistar obtained an additional 15 MHz in the 1900 MHz band to reach this cap, agreeing to expand coverage. The third operator Tigo obtained an additional 10 MHz in 2008. Comcel and Movistar requested an additional 15 MHz in the 1900 MHz band in 2007 and 2008 respectively. In order to do so, the government is currently drafting a provision to increase the cap restriction implemented by Decree 4234. Currently Comcel and Movistar each have 25 MHz in the 850 MHz band and 15 MHz at 1900 MHz, while Tigo also holds a total of 40 MHz, all in the 1900 MHz band.

In early 2008 Comcel launched 3G services in its existing spectrum. Tigo did the same in late October 2008 and Movistar is expecting to do so in early December 2008. However, unless additional spectrum beyond the 40 MHz cap is attributed to mobile operators, hopes of using mobile broadband as a major contributor to the overall development of broadband services, to help assure their widespread availability in Colombia within the next few years, seem very unrealistic.

The 1.7/2.1GHz (AWS) band has been reserved for 3G broadband services, and offers one obvious opportunity for releasing additional capacity for mobile broadband services. As elsewhere in the region, unless the current spectrum cap is changed or removed one or more existing operators will be precluded from acquiring any of this spectrum, which is not necessarily in the best interests of customers or the goal of expanding the availability of broadband services.

3. HARMONISATION OF SPECTRUM DEMAND AND COMPETITION POLICY

As demands for mobile broadband services develop, high growth in spectrum needs is anticipated (Table 1), exceeding even all IMT-2000 spectrum identified to date.

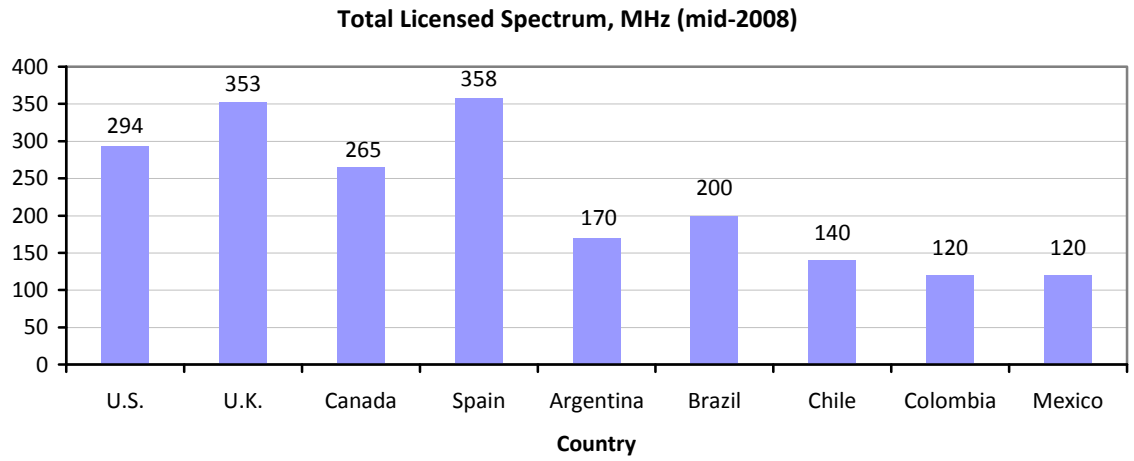
TABLE 1: FUTURE SPECTRUM NEEDS

Demand Scenario	Total Spectrum Requirement (MHz)			
	2010	2015	2020	2025
High Demand Setting – ITU[1]	840	1300	1720	N/A
Low Demand Setting – ITU[1]	760	1300	1280[3]	N/A
High Urban Demand – U.K.[2]	430	1270	1200[3]	1310
Low Urban Demand – U.K.[2]	200	210	520	550

Notes: 1. ITU-R Report M.2078 (2006); 2. Analysys Mason, "Spectrum demand for non-government services 2005–2025", report to the U.K. Independent Audit of Spectrum Holdings, ***http://www.spectrumaudit.org.uk*** *- total capacity for mobile use in 900MHz, 1800MHz, 1.9/2.1GHz and 2.6GHz bands in the U.K. is assumed to be 540 MHz; 3.Decrease due to deployment of more efficient system beyond current and near term IMT-2000 systems.*

A range of new services is driving demand, such as broadband internet access, web TV, games, social networking etc. to support which many operators will require much more spectrum than they currently hold. The anticipated spectrum requirements shown in Table 1 substantially exceed the total spectrum that is licensed in Latin America. Total mobile spectrum licensed in Brazil after its 3G auction in late 2007, for which its spectrum cap was increased, equals 200 MHz (total in 850/900/1800 MHz and 3G 1.9/2.1 GHz bands), but several other countries in the region have total current bandwidth licenses of well below this amount. According to Citel, the additional spectrum need in the Americas in 2020 will be 721 MHz in areas of low, and 1161 MHz in areas of high market usage (existing IMT-2000 allocated spectrum amounts to 559 MHz as of CCPIII/Rec 70 (XXI-02, the majority of which has not yet been awarded or licensed to operators). Figure 3 shows that Europe, the U.S., and Canada have already licensed considerably more bandwidth for commercial mobile communications than Latin America.

FIGURE 3: CURRENTLY LICENSED SPECTRUM IN SELECTED COUNTRIES



The U.S. spectrum total shown in this table includes AWS-1 & 700 MHz "digital dividend" spectrum but excludes 2.5 GHz mobile WiMax, i.e. primarily the Clearwire/ Sprint networks. The U.K. spectrum total includes 3G 1.9/2.1GHz spectrum, while the total in Canada includes the AWS spectrum auctioned in 2008, and the licensed spectrum in Brazil covers 850/900/1800 MHz and 3G 1.9/2.1GHz frequencies (almost all other Latin American countries will use the AWS band for 3G). With the exception of Brazil, the currently licensed spectrum in the Latin American countries shown includes 50 MHz in the 850 MHz band, with the rest (from 70-120 MHz depending on the country) in the 1900 MHz band. Spectrum assigned for trunking services is excluded in all cases.

The discussion and assessment of the relationship between spectrum demand and competition policy must be related to the goal that public policy is striving to achieve. For the purposes of this discussion the goal can be summarized at the highest level as maximization of the value - the economic and social benefits - that is generated by use of the spectrum. The importance of this goal, and hence the increasing intensity of interaction and overlap between spectrum demand, including of necessity spectrum management, and competition policy since spectrum is a scarce resource, lies in the growing awareness and belief throughout the world that access to broadband services is a key enabler for a country's economic and social development, and its ability to be competitive in global markets. Mobile broadband has the potential of playing a significant role in Latin America in the development of broadband services, given the often limited coverage of fixed access networks. Hence the need is critical to ensure congruence and coherence between sector-specific regulations that affect the competitive environment for mobile services and overall competition policy.

Two conclusions about the desirable emphasis in the measures applied to avoid and limit or stop anti-competitive behavior can be drawn from this basic observation:

- One approach would involve leaving questions of anti-competitive behavior up to the application of general competition policy and procedures, with no or little application of sector- or mobile-specific rules and measures

- Alternatively, while competition policy would have a key role to play, nevertheless the nature of telecommunications, and within that mobile communications, would justify the design and implementation of specific measures to prevent or prohibit anti-competitive behavior in these markets, taking account of their special characteristics such as high capital intensity and the central role played by scarce resources, most notably spectrum, but also by other potential bottlenecks such as access to buildings and other sites required for the deployment of wireless as well as fixed networks.

A strong justification for adopting the second rather than the first approach is that most remedies under competition policy involve ex post actions as a result of complaints, which may only be resolved long after the alleged damage has been done, when circumstances have changed beyond most, if not all, recognition, especially in technologically dynamic markets such as telecommunications. Thus the actions taken are likely to be at best irrelevant, and at worst a case of "justice delayed is justice denied." Exceptions to this observation arise in the case of reviews of proposed mergers, when action by a Competition Authority can prevent or change the conditions of a merger to pre-empt anticipated anti-competitive outcomes.

In contrast, a sector regulator can introduce ex ante means, of which spectrum caps are one example, to help ensure that markets are and remain truly competitive. To the extent that policy makers believe they should have a portfolio of ex post and ex ante measures at their disposal to facilitate and ensure effective competition in markets for the sake of users, consumers, and overall welfare, then both a sector regulator in telecommunications and a Competition Authority have valuable roles to play. Coordination between these entities becomes essential if disputes between different Government agencies and departments are not themselves to become sources of undesirable delays and confusion in market development, multiplying the already substantial impact of the interventions of conflicting claims from private sector organizations

advocating on behalf of their perceived individual interests. An illustration of the need for this coordination can be found in the use of the Herfindahl-Hirschman index (HHI), which is calculated as the sum of the squares of the percentage shares of competitors in a market; a value of 1000-1800 indicates a moderately concentrated and a value above 1800 a highly concentrated market according to U.S. Department of Justice guidelines. An HHI of 10,000 is a monopoly. As of December, 2007 selected HHI indices in the mobile communications market were: Brazil: 2265; Chile: 3687; India: 1593. The high capital intensity of mobile networks, which as argued earlier tends to limit the number of economically viable operators, given the techno-economic efficiencies associated with multiple wireless networks, means that mobile HHIs are almost bound to indicate at least a moderately concentrated market according to this guideline. A mobile market served by four operators with equal market shares will have an HHI of 2500, while unequal shares (the typical situation) of these four operators will lead to an even greater value of the HHI index. The sector regulator and Competition Authority should agree on whether and if so how to apply the HHI to assess whether the mobile market is competitive or will be competitive after a proposed deal such as a merger between operators or a spectrum trade is consummated, since the numerical value of the HHI or changes in it that may be a signal of potential competition problems for mobile communications should not necessarily be the same as in the market for, e.g. shoes or TV sets.

The objection to ex ante measures, or to a substantial reliance on them, is that they depend on decisions and judgments reached by bureaucrats and their political masters about market conditions and prospects and how best to ensure that these markets remain or become competitive. The likelihood that these decision makers will be correct in their decisions, e.g. with respect to how large a spectrum cap should be imposed, is surely not a reasonable bet according to these critics. According to this line of argument, the credence or value that should be attached to judgments by bureaucrats subject to political masters about markets and technologies should be lower than that which is attached to the decisions and probable outcomes of the diverse choices made by business people and organizations which are actually competing in the market and have to satisfy customers. Whatever weight is given to this objection, it is evident that there are many market-related uncertainties and risks in mobile broadband communications, which are beyond the power or ability of either regulators, or business executives or indeed any other forecasters to eliminate. Hence any ex ante measures introduced should be flexible and not rigid, and capable of adjustment or even removal in a timely manner as and if evidence develops that they are either irrelevant or, even worse, an obstacle to healthy market development.

In the particular case of spectrum caps the arguments just presented suggest that tight or rigid (such as all-band) spectrum caps are likely to become obsolete and even harmful to consumers' interests if they remain in place over many years while technology and the nature of demand for mobile services undergo major transformations, both quantitatively and qualitatively. Consequently, they should either be abolished, and reliance placed upon more flexible and adaptable measures of dealing with competition problems, or if retained they should be replaced with much looser and flexible spectrum caps.

Examples of different forms of spectrum cap are presented in Table 2. Even if one or more of these alternatives are applied the use of flexible spectrum caps will not be the only tool available for the application of competition policy. It will be important that a sector regulator and the Competition Authority reach agreements regarding the modalities of these caps (e.g. whether they will be applied as guidelines, or as "soft" or hard caps), for the sake of coherence in public policy as noted earlier.

TABLE 2: SPECTRUM CAP ALTERNATIVES

ALTERNATIVE CHARACTERISTICS OF SPECTRUM CAPS (A cap may exhibit more than one of these characteristics, although some are mutually exclusive)	
"HARD" CAP	A "hard" cap or absolute limit on the amount of spectrum any one operator can hold
"SOFT" CAP	A "soft" cap, i.e. if exceeded other conditions may be applied to the spectrum license, such as a different initial license period
"LOOSE" CAP	A "loose" or high-level cap with only limited impact on spectrum uses by an operator - a general safeguard to prevent high concentration of spectrum holdings
"TIGHT" CAP	A "tight" or low-level cap severely constraining the structure of spectrum holdings - to mitigate a perceived high risk of non-competitive market structures
BAND-SPECIFIC CAP	A band-specific only spectrum cap with no reference to other spectrum holdings
CUMULATIVE CAP	A cap that considers spectrum holdings across other spectrum bands - may be cumulative only and/or include cumulative and band-specific elements
EVENT-RELATED CAP	Event-related spectrum applicable only at the time of a spectrum award - no restrictions on subsequent spectrum trades and acquisitions
DURABLE CAP	Durable caps set at the time of the award – and applicable to subsequent spectrum trades and acquisitions
OTHER CAP	e.g. Initial bidding caps in a spectrum auction that can be exceeded in later rounds (Norway)

Source: Ofcom and Arthur D. Little analysis

Tight spectrum caps entail risks of adverse consequences for broadband customers and inhibit operators from offering future services efficiently. Operators under tight spectrum caps (well below 100 MHz in all bands) will incur higher costs to offer a full-service portfolio of mobile voice and broadband services. Additional cell splitting will be needed as spectrum becomes congested, thereby increasing the costs (capex and opex) of serving customers. Furthermore a regional patchwork of spectrum caps will inhibit operators licensed in multiple countries from offering comparable service portfolios to customers traveling internationally. Hence very heterogeneous spectrum cap policies will impair the potential contribution of mobile services to reaping the socio-economic benefits of regional coordination.

Among the types of cap outlined in Table 2 above "loose" and "band-specific" caps in particular are being applied as described earlier by some regulators, for example:

- The FCC has defined a "loose" cap, or screening guideline, currently set at 95 MHz across all bands, beyond which it can review the situation for potential competition problems

- The Swedish regulator PTS applied a band-specific cap of 140 MHz in its 2.6 GHz auction while Ofcom in the U.K. also envisages a band-specific cap for its planned auction of spectrum in this band, as well as for its eventual digital dividend spectrum auction.

The key advantage of "loose" (and generous) caps lies in the flexibility they provide to regulators in assessing whether they should be applied strictly or not as circumstances unfold, thereby reducing the risk that unforeseeable developments will render the caps unreasonable. At the same time these caps give regulators a basis for remedies which they can apply if competition problems emerge. The disadvantage of "loose" caps is also inherent in their very flexibility, namely that they can provide a potential justification for interested parties to criticize and challenge a regulator's decision about whether or not to enforce the cap in any particular situation, thereby delaying issuance of licenses to spectrum winners. In contrast band-specific caps

are aimed at ensuring that no single operator is able to monopolize a new valuable band that is being made available, in order to maintain intensity of competition as the demand for more and new services justifies or requires the use of additional bandwidth by operators. However, finding the "right" level for a band-specific cap requires assessment of the balance between the benefits of ensuring that several operators can acquire spectrum in the new band, and the risk of inefficient use of this new spectrum if it becomes increasingly fragmented. Since by their very nature band-specific caps will be smaller than "loose" generous caps, they incur the risk that regulators may choose too stingy a cap for the efficient deployment of broadband networks at these frequencies.

Further evidence for the obsolescence (current or imminent) of several Latin American spectrum caps can be found in the observation that several major operators in Europe and the U.S. already have spectrum holdings that exceed them, sometimes by substantial amounts.(Tables 3-5). This conclusion is reinforced even more strikingly by the forecasts of future spectrum requirements as shown earlier in Table 1 under a variety of scenarios, which demonstrate that substantial additional spectrum will have to be allocated for mobile broadband communications if congestion and suppression of demand are to be avoided.

TABLE 3: SELECTED SPECTRUM CAPS IN LATIN AMERICA

Country	Spectrum Cap, MHz	Comments
Argentina	50[1]	Has recently announced it will license 1.7/2.1 GHz band in 2009
Brazil	80	Increased from 50 to 80 for the recent (end-2007) new 3G spectrum auction. Planning structure of 2.6GHz band
Chile	60	Ongoing dispute about whether existing operators with 60 and 55 MHz will be excluded from new 3G spectrum auction. Planning structure of 2.6 GHz band
Colombia	40[2]	This cap is even tighter than those in other countries in Latin America. The 1.7/2.1GHz (AWS) band has been reserved for 3G broadband services
Mexico	65	Licenses for some 1900 MHz spectrum awards cannot be issued because of Competition Commission's 35 MHz band-specific cap

Notes: 1. Decree 260/98 of 1998; 2. Decree 4234 of 2004
Source: Telefonica, National Regulators' Websites, Comision Federal de Competencia (Mexico)

TABLE 4: OPERATORS' SPECTRUM HOLDINGS

Country / Region / Operator	Spectrum Holding per Operator, MHz	Spectrum Cap
EU Average	92.6	No
Germany	65	No
UK	82.2	No
France	138.5	No
Italy	72.7	No
Spain	100.6	No
Sweden	92	No
Denmark	118.4	No
U.S. – Verizon Wireless	National average ~89	No(1)
U.S. – AT&T Mobility	National average ~96	No(1)
U.S. – T-Mobile	National average ~75	No(1)

Note: 1. Includes results of 2008 700 MHz auction; FCC has current screening guideline of 95MHz - after the 700 MHz auction AT&T Mobility and Verizon Wireless exceed this guideline in some areas (e.g. AT&T has a total of 124 MHz in the Dallas/Fort Worth area), which has led to a request from some quarters to reinstitute a spectrum cap.

TABLE 5: VODAFONE'S EUROPEAN SPECTRUM HOLDINGS

Country	Vodafone's Spectrum Holdings, MHz(1)
Germany	55.6
Italy	70.4
Spain	100.3
U.K.	76.5
Greece	100
Portugal	68
Netherlands	63.2

Note: 1. Total FDD spectrum (DL + UL) in 900/1800 MHz and 1.9/2.1 GHz bands – except in U.K. Vodafone also holds an additional 5MHz TDD spectrum
Source: Vodafone Technology Update, March 5, 2008

Spectrum holdings of several major mobile operators in Latin America are already at their national caps, so that absent access to additional spectrum these operators' ability to meet growing market demands such as are shown in Table 1, may be inhibited, even with the introduction of more efficient, e.g. 3G technologies, in existing frequencies.

Furthermore, new mobile technologies are being designed for wider channel bandwidths not foreseen at the time current caps were instituted. Only one wide bandwidth channel, e.g. 2x20MHz for LTE, to achieve maximum efficiencies and speeds, e.g.100 Mb/s+ downlink and 50 Mb/s+ uplink, would consume a major

proportion of current spectrum caps. Hence an operator's ability to deploy next generation technologies flexibly in different frequency bands will be impaired or even impossible unless caps are relaxed substantially.

If these caps are maintained then the number of operators per country required to meet market demands in the broadband era is likely to reach or even exceed ten (Table 6).

TABLE 6: NUMBER OF OPERATORS PER MARKET TO MEET FUTURE DEMAND UNDER CURRENT SPECTRUM CAPS

Country	Current spectrum cap, MHz	Number of operators per market required to meet future broadband demand under current spectrum caps, as a function of total spectrum requirements in MHz		
		430	540	720
Argentina	50	9	11	15
Brazil	80	6	7	9
Chile	60	8	9	12
Colombia	40	11	14	18
Mexico	60	8	9	12

The assumption in this table is that all operators hold the maximum spectrum allowed. The alternative amounts of total available spectrum are derived as follows:

- *430 MHz*: Current IMT-2000 spectrum as per Citel document CCP.II-RAD/doc.578/04 Rev. 2
- *540 MHz*: Total cellular spectrum available in U.K. in 900 and 1800 MHz, and 1.9/2.1 and 2.6 GHz bands
- *720 MHz*: Approximate total IMT-2000 spectrum currently identified for Region 2 (Americas).

However, the number of financially viable operators in a national or regional market is limited, probably to well under ten, by the high capital requirements of mobile networks even if mitigated by facilities sharing, and the combined impact of market fragmentation on the revenue side and trunking and other inefficiencies on the cost side as this number grows. Current tight spectrum caps such as prevail in Latin America will have to be changed, namely increased by significant amounts to preempt this outcome or otherwise modified or even removed. Furthermore, since it is hard to predict the exact scale and pace of development of the growth in demand for mobile broadband services, it would be sensible not simply to increase current tight caps to a higher but also rigid amount, Rather if they are not to be eliminated as they have been in the U.S. and Canada, at least they should be structured to be flexible and capable of adjustment as markets develop, rather than embodied in rigid rules or regulations that may be difficult to change in a timely manner.

The amounts of spectrum which operators trying to meet demands for broadband services are likely to want to acquire are indicated in Table 7, which presents the possible ranges of spectrum that would be assigned to these operators when various new bands are awarded (AWS, 2.6 GHz extension, and "digital dividend"), assuming that there are three or four winners.

TABLE 7: POTENTIAL SPECTRUM ATTRIBUTIONS PER OPERATOR FROM NEW BANDS

Frequency Band	Available Spectrum for Mobile Services, MHz	Average spectrum per operator (if 4 winners)	Average spectrum per operator (if 3 winners)
AWS-1	90	22.5	30
2.6GHz extension	190, of which typically FDD 140 and TDD 50	47.5	63.3
"Digital Dividend" – 700 MHz	Assume 72 MHz[1]	18	24
Total of Three New Bands	362	88	117

Range of total likely Spectrum Holdings including existing frequency holdings (assumed to be between 40-60 MHz)

- *88 - 148 MHz per operator, with 4 active operators (i.e. one new entrant in many countries)*
- *157 – 177 MHz per operator, with 3 active operators (i.e. no new entrants in many countries)*

Notes: 1. Conservative estimate, subject to national decisions: The ITU has identified 698-862 MHz for IMT-2000 in Region 2 (Americas) but only 790-862 MHz (i.e. excluding lower 700 MHz band) in Region 1 (Europe, Africa, the Middle East west of the Persian Gulf and including Iraq, the former Soviet Union and Mongolia)

Operators are likely to bid on all the bands shown in Table 7, given their different propagation properties. In practice, depending on the details of the band plans, some operators will acquire substantially more than the average amounts, particularly since a very desirable arrangement for LTE deployment would require 40 MHz (2x20 FDD). With these three bands added to existing 850 MHz and PCS (1900 MHz) frequencies, the total spectrum allocated to commercial wireless use will amount to 560 MHz, which is still well under forecast spectrum requirements by 2015-2020 (Table 1). The forecasts of total spectrum holdings assume that existing operators which currently hold 40-60 MHz of spectrum (e.g. in 850 and 1900 MHz bands) win spectrum in new bands. It should be noted that Vodafone asserts that its current spectrum holdings in Europe (70-100 MHz/country, including 3G 2.1 GHz spectrum) are adequate for the medium term (3-4 years), but it does intend to seek additional spectrum in the 2.6GHz and "digital dividend" bands for 2012 and beyond.

Hence it is evident that operators which plan to be competitive in the era of broadband mobile communications will be looking within the next few years for total spectrum holdings amounting to 100 to well over 100 MHz across all the bands that are allocated for mobile services.

3.1 CONCLUSION – LESSONS FOR LATIN AMERICA

Tight spectrum caps such as are in place in some countries in Latin America will inhibit mobile broadband development. These caps entail substantial risks in the emerging and unpredictable mobile broadband environment, with regard to:

- The ability of innovative operators to deploy new valuable services may be impaired if they are subject to some current rigid spectrum caps that will not allow them to acquire sufficient additional spectrum to exploit the maximum efficiencies of new broadband wireless technologies and offer a wide portfolio of broadband services to their customers
- Techno-economic efficiencies may be reduced as cell splitting has to increase when spectrum becomes congested
- The number of operators may increase beyond an economically sustainable number, leading to under-investment while the assets of weaker participants are reorganized and caps have to be renegotiated[11].

Furthermore, the chances that a regulator or indeed anyone will hit upon and choose an "optimum" fixed spectrum cap that ensures the best outcome for mobile broadband market development in the interests of customers is remote, given all the uncertainties around this emerging and potentially very important segment of the telecommunications sector.

Several alternative measures are available and are being invoked elsewhere (and in a few cases in Latin America itself) to address potential competition problems, and achieve universal service goals, without having to depend upon tight spectrum caps. They include remedies such as:

- Increased technology- and service-neutrality of spectrum use to allow operators more flexibility in the services they offer
- Spectrum trading
- Traditional measures such as issuance of new licenses (e.g. France's proposed 4th 3G license), spectrum set-asides (e.g. Canada's AWS auction), and rollout or coverage obligations.

It would be helpful in terms of the efficiencies which multi-country operators can achieve if these measures were coordinated as far as possible across countries throughout Latin America, so these operators can acquire spectrum that enables them to offer comparable services across all their mobile networks.

The most immediate and widespread opportunities for attributing new spectrum for mobile broadband services in Latin America in a timely manner lie in the AWS (or in Brazil the 1.9/2.1 GHz band which has already been auctioned) and 2.6GHz expansion bands. The AWS band can provide a total of around 100 MHz of new bandwidth and will benefit from the learning curve of equipment and experience that is already in place or being deployed in AWS networks in the U.S. and Canada, while the 2.6GHz band that offers a total of around 190 MHz of spectrum is being pursued and implemented on a global basis with a structure that can accommodate preferences for both FDD and TDD duplexing modes. Somewhat later "digital dividend" spectrum at 700 MHz will become available, which if experience in the U.S. and Europe is a guide could provide a further 75-125 MHz (approximately) of bandwidth for mobile broadband services, depending on how spectrum is allocated among the various applications envisaged for this UHF spectrum. The development of

[11] "**Optimal Number of Mobile Service Providers in India: Trade-Off between Efficiency and Competition", R. Prasad and V. Sidhar,** International Journal of Business Data Communications and Networking , Volume 4, Issue 3, July -September 2008

system profiles and equipment such as LTE for use at 700 MHz is currently being actively pursued by vendors and standards organizations. These three bands combined can deliver a total of between about 350-400 MHz of spectrum for mobile broadband communications, corresponding to an increase in the total amount of spectrum licensed for mobile communications by a factor of more than three compared to the amounts of spectrum currently licensed in most Latin American countries for this purpose.