Spectrum Analysis - The Critical Factor in BWA/WiMAX versus 3G

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TABLE OF CONTENTS

FOREWORD

Maravedis has written this white paper, which is based on extensive research, to share its unique understanding of the evolving worldwide regulatory environment for broadband wireless. We believe that the industry is at a critical juncture for gaining widespread acceptance and sales momentum: this report addresses a critical factor for the success of BWA/WiMAX. We have been surveying regulators for two years on a regular basis. Some of the regulators who are in the process of establishing national allocations for BWA/WiMAX also requested our guidance about what is being done elsewhere.

We are pleased to share with you the result of hundreds of hours of research. Detailed country and operator information remains premium information contained in our landmark database, branded **ClearSpectrum,** available to customers only.

1. KEY FINDINGS

The low cost of the BWA/WiMAX spectrum compared to 3G is a clear driver for service providers to enter the field of wireless services with BWA/WiMAX. This difference in cost/Hz is particularly significant in Europe, where the average 3G spectrum cost/Hz is 1000 times higher than the average BWA/WiMAX spectrum cost/Hz. The proportion is smaller in other regions, but remains in favor of BWA/WiMAX.

It is important to highlight that the aggregate 3G spectrum is in lower frequency bands than the aggregate BMA/WIMAX spectrum. This shifts the cost/Hz on a deployed equipment basis, due to the requirement for at least twice the equipment for each doubling of the frequency. However, even with that adjustment it is clear that the BMA/WIMAX spectrum is more economical, particularly when it is mapped to trends of devices to mitigate spectrum bands and modulation schemes.

The much lower cost of BMA/WIMAX licenses[1] resulted in a high number of licensees, with a total of 721 and 106 license holders for BWA/WiMAX and 3G, respectively. However, the average amount of spectrum owned by a carrier is similar for the two technologies.

North America is by far the leading region in number of BWA/WiMAX awarded licensees, with a total of 394 BWA/WiMAX license holders, against 186 in Europe, 97 in the Asian Pacific (APAC) region and in the Central America / Latin America (CALA) region. Note that EBS (Educational Broadband Services) in the USA were not included in the North America figure.

In contrast to 3G licenses, the BWA/WiMAX licenses awarded around the world are essentially regional. North America is a perfect example, where 100% of its BWA/WiMAX licenses are regional, against 78% in Europe and 71% in the CALA region.

This crowded environment will result in a highly fragmented, unpredictable and more competitive market, open to smaller and cost-aggressive players. **Note that not all licensees are active**. In fact, we estimate that more than half of the

[1] (Note: the terms “licensee” and “license holder” are used interchangeably, and refer to any entity that holds one or more licenses.)

license holders in the BWA/WiMAX spectrum are still in the evaluation or trial stage.

On the other hand, the low-cost spectrum has also attracted players that have fewer resources than the large mobile operators. One must remember that the BWA spectrum was initially allocated for fixed-only applications and remains so in many countries.

While 3G, with the emergence of enhanced 3G technologies like HSDPA/HSUPA, Scalable Bandwidth EV-DO, 3.9G and Super 3G, is expected to reinforce its head start over Mobile (BWA/WiMAX) in terms of performance, it appears clear that 3G carriers will have to compete with new players once BWA/WiMAX mobile technology is embedded in cell phones and reaches attractive price points and significant volume sometime in 2008.

Most regulators have not kept pace with the progress of technology that **makes fixed-mobile convergence a reality.** 77% of regulators still limit 3.5 GHz usage to fixed-only applications. More importantly, the 2.5-2.9 GHz band remains locked to BWA/WiMAX in most European countries, but the pressure on regulators to include BWA/WiMAX in the IMT 2000 definition will increase over time, once 802.16e systems become commercially available. Sweden has already opened a public consultation to allow the 2570-2620MHz band to be technology agnostic.

Whether it is fixed applications with CDMA technology or mobile applications with BWA/WiMAX, the two fields are converging and will be competing for a share of the one-billion-subscriber market.

2. METHODOLOGY & RESOURCES

To conduct this comparative analysis between 3G and BWA/WiMAX, Maravedis proceeded as follows:

- **Step 1**: Selecting a similar list of countries by region (Europe, North America, Central America / Latin America (CALA), and Asian Pacific (APAC)) for both 3G and BWA/WiMAX. Those countries include:

European Union: Austria, Belgium, Cyprus, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Ireland, Italy, Latvia, Lithuania,Luxembourg, Malta, Netherlands, Poland, Portugal, Slovakia, Slovenia, Spain, Sweden, United Kingdom.
Non-EU countries: Norway, Russia, Romania, Turkey, Croatia
APAC: China, Japan, South Korea, Malaysia, Thailand, Taiwan, Singapore, Hong Kong, India, Australia, Vietnam, Philippines, Indonesia and New Zealand.
CALA: Argentina, Brazil, Venezuela, Colombia, Uruguay, Mexico, Peru.
North America: USA, Canada.

However some important countries such as USA, Russia, China and India did not allocate any formal 3G+ licenses yet. Therefore, the spectrum cost comparison between 3G and BWA/WiMAX remained limited to the countries where auctions/allocations took place for both spectrums.

- **Step 2:** For both 3G and BWA/WiMAX, gathering the following information for each license holder, country and region:

* Total amount paid by the license holders for their licenses
* Total amount of spectrum (MHz) acquired
* Geographical scope of licenses acquired (national, regional)
* Number of people living in the covered areas

In the case of BWA/WiMAX, we used **ClearSpectrum** – our unique database covering over 50 countries and their BWA/WiMAX spectrum allocation policies (licensing and technical information per frequency band and license holder). This database is updated on a quarterly basis, by gathering information from the national regulators. For the sake of this analysis, we only took into consideration the 2.3 – 2.7 GHz and 3.5 GHz bands.

For 3G, we used information provided by "Technology Marketing Industry Intelligence (QG2)."

- **Step 3:** Calculating the cost per Hz paid by each 3G and BWA/WiMAX license holder, by dividing the total amount paid by those license holders for their licenses by the total amount of spectrum (MHz) acquired. We added those costs paid by all the license holders in order to obtain a cost per Hz per country. We finally summed the costs across countries in order to calculate a regional cost per Hz. This process was repeated for each region.

- **Step 4:** Calculating the cost per Hz per population paid by each 3G and BWA/WiMAX license holder, by dividing cost per Hz paid by those license holders, by the population (expressed in millions) in the served areas. We summed those costs across license holders in order to obtain cost per Hz per Million Population by country. We finally took the average of the per-country costs, in order to obtain a regional cost per Hz per Million Population. We repeated this process for each region.

- **Step 5:** Conducting a regional comparative analysis respectively for 3G and BWA/WiMAX, in terms of amount paid for licenses, cost per Hz and cost per Hz per Million Population. Then we compared 3G and BWA/WiMAX in terms of cost per Hz by region, cost per Hz per Million Population by region, number of licensees and their coverage areas. Note that we only considered Europe and the APAC region in comparing 3G with BWA/WiMAX auction results, since only those two regions have to this date auctioned 3G licenses.

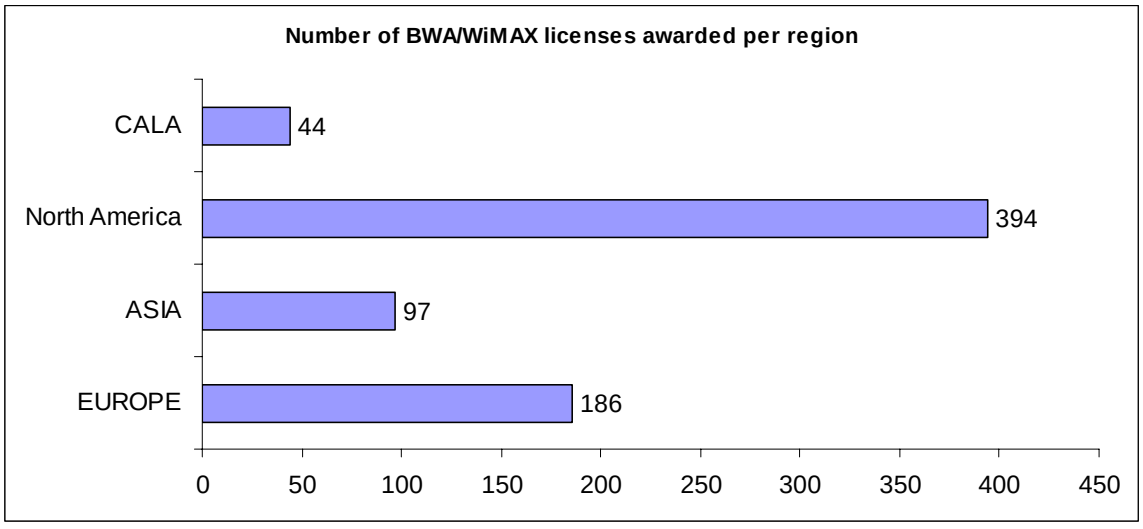
3. BWA/WIMAX LICENSES AND SPECTRUM

3.1 Regional Analysis

3.1.1 Number of BWA/WiMAX Licenses – by Region / by Frequency

A total accumulated 721 BWA/WiMAX licenses exist today, net of licenses returned or resold in the countries surveyed. North America is by far the leading region in terms of number of BWA/WiMAX licenses awarded, with a total of 394, against 186 licenses in Europe, 97 licenses in the APAC region, and 49 licenses in the CALA region. Note that EBS (Educational Broadband Services) licenses were not included in the USA number because they are not primarily allocated for commercial applications.

Exhibit 1: Number of BWA/WiMAX Licenses Awarded per Region (3.3-3.8 GHz and 2.3-2.7 GHz)



Source: ClearSpectum Database-Maravedis

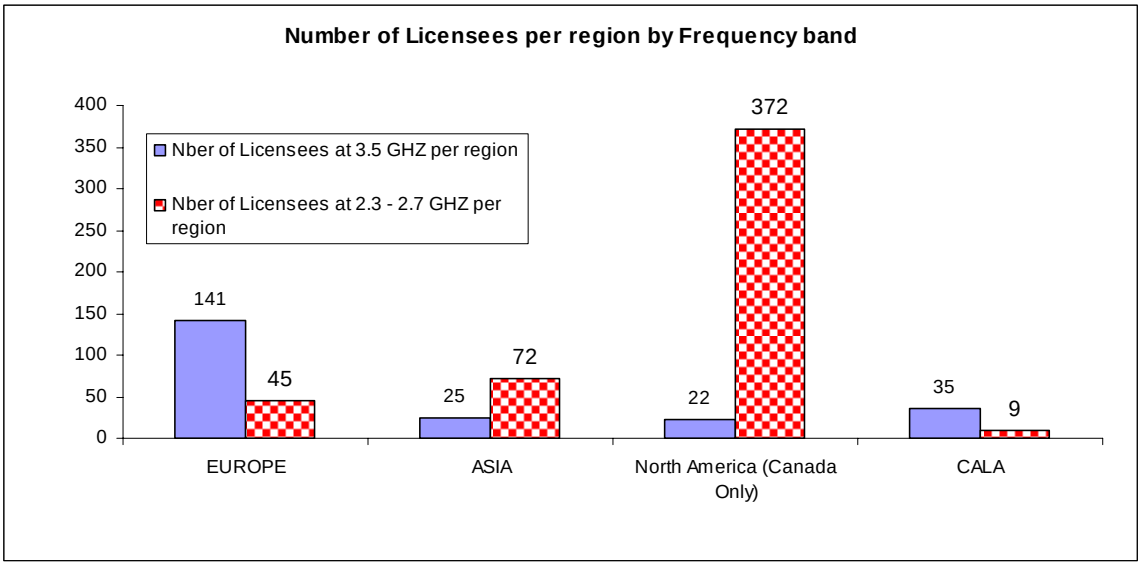
More precisely, there is a clear difference between North America and Europe in the type of BWA/WiMAX frequencies awarded. In North America, 94% of the

frequencies have been allocated in the 2.3-2.5 GHz band, with the remaining licenses being allocated in the 3.5 GHz band, and only in Canada.

In Europe, 76% of the BWA/WiMAX frequencies have been allocated in the 3.5 GHz band (141 licenses in the 3.5 GHz band, against 45 licenses in the 2.5 GHz band). Most 2.5 GHz licenses in Europe were allocated in Russia.

In most of Europe, the license holders will be able to use the 3.5 GHz band to provide only fixed services in the short term. The 2.5-2.69 GHz band is still reserved for UMTS extension in 2007-2008 in most Western European countries. However, Maravedis believes that when working 802.16e products become available, the ability of the regulatory working group of the BWA/WiMAX forum to influence regulators towards a more BWA/WiMAX-friendly attitude will increase.

Exhibit 2: Number of Licensees per Region by Frequency Band



Source: ClearSpectum Database-Maravedis

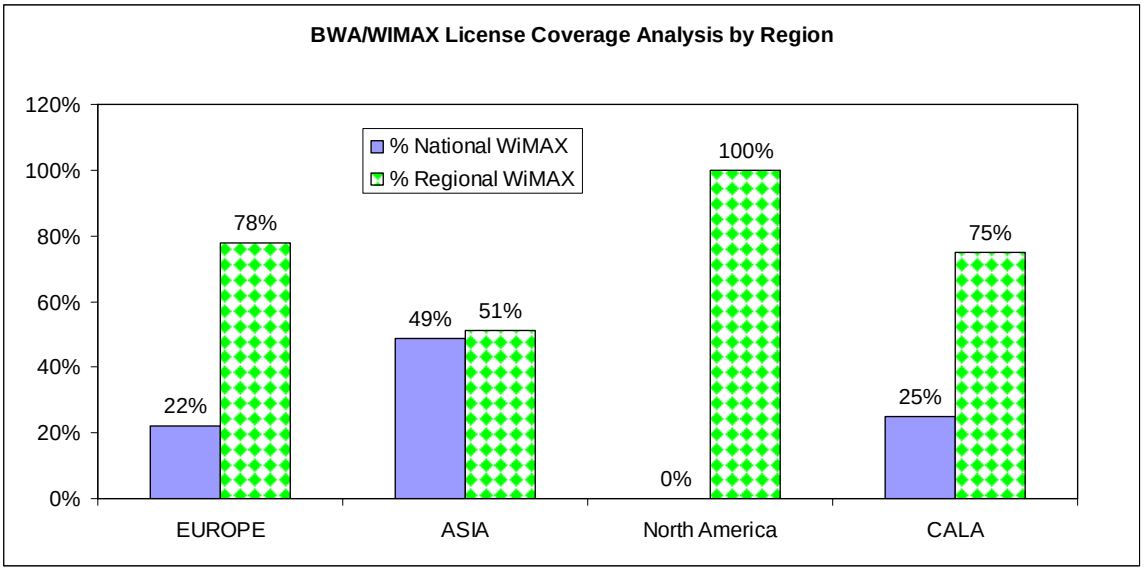
In the APAC region, 74% of the BWA/WiMAX licenses have been allocated in the 2.3-2.5 GHz band (72 licenses in the 2.5 GHz band, against 25 licenses in the 3.5 GHz band), as Mobile BWA/WiMAX – and especially WiBro – is expected to operate in this band in countries like South Korea. Finally, the CALA region has a situation quite similar to Europe, with 79% of its licenses allocated in the 3.5 GHz band.

3.1.2 Number of BWA/WiMAX Licenses by Coverage Area

Our research also revealed that across the world, most BWA/WiMAX licenses are regional licenses. North America is a perfect example, as 100% of its BWA/WiMAX licenses are regional, against 78% in Europe and 71% in the CALA region. This situation did not prevent large players such as Sprint-Nextel from consolidating regional licenses to achieve a national footprint.

However, those numbers do suggest that BWA/WiMAX markets may become more fragmented and less predictable than Cellular/3G+.

Exhibit 3: BWA/WiMAX License Coverage Analysis by Region



Source: ClearSpectum Database-Maravedis

3.2 Countries / Operators Allowing Mobility for BWA/WiMAX in 3.5GHz

Australia represents one of the few countries allowing Mobile BWA/WiMAX in that band.

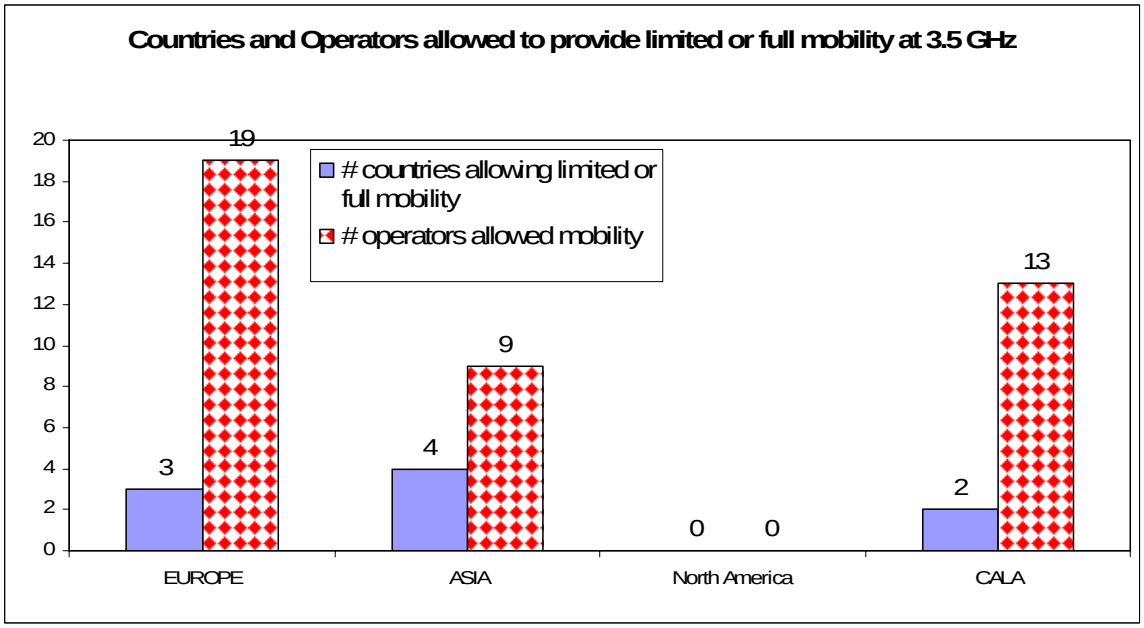
European regulators remain predominantly opposed to allowing mobile services in the 3.5 GHz band. Nonetheless, three countries (Hungary, Spain, Norway),

accounting for 19 license holders, do permit limited mobility within a certain radius.

The APAC region, which accounts for the second highest number of countries allowing mobility for BWA/WiMAX at 3.5 GHz, with 2 countries (Australia, New Zealand), is expected to be a big market for Mobile BWA/WiMAX because of the great involvement of various governments towards BWA/WiMAX, as well as high population densities.

Finally, the CALA region is slightly behind those three regions with only Venezuela and Colombia (representing 13 license holders) allowing limited mobility at 3.5 GHz. Even though Mobile BWA/WiMAX is expected to grow in this region, it will certainly be limited by economics, and Mobile BWA/WiMAX-based products will certainly be primarily used by high-end users.

Exhibit 4: Countries and Operators Status vis-a-vis 3.5 GHz Mobility



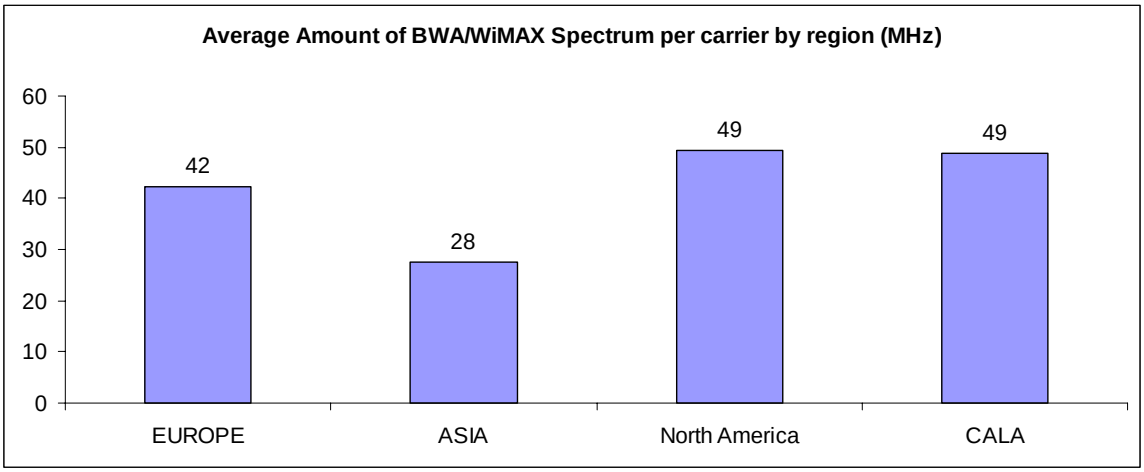
Source: ClearSpectum Database-Maravedis

3.3 BWA/WiMAX Cost – Amount of Spectrum

3.3.1 BWA/WiMAX Amount of Spectrum per Carrier by Region (MHz)

In terms of total amount of BWA/WiMAX spectrum acquired by license holders by region, the carriers located in the three leading regions (North America, Europe, and CALA) acquired a quite similar amount of spectrum, at 49 MHz (North America), 49 MHz (CALA) and 42 MHz (Europe). Note that in Canada, the average spectrum acquired by license holders is much higher (77 MHz) than in the USA (24 MHz). This can be explained by the amount of spectrum in Canada varying dramatically from one license holder to another (from 30 to 150 MHz). On the other hand, the APAC region is not far behind, with an average of 28 MHz per carrier. In Brazil and Mexico, we only took into consideration the 3.5 GHz band, due to the large variation of spectrum acquired in the 2.3-2.7 GHz band.

Exhibit 5: Average Amount of BWA/WiMAX Spectrum per Carrier by Region



Source: ClearSpectum Database-Maravedis

3.3.2 Cost of BWA/WiMAX Licenses ($)

In the North American and APAC regions, the total amounts paid by licensees were $421 million and $306 million, respectively. (Note: throughout this report, monetary amounts are depicted in USA dollars.)

The MDS auction in 1996 raised $216.2 million (net). The totals presented by the FCC agree with the net amounts paid by the winning bidders. In this case,

each winning bidder was required to submit a 25% down payment at the close of the auction.

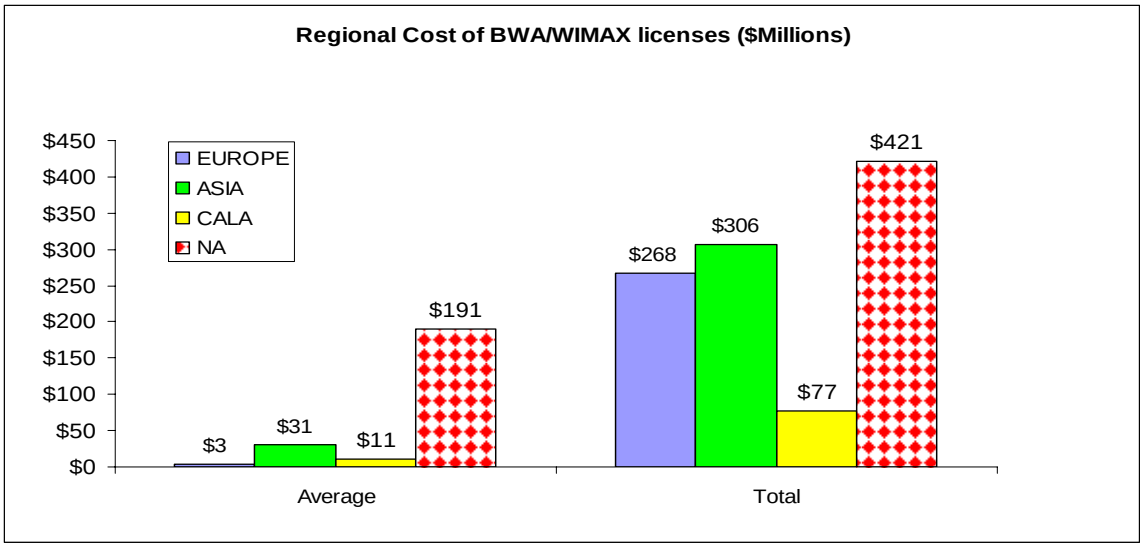
The initial 1997 WCS auction proceeds totaled $13.6 million. The remaining payments, however, were considerably higher - resulting in total proceeds of $205.4 million for all licenses. It would appear that the WCS winners paid considerably more per MHz than the winners of the MDS auction.

European licensees paid a total of $268 million, while their CALA counterparts paid $77 million.

The APAC region's higher license costs were driven by countries like South Korea ($228 million) and Australia ($71.5 million), while figures for the European region were impacted by Finland ($185 million) and France ($30.75 million). However, in all regions, some of the licenses were either awarded at a very low price or following a beauty contest with only marginal annual fees. In Europe, this occurred in countries like Austria, Belgium, Denmark and Spain.

In the CALA region, Brazil, the largest market, auctioned 3.5 GHz licenses for a total of 23.05 million reals ($6.8 million).

Exhibit 6: Regional Cost of BWA/WiMAX Licenses



Source: ClearSpectum Database-Maravedis

3.3.3 Cost per Hz for BWA/WiMAX Licenses ($)

The previous analysis leads us to the average cost per Hz by region. The APAC region has by far the highest average cost per Hz, at $1.69.

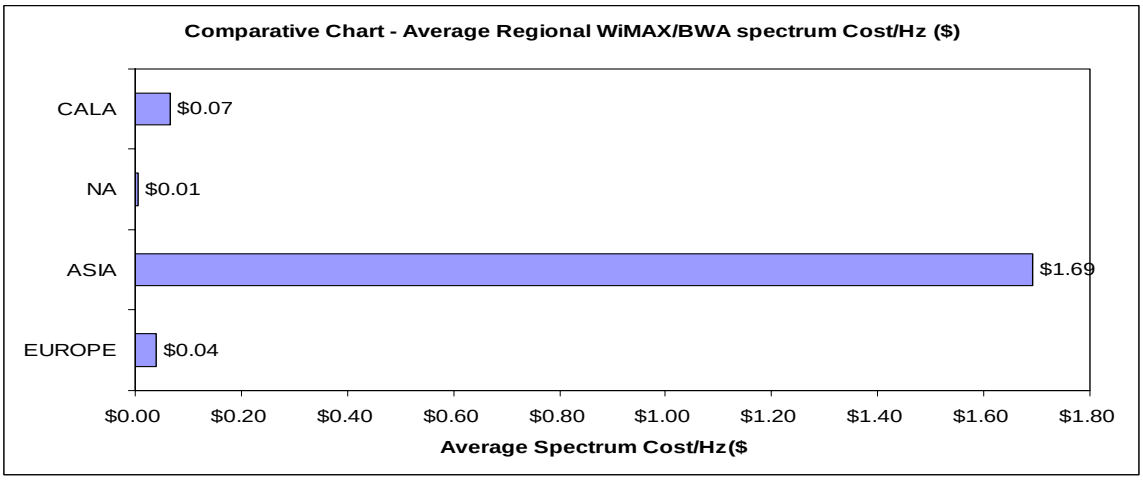
The APAC region's high average cost per Hz can be explained by the heavy cost of WiBRO licenses in South Korea ($228 million) and BWA licenses in Australia ($71 million). As a result, those 2 countries have the first and second highest cost per Hz, $11.40 and $0.37, respectively.

On the other hand, the APAC countries recording the lowest cost per Hz include Taiwan ($0.00), China ($0.00 - licenses awarded at no cost), Malaysia ($0.00), New Zealand ($0.02) and Singapore ($0.05).

In the European region, the countries with the highest cost per Hz include Finland ($0.18), France ($0.16), UK ($0.14), Greece ($0.08) and Hungary ($0.08).

On the other hand, the European countries recording the smallest cost per Hz are where licenses were offered following a beauty contest or through lost-cost auctions. Those countries include Spain ($0.00, only marginal annual fees), Austria ($0.001), Poland ($0.001), Ireland ($0.0014), Denmark ($0.002) and Sweden ($0.003), as most of the license holders of those countries' carriers are only required to pay marginal annual fees.

Exhibit 7: Average Regional BWA/WiMAX Spectrum Cost/Hz



Source: ClearSpectum Database-Maravedis

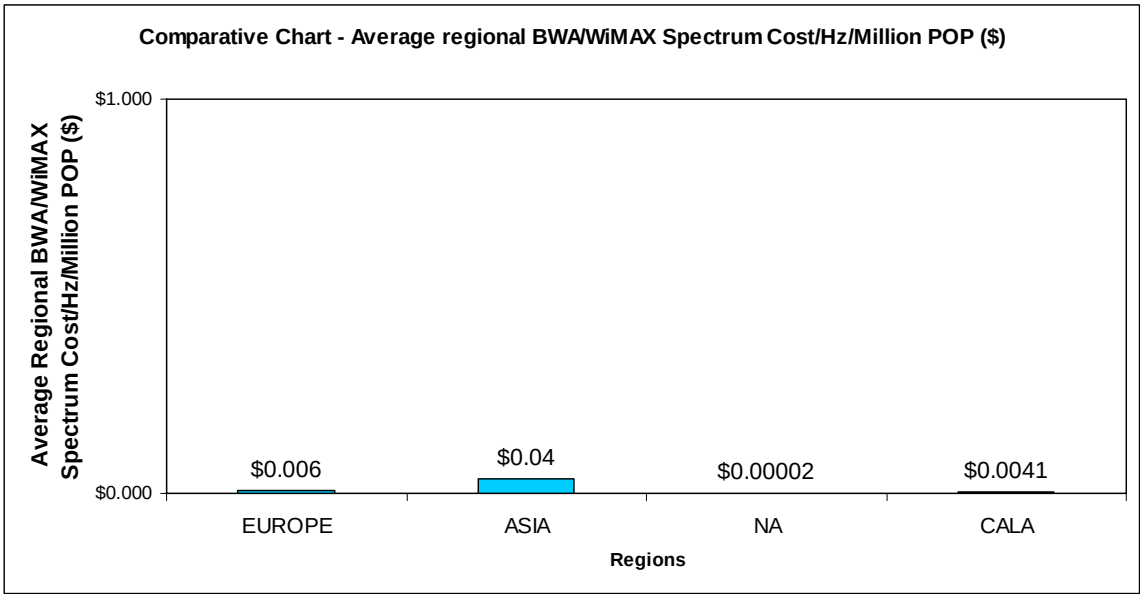
In the CALA region, the countries recording the highest cost per Hz include Brazil ($0.33) and Venezuela ($0.13). Venezuela leads the way with a total of $60.6 million paid for the licenses, but its amount of spectrum is much higher than Brazil's: 480 MHz versus 50 MHz.

Finally, North America's low cost per Hz ($0.01) can be explained by the relatively low cost per Hz in Canada ($0.004) and the USA ($0.01).Note that the cost per Hz in the USA was calculated by dividing the total amount paid for all of the BRS and WCS licenses ($421 million) by the total amount of spectrum acquired (50,000 MHz).

3.3.4 Average Cost per Hz per Million Population for BWA/WiMAX Licenses ($)

The lower cost per Million POP in the APAC region is explained by the greater population density in the region.

Exhibit 8: Average Regional BWA/WiMAX Spectrum Cost / Hz / Million POP



Source: ClearSpectum Database-Maravedis

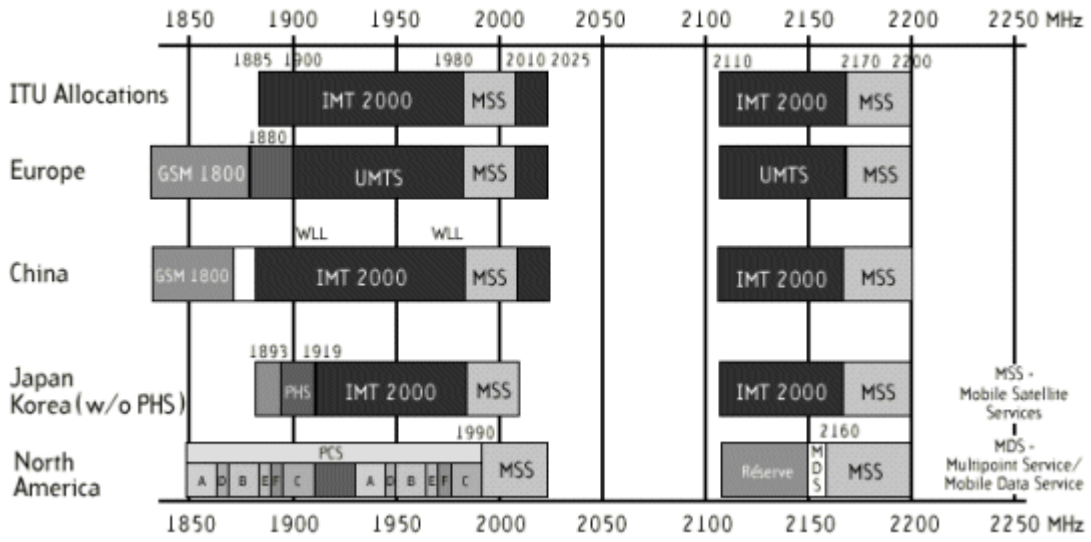
4. 3G LICENSES AND SPECTRUM

4.1. 3G Regional Analysis

4.1.1. Number of 3G Licenses – by Region

Europe is the leading region in terms of number of 3G UMTS licenses awarded, with a total of 72, against 31 in APAC and 3 in North America (all within Canada). Since GSM is the dominant technology in Europe, especially in the western part, many carriers have upgraded their networks to HSDPA.

Exhibit 9: 3G Spectrum Chart



As a result, WCDMA (UMTS) has become the most dominant 3G technology in this region. Maravedis expects WCDMA to reinforce its lead over CDMA2000, as many of the leading 3G European carriers have announced their intention to deploy HSDPA by the end of 2005 / beginning of 2006. A very promising 3G market like Russia, where carriers are expected to acquire their 3G UMTS licenses in mid-2006 and launch their networks in Q1 2007, will also drive this lead. The APAC region, accounting for only 31 licenses, remains behind the European region in terms of 3G UMTS licenses awarded.

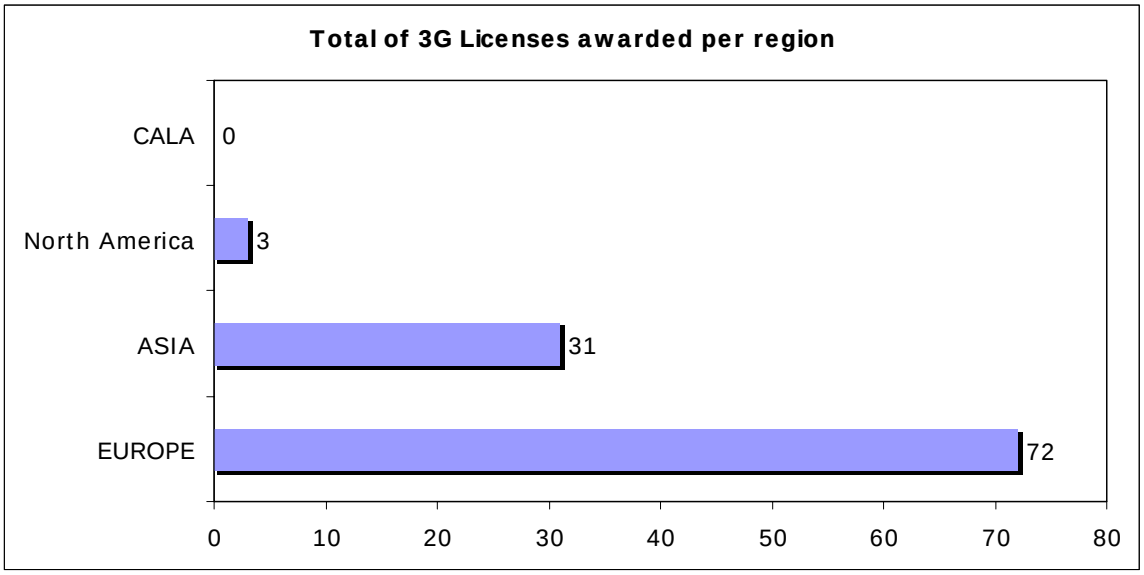
Maravedis expects the APAC region to catch up with the European region in number of 3G licenses awarded, as regulators in the Philippines, Thailand, China and India are scheduled to release 3G licenses sometime in 2006.

In North America, Canada is the only country that has already awarded its 3G UMTS licenses (3 licenses), while USA carriers still do not have any 3G licenses. However, the USA market, dominated by the CDMA2000 technology, is not lagging behind Europe and the APAC region in terms of 3G deployments, since the FCC does not limit what can be done with the existing spectrum.

Consequently, leading carriers like Cingular Wireless / AT&T are upgrading their existing networks (850/1900 MHz) with HSDPA, while Sprint Nextel and Verizon are upgrading their networks with EV-DO.

However, the FCC is expected to auction new 3G spectrums (1710-1755, 2110-2155 MHz) in 2006 or 2007 in order to harmonize its frequencies with the rest of the 3G markets around the world. Even with twelve 3G licenses expected to be awarded in six regions in the USA, Maravedis expects North America to remain behind Europe and the APAC region, as CDMA2000 is set to remain the most dominant 3G technology in the USA. This lead should also be reinforced by the emergence of an enhanced EV-DO network known as “Scalable Bandwidth EV-DO” developed by Qualcomm, and expected to be launched in the USA in 2008/2009.

Exhibit 10: Total 3G License Holders by Region



Source: Maravedis and Marketing Industry Intelligence (QG2)

Finally, the national regulators in the CALA region still have not awarded any 3G UMTS licenses. However, Jean-Pierre Bienaimee, Chairman of the UMTS forum, anticipates that regulators in leading countries like Brazil, Uruguay, Argentina and Mexico will proceed with their 3G licenses as early as mid-2006.

4.1.2. 3G Licenses by Coverage Area

With 100% of the 3G UMTS licenses awarded being national licenses, and sometimes very expensive, especially in Western Europe, the 3G market has been dominated by national carriers, making it very hard for small players to penetrate this type of market. This situation is changing only slowly, with the emergence of MVNOs (Mobile Virtual Networks Operators) like Virgin MobileUSA, Page Plus, EZ Link Plus and Air Voice Wireless, capable of leasing wireless capacity from pre-existing mobile service providers and establishing their own brand names to differentiate themselves from those providers.

4.2 3G Cost & Amount of Spectrum

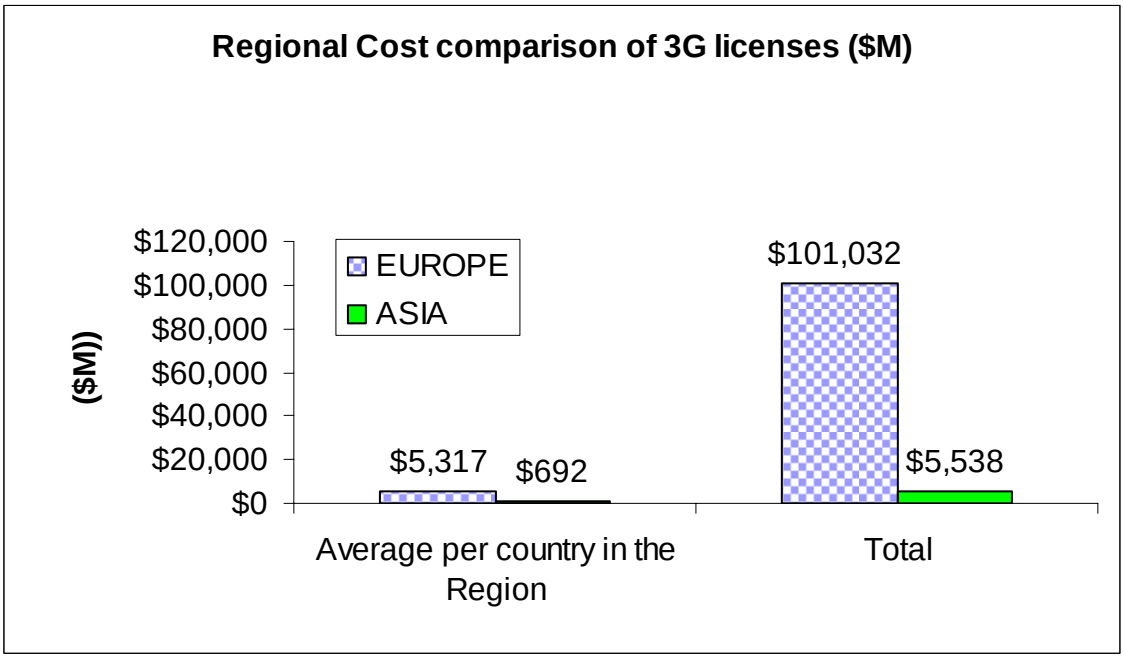
4.2.1 Cost of 3G Licenses ($)

The amount paid for 3G licenses in Europe was $101 billion, nearly 20 times greater than in the APAC region ($5.38 billion).

This difference is mostly explained by the exorbitant prices paid by some of the European operators to acquire their 3G licenses in the middle of the telecom bubble.

In fact, Germany's auction raised $45.85 billion for six 3G licenses, against $35.25 billion in the UK. The giant Vodafone UK had to pay up to $9.4 billion for its 3G license. Within the APAC region, operators in South Korea (KTF, SK Telecom) and Taiwan paid the highest aggregate price for their 3G licenses: $2.9 billion for South Korea and $1.4 billion for Taiwan. Operators in Japan were awarded their 3G licenses at no charge.

Exhibit 11: Regional Comparison of 3G License Costs

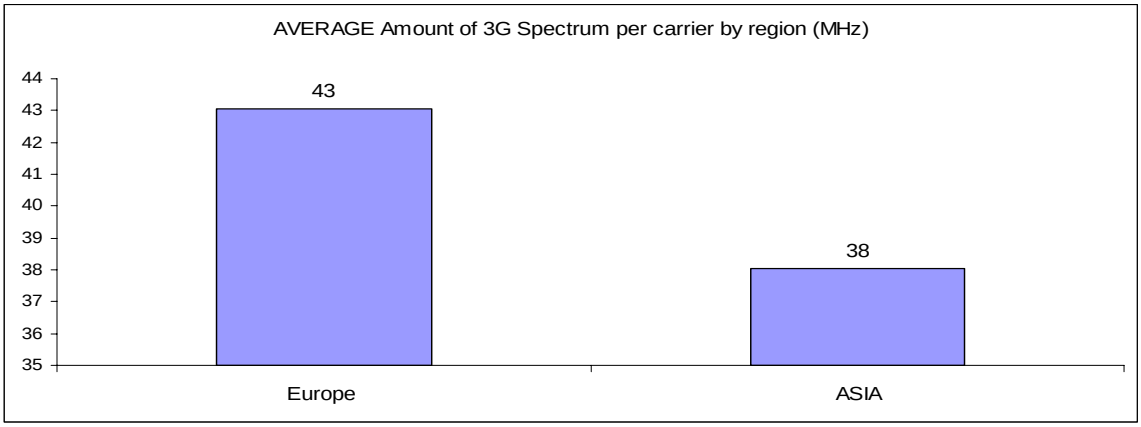


Source: Maravedis and Marketing Industry Intelligence (QG2)

4.2.2 3G Amount of Spectrum

Our study revealed that the average amount of spectrum acquired by 3G carriers in Europe (43 MHz) is slightly higher than in the APAC region (38 MHz). More precisely, in Europe, over 50% of the European carriers studied in our survey own an average of 40 MHz of 3G spectrum. In the APAC region, while some 3G carriers own up to 80 MHz of 3G spectrum in countries like Singapore, the majority of them were awarded between 30 and 40 MHz.

Exhibit 12: Average Amount of 3G Spectrum per Carrier



Source: Maravedis and Marketing Industry Intelligence (QG2)

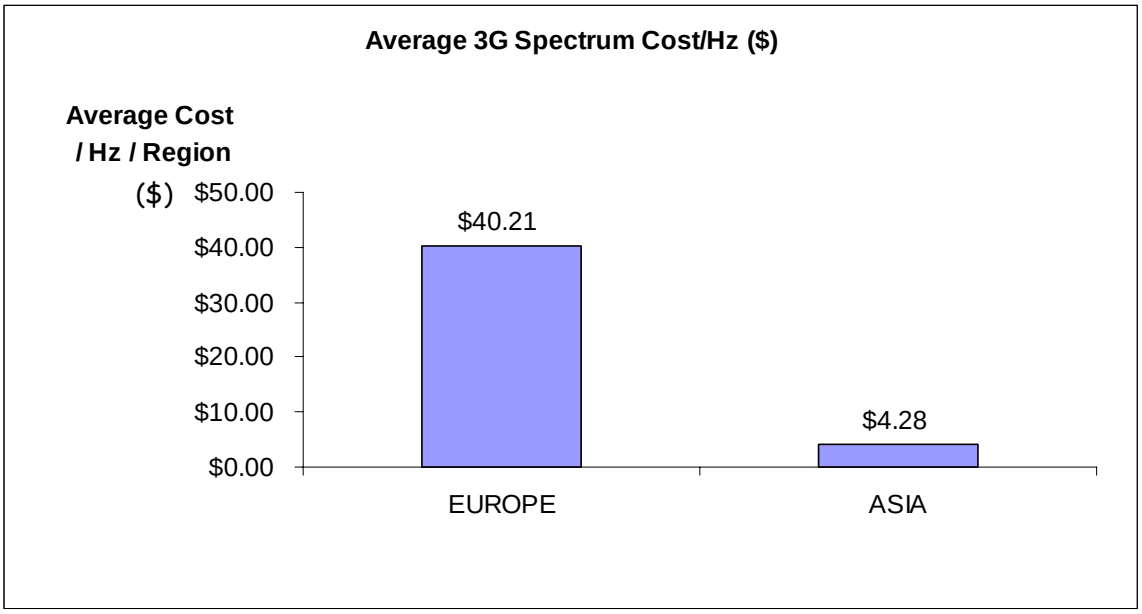
4.2.3 3G Cost per Hz ($)

Comparing the average cost per Hz by region, Europe naturally has the higher average cost per Hz at $40.21, which is nearly 10 times greater than the $4.28 for the APAC region.

The European countries with the highest cost per Hz include
1. Germany ($316.21)
2. UK ($251.79)
3. Italy ($75.41)
4. Netherlands ($21.74)
5. Poland ($13.98)
6. France ($13.78)

Scandinavian countries have some of the lowest costs per Hz. Indeed, while a country like Finland has the smallest cost per Hz ($0) since its national carriers acquired their 3G licenses at no charge, Sweden's cost per Hz is also one of the smallest ($0.0003) in Europe. Only initial auctions were considered in this analysis. **Licenses that were returned or resold were not taken into account.**

Exhibit 13: Average 3G Spectrum Cost/Hz



Source: Maravedis and Marketing Industry Intelligence (QG2)

The gap between Europe and the APAC region can be explained by major 3G markets like China and India not having issued 3G licenses yet. In future auctions, it is reasonable to assume that regulators will be cautious about inflating prices, in light of past mistakes elsewhere.

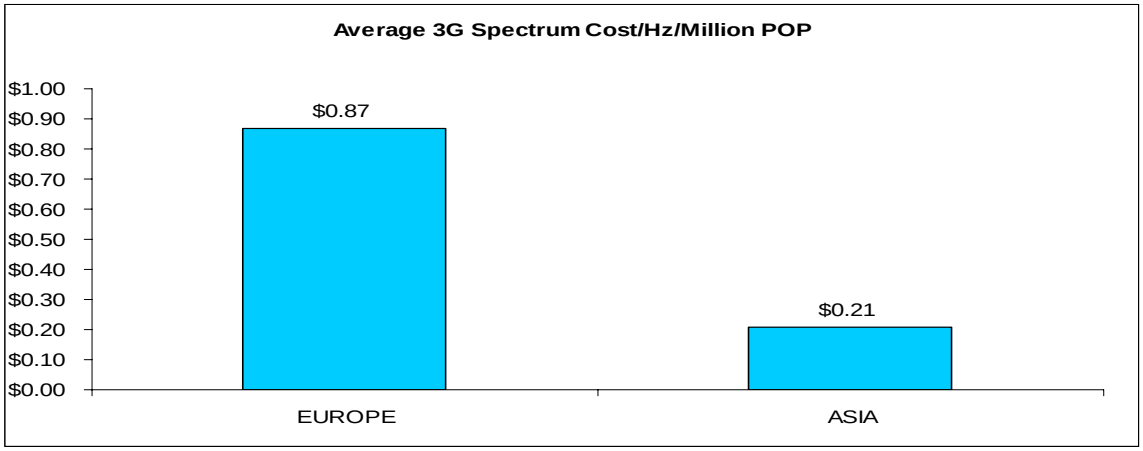
However, according to the National Business Daily, Chinese 3G operators could spend at least $24 billion for their 3G licenses. Jean-Pierre Bienaimee, Chairman of the UMTS Forum, anticipates that Chinese operators would get their 3G licenses as early as mid-2006 and launch their 3G networks in 2007, which will dramatically increase the cost per Hz in this region. Currently, South Korea and Taiwan have the first and second highest costs per Hz, at $24.08 and $7.77, respectively, which can be justified by the relatively high price paid by leading South Korean 3G carriers (KTF, SK Telecom) to acquire their 3G licenses. APAC countries showing some of the lowest costs per Hz include Malaysia ($0.44) and New Zealand ($0.36).

4.2.4 3G Cost per Hz per Million Population ($)

The gap between those 2 regions is also confirmed in terms of cost per Hz per Million Population. In fact, Europe's average cost per Hz per Million POP, $0.87,

is 314% greater than the APAC region's figure of $0.21. One major reason: a higher population density in APAC countries, especially South Korea and Japan.

Exhibit 14: Average 3G Spectrum Cost / Hz / Million POP



Source: Maravedis

5. BWA/WIMAX VERSUS 3G

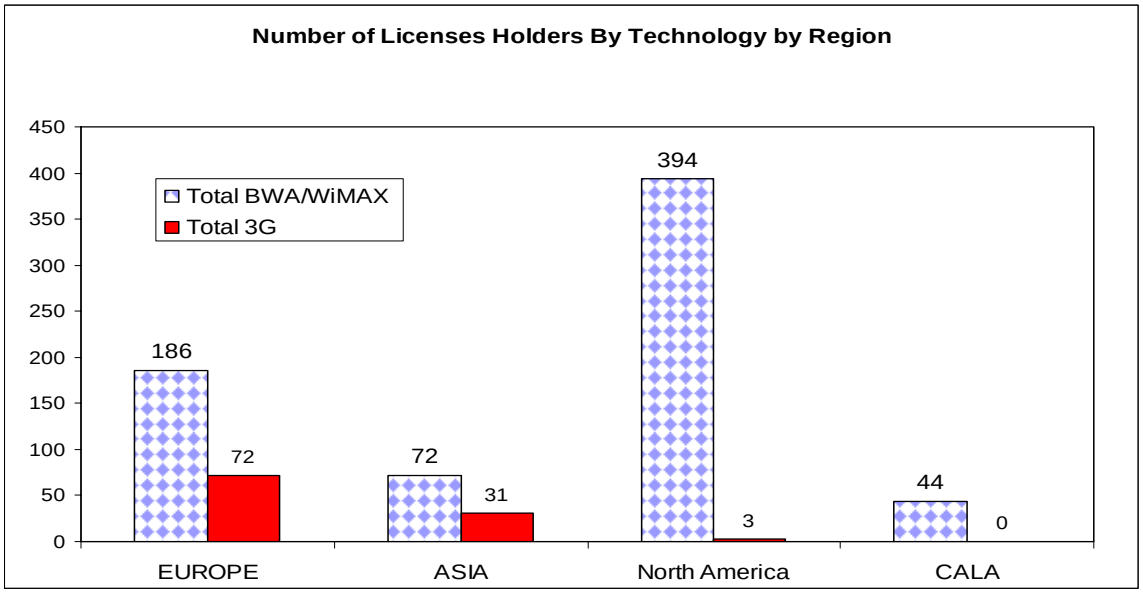
5.1 Number of Licensees

Our study revealed that there are many more BWA/WiMAX license holders than 3G license holders across the leading regions (North America, Europe, APAC, CALA). An accumulated 721 licenses were awarded for BWA/WiMAX, against 106 licenses for 3G.

This is particularly true in North America, with 394 BWA/WiMAX license holders against three 3G license holders (all in Canada), and in the CALA region, with 44 BWA/WiMAX licenses against no 3G licenses (the 3G+ licenses should be awarded in mid-2006).

As mentioned earlier, this huge difference can be explained by two major factors: First, regulators in those two regions allow mobile operators to upgrade their networks using existing bands. Second, the cost of 3G licenses in other areas, coupled with lower income and bandwidth requirements from end-users (especially in CALA), did not create a demand for 3G licenses or networks.

Exhibit 15: Number of License Holders by Technology by Region

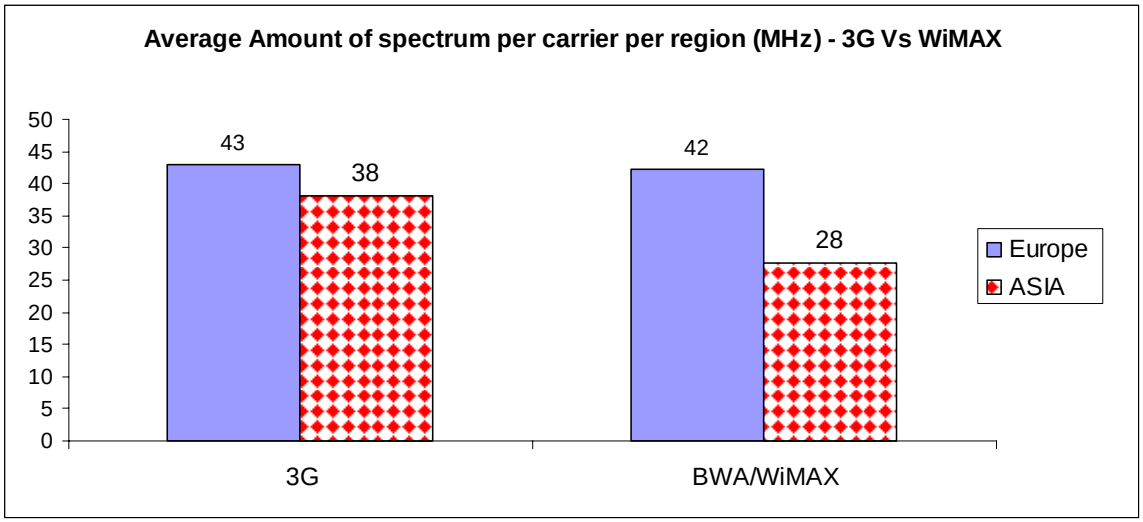


Source: ClearSpectum Database-Maravedis

Furthermore, that the majority of the BWA/WiMAX licenses are regional licenses (sometimes 100% of them, as in North America), while 100% of 3G licenses are national licenses, shows that BWA/WiMAX will be a much more fragmented market than the 3G market. The BWA/WiMAX market will also be a more competitive market, open to smaller players – mostly due to the much lower cost of BWA/WiMAX licenses, and not as predictable as the 3G market.

5.2 Average Amount of Spectrum per Carrier by Region (MHz)

Exhibit 16: Average Amount of Spectrum per Carrier by Region (MHz)

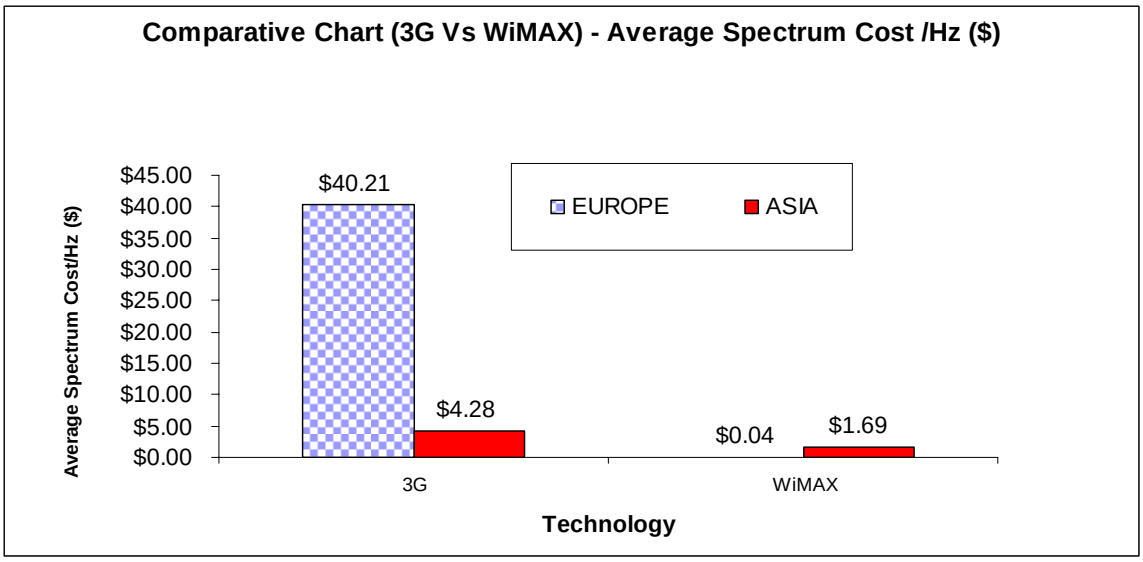


Source: ClearSpectum Database-Maravedis

After comparing the average amount of spectrum acquired by 3G and BWA/WiMAX carriers in Europe and the APAC region, our study revealed a slight difference between those 2 regions. In Europe, while the amounts of spectrum acquired by 3G and BWA/WiMAX carriers are very similar (43 MHz for 3G carriers against 42 MHz for BWA/WiMAX carriers), we notice a larger difference in the APAC region, where the BWA/WiMAX carriers acquired in average 26% less spectrum than the 3G carriers (38 MHz for 3G carriers against 28 MHz for BWA/WiMAX carriers). This in turn leads to assessing the cost/Hz in order to compare both spectrums with a common denominator.

5.3 Cost / Hz by Region

Exhibit 17: Average Spectrum Cost/Hz by Technology



Source: ClearSpectum Database-Maravedis

After comparing the average spectrum cost per Hz between 3G and BWA/WiMAX, our study reveals that the average 3G spectrum cost per Hz is much higher than the average BWA/WiMAX spectrum cost per Hz.

This difference is particularly significant in the European region, where the average 3G spectrum cost per Hz is 1000 times higher than the average BWA/WiMAX spectrum cost per Hz.

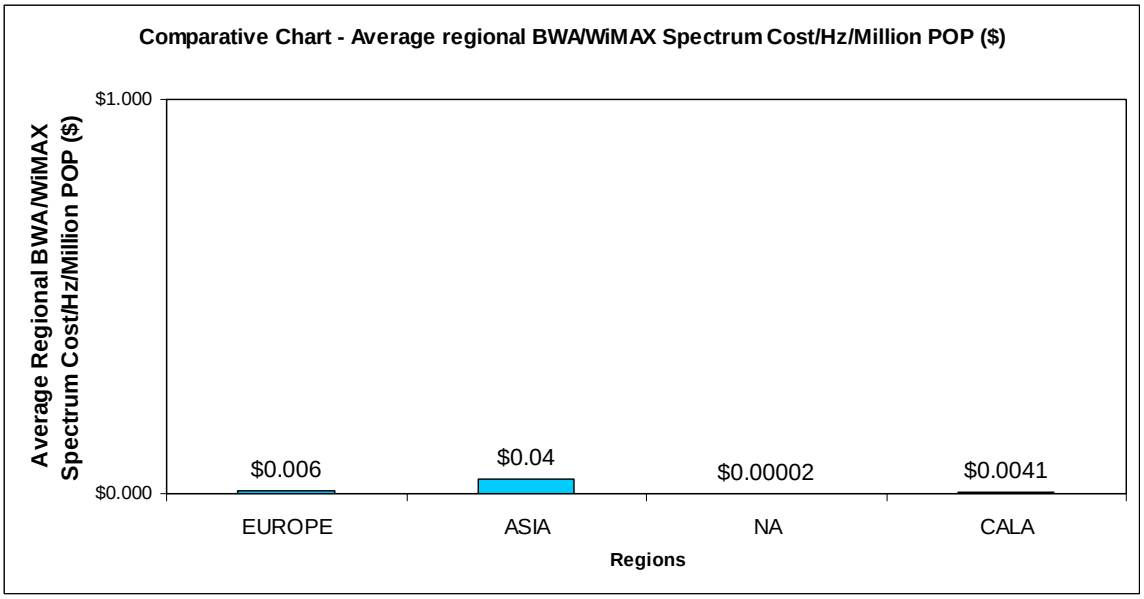
This difference can be explained by the following factors:

1. 3G licenses in Europe were auctioned at distorted prices during the telecom bubble.
2. BWA/WiMAX licenses were auctioned for fixed applications only, a much smaller market than mobile services.
3. Regulators were more cautious with BWA/WiMAX auctions in light of past failures, including some first generation BWA/WiMAX players, such as FirstMark, going bankrupt.

However, exceptions like Finland exist in this region. In fact, Finnish BWA/WiMAX carriers paid a total of $185 million for their licenses, while the 3G carriers acquired their licenses at no charge. In general, our study clearly shows that BMA/WIMAX is a much better deal for carriers, especially smaller carriers willing to offer services based on low cost.

5.4 Cost / Hz / Million POP by Region

Exhibit 18: Average Spectrum Cost / Hz / Million POP by Technology



Source: ClearSpectum Database-Maravedis

The lower cost of BMA/WIMAX compared to 3G is confirmed by analyzing the average spectrum cost per Hz per Million Population. In the case of BWA/WiMAX, the cost per Hz is divided by smaller populations, reflecting the regional scope of many licenses.

CONCLUSIONS[2]

The major difference between BWA/WiMAX (or any new competition for wide area wireless) and established cellular is the allocation of harmonious spectrum. In order to build mass market acceptance and deliver the full extent of ease of use, entertainment value and productivity enhancements, wireless service must be widely available across geographies and regulatory jurisdictions.

Five major trends influence the ability of BMA/WIMAX to become pervasive:

1. Changes in regulations that make spectrum available and harmonize use of spectrum across international boundaries.
2. Multi-mode and multi-band enabling semiconductor ICs, devices and system designs that mitigate differences among spectrum regulations. As further progress is made in combining multiple radios that work in multiple frequency spectrums, the user experience will become similar to having an internationally harmonious spectrum.
3. All underlying wireless transport systems are converging upon communications protocols IP/SIP and network architectures such as IMS.
4. Communications industry revenues are increasingly driven by content and services rather than specific type of wireless network that delivers restricted/tailored voice and messaging applications. This trend will accelerate as the shift to IP/SIP and IMS takes place.
5. Markets served and revenue streams are becoming more diverse and customer-segment-specific. This diversity or ”one size does not fit all” marketplace means that service providers must have a full arsenal of solutions, from high bandwidth dedicated ”fixed” solutions to generic cellular phone services, in order to make ”highest revenue and profit density” use of spectrum.

Other factors, including the trend towards community wireless, the adoption of standards and concentration of IP into the hands of major semiconductor companies, also tend to press for liberalization, harmonization and availability of spectrum. Long term trends towards smart/cognitive radios are preceded by the current trend towards multi-mode, multi-band radios.

[2] Robert Syputa, Senior Analyst and Contributor

The visible signs of these trends will be BWA/WiMAX CPEs/SUs that operate in both the 2.3 to 2.7 GHz and 3.3 to 3.8 GHz frequency bands and adapt to use either TDD or FDD. This is made possible through the use of flexible SoCs and tunable RF ICs, and both board-level and antenna designs. This multi-band capability in CPE and BS design will ”harmonize” the ability to provide service across otherwise incongruent service areas.

Whether it is fixed applications with CDMA technology or mobile applications with BWA/WiMAX, the two fields are converging and will be competing for a share of the one-billion-subscriber market.

About the Author

Adlane Fellah, MBA, is CEO and founder of Maravedis Inc, a world leader in market research and analysis, specializing in BWA/WiMAX and broadband wireless markets. He is a leading industry analyst who authored various landmark reports on BWA/WiMAX, broadband wireless and Voice Over IP. He is a frequent speaker at leading wireless events and a contributor to various portals and magazines covering the broadband wireless industry, including Telephony Magazine, WiMAX Trends and WiMAX.com. He has served on the Program Advisory Board for the World WiMAX Conference since 2004, and is a member of World Communications Association International and the Broadband Wireless Association. Prior to founding Maravedis, he held various positions at Harris Corporation in charge of market intelligence and business development for several product lines.

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