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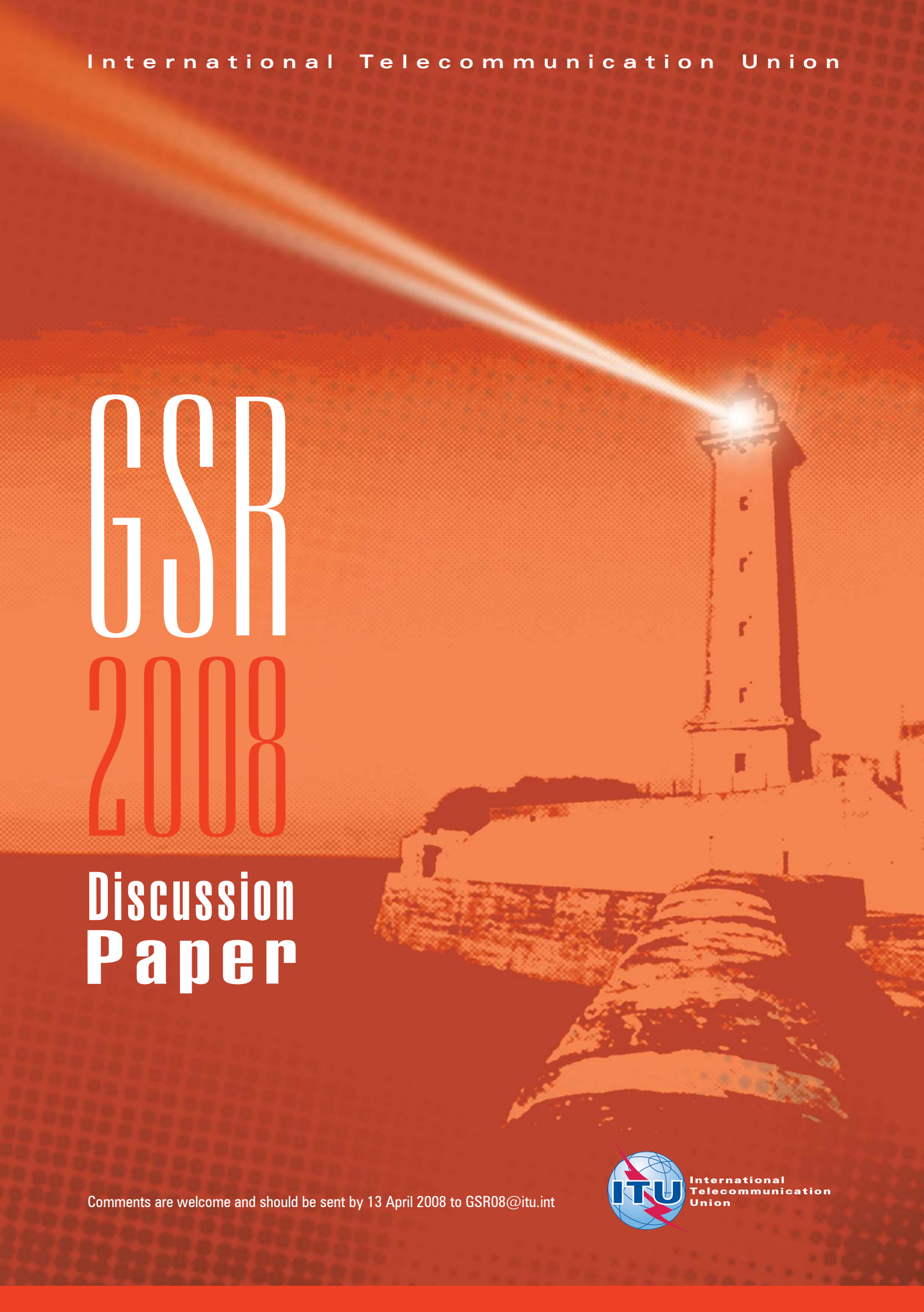

Comments are welcome and should be sent by 13 April 2008 to GSR08@itu.int

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WRC-07 RESULTS AND IMPACT ON TERRESTRIAL BROADBAND WIRELESS ACCESS SYSTEMS

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COMMENTS ARE WELCOME AND SHOULD BE SENT BY 13 APRIL 2008 TO

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International Telecommunication Union (ITU), Geneva

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Since the implosion of the "dot-com" bubble during the first years of this decade, the global telecommunications industry has focused primarily on the growth of two sub-sectors: mobile services and Internet access services. It was perhaps inevitable, then, that attention would turn to the nexus between these two growth markets: broadband wireless access (BWA) systems.

The need to identify sufficient spectrum availability for current and future generations of BWA systems proved to be the dominant issue at the ITU World Radiocommunication Conference (WRC) held from October 22 to November 16, 2007 (WRC-07). Several WRC agenda items touched upon issues relating to BWA, but most of the work focused on Agenda Item 1.4 – a catch-all agenda item that proved to be the most contentious of the Conference. In the end, the WRC agreed upon a mix of new allocations and identifications in bands below 4 gigahertz:

- 450-470 MHz (global);
- 698-806/862 MHz (with some countries identifying only 790-862 MHz)
- 2300-2400 MHz (global); and
- 3400-3600 MHz (through opt-in provisions in new footnotes to the Radio Regulations);

To understand how WRC-07 arrived at these bands – and more importantly, to understand where the industry goes from here – it's necessary first to explain how the burgeoning development of commercial wireless technologies ran headlong into a logjam of constrained spectrum.

2 THE EVOLUTION OF IMT

2.1 IMT-2000/3G

To its credit, the ITU saw this coming – or at least, it saw the potential of BWA early on. And it acted to take a leadership role, through the development of a "family" of five air interface standards that was given the collective name "IMT-2000" ("International Mobile Telecommunications" pegged to the start of the new century).[1] The actual standards are:

- IMT-Direct-Sequence (IMT-DS)
  - Also known as Wideband-Code Division Mulitple Access (W-CDMA) or UMTS Terrestrial Radio Access – Frequency Division Duplexing (UTRA-FDD), used in the Universal Mobile Telecommunications System (UMTS) 3G standard.
- IMT-Multi-Carrier (IMT-MC)
  - Also known as Code Division Multiple Access 2000 (CDMA2000), the successor to second-generation (2G) CDMA
- IMT-Time-Division (IMT-TD)
  - This comprises: TD-CDMA (Time Division - Code Division Multiple Access) and TD-SCDMA (Time Division - Synchronous Code Division Multiple Access).
- IMT-Single Carrier (IMT-SC)
  - Also known as Enhanced Date rate for GSM Evolution or "EDGE"
- IMT-Frequency Time (IMT-FT)
  - Also known as Digital Enhanced Cordless Telecommunications or "DECT"

Collectively, the IMT-2000 standards became the basis for what the industry and regulators came to refer to as "third-generation" or "3G" mobile systems, distinguishing them from the existing generations of analogue (1G) and digital (2G) mobile systems.[2] IMT-2000 envisioned transmission speeds ranging from 2 megabits per second (Mbit/s) on a stationary or nomadic basis, up to 348 kilobits per second (kbit/s) at vehicular speeds.

At two different Conferences – the 1992 World Administrative Radiocommunication Conference (WARC-92) and the 2000 World Radiocommunication Conference (WRC-2000) – the ITU denoted spectrum bands for IMT-2000.[3] The initial bands, approved in 1992, were 1885 - 2025 MHz and 2110 – 2200 MHz (see RR No. 5.388). WRC-2000 added 806-960 MHz, 1710-1885 MHz and 2500-2690 MHz (see RR Nos. 5.317A and 5.384A). By 2001, then, the following bands were identified for 3G systems in the Radio Regulations[4]:

- 806-960 MHz,
- 1710-2025 MHz,
- 2110-2200 MHz, and
- 2500-2690 MHz.

Not all of these bands were available in all countries, however, and therefore different national administrations were able to assign only a fraction of the overall amount of spectrum the ITU had identified. Moreover, different countries took different approaches. Some (for example, in Europe) set aside entirely new bands of spectrum, commonly in paired bands, to allow existing operators to maintain 2G operations and add on 3G networks in separate bands. Other administrations (e.g., the United States) were slower to set aside new bands for 3G, but they encouraged existing operators to evolve their 2G operations toward 3G capabilities, using their already-licensed spectrum.

Even before the majority of the world's economies could implement 3G systems, however, industry groups were forecasting further spectrum requirements. In 2003, the WRC approved Agenda Item 1.4 for the next Conference, setting the stage for a show-stopping debate, four years later, over identification of additional bands.

2.2 The Rise of WiMAX

The development of the IMT-2000 suite of technologies was not, meanwhile, the only progress being made on BWA systems. Standards work continued, in parallel, on another approach to providing wireless last-mile services at high data rates: something called a *wireless metropolitan area network* or "Wireless MAN." Developed under the IEEE 802.16 standard, it became known as the "Worldwide Interoperability for Microwave Access" or "WiMAX." In June 2001, an industry group, the WiMAX Forum, was formed to advocate for interoperability and acceptance of the standard[5].

On first impression, WiMAX sounds something like Wi-Fi – a technology in widespread use by the middle of this decade. Despite the similarity in nomenclature, however, WiMAX and Wi-Fi were designed for entirely different applications. Wi-Fi is a short-range technology, often used over unlicensed spectrum (i.e., in retail or public spaces such as coffee shops and airports), while WiMAX has a longer range (up to 50 kilometers) and primarily utilizes licensed spectrum. Different "extensions" of the technology allow for fixed (IEEE 802.16d) or fixed and/or mobile (IEEE 802.16e).

While they developed on different paths, WiMAX and IMT-2000 are really evolving toward functional equivalency. Both are being developed to provide broadband Internet access (roughly equivalent to a DSL line), as well as voice connectivity. So in terms of market definition, either set

of technologies (WiMAX or IMT-2000) could be said to be "substitutable" for each other, particularly since they continue to evolve toward something called "4G."

2.3 The Evolution of "IMT-Advanced"

As early as 2000, the ITU had commenced work on standardizing systems beyond IMT-2000 – now known as IMT-Advanced. The framework for the development of IMT-Advanced is specified in Recommendation ITU-R M.1645. This prompted a range of global research and development activities:

- The Third Generation Partnership Project (3GPP) terms of reference were expanded to drive improvement of the W-CDMA-based UMTS standard, a project known as 3GPP *Long-Term Evolution* or "LTE."
- Similarly, a separate group, the Third Generation Partnership Project 2 (3GPP2) began to pioneer improvements to the CDMA2000 standard, under the banner of *Ultra Mobile Broadband* or "UMB."

Both projects aspire to increased capabilities, laying down stakes as "next generation" or "fourth generation" (4G) technologies. Meanwhile, the IEEE 802.16e group was considering enhancements to its standard to meet the IMT-Advanced requirements. So even while most countries were only beginning to license 3G networks, the technology trends appeared to point toward even greater capabilities, provided by both WiMAX and IMT-Advanced developments.

The biggest functional difference between WiMAX and IMT-Advanced was that while the latter was by definition a mobile service, WiMAX had multiple incarnations that could be either fixed, mobile or nomadic. In fact, many administrations did not wait for the completion of standards work on mobile WiMAX (i.e., the IEEE 802-16e extension), but rather began issuing licenses for WiMAX in the fixed service – as a wireless substitute for DSL or fiber-based systems. And ironically, there were no existing "identifications" of spectrum for WiMAX (as there were for IMT-2000). So national administrations had substantial flexibility, during the early years of this century, to authorize WiMAX in multiple bands. By the middle of the decade, the most popular bands for fixed WiMAX were the 3.5 GHz band, the 5 GHz band (in a small slice of unlicensed spectrum), and the 2.5 GHz band (the same band identified for IMT-2000).[6]

As this storm of commercial rivalries and possibilities gathered, the 2003 WRC seeded the clouds by placing on the agenda for WRC-07 its item to consider expanding the bands identified for IMT-2000 and "systems beyond IMT-2000." The stage was set for two significant events – both occurring within days of each other – that would reorder the spectrum use profile of multiple bands below 5 GHz.

3 THE RADIOCOMMUNICATION ASSEMBLY ACTS ON WIMAX

In November 2006, IEEE proposed incorporating *orthogonal frequency division multiple access* or *OFDMA)* into the existing Recommendation ITU-R M.1457. Behind the technical jargon was a momentous proposal, to add an OFDMA-based air interface (known officially as *OFDMA TDD WMAN)* to the family of IMT-2000 systems. This is the very air interface that underpins WiMAX. From a market standpoint, the 3G and WiMAX worlds appeared headed toward convergence, and the proponents of WiMAX wanted the ITU to recognize that. The proposal was considered over the next year by ITU-R Working Party 8F (WP8F) [7].

The question of whether to add the WiMAX air interface into the IMT-2000 suite tapped directly into a debate within the telecommunication industry over technology neutrality. Particularly in Europe, the developing WiMAX technology had been seen as a potential market rival to 3G licensees and

equipment makers, still struggling to gain a widespread commercial footprint for UMTS.[8] They also questioned whether WiMAX, traditionally a fixed service platform, was mature enough to be considered for mobile service. Other countries – notably the U.S. and the U.K. – staked out a position for technology neutrality in bands such as 2500-2690 MHz, allowing either WiMAX or 3G mobile systems.

The proposal to expand IMT-2000 crystallized the debate over WiMAX. WP8F proceeded with its analysis and gave the proposal a positive preliminary recommendation during a meeting in Japan in May 2007. Germany and China, however, continued to raise technical questions concerning the potential for unwanted radio emissions from WiMAX base stations. That necessitated a special meeting to resolve these concerns, held in September 2007 in the Republic of Korea. There, Working Party 8F prepared a draft revision of the recommendation and forwarded it to the Radiocommunication Assembly (RA).

In a meeting held 15-19 October 2007 – immediately prior to the start of WRC-07 – the RA reached a consensus on:

- Revising Recommendation ITU-R M.1457 by adding OFDMA-based technologies;
- Adding the specific WiMAX air interface, OFDMA TDD WMAN, as the sixth IMT-2000 technology; and
- Revising the naming conventions for various technologies:
  - 3G technologies will continue to be known as "IMT-2000"
  - 4G technologies will be known as "IMT-Advanced" and
  - Collectively, all of the 3G and 4G technologies will be known as simply "IMT"

The RA's decisions were almost immediately overwhelmed by the start of the WRC the following Monday. Nevertheless, although the RA decisions can be viewed as essentially definitional, they may be just as far-reaching as the spectrum-use decisions made by the vastly larger Conference that followed.

First, the RA gave a tremendous boost to the fortunes of mobile WiMAX (and its corporate backers) by recognizing it as a legitimate mobile technology, on parity with W-CDMA and CDMA2000. Of course, the decision did nothing to alter the relative empirical virtues of the technologies themselves. But through the WP8F process,[9] WiMAX gained the ITU-R's "seal of approval" – hugely important for the potential future deployment of the technology in the competitive global market.

Second, the decision bolstered arguments for technology neutrality. If mobile WiMAX could be accepted as a functional equivalent to the longstanding IMT-2000 standards, it lent credibility to the idea that a broad choice of network technologies was possible, so long as they were technically capable and compatible. Supporters of including WiMAX immediately praised the decision as a pro-consumer measure, saying that it would let market forces pick the most cost-effective and functional technologies.

Third, the decision on naming conventions appeared to signal, at least symbolically, a new chapter on broadband wireless access systems. By definition, the list of 3G technologies is now underlined and the book on IMT-2000 is now essentially closed (although deployment of networks is, in many places, just beginning). The era of IMT-Advanced technologies – 4G – has begun. The ITU-R announced at the end of the RA that 2008 will see an "open call for candidates" to be defined as IMT-Advanced technologies.[10] The ITU further predicted that 4G systems could be commercially available as early as 2011 – perhaps coincidentally, the year of the next WRC.

4 SPECTRUM DECISIONS AT WRC-07

As delegates gathered in Geneva for the WRC during the weekend of 20-21 October, 2007, it was apparent that BWA issues were among the most important – and perhaps the most contentious – matters to be resolved. The focus would be on Agenda Item 1.4, which called upon the Conference:

"To consider frequency-related matters for the future development of IMT-2000 and systems beyond IMT-2000 taking into account the results of ITU-R studies in accordance with Resolution 228 (Rev.WRC-03)".

This amounted to a rather broad mandate, but the net result was that over the four previous years, administrations had utilized the agenda item to consider several additional spectrum bands to identify for IMT-2000 and/or IMT-Advanced.

4.1 The IMT Candidate Bands

As a result of the final Conference Preparatory Meeting, held in Geneva during February 2007, the Conference had teed up the following new spectrum bands for consideration:

- 410-430 MHz
- 450-470 MHz
- 470-960 MHz
- 2300-2400 MHz
- 2700-2900 MHz
- 3400-4200 MHz
- 4400-4990 MHz

With the seemingly large range of bands from which to choose, there was no consensus going into the conference on which band(s) would be most appropriate for IMT. The problem was that each of the bands was already heavily constrained with other uses. Because of previous divergence in uses globally, each of the regional groups -- e.g., CEPT (Europe), CITEL (Americas), APT (Asia-Pacific), ATU (Africa), RCC (the former USSR republics) and the ASMG (Arab countries) -- had a slate of different candidate bands they favored and opposed. This was also sometimes true *within* the regional groups. As the Conference was about to find out, the slates did not match up.

4.2 Bands Eliminated Early

As the Conference got under way, it became apparent that certain of the bands would not be practical because of a combination of lack of positive support and/or overwhelming opposition. As a result, Working Group 4A (a subcommittee of WRC-07 Committee 4, which considered Agenda Item 1.4), agreed that three of the bands lacked sufficient support to go forward in the identification process. These were the following:

410-430 MHz – Most regional groups opposed the identification of this band because of its existing uses, which included everything from space mission communications to public mobile radio (PMR) and public access mobile radio (PAMR).

2700-2900 MHz – This band already was allocated, in all three Regions, for aeronautical radionavigation and ground-based meteorological radars. Aeronautical radionavigation is classified as a safety-of-life service, and ITU-R studies showed that sharing the band with IMT systems was not feasible.

4400-4990 MHz – In North America and Europe, this band was already extensively used for fixed and mobile services, and segments of the band were also used for fixed satellite service and public protection and disaster relief (PPDR) applications. Japan maintained its support for identification of this band in the face of both opposition and lack of interest in much of the rest of the world. In the end, although Japan reserved its right to reintroduce the band in Committee 4 or the plenary, it was never able to garner sufficient support from other administrations.

4.3 Bands Negotiated at WRC-07

As a result, Committee 4 eliminated these three bands from consideration as IMT bands. That left four remaining bands to be considered for identification for terrestrial IMT: 450-470 MHz, 470-960 MHz, 2300-2400 MHz, and 3400-4200 MHz. In practice, however, proposals regarding the 470-960 MHz band centered on the heart of the UHF band: 698-806/862 MHz.[11]

Ultimately, the negotiation at WRC-07 came down to a decision on reconciling two highly contested bands: the 698-806/862 MHz or "UHF band," and the 3400-4200 MHz or "C band." In a situation with no clear favorite prior to the Conference, these two bands drew diametrically opposite support; that is, administrations tended to favor one and oppose the other, for reasons that will be explored in the following subsections.

4.3.1 The UHF Band

The issue of whether to identify all or part of the 698-806/862 MHz band cannot be understood without understanding the costs and opportunities inherent in the so-called "digital dividend." For decades this band has been allocated globally (and accepted almost universally) as broadcasting spectrum and used for analogue television. The advent of digital television ("DTV"), however, created a new possibility to broadcast more channels over the same amount of spectrum. Thus, the conversion, over time, to digital broadcasting transmission could allow the consolidation of spectrum usage, freeing up "excess" spectrum for other uses. This was to be the dividend: efficiency from digital transmission would allow governments to benefit the public by redirecting the use of this newly recovered spectrum.

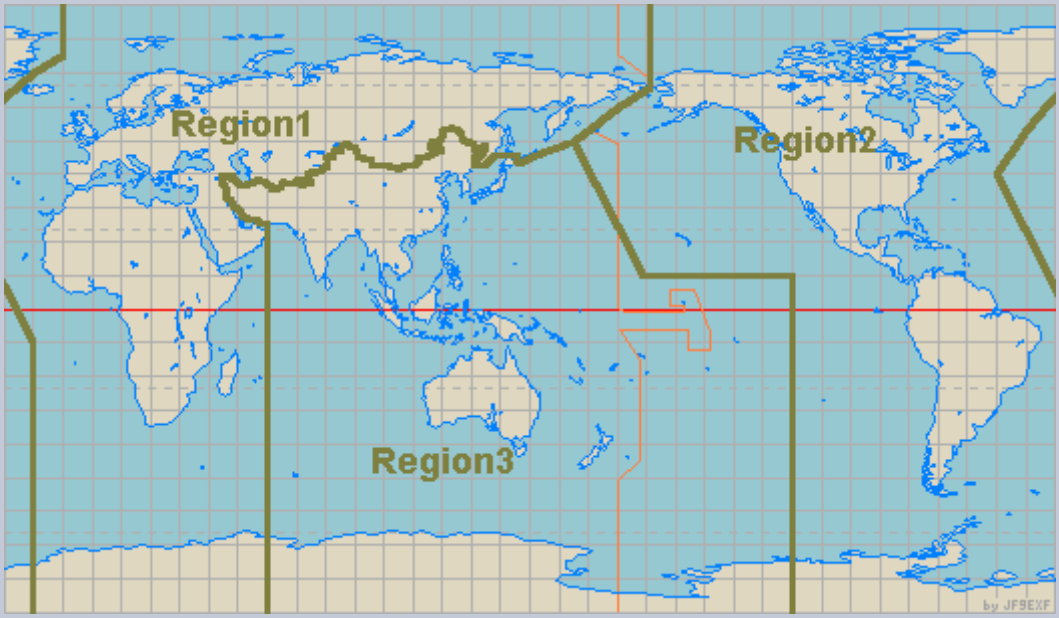
At a certain juncture, however, it appears that national and regional approaches to leveraging the digital dividend diverged onto different paths. There are at least two reasons for this divergence:

- Different countries varied in the speed at which they planned to complete the transition to DTV broadcasting, and
- Governments were divided over how to re-allocate the dividend, with some seeking to retain it for expanded broadcasting and others seeking to make it available for BWA systems.

Essentially, administrations with conservative transition timelines were skeptical of identifying the UHF Band for BWA systems. The opponents of identification argued that it was premature to identify the band, since many countries were still using it for broadcasting and would continue to do so for at least the next eight years. They cited the output of ITU Regional Radio Conference 2006 (RRC-06) held in Geneva the previous year – known as the "GE-06" Agreement. This agreement did not call for completing the DTV transition until 17 June 2015 in parts of Region 1 (see RR No.5.2) situated to the west of meridian 170° E and to the north of parallel 40° S, except the territory of Mongolia, and in the Islamic Republic of Iran (all together 120 countries). Moreover, the GE-06 Agreement allowed for the band (also known as "Bands IV-V") to continue as a digital broadcasting band – including for mobile broadcasting -- using standards such as DVB-T (Digital Video Broadcasting-Terrestrial) and DVB-H (Digital Video Broadcasting – Handheld). So it

appears that the platforms driving continued use of the UHF band in Europe grew out of the broadcasting model, as embraced in the GE-06 Agreement.

Figure 1: ITU Regions



Source: ITU

By contrast, countries outside the RRC-06 planning area appeared more likely to promote or at least acquiesce in the use of part of the UHF band for IMT systems. The proponents of IMT identification for the digital dividend took a position that countries could complete the DTV transition at their own pace; the IMT designation would be waiting for them whenever they could make use of it.[12] Moreover, they argued that the frequencies in the 700 MHz band were intrinsically ideal for mobile services, because of their range, ability to penetrate into buildings and general propagation capabilities. The high quality of the spectrum could translate into lower costs for network infrastructure, they argued.

The output agreement reached at WRC-07 was essentially a compromise that, however, did provide a global identification in the UHF range – albeit with regional differences in the size of the band and the timing of implementation. More specifically:

- *In Region 1 (Europe, Africa and part of Asia),* the 790-862 MHz band was identified for IMT, but only after 17 June 2015 – and subject to conformity with the GE-06 Agreement;

- *In Region 2 (the Americas)*, the 698-862 MHz band was identified for IMT systems with a co-primary allocation, except that in Brazil, the 698-806 MHz band will be allocated to mobile service on a secondary basis;

- *In Region 3 (Asia-Pacific),* several nations, including China, India, Japan, New Zealand and Singapore, opted to identify the 698-790 MHz band, in addition to the 790-862 MHz band, which was accepted by all countries in the region[13].

The net result was that, after 17 June 2015 there would be a global identification of the 790-862 MHz band for IMT. In addition, major portions of the world – including the Americas and the most populous nations of Asia – identified a larger band (698 – 862 GHz). With the notable exception of China, those countries will implement the identification without the eight-year delay.

4.3.2 The C Band

The 3400-4200 MHz band had been traditionally a band shared among fixed and fixed satellite services, on a co-primary basis, with mobile, amateur and radiolocation allocations in some sub-bands and regions. In addition, many countries already had turned to the lower portions of the band (3400-3700 MHz) to begin licensing fixed WiMAX networks.

The C-Band became the primary focus of administrations that opposed identifying the UHF band – particularly in Western Europe (CEPT) and East Asia (e.g., Japan and Republic of Korea). The large block of contiguous spectrum was attractive, despite the presence of satellite downlinks in the band. The satellite industry, however, opposed what it viewed as an incursion into vital FSS spectrum, citing concern about the ability to prevent or mitigate interference with a wave of ubiquitous mobile devices. The satellite industry's mantra entering the Conference was "No Change" to the C-Band, a position that was echoed by the United States and several other administrations concerned about the potential effects on incumbents.

As the Conference went on, the debate in Agenda Item 1.4 pitted the proponents of the UHF band against proponents of the C Band – with very little yielding in the positions on either side.

Ultimately, in the final hours of the Conference, the same agreement that yielded a compromise on the 698-806/862 MHz (UHF) band also provided a result on 3400-4200 MHz (the C Band). There would be no change to the majority of the C band, from 3600-4200 MHz. With regard to the remaining, lower portion (3400-3600 MHz), the result was fractured along regional lines once again:

- *Region 1* – Nearly 90 countries opted in, through a footnote to the Table of Allocations in the Radio Regulations, to a mobile allocation and IMT identification for the 3400-3600 MHz band[14];
- *Region 2* – There was no identification for IMT, but a footnote was added to allow certain countries to "opt-in" to a primary mobile allocation (with no IMT identification) in the 3400-3500 MHz band;
- *Region 3* – Several of the most populous countries, including China, Japan and Pakistan, opted in to a mobile allocation and/or IMT identification in either the 3400-3500 MHz band or the 3500-3600 MHz band – and in several cases, both.

Table 1: Review of Actions in WRC-07 Agenda Item 1.4

Band	Region 1	Region 2	Region 3
450-470 MHz	IMT identified	IMT identified[15]	IMT identified
UHF Band	790-862 MHz Effective 2015	698-862 MHz Effective now	698-862 MHz or 790-862 MHz, Depending on country
2300-2400 MHz	IMT identified	IMT identified[16]	IMT identified
C Band	3400-3600 MHz Opt-in by footnote	3400-3500 MHz Opt-in to primary allocation by footnote	3400-3600 MHz Opt-in by footnote

Source: ITU

Where countries opted in to IMT identifications, the footnotes stipulated that those countries follow required agreement or coordination procedures.[17] In addition, the Conference added interference safeguards in the form of power flux density (PFD) limits on the IMT systems. While there was no global identification, the "opt-ins" allowed many countries to signal their intent to move forward with IMT systems in the lower portion of the C Band.

4.3.3 The Remaining Bands

The 450-470 MHz and 2300-2400 MHz bands were not as contentious as the UHF and C Bands, although support for identifying them was not universal. In the final agreement, both bands were identified globally, with provisions added to protect incumbents from interference.[18]

5 IMPLICATIONS FOR ADMINISTRATIONS

The results of four long weeks – culminating in a marathon all-night session – in Geneva during the autumn of 2007 will be felt into the next decade. The bottom line is that national regulators were given multiple options for adding spectrum to the total amount that could be deployed for terrestrial IMT systems – current and future. In addition, the ITU laid the groundwork for further development of IMT-advanced systems, along the lines of mobile WiMAX, Long-Term Evolution (LTE) and Ultra-Mobile Broadband (UMB) technologies.

Some general trends are apparent:

- WRC-07 did agree to open up the UHF band worldwide (with regional variations discussed above), endorsing at least a partial use of the digital dividend for BWA systems;
- The Conference acted mostly to protect countries' preferences for IMT spectrum – preserving administrations' multiple options -- rather than picking a single option and disallowing the rest[19];
- Wherever it could, the Conference sought to ameliorate the effects of IMT deployment upon incumbents – either through coordination requirements or regulatory mandates such as power limits.

The results of WRC-07 reflect the realities of regional divergence in allocations, as well as the constraints on spectrum usage posed by the need to share spectrum.

5.1 Regional Variations

Given the vast gulf in competing proposals coming into the Conference, a compromise with regional variations was perhaps the most that could be realistically achieved. Administrations were bound by the need to protect their incumbents in all of the bands proposed for identification. As a result, there are clear regional differences around the world in how the WRC-07 bands are likely to be utilized – at least initially.

- Europe and Africa – The countries that are partners in the GE-06 agreement will likely opt for bands other than UHF, at least until the middle of the next decade. The delayed transition to digital TV broadcasting will force them to pursue their other options, including the lower C-Band frequencies (3400-2600 MHz) that many of them proposed before and during WRC-07.
- North America – The United States and Canada have already stated that they will not be using the "globally" identified spectrum at 450-470 MHz and 2300-2400 MHz. In addition, the U.S. has so far stood firmly against allocating all but a small sliver of the C Band (3650-

3700 MHz) for BWA. Conversely, the U.S. has already proceeded to auction spectrum for BWA in the 700 MHz band.

- Asia-Pacific – The countries in this region were largely split in their support of the UHF or C Band positions. In the end, however, many of them chose to take advantage of identification or primary allocation in both bands – including the populous markets of India, China, Japan and the Republic of Korea.
- South America – Region 2 identified the larger portion of the UHF band (698-862 MHz), and some of the countries also signed onto the footnote designating mobile service as primary in the 3400-3500 MHz band. Brazil was among those countries, and it also departed from the regional position on UHF, where it will maintain a secondary allocation for mobile service.

It will now be up to industry to continue developing, marketing and deploying BWA equipment in the plethora of bands now available to it.[20] But the presence of regional variations poses the question of whether the industry has been given sufficient cues or direction regarding the band(s) for which it should build equipment. The implicit goal in establishing global identification of spectrum, after all, is to promote a global market that will provide economies of scale in equipment manufacturing. The question now is whether any single band – and which one – will become the predominant site for future IMT buildouts.

The long-term outlook seems to favor the build-out of systems in the UHF band – not only because of the inherent propagation characteristics (which may lower operators' costs) but also because of the omnipresent identification of the 790-862 MHz band after 2015. In the end, however, the existence of large equipment markets in North America, Europe and the Asia-Pacific may help ensure the viability of multiple bands, in addition to the UHF band. The Asia-Pacific markets may be key to this process, as they have the most flexibility to allocate any or all of the spectrum bands approved at WRC-07.

5.2 Spectrum Sharing Challenges

One of the most important factors in determining which bands are used for future IMT services is the situation regarding spectrum sharing in each band. Both the UHF and C Bands pose real challenges for the advent of ubiquitous IMT devices.

5.2.1 Broadcasting

The transition to DTV is well under way in some countries, but in many others, it has barely begun. The RRC-06 agreement reflected the reality that in many countries, it will take years to convert the UHF band from an analogue broadcasting band into a home for digital media. Even then, it is not clear that all countries would prefer to follow the lead of the United States in reclaiming spectrum from broadcasters and auctioning it to new licensees that would build IMT systems.[21]

One of the primary arguments against identifying the UHF band during WRC-07 was the issue of potential sharing between IMT and broadcasting systems in the band. This issue was not resolved to the satisfaction of those administrations that had opposed identification. So the UHF sharing issues will carry over into the next WRC, as the WRC-07 delegates approved an agenda item (1.17) for WRC-11 with the following language:

"To consider the results of sharing studies between the mobile service and other services in the band 790-862 MHz in Regions 1 and 3, in accordance with Resolution 749 (WRC-07), to ensure the adequate protection of services to which this frequency band is allocated, and take appropriate action";

This could be a wedge issue for some administrations to reopen the entire question of identification of the UHF band. That effort may come too late, however, because the United States is currently scheduled to complete the DTV transition in February 2009, shutting off over-the-air analog broadcasts and paving the way for deployment of new BWA systems by licensees from the January 2008 700 MHz band auction. For the U.S., the sharing issue has been avoided by essentially moving the broadcasters and giving the freed spectrum to their IMT successors.

5.2.2 Satellite Systems

In addition to broadcasting, there remain sharing issues with regard to the compatibility of terrestrial BWA systems with satellite systems. WRC-07 dealt with one such issue, relating to BWA systems (WiMAX, in particular) and future satellite systems in the 2 gigahertz range. As previously noted, the 2500-2690 MHz band had been identified for broadband wireless access systems (IMT-2000 and WiMAX) by previous WRCs. Some countries (e.g. the United States) had already licensed the band to companies planning to offer terrestrial services. However, the band also was allocated internationally for sharing with fixed satellite service (FSS), mobile satellite service (MSS) and broadcasting satellite service (BSS). By WRC-03, there was a growing recognition of the potential of incompatibility between the potential use of the band for BWA systems and the use for satellite systems – particularly MSS. Several countries – many of them in Asia – were preparing to launch satellites in this band, raising fears of interference that could compromise the ground-based systems.

In Agenda Item 1.9, WRC-07 considered proposals to establish regulatory limits on the future satellite systems in order to protect terrestrial systems from over-the-horizon interference -- but without unduly hampering the satellite systems. The conference adopted limits on future satellite systems designed to avoid interference[22].

Another potential sharing problem arose with proposals to identify the C Band for IMT. Initially, many proposals included the entire band, from 3400 to 4200 MHz. This would have posed sharing issues for the communications satellite systems that employ the C Band. The final agreement at WRC-07 left most of the larger band untouched, but allowed “opt-in” use of the 3.4-3.6 GHz band, which is commonly known in the industry as the “extended C Band.”

The industry now faces a somewhat confused situation, in which some of its operators, in some countries, may be subject to interference in the lower C Band frequencies. The footnotes that enable “opt in” access to the band do require mutual agreement between administrations in some circumstances. Meanwhile, the footnotes also spell out power flux density limits that the terrestrial IMT systems must comply with in order to protect the satellite incumbents.

As countries implement the IMT provisions of WRC-07 over the next four years, the broadcasting and satellite industries will seek to work with governments to ensure that they are not overwhelmed by future BWA system deployments. Meanwhile, administrations and sector members alike will begin preparing for WRC-11. The next section previews the relevant issues that could impact on BWA systems four years from now.

6 LOOKING AHEAD

As the previous section indicated, WRC-07 did not completely resolve the questions of spectrum sharing and protection of incumbents in the IMT bands. Moreover, the battle over the UHF band raised new questions regarding convergence between mobile, fixed and broadcasting services. Several of these compatibility and convergence questions have been teed up for WRC-11, in the following agenda items:

Agenda Item 1.2 – This item calls for studies pursuant to Resolution 951, in which the ITU noted the increasingly blurred lines between terrestrial broadcasting, fixed and mobile services – precisely the kind of blurring associated with the digital dividend services in the UHF band. At present, there appears to be little understanding of what the agenda item would lead to – it is essentially open-ended – but the language calls on WRC-11 to "take appropriate action with a view to enhancing the international regulatory framework."

Agenda Item 1.17 – This item is an explicit follow-up to WRC-07 Agenda Item 1.4; it calls for studies on sharing between mobile services and other services (i.e., broadcasting) in the upper UHF band (790-862 MHz) in Regions 1 and 3. Accepted at the insistence of countries opposed to IMT identification in the band, the agenda item calls on WRC-11 to "ensure the adequate protection of services to which this frequency band is allocated, and [to] take appropriate action." Needless to say, this also ensures a revisiting of the UHF identification decision, particularly in Region 1.

Agenda item 1.19 – The 2011 conference will also take up "regulatory measures and their relevance, in order to enable the introduction of software-defined radio and cognitive radio systems." Meanwhile, ITU-R will be conducting studies, and discussions will proceed over the next four years regarding how to begin "regulating" (or perhaps even *whether* to begin regulating) the Dynamic Spectrum Allocation (DSA) systems.

Until then, the focus shifts to the business world and to the national governments that will implement the WRC-07 decisions. It looks certain to be a world of even greater complexity in four years – not less.

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[1] The specifications of these air interfaces are included in Recommendation ITU-R M.1457.

[2] See ITU information briefing at www.itu.int/osg/spu/imt-2000/technology.html#Cellular%20Standards%20for%20the%20Third%20Generation

[3] Interestingly, the ITU utilized what it called an "identification" of bands, which is not the same as an allocation. Following the Radio Regulations, allocations are made for particular radiocommunication services – in this case, the mobile service. The identification process serves as an official endorsement by the ITU for a particular technology or application – in this case, for IMT-2000. The underlying allocation would still be mobile, and technically, countries could license IMT-2000 in any band bearing a mobile allocation. The identification is meant to narrow down the choice and provide guidance to administrations through a global harmonization process.

[4] Resolution ITU-R 212 (Geneva 1992) and RR Footnotes S5.317A and S5.384A (Istanbul 2000).

[5] www.wimaxforum.org/home/

[6] In Europe, the 2.5-2.69 GHz band was reserved solely for IMT-2000, while in many other countries, including the United States, both fixed and mobile services were allowed, making this band an ideal crossover point for mobile WiMAX. See www.wimax.com/commentary/spotlight/wimaxspotlight2005_04_25

[7] WP8F addressed IMT-2000 and systems beyond IMT-2000.

[8] "WiMAX Spectrum Row Heats Up," ZDNet, July 18, 2006, http://news.zdnet.co.uk/communications/0,1000000085,39279140,00.htm

[9] Incidentally, the RA also restructured the working parties, realigning and renumbering them; consequently, the WiMAX debate will likely be remembered as the "last hurrah" of WP8F.

[10] See "ITU-R Newsflash: ITU-Radicommunications Assembly Expands IMT-2000 Radio Interface Family with OFDMA technology; establishes IMT-Advanced as the name for 4G, 19 October 2007."

[11] The different configuration, "806/862" refers to the fact that in some regions, the spectrum between 806-862 MHz had already been set aside, with the result that an identification of the entire block would only take in 108 MHz of new spectrum (i.e., 698-806 MHz).

[12] CITEL among others, was an active proponent of identifying the UHF band at the Conference, proposing a "package" deal covering the four remaining terrestrial bands. With part of CEPT actively opposing identification of the UHF band, the swing votes were largely in Asia and Africa.

[13] China, out of deference to interference concerns of its Geneva-06 neighbors, delayed implementation of the IMT identification until 17 June 2015 in its territory.

[14] In the Table of Allocations, footnotes are often used to allow countries to note differences in the allocations within their jurisdictions.

[15] Not effective in the U.S. or Canada.

[16] Not effective in the U.S. or Canada

[17] These measures are spelled in RR Nos. 9.21, 9.17 and 9.18.

[18] The United States and Canada presented declarations that the bands would not be used for IMT in those countries.

[19] Some countries (e.g., Japan) saw some of their favoured bands be eliminated due to lack of support by other administrations, but these were perhaps exceptions that proved the rule.

[20] In the immediate aftermath of WRC-07), industry groups did weigh in to endorse the decisions to identify spectrum. See, for example, the CDMA Development Group (CDG) press release dated 20 November 2007: "CDG Applauds Landmark at ITU WRC-07:International Telecommunication Union Approves 450 MHz and 700 MHz bands for 3G and Next-Generation (IMT) Mobile Services, http://biz.yahoo.com/pz/071120/131766.html (downloaded 23 January 2008)

[21] Ironically, while broadcasting and telecommunications remain separate industries or sector, the types of services and applications they want to offer are converging. Both industries are avidly preparing standards and technologies to deliver interactive multimedia content (including video programming) to both fixed and mobile terminals.

[22] Ironically, despite this action, strongly favored by the U.S., the American operator Sprint almost simultaneously suspended plans (at least temporarily) to roll out WiMAX service in the 2500-2690 MHz band.