WiMAX FORUM® WHITEPAPER

The WiMAX Forum Certified™ Program

Driving the adoption of interoperable wireless broadband worldwide

September 2008

Table of Contents

1. Introduction

WiMAX™ technology will make mobile broadband widely available on a large variety of devices and affordable to the mass market. Cutting-edge performance, high spectral efficiency, and interoperability make WiMAX the technology best positioned to meet the rapidly growing demand for mobile broadband services in the market today.

The WiMAX Forum Certified program plays an essential role in enabling and accelerating the adoption of WiMAX products and services. It ensures that subscriber devices from any manufacturer work in any network, provided that the devices and the base stations are WiMAX Forum Certified™ under the same certification profile.

Subscribers will enjoy the freedom to buy any WiMAX device from the retail source of their choice with the confidence that, when they switch it on, they will see all the available networks and will be able to connect to the one they prefer. Certified products strengthen the WiMAX business model. Operators rely on certification to know that devices in the market will bring high-quality subscriber experience straight out of the box, and that they will seamlessly work within their networks, without causing any disruption.

The WiMAX Forum has developed a certification program that extensively tests subscriber devices and base stations to ensure that they conform to the standards, perform as expected, and interoperate with equipment from other vendors. This was made possible through extensive collaborations with standards-setting organizations such as the Institute of Electrical and Electronics Engineers (IEEE) and the European Telecommunications Standards Institute (ETSI), testing labs, and the 530 WiMAX Forum member companies that today form a robust and diverse global ecosystem for WiMAX. Certification is the core of WiMAX Forum activities. Having strong ties with the industry but independence from individual players, the WiMAX Forum has established and is committed to further developing the robust certification program that the marketplace needs. Today certification focuses on conformance to the standard at the Physical (PHY) and Media Access Control (MAC) layers, and on interoperability. In the future, certification testing will be expanded to include radiated performance, conformance above the MAC layer, and interoperability with core network elements.

The first WiMAX Forum Certified products based on IEEE 802.16d were announced in January 2006 and operate in the 3.5GHz band. The WiMAX Forum Certified program's scope continues to expand; it now includes equipment that complies with the IEEE 802.16e-2005 standard, which supports full mobility. The first certified equipment based on IEEE 802.16e-2005 was announced in the second quarter of 2008, and it includes base stations and subscriber devices that operate in the 2.3GHz and 2.5GHz bands. Mobile WiMAX™ was added as the sixth radio interface in the International Mobile Telecommunications (IMT) 2000 family, in recognition of the worldwide demand to deploy WiMAX technology. The International Telecommunication Union (ITU) decision

opened the way for wider opportunities for operators to deploy WiMAX within existing and new spectrum allocations.

To date, more than 62 companies are developing WiMAX chipsets and end user devices, and 37 companies developing infrastructure equipment. Their products are used in WiMAX deployments by 407 operators in 133 countries as of September 2008.

Further expansion of the program will include new bands, an increasingly comprehensive set of tests, support for new versions of the standard, and a widening range of subscriber devices.

The Certification Working Group (CWG) manages the certification program within the WiMAX Forum. It works closely with the Technical Working Group (TWG), the Service Provider Working Group (SPWG), and the Network Working Group (NWG), which develop the specifications that are at the core of certification testing (Figure 1).

This WiMAX Forum paper is an initial guide to what certification covers, what its goals and core value propositions are, how it works, and how it will develop over time. It also provides further information on how the WiMAX Forum can assist vendors, operators, and other ecosystem players that work together to make wireless broadband ubiquitous.

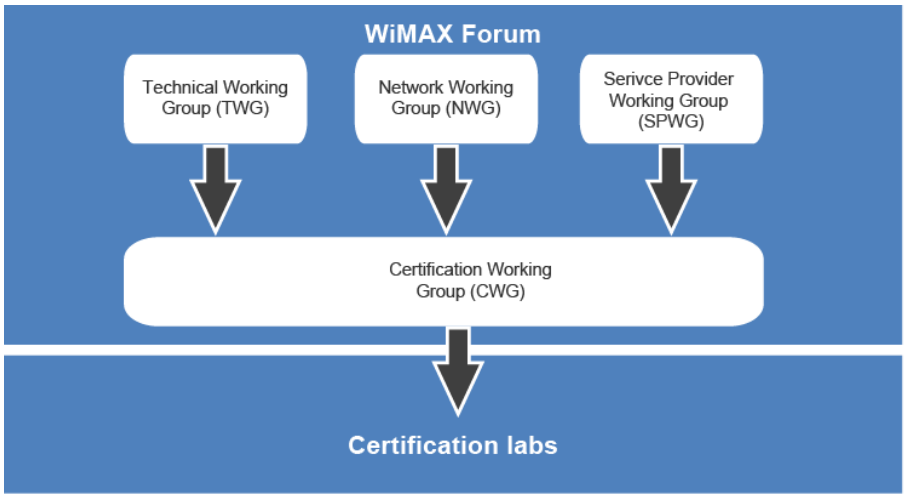

Figure 1. WiMAX Forum Working Groups involved in the certification program

2. Value propositions of certification

Certification brings substantial advantages to vendors, operators, and subscribers. It ensures that WiMAX technology can be deployed and used worldwide and that it will retain commercial continuity as new capabilities are added to the IEEE 802.16 standard.

WiMAX Forum Certified products bring to the market:

- **Interoperability and performance testing.** Network operators can deploy a network with WiMAX Forum Certified base stations and subscriber devices from multiple vendors that operate in the same certification profile, with the confidence that they will work together seamlessly within the network. This will lead to faster deployments, because operators do not need to independently test interoperability of certified equipment.

- **Gradual introduction of new functionality.** The certification program will continue to be updated so that WiMAX equipment will evolve and improve performance over time. Certification testing will eventually expand from the PHY and MAC layers covered by the IEEE 802.16 standard to include core network functionality defined in the WiMAX Forum Network specifications. The WiMAX Forum certification program defines the roadmap for the inclusion of new, tested features and new standards versions in future certified products, and enables network operators to smoothly enhance performance over time within their existing networks.

- **Backward compatibility.** Any new certified product will be backwards compatible with all products certified within the same certification profile, and under the same or previous releases. This allows operators to keep existing subscriber devices in use as they upgrade their base stations.

- **Utilization of spectrum bands with common allocations worldwide.** The WiMAX Forum defines certification profiles that use spectrum bands available in many markets worldwide, thus helping to generate the economies of scale needed to keep equipment costs down, and facilitating roaming. Subscribers will be able to purchase devices that will work worldwide, and operators will be able to establish international roaming deals.

The value that certification brings to all players in the value chain, from vendors to subscribers (Table 1), extends well beyond interoperability among vendors. It creates a more dynamic marketplace with more aggressive product development, more equipment choices, faster decline in equipment costs, and, eventually, an accelerated adoption of the technology (Figure 2).

Why choose WiMAX Forum Certified equipment?		
Vendors	**Network operators**	**Subscribers**
Early testing ensures that products are interoperable ahead of commercialization and that troubleshooting is completed during the certification process. Addressing the interoperability issues during deployment requires more cost and effort.	Operators can support any certified subscriber device, including devices sold by retailers and out-of-network roaming devices, without running any interoperability testing.	The WiMAX Forum Certified seal gives subscribers confidence that devices will be able to connect to any WiMAX network out of the box, as long as the device and the base station support the same certification profile.
Vendors with interoperable equipment can more easily and more quickly address the global market with their product line and add new form factors.	Choice among vendors leads to more flexibility and choice in network planning, avoidance of vendor lock-in, and faster, more cost-effective deployments.	A wider array of devices available will often lead to increased choice and lower prices for subscribers. The addition of WiMAX to Consumer Electronics (CE) devices will also increase the value of connectivity to subscribers.
Certified equipment leads to the availability of integrated, lower-cost WiMAX modules that can be added to a wide array of CE devices.	Operators may actively market a few devices to subscribers, but they can also safely support devices sold by third parties. Those devices will not require subsidies and will generate additional revenues.	Interoperability facilitates domestic and international roaming and allows subscribers to use their devices wherever they go.
Vendors can focus on specific network elements (e.g., base stations or subscriber devices), instead of having to develop end-to-end product lines.	Backward compatibility allows network operators to retain continuity of service as they introduce new products with enhanced functionality and performance.	

Table 1. Why choose WiMAX Forum Certified equipment?

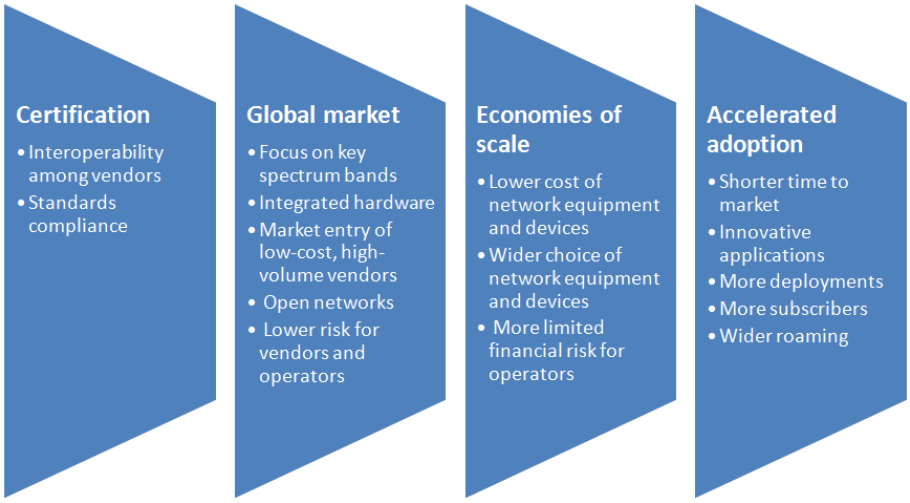

Figure 2. Market dynamics enabled by certification

3. WiMAX Forum Certified program milestones

The WiMAX Forum was established in 2001 to promote and certify wireless broadband equipment based on the IEEE 802.16 (Table 2) and ETSI HiperMAN standards. As of September 2008, it has attracted 530 member companies from 51 countries, representing the entire value chain—from component suppliers (92 members), to system vendors (132), to service providers (162), to content providers and ecosystem players (144).

The WiMAX Forum has established a rigorous program to test equipment for compliance with the standards and for interoperability among vendors that is trusted, flexible, and cost effective, and that meets the requirements of subscribers, operators, and ecosystem vendors. Key milestones of the certification program include:

- **October 2004:** After the ratification of the IEEE 802.16-2004 version of the standard, work on the certification program started with the creation of specifications and test suites to guide subsequent certification testing.

- **January 2006:** The WiMAX Forum announced the certification of the first base stations, and indoor and outdoor subscriber devices operating in the 3.5GHz band based on IEEE 802.16-2004. As of September 2008, there are 16 base stations and 18 subscriber devices certified under the Fixed WiMAX™ certification profiles.

- **April 2008:** Three base stations and four subscriber devices were announced as the first Mobile WiMAX™ Forum Certified products operating in the 2.3GHz band and based on IEEE 802.16e-2005. Products in this certification group meet the South

Korean regulatory requirements and are mainly targeted at that market.

- **June 2008:** The WiMAX Forum announced the first Mobile WiMAX Forum Certified base stations (six) and subscriber devices (four) based on IEEE 802.16e-2005 and operating in the 2.5GHz. As of September 2008, there are 11 base stations and 17 subscriber devices certified under the Mobile WiMAX certification profiles.

By September 2008, 25 vendors had successfully completed the certification process and 62 products have received the WiMAX Forum certification. Many more have submitted their products for certification, and the WiMAX Forum expects to have certified additional products by the end of 2008.

IEEE 802.16 or WiMAX?

WiMAX™ technology is based on two standards, the IEEE 802.16 and the ETSI HiperMAN. The IEEE and ETSI standards serve as the basis for the WiMAX Forum's WiMAX air interface specifications at the PHY and MAC layers. Standards evolve through time to support new capabilities and to improve performance. There are three versions of the IEEE 802.16 standard that are key to the WiMAX Forum Certified program:

- IEEE 802.16-2004 (or 802.16d). Based on Orthogonal Frequency Division Multiplexing (OFDM), it supports fixed and nomadic access. WiMAX Forum Certified equipment was certified for conformance only to this standard until mid-2008.

- IEEE 802.16e-2005 (or 802.16e). Based on Orthogonal Frequency Division Multiple Access (OFDMA), this standard version supports fixed and nomadic access, but it also includes additional capabilities to serve mobile access. The WiMAX Forum Certification program issued the first certifications for the 2.3GHz band in April 2008 and for the 2.5GHz band in June 2008.

- IEEE 802.16m. Currently under development, the new version of the standard will include improved mobile access and voice services and is a candidate for inclusion as one of the future ITU IMT-Advanced technologies. The WiMAX Forum is committed to preserving compatibility with the IEEE 802.16e-2005 standard, which will enable operators to roll out 802.16m-based equipment within their existing networks.

On the basis of the IEEE 802.16 standard, the WiMAX Forum develops system profiles, which select a subset of capabilities included in the standard to define the capabilities that all WiMAX products are required to support. There are currently two system profiles: one for Fixed WiMAX (IEEE 802.16d) and one for Mobile WiMAX (IEEE 802.16e-2005). Additional capabilities may be added to the system profiles when a new version of the standard is approved.

Table 2. IEEE 802.16 or WiMAX?

4. The approach to certification

The WiMAX Forum designed the WiMAX Forum Certified program to satisfy five goals.

a. Support flexible deployments and retail distribution models

WiMAX technology is based on open standards and therefore can support deployments in which base stations, subscriber devices, and core network elements from multiple vendors seamlessly coexist. It also allows the growth of a retail distribution model similar to that used by CE manufacturers, in which users directly buy and activate their devices. As they develop products, vendors may interpret differently some standards specifications, and this may limit interoperability. The WiMAX Forum Certified program ensures that these differences are resolved by including tests for conformance to the standard, and by operating test networks with equipment from multiple vendors to assess interoperability explicitly. Interoperability testing makes certification testing more demanding and requires a higher level of collaboration among vendors, but it also facilitates more comprehensive troubleshooting ahead of commercial availability.

b. Develop a certification framework for end-to-end WiMAX networks

For true interoperability, it is not sufficient that a subscriber device can connect to any WiMAX base station. Both the subscriber device and the base station also have to perform as expected and support the capabilities they have been certified for, as well as the applications and services offered by the operator. This widens the scope of certification testing to include network-level specifications developed by the WiMAX Forum which complement the IEEE 802.16 specifications that cover the MAC and PHY layers only.

To pass certification, base stations need to interoperate with a minimum of three subscriber devices from other vendors, and subscriber devices with a minimum of two base stations from other vendors.

The WiMAX Forum certification framework includes test suites to cover the following:

A. Current testing modules:

- **Radio Conformance Testing (RCT)** assesses compliance to the PHY layer.
- **Protocol Conformance Testing (PCT)** assesses the compliance to the MAC layer, including the Security Sublayer, the Media Access Control Common Part Sublayer, and the Service-Specific Convergence Sublayer.
- **Interoperability Testing (IOT) or Mobile Interoperability Testing (MIOT)** verifies interoperability within a test bed that includes base stations and subscriber devices from multiple vendors.

B. Planned testing modules:

- **Radiated Performance Testing (RPT)** provides PHY-layer metrics to determine over-the-air radio performance of subscriber stations (but not base stations), during normal operation, in the presence of near-field impairments due to objects (head, hands, desktop) typically found near the device. These tests will be required as of July 2009.

- **Network Conformance Testing (NCT)** is a planned program to test conformance above the MAC layer to test Internet Protocol (IP) layer signaling and messaging to and from the subscriber device. The WiMAX Forum expects network conformance testing to start at the end of 2008.

- **Infrastructure Interoperability Testing (IIOT)** will focus on Access Service Network (ASN) and Connectivity Service Network (CSN) elements and will test interoperability at defined reference points within the network for inter-ASN, intra-ASN, and ASN-to-CSN messaging. IIOT certification program is expected to be available in the second half of 2009.

RCT, PCT, RPT, IOT and MIOT are based on the IEEE 802.16 and the ETSI HiperMAN standards, and exclusively target MAC and PHY capabilities. NCT and IIOT are based on the WiMAX Forum Network specifications and target upper layers (Table 3).

<table>
<tr><th>Open Systems Interconnection (OSI) model</th><th>WiMAX Specifications</th><th>Certification modules</th></tr>
<tr><td>Application layer</td><td rowspan="6">WiMAX Forum Network Specifications</td><td rowspan="6">NCT, IIOT</td></tr>
<tr><td>Presentation layer</td></tr>
<tr><td>Session layer</td></tr>
<tr><td>Transport layer</td></tr>
<tr><td>Network layer</td></tr>
<tr><td>Data link layer– Logical Link Sublayer</td></tr>
<tr><td>Data link layer – Media Access Control (MAC) layer</td><td rowspan="2">WiMAX Forum System Specifications (based on IEEE 802.16)</td><td>PCT, IOT, MIOT</td></tr>
<tr><td>Physical (PHY) layer</td><td>RCT, IOT, MIOT, RPT</td></tr>
</table>

Table 3. The OSI model, WiMAX specifications, and the WiMAX Forum certification modules

c. Expand WiMAX capabilities while retaining market continuity

One of the major challenges of certification is to balance the need to retain backward compatibility with the drive to upgrade to the latest technology and market developments. To retain continuity in the market and technological relevance, the WiMAX Forum Certified program carefully manages the evolution path and ensures that the certification testing evolves gradually.

The WiMAX Forum defines successive releases to deal with the evolution in the standards and changes in the marketplace. WiMAX Forum releases are aligned with major phases in the IEEE 802.16 standard, with a new release reflecting a new version of the standard. (Not all new versions of the IEEE standard correspond to a new WiMAX Forum release, however). Releases include the list of capabilities that will be tested during certification and that products will have to support (see Annex).

To ensure market continuity, all changes through releases are incremental: new tests are added and the old ones retained. Furthermore, the WiMAX Forum is committed to retaining backward compatibility, allowing operators to support devices certified under previous releases when they upgrade their networks.

d. Address the global market and enable economies of scale

Another challenge for certification is to address the global market. The WiMAX Forum Certified program is restricted to carefully selected frequencies that are widely available to WiMAX operators. This approach will accelerate achieving the economies of scale needed for cost-effective deployment and low-cost devices. Certification profiles are the tool the WiMAX Forum uses to address the global market and enable international roaming. A certification profile is closely associated to appropriate regulation: it defines a spectrum band (e.g., 3.5GHz or 2.5GHz), one or multiple channel sizes (e.g., 5MHz and/or 10MHz), and a duplexing mode (Time Division Duplexing [TDD] or Frequency Division Duplexing [FDD]) in which the equipment can operate in compliance with regulatory requirements. Products submitted for certification are separately tested for each certification profile they support. Base stations typically support only one profile at a time, but subscriber devices may support multiple profiles so they can connect to a larger number of networks to facilitate global roaming.

Collectively, certification profiles define the spectrum bands in which WiMAX Forum Certified products operate worldwide. Because spectrum access is not harmonized across all countries, multiple certification profiles are necessary to allow operators to deploy WiMAX worldwide. If the number of certification profiles is too low, many operators will not be able to deploy WiMAX despite having access to spectrum. On the other hand, if there are too many certification profiles, the market quickly becomes fragmented. In this scenario, equipment and device costs could remain high and choice limited, and subscribers might not be able to use their devices internationally. In defining certification profiles, the WiMAX Forum has relied on feedback from vendors, operators, and regulators to determine a good balance between serving the largest possible addressable market and avoiding fragmentation. In the future, the WiMAX Forum may add new certification profiles in response to market demand and vendor readiness. Vendor readiness is a prerequisite to the commencement of certification for a new profile: a minimum of three vendors are necessary to validate a certification profile.

e. Establish the WiMAX Forum Certified program as the trusted resource for equipment selection

In certification, trust is an essential ingredient. Subscribers in a retail store will choose a WiMAX Forum Certified device over a possibly cheaper product without certification if they are confident that the certified device will work as expected straight out of the box. Similarly, operators require WiMAX Forum Certified equipment from their vendors. The WiMAX Forum has developed the certification process in close collaboration with the entire WiMAX ecosystem, including standards-setting organizations, testing labs and vendors of testing equipment, chipset and system vendors, and operators. All main vendors with WiMAX-based products have enthusiastically embraced certification as a requirement to enter and succeed in the market.

In addition, to ensure independence, consistency, and choice, WiMAX Forum Designated Certification Labs (WFDCLs) have been selected to conduct the certification testing under the guidance of the WiMAX Forum, following the specifications and test suites set forth by the WiMAX Forum, and using the testing equipment sanctioned by the WiMAX Forum. Test equipment is supplied by leading vendors that include Agilent, Anite, AT4, Azimuth, Innowireless, Tektronics, Rohde and Schwarz, and Sanjole. When a product passes the certification testing, the WFDCL formally issues the WiMAX Forum Certified certificate.

WiMAX Forum Designated Certification Laboratories (WFDCLs)
AT4 Wireless (Spain, USA) www.at4wireless.com Parque Tecnologico de Andalucia (Spain) Calle Severo Ochoa 2 29590 Campanillas, Málaga, Spain and 520B Huntmar Park Drive, Herndon, VA 20170 (USA)
Bureau Veritas ADT (Taiwan) www.adt.com.tw No. 19, Hwa Ya 2nd Rd, Wen Hwa Tsuen, Kwei Shan Hsiang, Taoyuan Hsien 333, Taiwan
CCS/TTC (Taiwan) Compliance Certification Services (CCS) www.ttc.org.tw 11 Wugong 6th Rd., Wugu Industrial Park Taipei County 248, Taiwan and Telecom Technology Center (TTC) www.ccsemc.com.tw 4F, No.300, Yangguang St. Neihu District, Taipei City 114, Taiwan
China Academy of Telecommunication Research (China) www.catr.cn 52 Hua Yuan Bei Lu, Haidian District, Beijing 100083, China
Telecommunications Technology Association (South Korea) www.tta.or.kr 267-2 Seohyun-dong, Bundang-gu, Seongnam-City, Gyeonggi-do, 463-824 Korea

Table 4. Location of WFDCLs

WFDCLs undergo a rigorous selection process, and their final nomination is sanctioned by the CWG and approved by the WiMAX Forum Board of Directors. Current certification labs are located in China, Spain, South Korea, Taiwan, and the USA (Table 4). The WiMAX Forum is evaluating additional labs in Brazil, Japan, and India.

5. Certification profiles to address the global market for wireless broadband

Certification testing is conducted on the basis of certification profiles that define the key operation parameters (spectrum band, channel bandwidth, and duplexing) for the product submitted for certification. Products are certified for one or more certification profiles, and they are expected to interoperate with other products within the same certification profiles. For instance, a subscriber station certified for the 2.3GHz profile will not work in a network with base stations operating within the 3.5GHz spectrum, but will be able to connect to any base station in the 2.3GHz spectrum with the same channel bandwidth and duplexing.

There are two groups of certification profiles, each defined by a system profile: one for Fixed WiMAX systems (based on IEEE 802.16d) (Table 5) and one for Mobile WiMAX systems (IEEE 802.16e-2005) (Table 6). The first WiMAX Forum Certified products were announced in January 2006 for Fixed WiMAX products, which support fixed and nomadic access. The first WiMAX Forum Certified products for Mobile WiMAX were announced in April 2008. Active profiles are those with ongoing certification testing and with announced certified products. Additional profiles have been defined to address the regulatory requirements of specific countries, and the demand from operators and vendors operating in these countries. Testing for these profiles can start as soon as at least three vendors are ready to validate the new profile.

Fixed WiMAX certification profiles				
Profile name	Spectrum band	Channel bandwidth	Duplexing	Status
ET01	3.4–3.6GHz	3.5MHz	TDD	Active
ET02	3.4–3.6GHz	3.5MHz	FDD	Active

Table 5. Fixed WiMAX Certified profiles. Certified products are available for active profiles.

Mobile WiMAX certification profiles				
Profile name	Spectrum band	Channel bandwidth	Duplexing	Status
MP01	2.3–2.4GHz	8.75MHz	TDD	Active
MP02	2.3-2.4GHz	5,10MHz	TDD	2009*
MP05	2.496–2.69GHz	5 and 10MHz	TDD	Active
MP09	3.4–3.6GHz	5MHz	TDD	4Q2008*
MP10	3.4–3.6GHz	7MHz	TDD	4Q2008*
MP12	3.4–3.6GHz	10MHz	TDD	4Q2008*

* Projected start date of certification testing, subject to change

Table 6. Mobile WiMAX Forum Certified profiles. Certified products are available for active profiles.

6. What's next: the certification roadmap

WiMAX technology is evolving rapidly to meet demand in a growing number of countries and to provide improved performance and support for applications. The WiMAX Forum Certified program will continue to drive the evolution of the technology through an aggressive Mobile WiMAX certification roadmap (Figure 3) over the next few years.

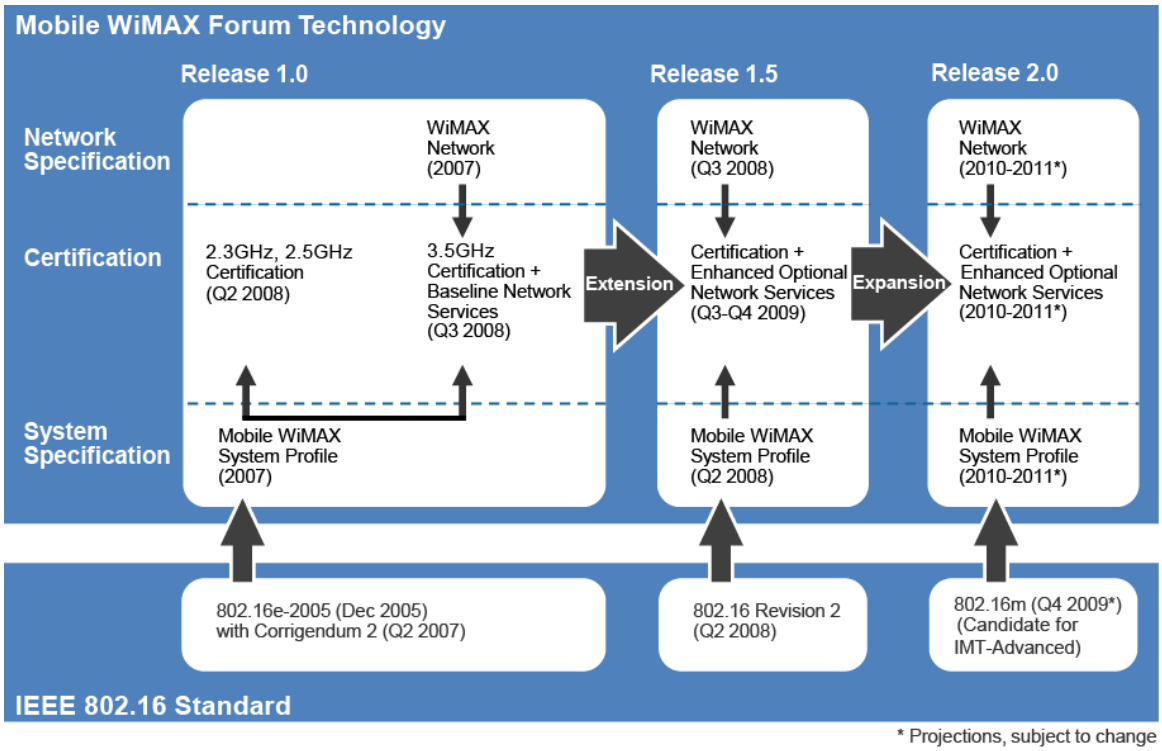

Figure 3. Mobile WiMAX certification roadmap

Products are currently certified under Release 1.0, which is based on the IEEE 802.16e-2005 standard. The focus of certification during the initial stages of Release 1.0 is on radio and protocol conformance, and on interoperability testing. Towards the end of 2008, Release 1.0 will include testing for baseline network services, based on the WiMAX Network specifications developed by the NWG.

Release 1.5 is expected for 2009. It will be an expansion of Release 1.0 and will have an increased emphasis on the WiMAX Network specifications. Radio and protocol conformance, and interoperability testing will be based on IEEE 802.16e Revision 2 and the corresponding updated version of the Mobile WiMAX System Profile. Release 1.5 will also include new certification profiles that will support FDD duplexing in response to a growing demand for FDD in markets where FDD is mandated or more easily supported by regulatory mandates.

Release 2 will be a major step forward in the evolution of WiMAX technology and is

expected for 2010–2011. It will rely on the IEEE 802.16m version of the standard, which is a candidate for inclusion among IMT-Advanced technologies. IEEE 802.16m will feature higher throughput and wider channels, in addition to improved support for voice services. Certification testing will rely on an updated version of the Mobile WiMAX System Profile and on an updated version of the WiMAX Network Specifications (NWIOT Release 2.0).

7. Pre-Certified WiMAX Modules

WiMAX will bring wireless connectivity to a large variety of devices beyond laptops and phones. CE devices such as game consoles, cameras, MP3 players, and other content delivery devices like the Kindle may soon have a WiMAX module that provides a broadband connection. The proliferation of devices—especially when multiple models are available—can place an undue burden on device vendors if they have to follow the certification process for each model.

To address this issue, the WiMAX Forum has created a streamlined, low-cost certification process for Pre-Certified WiMAX Modules. The original modules can be submitted for certification in a white-box device and can then be embedded in multiple WiMAX devices without undergoing further certification testing. If the housing or the antenna is different, the Original Equipment Manufacturer (OEM) is required to submit the product for a limited number of radio tests.

This will enable OEMs and Original Design Manufacturers (ODMs) to simplify the development and market introduction of WiMAX subscriber devices, as well as to reduce cost and time to market for new devices.

8. How does certification work?

The WiMAX Forum manages the certification process by developing and adopting the relevant specifications, establishing the process and test suites to be used, selecting the testing labs, issuing the certification certificates, and maintaining a registry of WiMAX Forum Certified products. However, it is not directly involved in certification testing; this keeps the program independent and gives vendors the freedom and flexibility to choose their preferred lab.

Vendors primarily work with the WFDCL of their choice (Figure 4), which accepts the certification application, conducts the tests, and, if tests are successful, issues a certification certificate.

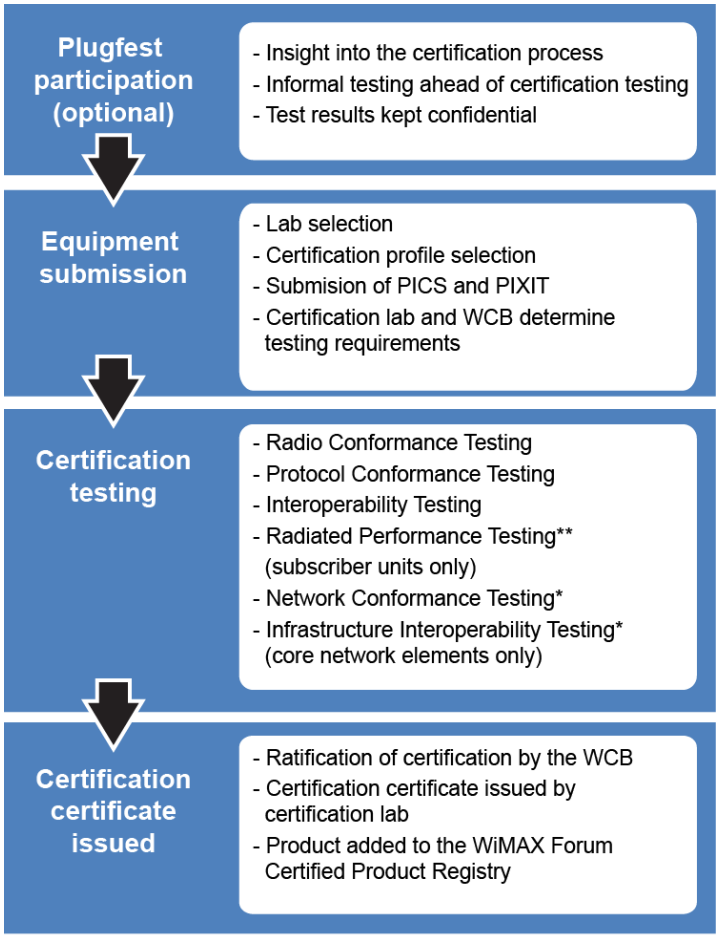

Figure 4. The certification process

For many vendors, the work on certification starts well ahead of the equipment submission, during plugfests sponsored by the WiMAX Forum. Although participation in plugfests is not required, vendors often find it a very valuable experience to get a deeper insight into the certification process, and to informally test their equipment with that of other vendors ahead of formal certification testing. This enables them to address any issues that would otherwise emerge later during certification testing, and could delay certification. Participation to plugfests is public, but the WiMAX Forum, test labs, and participating vendors are required to keep the testing results confidential.

The certification process for a product starts when the vendor selects a testing lab and a certification profile for the product. The vendor also can choose whether the submitted product should be treated as a device or as a module that will be added to multiple devices, and whether it is an upgraded version of a previously certified product or a product with a previously certified WiMAX module. At this stage, the vendor has to submit the Protocol Implementation Conformance Statement (PICS), which affirms that the vendor supports all the capability to be tested during the certification process and that the product meets the certification requirements. The testing lab will also require the

submission of a Protocol Implementation Extra Information for Testing (PIXIT) document that provides information on the equipment configuration, plus additional information on the product.

Certification testing can start once the chosen lab identifies the test suites relevant to the submitted product, based on the equipment submission materials and the Certification Requirements Status List (CRSL) that keeps track of the current WiMAX Forum testing requirements at any given time. Currently, the WiMAX Forum has defined up to six certification testing modules (Section 4.b), which test conformance to the standards, performance, interoperability, network conformance, and network interoperability. If any test fails, the certification testing is halted and the vendor is asked to make the needed changes and to restart the certification process.

If all tests are completed successfully, the WiMAX Certification Body (WCB) reviews the results and acknowledges the product certification. The certification lab issues the certification certificate and the product is added to the WiMAX Forum Certified Product Registry. The registry is publicly available on the WiMAX Forum website.

9. WiMAX Forum Certified resources

This document provides an initial guide to the WiMAX Forum Certified program. Readers who have specific queries or want more detailed information have access to further information on the WiMAX Forum public website (www.wimaxforum.org) or, if they are WiMAX Forum members, on the WiMAX Forum member website (www.wimaxforum.org/members).

The WiMAX Forum Certified Product Registry is available to provide specific information on WiMAX Forum Certified products. The page is designed to provide quick access to posted products and certifications by company or product category. The Registry can be accessed at:

http://www.wimaxforum.org/kshowcase/view

Information about WiMAX certification fees is available at:
http://www.wimaxforum.org/members/certification

WiMAXCert is a tool that enables vendors to submit an online application for certification. It is also accessible from the WiMAX Forum website in the Certification Resources area.

The WiMAX Forum also provides X.509 certificates to vendors. X.509 certificates and their associated keys are documents used in a Public Key Infrastructure (PKI) system to identify and authenticate the identity of devices and servers. Information about the

certificate ordering process and fees is available at:
http://www.wimaxforum.org/certification/x509_certificates/

For further information, vendors can refer to the following documents:

- **Certification Program Reference Manual (CPRM):** a detailed guide to the certification process, with an extensive list of reference documents.
- **Certification Requirements Status List (CRSL):** a complete list of all the test cases that have to be passed to gain certification.
- **WiMAX System profiles:** an overview of the capabilities that have to be supported within a certification release.
- **WiMAX Network specifications:** developed by the NWG, the specifications for NCT and NWIOT.
- **IEEE 802.16 and ETSI HiperMAN standards**: the specification for WiMAX PHY and MAC.

10. Conclusions

The WiMAX Forum Certified program is the catalyst that the marketplace needs to accelerate the adoption of wireless broadband services worldwide. Since the first WiMAX Forum Certified products were announced in 2006, the WiMAX Forum has steadily expanded the certification program. Mobile WiMAX products in the 2.3GHz band were included in April 2008 and in the 2.5GHz band in June 2008. Future expansion milestones include additional Mobile WiMAX bands (3.5GHz) and the introduction of NCT testing by the end of 2008, and the introduction of RPT by July 2009. Additional capabilities will be included in Release 1.5 (2009), based on IEEE 802.16 Revision 2, and Release 2.0 (2010–11), based on IEEE 802.16m.

Vendors can rely on a program they trust to help them bring to market products that have demonstrated interoperability and high performance levels, and that will provide a great subscriber experience.

Certification brings operators the confidence that WiMAX equipment from different vendors will interoperate seamlessly and will support an expanding set of capabilities, and yet allow them to upgrade their networks at their own pace.

Subscribers stand to benefit, as well, from the choice of certified products whose capabilities and performance has been rigorously tested and which they can expect to work reliably right out of the box.

Acronyms

3GPP	The Third Generation Partnership Project
3GPP2	The Third Generation Partnership Project Two
AAA	Authentication, Authorization, Accounting
AES	Advanced Encryption System
ASN	Access Service Network
APDO	Activation Provisioning Device OTA
ARQ	Automatic Repeat Query
BF	Beam Forming
CE	Consumer Electronics
CRSL	Certification Requirement Status List
CS	Convergence Sublayer
CSN	Connectivity Service Network
CPRM	Certification Program Reference Manual
CRSL	Certification Requirements Status List
CWG	Certification Working Group
DSL	Digital Subscriber Line
ETSI	European Telecommunications Standards Institute
FDD	Frequency Division Duplexing
H-ARQ	Hybrid Automatic Repeat Query
HDFDD	Half Duplex FDD
HO	Handover
IEEE	Institute of Electrical and Electronics Engineers
IIOT	Infrastructure Interoperability Testing
IMT	International Mobile Telecommunications
IMS	IP Multimedia Subsystem
IIOT	Infrastructure Interoperability Testing
IOT	Interoperability Testing
IPV4	Internet Protocol Version 4
IPV6	Internet Protocol Version 6
ITU	International Telecommunication Union
IWLAN	Interworking WLAN
IWK	Interworking
MAC	Media Access Control (Layer)
MAN	Metropolitan Area Network
MBS	Multicast Broadcast Services
MCBCS	Multicast and Broadcast Services
MIOT	Mobile Interoperability Testing
MIMO	Multiple Input Multiple Output
NCT	Network Conformance Testing
NWG	Network Working Group
NWIOT	Networking Interoperability Testing
ODM	Original Design Manufacturers
OEM	Original Equipment Manufacturer
OFDM	Orthogonal Frequency Division Multiplexing
OFDMA	Orthogonal Frequency Division Multiple Access
OSI	Open System Interconnection
OTA	Over The Air
PCC	Policy and Charging Control
PCT	Protocol Conformance Testing
PHY	Physical (Layer)
PICS	Protocol Implementation Conformance Statement
PIXIT	Protocol Implementation Extra Information for Testing
PKI	Public Key Infrastructure
PKM v2	Privacy Key Management Protocol Version 2
QoS	Quality of Service
RADIUS	Remote Authentication Dial In User Service
RCT	Radio Conformance Testing
RoHC	Robust Header Compression
RRM	Radio Resource Management
RPT	Radiance Performance Testing
SAE	System Architecture Evolution
SPWG	Service Provider Working Group
TDD	Time Division Duplexing
TWG	Technical Working Group
VLAN	Virtual Local Area Network
VoIP	Voice over IP
WCB	WiMAX Certification Body
WFDCL	WiMAX Forum Designated Certification Lab
WLAN	Wireless Local Area Network

Annex: WiMAX Forum Certified releases

Incremental capabilities supported in WiMAX Forum Certified releases	
System Specifications	**Network Specifications**
Release 1.0 Mobile and stationary WiMAX base specifications, with Access Service Network (ASN) and Connectivity Service Network (CSN) mobility Orthogonal Frequency Division Multiple Access (OFDMA) Time Division Duplexing (TDD) Multiple Input Multiple Output (MIMO) Beam Forming (BF) Multicast Broadcast Services (MBS) Ethernet Input/Output Sleep and idle modes Power control and saving Internet Protocol Version 4 (IPV4) and Internet Protocol Version 6 (IPV6) Pre-provisioned and static Quality of Service (QoS) Advanced Encryption System (AES) and Privacy Key Management Protocol Version 2 (PKM v2) Hybrid Automatic Repeat Query (H-ARQ) Optional Radio Resource Management (RRM) Network discovery and selection IP and Ethernet Convergence Sublayer (CS) support	**Release 1.0** Initial testing of Networking Interoperability Testing (NWIOT) (Network Conformance Testing [NCT] and Infrastructure Interoperability Testing [IIOT]) ASN profiles Handoff support Flexible credentials, with prepaid and postpaid accounting Remote Authentication Dial In User Service (RADIUS) based roaming The Third Generation Partnership Project (3GPP) Interworking WLAN (IWLAN) compatible Interworking (IWK)

Incremental capabilities supported in WiMAX Forum Certified releases	
System Specifications	**Network Specifications**
Release 1.5 Frequency Division Duplexing (FDD) Half Duplex FDD (HDFDD)	**Release 1.5** IP Multimedia Subsystem (IMS) and Policy and Charging Control (PCC)/Dynamic Quality of Service (QoS) Voice over IP (VoIP) with emergency services and lawful interception Multicast and Broadcast Services (MCBCS) Diameter-based Authentication, Authorization, Accounting (AAA), Over The Air (OTA), Activation Provisioning Device Over-the-air (APDO) and device management 3GPP System Architecture Evolution (SAE) IWK, 3GPP IWK optimization Ethernet services, (VLAN), Digital Subscriber Line (DSL) IWK Multi-host support Location-based services Robust Header Compression (RoHC) Normative ASN interface R8 Non-IMS/Universal Services Interface Femtocell support
Release 2.0 802.16m Media Access Control (MAC) and Physical (PHY) layers protocol enhancements	**Release 2.0** Multimedia Session Continuity Seamless Wi-Fi to WiMAX Handover (HO) 3GPP and 3GPP2 IWK (optimized HO) Roaming enhancements Emergency services Support for relay links (IEEE 802.16j) and optimized femtocells

About the WiMAX Forum®

The WiMAX Forum® is an industry-led, not-for-profit organization formed to certify and promote the compatibility and interoperability of broadband wireless products based upon the harmonized IEEE 802.16/ETSI HiperMAN standard. A WiMAX Forum goal is to accelerate the introduction of these systems into the marketplace. WiMAX Forum Certified products are interoperable and support broadband fixed, nomadic, portable and mobile services. Along these lines, the WiMAX Forum works closely with service providers and regulators to ensure that WiMAX Forum Certified systems meet customer and government requirements. Through the WiMAX Forum Congress Events Series of global trade shows and events, the WiMAX Forum is committed to furthering education, training and collaboration to expand the reach of the WiMAX ecosystem. For more information, visit the trade show link at www.wimaxforum.org.