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## About the WiMAX Forum™

The WiMAX Forum is an industry-led, non-profit corporation formed to help promote and certify the compatibility and interoperability of broadband wireless products using the IEEE 802.16 and ETSI HiperMAN wireless Metropolitan Area Network (MAN) specifications.

The Forum's goal is to accelerate the introduction of Metropolitan Broadband Fixed, Portable and Mobile Applications into the marketplace. The WiMAX Forum Certified™ program was launched in mid-2005 and ensures interoperability across vendors. The first certified products were announced in January 2006.

Founded in 2003, the WiMAX Forum consists of over 350 member companies including semiconductor and equipment manufacturers, network operators, content providers and other businesses in the broadband wireless ecosystem.

For more information about the WiMAX Forum and its activities, please visit [www.wimaxforum.org](http://www.wimaxforum.org).

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## Executive Summary

WiMAX is a wireless broadband technology based on the IEEE 802.16 and ETSI HiperMAN standards that combines cost-effective, interoperable equipment with advanced performance. To ensure that equipment conforms to these open standards and is interoperable, the WiMAX Forum has established a certification program that plays a central role in its efforts to promote the worldwide adoption of the technology.

The open-standards approach and the interoperability fostered by certification will lead to more intense competition in the market, and to economies of scale that will lower equipment prices. Operators will also benefit from greater flexibility, less dependence on individual vendors and backward compatibility. Vendors will gain access to a wider market and enjoy lower production costs.

The first fixed WiMAX Forum Certified products were announced in January 2006 and are based on IEEE 802.16-2004. As of May 2006, fourteen products have already been certified. While still in its early stages, the program is rapidly growing to include certification of mobile WiMAX equipment which is expected to be introduced in the marketplace early in 2007. The WiMAX Forum Certified program was designed to meet the requirements of network operators by combining robust conformance and interoperability tests with backward compatibility.

WiMAX testing requirements are defined by system profiles and certification profiles. There are currently two system profiles, one for fixed WiMAX and one for mobile WiMAX. Fixed WiMAX currently supports five certification profiles, which define classes of products that interoperate with each other on the basis of spectrum band, channelization and duplexing mode. To date, five certification profiles have been defined in the 3.5 GHz band—where both Time Division Duplex (TDD) and Frequency Division Duplex (FDD) can be used—and the 5.8 GHz TDD band. New certification profiles may be added in response to demand from vendors and operators.

As of May 2006, equipment is certified under Release 1, which focuses exclusively on testing for mandatory features. Release 2 will include three optional modules: QoS (Quality of Service) for improved support for real-time applications, AES (Advanced Encryption Standard) for advanced security and ARQ (Automatic Repeat reQuest) for improved link budget.

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## The WiMAX Forum Certified™ program for fixed WiMAX

### Introduction

WiMAX brings an entirely new approach to wireless broadband. It is a next-generation Orthogonal Frequency Division Multiplexing (OFDM) based technology with an all-IP core network that delivers superior performance through high throughput, low latency, advanced security and QoS functionality. At the same time, WiMAX has created an ecosystem that makes adoption of wireless broadband easier and more cost-effective for network operators and subscribers, while providing the capacity needed to support advanced services and applications. The wide industry support from component and system vendors, service providers and integrators ensures that there will be a vibrant and competitive market for WiMAX products. At the core of this new ecosystem is the Forum's commitment to open standards and interoperability as embodied in the WiMAX Forum Certified program.

The WiMAX Forum certification program started mid-2005, with the first certified products announced in January 2006. As of May 2006, fourteen products have been certified and more are expected to be announced soon. WiMAX Forum Certified products have been tested to show that they comply with the standards and that they interoperate with certified products from other vendors. Network operators can safely buy certified equipment without conducting further tests, confident that future product versions will be backward compatible with the equipment they have currently deployed.

This paper presents an overview of the WiMAX Forum certification program and of the value that certification brings to network operators and vendors. The first section discusses the role of certification in creating a more dynamic and competitive market and in increasing the cost-effectiveness of WiMAX solutions. The paper then outlines the approach followed by the WiMAX Forum for certification and provides information about the deployment opportunities (e.g. spectrum bands or duplexing) and the features tested during certification.

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## Why choose WiMAX Forum Certified equipment?

Interoperability is the most immediate reason for a network operator or a subscriber to buy WiMAX Forum Certified equipment. However certification brings additional advantages that extend well beyond interoperability and that create the basis for wide scale adoption of the technology.

The overall market dynamics are affected by a robust and trusted certification program that enjoys wide support from vendors and operators. The WiMAX Forum Certified program:

- **Defines how standards will be implemented in products.** Fixed WiMAX is based on IEEE 802.16-2004 and ETSI HiperMAN, but WiMAX certification requirements narrow even further the scope of the standards to certification profiles defined by spectrum band, channelization and duplexing. Certification profiles are required for interoperability (all equipment within a profile interoperates), but they also define which product classes will dominate in the market and how the technology will be implemented in real deployments. A stable technology roadmap reduces the complexity and risk involved in investing in a new technology.
- **Reduces overall costs by promoting economies of scale.** The converging focus of the industry towards one technology will lead to wider adoption and reduced fragmentation. Coupled with the rapid increase in demand for wireless broadband access, this approach will create the needed economies of scale to quickly drive down equipment prices.
- **Increases competition in the market.** An open-standards approach coupled with interoperability testing greatly encourages the entry into the market of low-cost and high-volume component and equipment vendors, which will lead to further price reductions. Furthermore, vendors will be able to specialize in the development of specific products (e.g. just base stations, or specific types of subscriber stations). An equipment vendor, for instance, may decide to focus on the development of high-end base stations and exit the subscriber unit market which can be more cost-effectively served by a high-volume vendor.

Service providers, in particular, stand to benefit greatly from choosing certified equipment. They will have:

- **No dependency on a single vendor.** Service providers can choose equipment from multiple vendors, thus gaining additional flexibility in planning or extending their deployments. Proprietary solutions tie operators to the technology roadmap of a single vendor and increase the financial risk of the deployment. Adoption of certified

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products will enable operators to transition smoothly to a different vendor, without having to replace the equipment already deployed.

- **Lower pricing.** Increased market competition and economies of scale will put pressure on equipment pricing.
- **Backward compatibility.** The assurance that new products will work with existing ones facilitates network planning and reduces the financial risk for operators.

Open standards and certification create a virtuous circle that benefits component and equipment vendors as well. They:

- **Gain access to a wider market.** Lower prices, increased market competition and more flexibility for operators will greatly increase the demand for WiMAX equipment and create a larger opportunity for vendors.
- **Benefit from lower production costs.** Lower prices do not lead to reduced profitability, as they are balanced by lower production costs due to economies of scale and higher sales volumes.
- **Address requirements from network operators.** Operators often demand vendor interoperability as a condition for deploying a technology. Certification makes it possible to meet this requirement without additional, expensive ad-hoc tests.
- **Establish interoperability early.** Certification allows vendors to address any interoperability issues before bringing a product to the market, when they are easier and less expensive to resolve.

## The WiMAX Forum approach to certification

The value that certification brings to a technology based on open standards like WiMAX is difficult to overstate. Interoperability is the major advantage of standards-based technologies, but with no certification program it is extremely difficult to ensure that equipment interoperates without going through extensive and costly independent testing.

In any standards-based technology, equipment vendors strive to develop products that comply with the standard, but different interpretations of the standards or varied implementations of the specifications may lead to a lack of interoperability that cannot be foreseen. The WiMAX certification program is designed to address these issues by fostering cooperation among vendors through plugfests, where they can informally verify interoperability, and through the official testing process. A robust set of test cases has been developed to ensure that the certification program meets the stringent requirements of network operators. The overall process is inevitably complex and requires substantial

effort and a collaborative approach from the vendors involved, but the rewards are substantial.

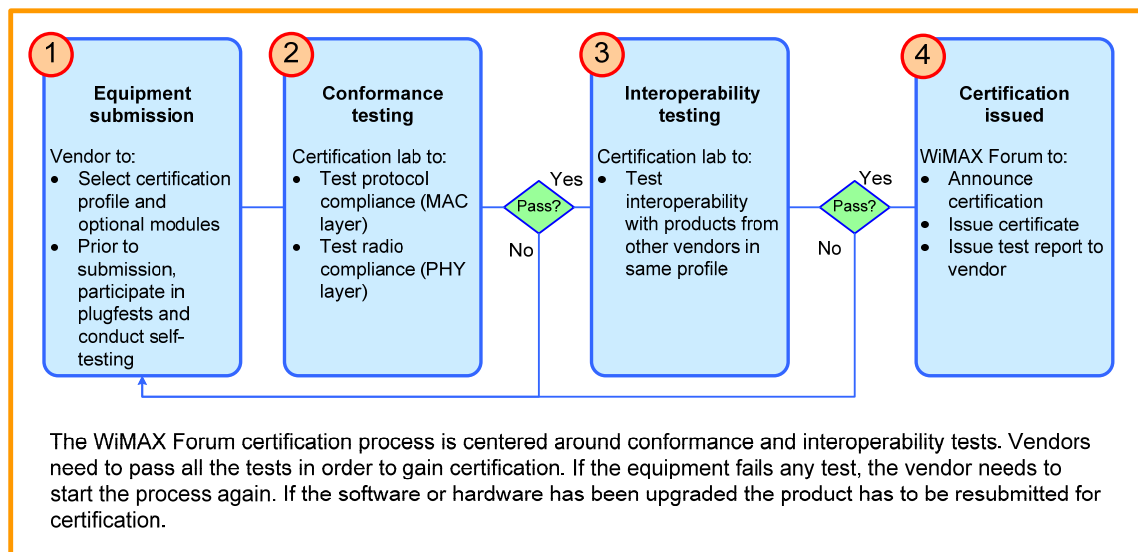
The WiMAX Forum was established in 2003 to promote and certify wireless broadband equipment based on IEEE 802.16 and ETSI HiperMAN. The certification program was launched mid-2005, after the ratification of IEEE 802.16-2004 in October 2004. The certification process described in Figure 1 includes two types of tests which focus, as do the standards, on the Physical (PHY) and Medium Access Control (MAC) layers:

- **Conformance testing** to ensure that the equipment correctly implements the specifications defined by the IEEE 802.16 and ETSI HiperMAN standards.
- **Interoperability testing** to verify that equipment from different vendors works within the same network. At least three vendors have to submit equipment within the same certification profile (defined by spectrum band, channelization and duplexing) to start interoperability testing.

Certification testing is conducted in independent labs. Cetecom in Spain was the first lab to test WiMAX equipment. Recently, the Telecommunications Technology Association (TTA) in Korea was added as the second certification lab. The WiMAX Forum plans to announce additional labs to meet demand from vendors and operators.

Upon successful completion of all tests, vendors receive a WiMAX Forum Certified certificate (Figure 2) and a test report, and can list their certified equipment on the WiMAX Forum Certified Product Registry, available at:

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



**Figure 1. The WiMAX Forum certification process**



Figure 2. WiMAX Forum Certified certificate

## Deployment opportunities

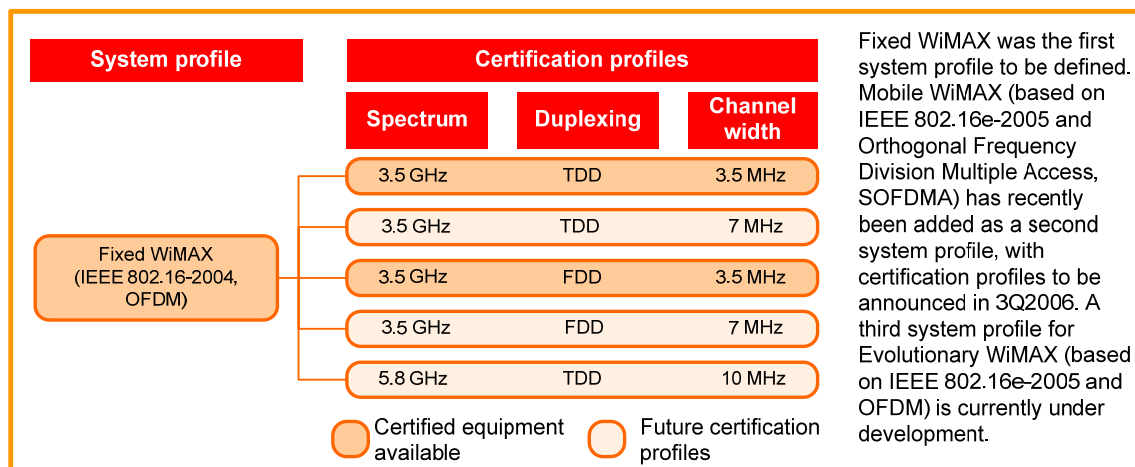
WiMAX can operate at any frequency below 11 GHz, using channel bandwidths ranging from 1.75 MHz to 10 MHz, and with both TDD and FDD duplexing<sup>1</sup>. To make interoperability effective and testable, the WiMAX Forum has created system profiles and certification profiles (Figure 3) that define classes of products:

- **System profiles** are based on versions of the IEEE 802.16 and ETSI HiperMAN standards and define the key mandatory and optional features that are tested in WiMAX equipment. The list of features tested in system profiles is more stringent than the underlying standards (features that are optional in the standards may be tested as mandatory by the WiMAX Forum Certified program), but does not include any new feature that is not included in the standards. For instance, the fixed WiMAX profile is based on IEEE 802.16-2004 and only allows testing on equipment using point to multipoint operations up to 11 GHz, while IEEE 802.16-2004 equipment can

<sup>1</sup> TDD uses a single channel for the uplink and the downlink, allowing the operators to dynamically allocate spectrum for uplink or downlink transmission based on traffic demand. FDD is a simpler but less flexible mechanism that uses channels in separate frequency bands for the downlink and uplink. Regulators typically mandate the use of either TDD or FDD in licensed bands.

operate up to 66 GHz. Similarly, fixed WiMAX uses OFDM multiplexing with 256 carriers, even though IEEE 802.16-2004 also supports an Orthogonal Frequency Division Multiple Access (OFDMA) mode. There are currently two system profiles, one for fixed and one for mobile WiMAX. The WiMAX Forum defines a list of test cases to use during the certification process for all equipment based on the same system profile.

- **Certification profiles** are instantiations of a system profile, defined by three parameters:
  - Spectrum band (<11 GHz)
  - Channel size (1.75 MHz to 10 MHz)
  - Duplexing (TDD or FDD).



**Figure 3. System and certification profiles**

All WiMAX Forum Certified equipment fully interoperates with other equipment in the same certification profile that is tested under the same release, and is backward compatible with equipment tested under previous releases. Certification profiles limit the number of WiMAX implementations allowed under a system profile to avoid market fragmentation, while meeting the demand from operators. The definition of certification profiles depends on market and vendor demand, which in turn are strictly linked to the availability of spectrum worldwide.

There are two spectrum bands covered by fixed WiMAX. More may be added at a later stage through the definition of additional certification profiles. The 3.5 GHz licensed

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band, widely available around the world with the exception of the US and a few other countries, has certification profiles for both TDD and FDD. The first fourteen WiMAX Forum Certified products operate in this band with 3.5 MHz channels for both TDD and FDD. The 5.8 GHz band is the second spectrum band. It is also commonly available worldwide, typically within a license-exempt regime. The 5.8 GHz profile is based on TDD as this is the prevalent duplexing mechanism used in this band and offers better cost performance than FDD.

Certification profiles define classes of interoperable equipment for the testing process. The effective range of interoperability among commercial products, however, will be wider because of multi-mode base stations or subscriber stations that will work at different frequencies or channel bandwidths, or even use a different duplexing mechanism. A multi-mode subscriber station, for instance, will interoperate with any base station that supports any of the certification profiles for which the subscriber station is certified. When available, multi-mode devices will offer network operators the ability to use the same subscriber equipment even if their network uses different bands in different locations. Subscribers will also benefit from multi-mode devices that will give them access to their home network at more locations and to networks managed by other operators.

## **Certification releases: mandatory and optional modules**

The scope of certification expands through time with the addition of new test cases. The list of requirements as defined in the system profiles does not change to ensure backward compatibility and technology stability. The new test casts are introduced either to include new features in the certification process or to expand coverage of existing ones. This is an incremental process in which all previously used test cases are retained.

A release framework is used to add new test cases. Several releases are defined for each system profile, each of them including additional tests and, if relevant, new certification profiles to be tested. The first release covers all the basic mandatory features required for network operation. Subsequent releases may include additional tests for mandatory features that all WiMAX products are required to support, and tests for optional features that vendors may choose whether to support or not.

Three releases are planned for fixed WiMAX, as shown in Figure 4. As of May 2006, equipment is being certified under Release 1. Release 2 is slated to be introduced in the third quarter of 2006. Release 1 for fixed WiMAX only covers mandatory features and includes testing for the air interface, network entry, dynamic services and bandwidth allocation. Release 2 will introduce three optional modules:

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- **Quality of Service (QoS).** QoS enhances WiMAX support for real-time applications that require low latency, such as Voice over IP (VoIP), video and audio streaming, video-conferencing and gaming. In a network where QoS is enabled, traffic from real-time applications is given priority over best-effort traffic.
  - **Advanced security with Advanced Encryption Standard (AES).** All fixed WiMAX equipment is required to support Data Encryption Standard (DES) for security. More advanced security functionality is offered by AES, the encryption standard adopted by the US government.
  - **Automatic Repeat Request (ARQ).** ARQ is a widely used error correction mechanism that leads to a better link budget and thus to improved performance.

Further optional features, such as sub-channelization in the uplink<sup>2</sup>, Convolutional Turbo Coding<sup>3</sup> (CTC) and Space Time Coding<sup>4</sup> (STC) can be tested for any certification profile when at least three vendors submit products that support them.

Backward compatibility ensures that equipment certified under a certification profile will always interoperate with others certified in the same or previous release. New releases enable operators to introduce new features in their deployments and to know which equipment supports those features. In a fixed WiMAX network with equipment certified in different releases, interoperability will be limited to the features tested in the earliest releases. Similarly, to add functionality defined by optional modules, both the base station and subscriber units have to be certified for them. For instance, Release 1 base stations will interoperate with any Release 2 subscriber station certified for QoS, but the subscriber unit will not be able to take advantage of QoS<sup>5</sup>.

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<sup>2</sup> Sub-channelization in the uplink improves transmission from the subscriber unit and, thus, greatly benefits indoor subscriber units and PCMCIA cards that typically operate under non line-of-sight conditions.

<sup>3</sup> CTC is a advanced error correction coding mechanism that increases the efficiency of spectrum utilization and, therefore, raises the throughput.

<sup>4</sup> STC introduces transmit diversity, which in turn boosts the link margin.

<sup>5</sup> It is nevertheless possible that a Release 1 base station supports QoS, but this capability was not tested, so interoperability, while possible, should not be expected.

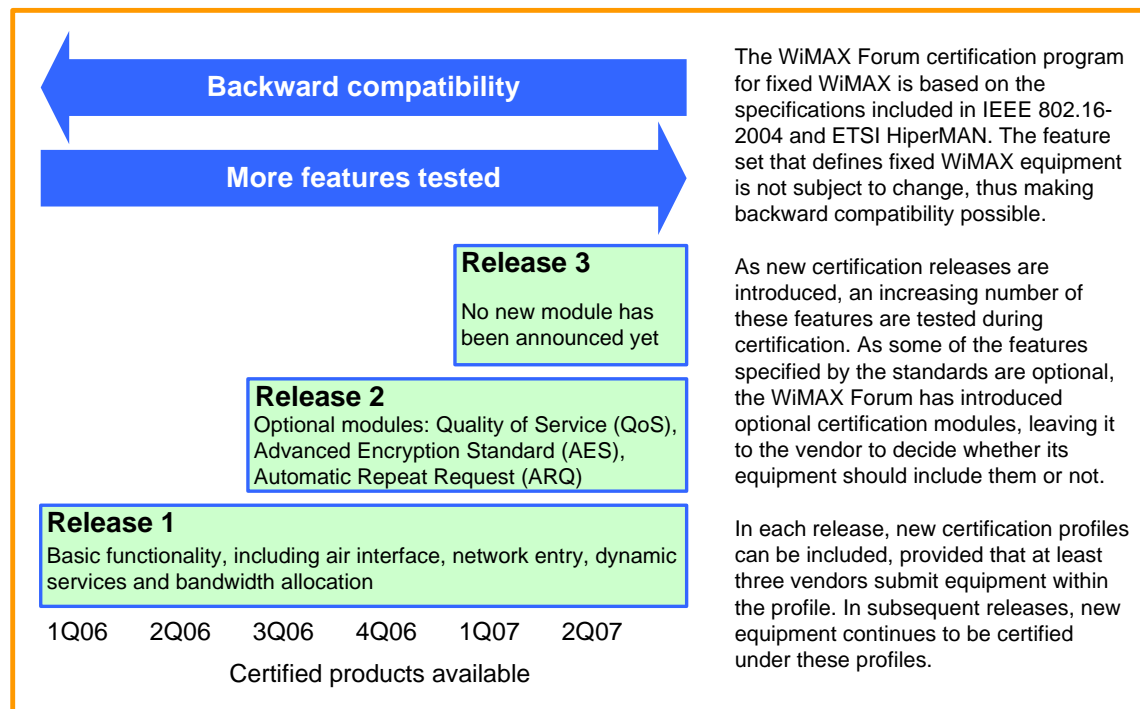


Figure 4. Certification releases

## Conclusions

The WiMAX Forum Certified program is at the core of the efforts at the Forum to promote the worldwide adoption of WiMAX through ensuring standards conformance and interoperability for IEEE 802.16 equipment. The certification program defines which WiMAX profiles will be implemented in commercially available products, thanks to industry-wide support from component and equipment vendors committed to submitting their equipment for testing, and from service providers requiring certified equipment for their deployments.

WiMAX certification is still in its early stages, but is rapidly evolving with the introduction of new releases for fixed WiMAX and of a new program and certification profiles for mobile WiMAX. Evolution in the certification program is necessary to ensure that WiMAX retains its flexibility and technological edge, and supports an increasingly wide range of features and services.

The need to update and extend the certification program has to be carefully balanced with the need to preserve continuity in the marketplace and to allow deployed equipment to continue to interoperate with new equipment. To ensure this, the WiMAX Forum is

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committed to preserving backward compatibility for all WiMAX Forum Certified devices.

Network operators and vendors stand to benefit greatly from an open-standards approach and a robust certification program. To operators, certification brings increased competition in the market that will result in lower prices, less dependence on vendors and greater flexibility when planning a network. Certified products will enable vendors to meet the requirements of network operators and to take advantage of the reduced production costs that result from the rapid worldwide adoption of WiMAX.

## Acronyms

AES	Advanced Encryption Standard
ARQ	Automatic Repeat request
CTC	Convolutional Turbo Code
DES	Data Encryption Standard
ETSI	European Telecommunications Standards Institute
FDD	Frequency Division Duplex
IEEE	Institute of Electrical and Electronics Engineers
IP	Internet Protocol
MAC	Medium Access Control
MAN	Metropolitan Area Network
NLOS	Non Line Of Sight
OFDM	Orthogonal Frequency Division Multiplexing
OFDMA	Orthogonal Frequency Division Multiple Access
PCMCIA	Personal Computer Memory Card International Association
PHY	PHYSical
QoS	Quality of Service
SOFDMA	Scalable OFDMA

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STC	Space Time Coding
TDD	Time Division Duplex
TTA	Telecommunications Technology Association
VoIP	Voice over Internet Protocol
WiMAX	Worldwide Interoperability for Microwave Access

## Resources

WiMAX Forum [www.wimaxforum.org](http://www.wimaxforum.org)

WiMAX Forum Certified Product Registry <http://www.wimaxforum.org/kshowcase/view>

CETECOM Spain [www.cetecom.es](http://www.cetecom.es)

Telecommunications Technology Association (TTA) [www.tta.or.kr](http://www.tta.or.kr)

We would like to thank Ed Agis and Aditya Agrawal, co-chairs of the WiMAX Forum Certification Working Group, for their support in preparing this white paper, by providing information on the certification process and its goals, and by reviewing the document. The WiMAX Forum Certification Working Group can be contacted at [cwg-chair@wimaxforum.org](mailto:cwg-chair@wimaxforum.org).