The Next Step in the WiMAX Migration Path

WiMAX 16e-Enhanced

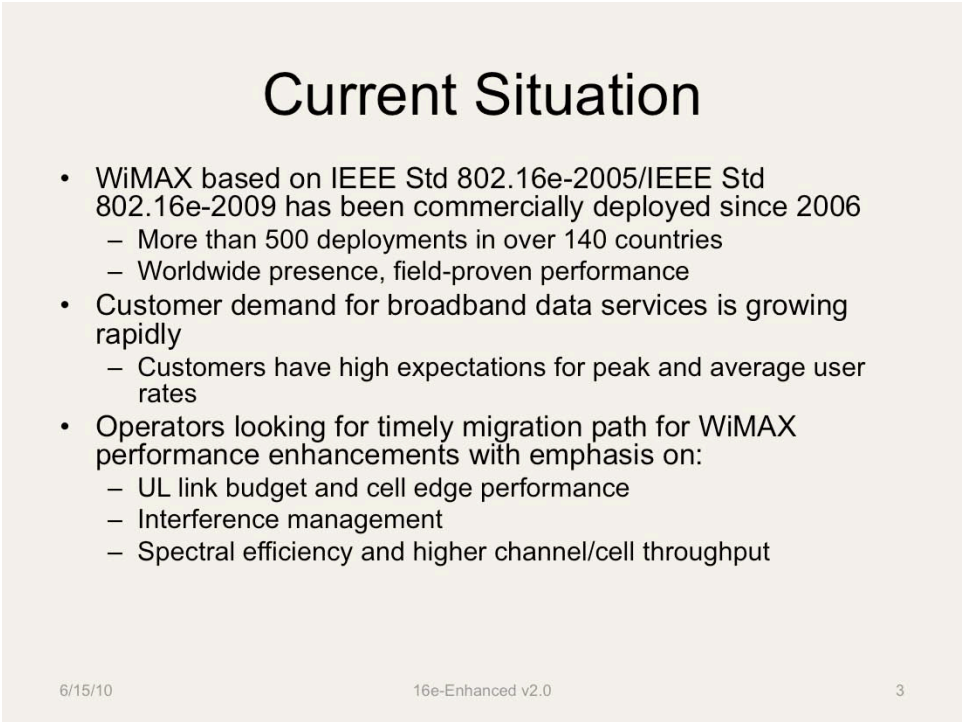
June 2010

This presentation was commissioned by Intel and summarizes technical contributions of the following equipment vendors and operators: Alvarion, Beceem, Clearwire, Hitachi, Huawei, Intel, Motorola, NEC, Samsung, UQ and ZTE.

Safe Harbor Statement

- THIS DOCUMENT AND RELATED MATERIALS AND INFORMATION ARE PROVIDED "AS IS" WITH NO WARRANTIES, EXPRESS OR IMPLIED, INCLUDING BUT NOT LIMITED TO ANY IMPLIED WARRANTY OF MERCHANTABILITY, FITNESS FOR A PARTICULAR PURPOSE, NON-INFRINGEMENT OF INTELLECTUAL PROPERTY RIGHTS, OR ANY WARRANTY OTHERWISE ARISING OUT OF ANY PROPOSAL, SPECIFICATION, OR SAMPLE. INTEL ASSUMES NO RESPONSIBILITY FOR ANY ERRORS CONTAINED IN THIS DOCUMENT AND HAS NO LIABILITIES OR OBLIGATIONS FOR ANY DAMAGES ARISING FROM OR IN CONNECTION WITH THE USE OF THIS DOCUMENT.

- PERFORMANCE OF WIRELESS SYSTEMS IS HIGHLY DEPENDENT ON THE OPERATING ENVIRONMENT, DEVICE AND NETWORK IMPLEMENTATION. THE COMPETITIVE RESULTS ARE BASED ON A GIVEN SET OF ASSUMPTIONS AND METHODOLOGY. DATA HAS BEEN SIMULATED AND IS PROVIDED FOR INFORMATIONAL PURPOSES ONLY. DATA WAS DERIVED USING SIMULATIONS. ANY DIFFERENCE IN SYSTEM HARDWARE OR SOFTWARE DESIGN OR DEPLOYMENT SCENARIO AND CHANNEL MODELS MAY AFFECT ACTUAL PERFORMANCE. THE PERFORMANCE NUMBERS ARE BEST USED AS GUIDELINES ON RELATIVE PERFORMANCE OF THE DIFFERENT

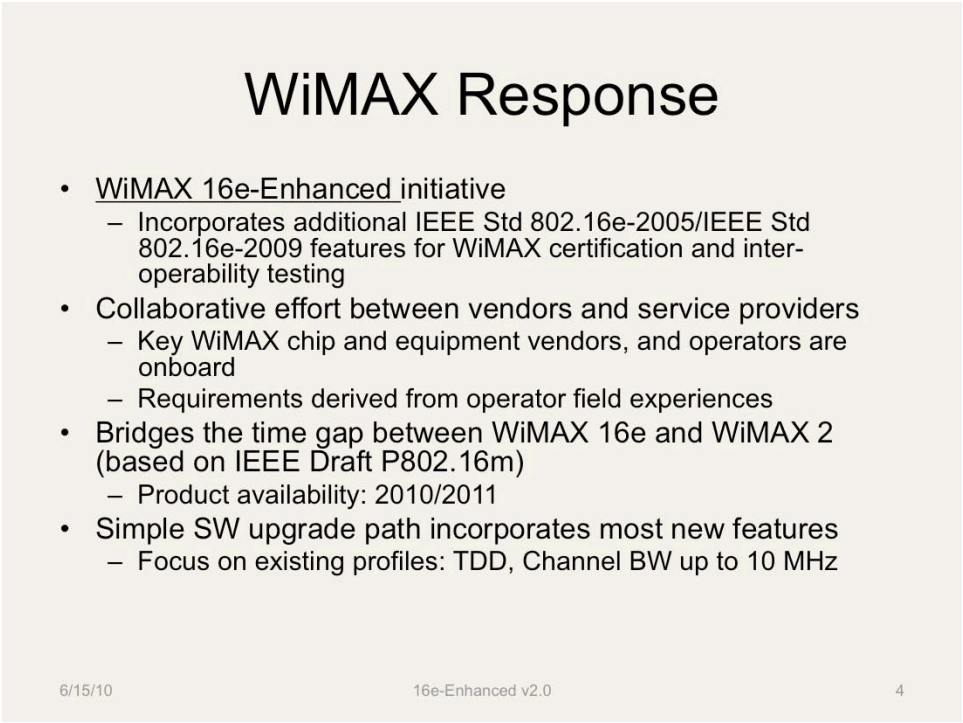


The growing availability of feature-rich client devices such as Smartphones and Netbooks, coupled with the proliferation of mobility oriented applications, has led to a dramatic shift in how consumers use wireless access networks.

With more than 500 deployments worldwide, WiMAX represents the only widely available, standards-based solution positioned to meet the rapidly growing consumer demand for broadband services generated by these new devices and applications.

Many or today's WiMAX Service Providers are already supporting Gigabytes of traffic per month for high end users and are anticipating further demand as more and more consumers step up to higher end client devices.

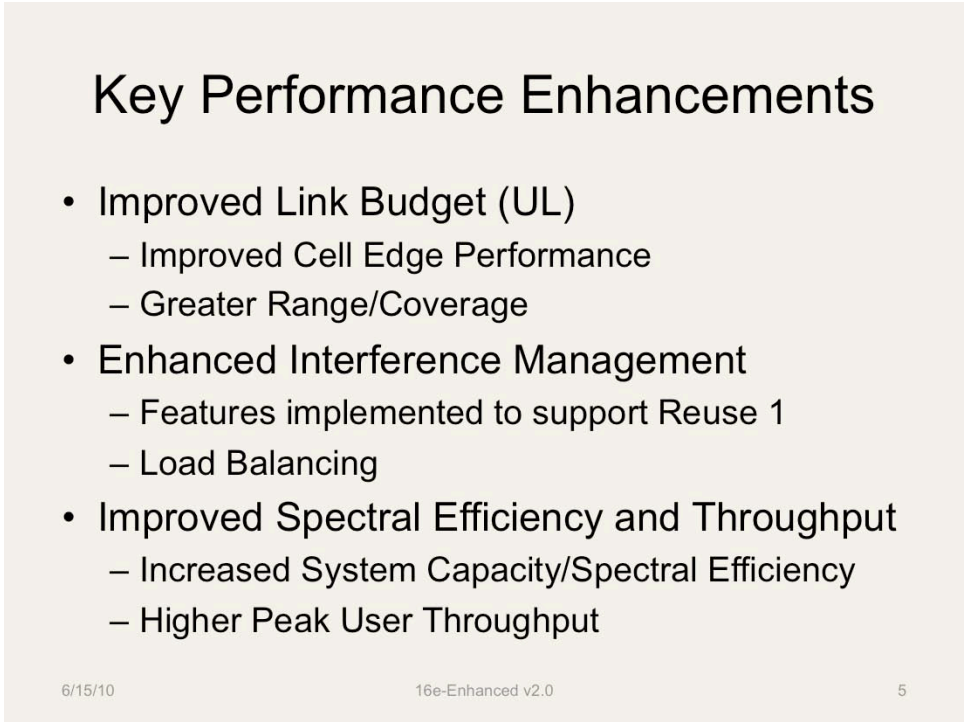
That said, WiMAX Operators are looking for a timely and cost-effective migration path for network enhancements to address the capacity and performance constraints they are either now encountering or expect to encounter in the near future.



To address the potential WiMAX network capacity constraints, WiMAX equipment and chip vendors, in partnership with WiMAX operators and the WiMAX Forum have launched an initiative to accelerate the adoption of features already supported in IEEE Std 802.16e.

This initiative will give today's WiMAX operators the opportunity to easily and cost-effectively enhance the performance of their networks and with availability in late 2010 , provides an upgrade path for today's WiMAX Operators to meet the growing consumer demand for broadband services while ensuring a smooth transition to WiMAX 2 based on the 802.16m standard.

With a focus on existing WiMAX profiles , the majority of WiMAX 16e-Enhanced benefits can be realized with a simple SW upgrade to currently deployed infrastructure



The performance improvements supported by WiMAX 16e-Enhanced can be grouped into the following major performance categories:

1. Improved Link Budget in the UL
2. Enhanced Interference Management to enable a reuse factor of 1, a key factor to enable ….
3. An increase in spectral efficiency and an increase in system throughput

Feature Summary for WiMAX 16e-Enhanced

Deployment/Certification Feature Set 1	
Link Budget (UL)	• HARQ on management messages in UL
Interference Management	• Load Balancing (Level 1) • Reuse 1 with Fractional Frequency Reuse (FFR)
Spectral Efficiency/ Throughput	• DL/UL HARQ Cat. 5
Deployment/Certification Feature Set 2	
Link Budget (UL)	• RNG/SBC with HARQ • SBC with Fragmentation • 4 Rx Diversity in the UL (with Collaborative SM with 1 Tx antenna)
Interference Management	• Load Balancing (Level 2) • UL Interference cancellation • Inter-Cell Interference Coordination (Network Layer ICIC)
Spectral Efficiency/ Throughput	• (4x2) MIMO Beamforming in DL • (1x4) MIMO in UL • DL/UL HARQ Cat. 6 (optional)

This slide provides a more detailed summary of the planned features for 16e-Enhanced divided into two groups, “Certification feature set 1” and “Certification feature set 2”. Feature Set 1 is simply a SW upgrade while Feature set 2 includes both a SW and Base Station antenna upgrade

Enhanced load balancing is a key requirement for the support of Reuse 1 with fractional frequency reuse

Load Balancing Level 1 includes:
a) DL frequency over-ride on network entry and re-entry and
b) b) Base Station initiated handover

Load Balancing Level 2 includes:
a) Ranging abort timer Range-Response (RNG-RSP) and
b) Preamble index over-ride

A key feature for improvement in spectral efficiency and throughput is reducing the overhead required for Hybrid Automatic Repeat request H-ARQ.

Today’s WiMAX, WiMAX 16e supports HARQ Category 4. Feature Set 1 supports HARQ Category 5 and Feature set 2 supports HARQ Category 6. The lower overhead with Cat 5 and Cat 6 results in improved spectral efficiency without sacrificing traffic integrity

Average Spectral Efficiency

TDD, 10 MHz Channel BW, 3:2 DL/UL Ratio

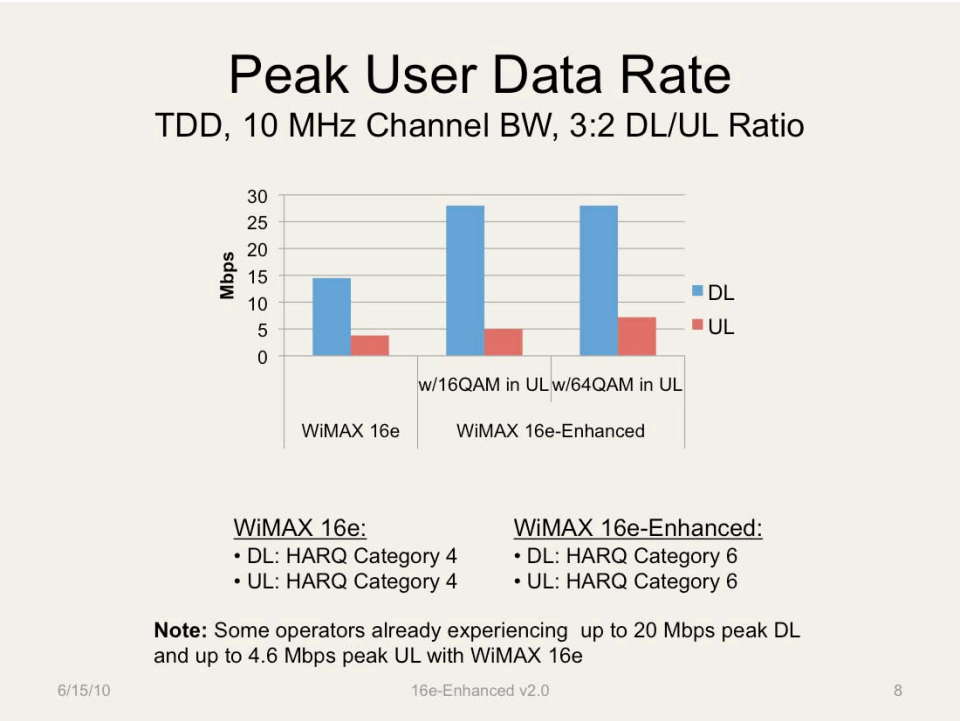
- Simple SW upgrade (Feature Set 1) provides ~40% Spectral Efficiency improvement
- Additional enhancement (Feature Set 2) provided with 4 Tx antennas (in DL) & 4 Rx antennas (in UL) at the base station (~60% DL & ~75% UL)

With an easy to implement SW upgrade to existing WiMAX infrastructure, Service Providers will realize a 40% increase in spectral efficiency.

This enables a cost-effective 40% increase in overall system capacity. There is no need for additional spectrum and no need to insert additional base stations to meet growing consumer demand.

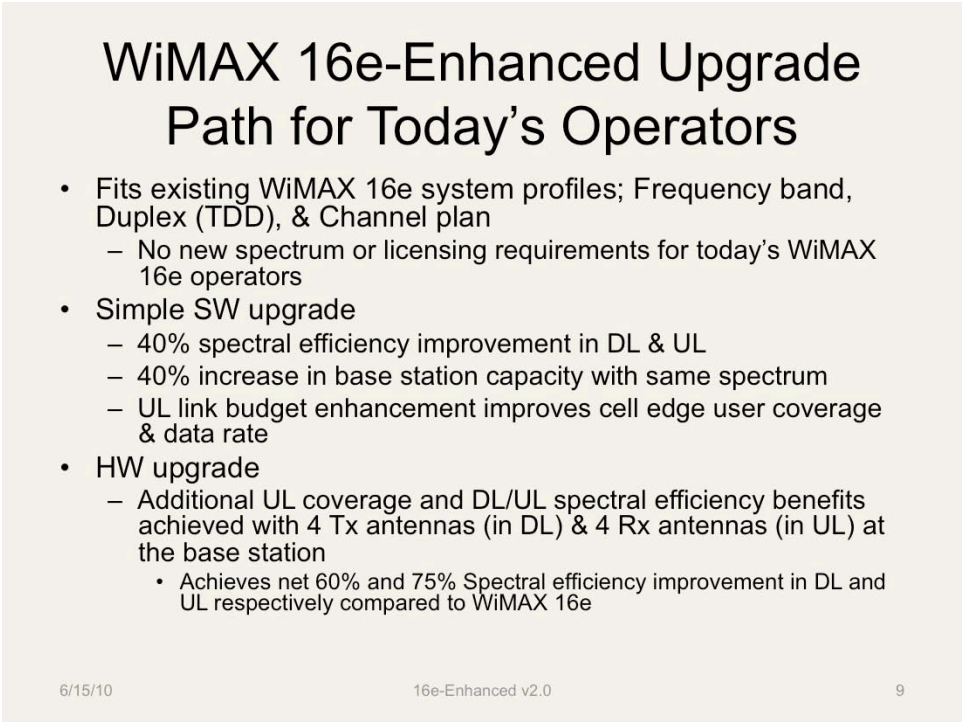
The added HW upgrade, included in feature set 2, results in an overall spectral efficiency increase of approximately 60% in the DL and 75% in the UL.

Bottom line is: A higher spectral efficiency translates to a lower cost per megabit for the operator.



Since the 16e-Enhanced features are already part of the current IEEE standard, some of them are already available from some vendors today. Some operators therefore are already experiencing higher peak user DL and peak user UL rates than are shown in the graph. 20 Mbps has been demonstrated in the DL and up to 4.6 mbps in the UL. The 14.5 and 3.8 peak user rates for DL and UL respectively shown in the graph for WiMAX 16e represent a conservative estimate of what we are experiencing with current WiMAX networks.

Fully implementing the 16e-Enhanced upgrades will achieve an almost 2x improvement in the DL peak user rate and ,with 16QAM in the UL, an improvement of 30% over what is typically available today.



For today's WiMAX operators WiMAX 16e-Enhanced provides a straightforward migration path.

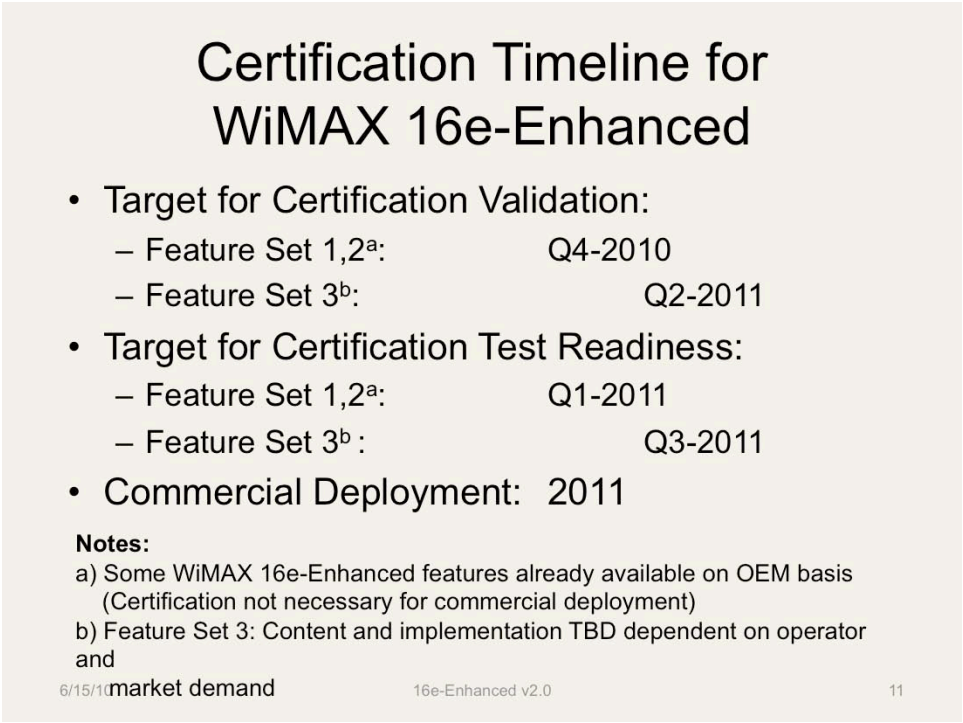
Operators can elect to go only with the simple SW upgrade for a 40% spectral efficiency and base station capacity improvement or implement all of the supported 16e-Enhanced features by also upgrading the base station antenna configuration.

Operators may also elect to implement the HW upgrade in only those portions of the network most in need of the added performance benefits such as urban areas with high customer densities.

WiMAX 16e-Enhanced also significantly increases the addressable market for WiMAX solutions. With improved interference management and support for reuse 1 WiMAX 16e-Enhanced is a more cost-effective solution for operators in markets with limited spectrum.

This is especially relevant in markets where Service Providers have less than 30 MHz of spectrum available.

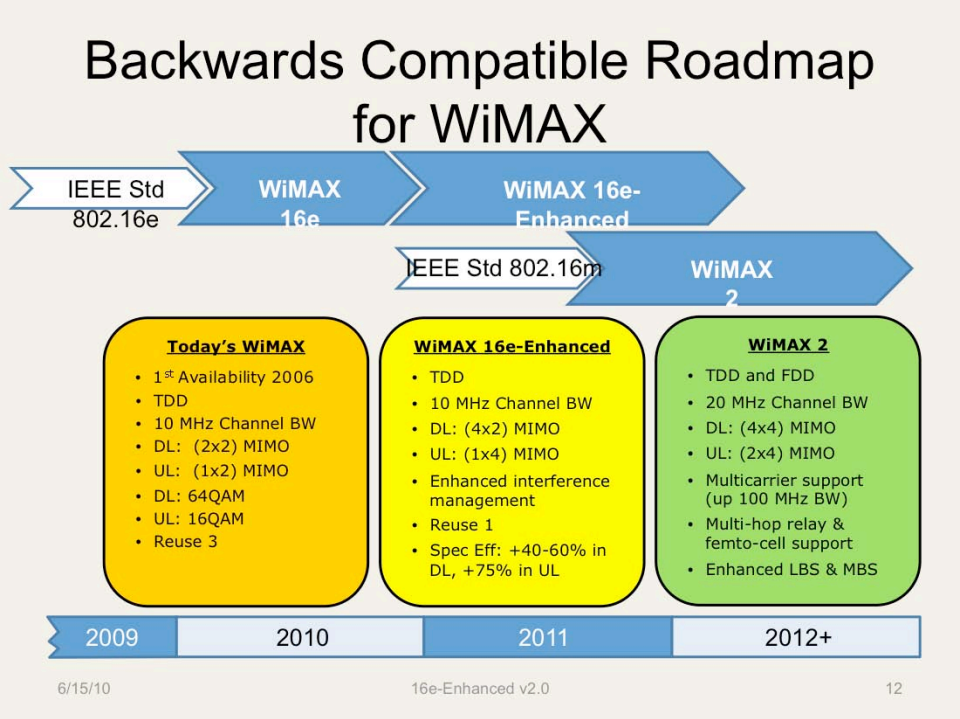
In India for example, where licensees are limited to 20 MHz of spectrum , an operator can deploy WiMAX 16e-Enhanced with a reuse factor of 1 and achieve a comparable base station capacity to a deployment with 30 MHz of spectrum with a reuse factor of 3.



As was stated earlier, since these additional features are already part of the current IEEE standard, some of them are already available from some vendors today and will be available on a broader scale from many vendors by the end of 2010.

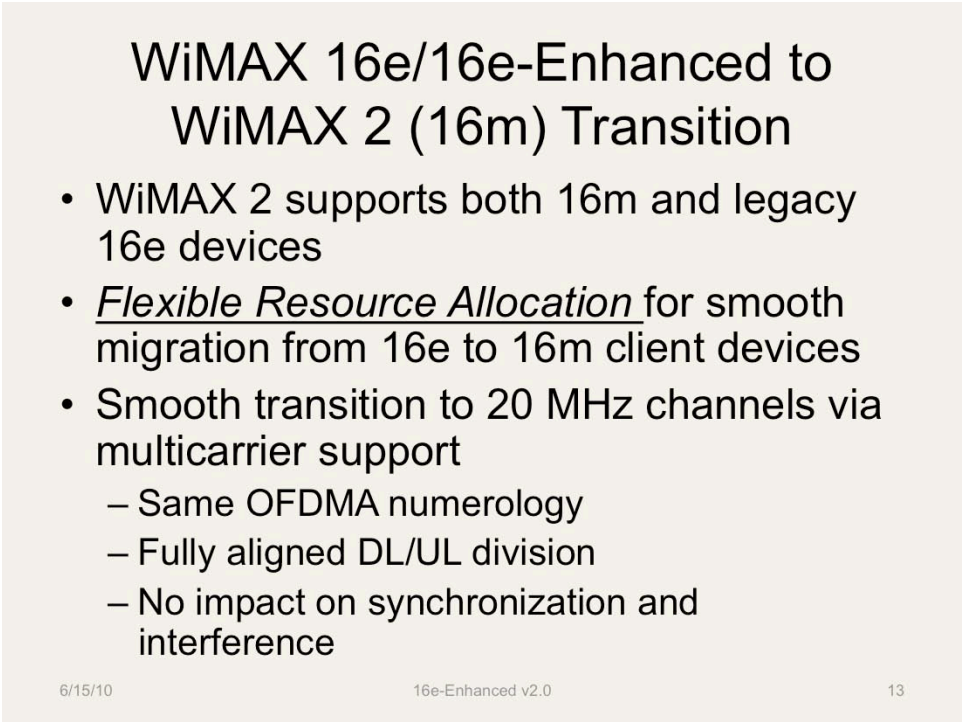
The WiMAX certification timeline will ensure full interoperability with target availability for certification test readiness in the first quarter of 2011.

Discussions have also been going forward with respect to a 3rd feature set anticipating the possible need for an additional interim step between WiMAX 16e and WiMAX 2. Details and timing for a possible feature set 3 will be dependent on operator and market demand.



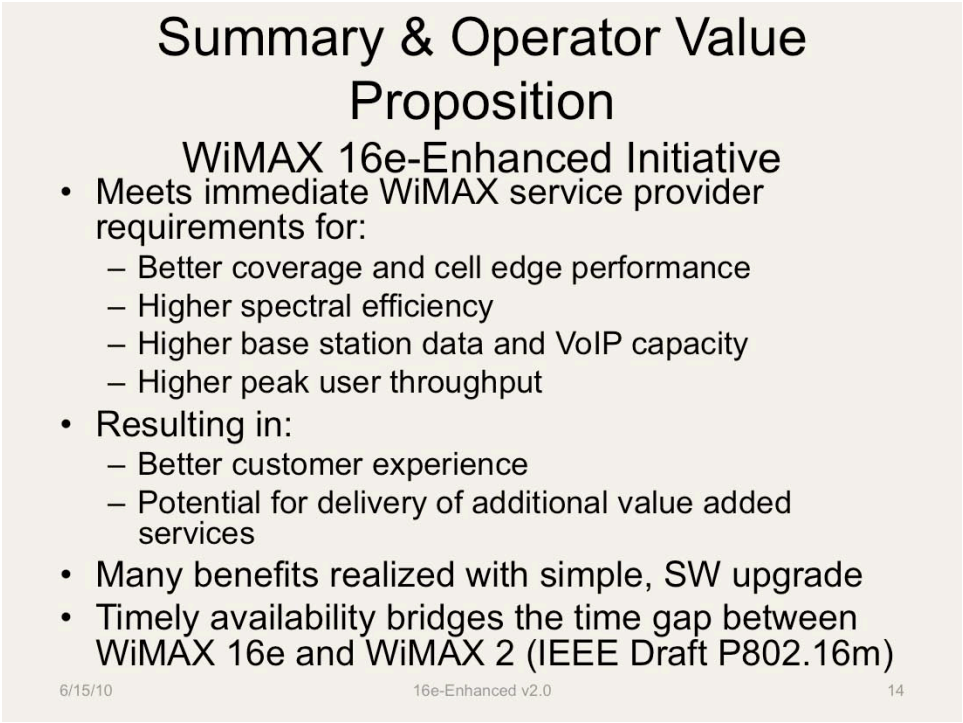
Availability of WiMAX 16e-Enhanced in late 2010 and on a broader scale in early 2011 provides a timely migration path for today's WiMAX Operators to meet the growing consumer demand for broadband services.

Additionally, 16e-Enhanced provides a timely stepping stone to WiMAX 2 based on 802.16m. Initial WiMAX 2 availability is expected in late 2011.



Throughout this collaborative effort, considerable attention is being paid to the transition from WiMAX 16e to WiMAX 2.

This is a backwards compatible migration path that will ensure support for both 16m client devices and legacy 16e client devices. It is especially important to ensure a smooth transition from 10 MHz channel BW as in 16e to 20 MHz channels that will be supported in WiMAX 2.



From a WiMAX operator perspective the value proposition is clear.

The WiMAX 16e-Enhanced Initiative meets the immediate service provider requirements for added performance.

This added network capability will result in an enhanced customer experience and provide the operator the opportunity to use the throughput improvements to deliver additional value added services.

Many of the enhancements can be implemented with a low cost, simple SW upgrade and for those operator desiring to go to the next step, a smooth and graceful transition to WiMAX 2 is assured.

Acronyms

• FFR	Fractional Frequency Reuse
• HARQ	Hybrid Automatic Repeat Request
• ICIC	Inter-Cell Interference Coordination
• LBS	Location Based Services
• MBS	Multicast Broadcast Services
• RNG	Range Response
• SBS	Subscriber (Station) Basic Capability
• SM	Spatial Multiplexing