WHITE PAPER

The Business of WiMAX: Impact of Technology, Architecture & Spectrum on the WiMAX Business Case

Table of Contents

Introduction....2
- Pairing performance with favorable economics....2
- Optimize investments, optimize returns....3

Cost of Ownership....4
- WiMAX Cost Categories....4
- Capital Outlay versus Operating Expense....5
- Cost of Ownership Contributions....6

WiMAX Service Revenue....7
- Fixed Today, Mobile Tomorrow....7
- Return on Investment....8

Spectrum....9
- WiMAX Spectrum Comparison....9

Infrastructure Selection....11
- Tower Top versus Ground Based Architecture....11
- Advantages of MIMO & TX-AA....14
  - Using MIMO & TX-AA for Maximum Advantage....14
  - Frequency Reuse with MIMO and TX-AA....15
  - Performance Comparison – Tower Top MIMO, Ground Based MIMO & TX-AA....17

Operator Deployment Considerations....18
- Wi4 WiMAX....18

Introduction

Pairing performance with favorable economics

The advent of next generation, wireless broadband platforms pairing performance with favorable economics is ushering in a new age of unprecedented connectivity in communities across a diverse range of global markets.

Mobile WiMAX, based on the IEEE 802.16e-2005 global standard, leads the evolution roadmap with market ready solutions leveraging the chief technology enablers attributable to 4G wireless platforms. With OFDMA air interface, all IP architecture, and multiple advanced antenna options including MIMO and beamforming, WiMAX delivers the high performing connections to deliver fixed broadband with deep indoor penetration as well as high throughput, mobile broadband addressing a new breed of devices and applications that rely on broadband connections for enhanced user experience.

As a standards-based technology with wide industry support, a large ecosystem of developers, and a rapidly growing list of commercial installations, WiMAX stands to benefit from economies of scale and a vast embedded base of WiMAX enabled devices – driving down costs while spurring growth in subscriber adoption.

Operators evaluating WiMAX investments must extend their consideration beyond the accepted virtues of the technology and consider how the platform fits into their specific near and long term business model, measuring cost of ownership with potential for harnessing time-to-market advantages to grow subscriptions and generate revenue.

Optimize investments, optimize returns

A particular operator's plans for service offerings, network evolution state, trajectory of network investments, and access to spectrum are all critical variables that will contribute to determining how and when an operator introduces WiMAX technology into their network mix.

With the introduction of WiMAX we are seeing new players emerge from diverse industries such as broadcasting, content studios, utilities, and consumer electronics – looking to redraw their lines and venture into broadband services. With the participation of new players and the tremendous capabilities of the WiMAX platform, we can look forward to how conventional service is transformed and innovative personal and social applications emerge to change the game, drawing WiMAX into our everday lives.

A highly versatile technology platform, WiMAX has relevance to a wide variety of application scenarios. When designing a WiMAX system, factors including capacity or coverage requirements, fixed or mobile application, sectorization and reuse schemes, and the radio environment throughout the service perimeter will all contribute to determining the right feature set and capability requirements of the network.

By having a view into the end to end considerations for a WiMAX deployment and access to a wide range of infrastructure options that include tower top and ground based design, MIMO and beamforming solutions, operators will have the flexibility to optimize their network design on a market by market and site by site basis to ensure their networks are optimized for performance, cost, and scalability.

In the end, detailed business modeling customized to the operator's market profile and service goals will provide the understanding of how to optimize the WiMAX investment to optimize the returns.

Cost of Ownership

The investment model for WiMAX installations must consider all aspects of design, deployment, and integration from the core through the systems architecture, service edge, access network and device. While the initial spend on a WiMAX deployment will have a large focus on capital components associated with procuring the necessary equipment throughout the network and systems architecture, as the WiMAX service is introduced and subscriber adoption and usage rates grow, the ongoing operating expenses will consume a growing share of the total cost of ownership. As such, it is important that the operator consider the end-to-end impact of deploying and operationalizing a WiMAX system and how each effort contributes to the cost of ownership.

WiMAX Cost Categories

Consider the following broad areas of WiMAX investment concerns:

Infrastructure
Infrastructure includes the WiMAX base station equipment providing the downlink and uplink communication channels as well as the WiMAX service edge network managed by the ASN Gateway supporting centralized control functions for the network and negotiating the bearer path traffic through the core.

Device
Device costs can contain subsidies for fixed and mobile WiMAX devices supported by the operator. Devices may include outdoor subscriber units for improved coverage and capacity, self-install desktop subscriber units receiving signals through the building walls, PC cards to bring the WiMAX connection directly to the laptop for a nomadic experience, mobile devices featuring multimode/multi-band operations and broadband-like data throughput.

Core
Core includes edge and core IP networking components supporting the IP traffic administered on the WiMAX network, content management and delivery nodes, and gateways to the Internet and public telephone network.

Site
Site costs include site acquisition for deploying WiMAX base sites on existing properties, development of new towers and associated zoning, engineering and construction costs, as well as any enhancements or modifications to existing sites to support the WiMAX equipment.

Backhaul
Backhaul considers the connections for backhauling traffic from each of the WiMAX base stations to aggregation hubs in the wider area network via point-to-point links. Traditional backhaul solutions have considered either T1/E1 leased line services or microwave links. More recently, as backhaul requirements for high capacity systems like WiMAX have made leased line services economically unfavorable, operators are increasingly selecting more cost-effective, next generation IP wireless backhaul solutions.

IT
IT costs consider all aspects of systems architecture development and integration in support of the WiMAX network architecture and service. IT may include operational and billing support systems, call record rating and mediation engines, and customer relationship management platforms.

Operations
Operating costs include ongoing network maintenance, support and warranty, subscriber acquisition costs, marketing and advertising, and general and administrative (G&A) expenses.

Infrastructure	Device	Core	Site	Backhaul	IT	Operations
WiMAX Base Station Equipment WiMAX Service Edge Network	Subsidies for fixed and mobile WiMAX devices	Edge and Core IP Networking Elements Content Management & Delivery Media Gateways	Development Acquisition Rental Utilities	Wireless Backhaul Equipment Wireline Backhaul Installation & Leasing	OSS / BSS Development & Integration CRM	Maintenance Support & Warranty Subscriber Acquisition Marketing G&A

Capital Outlay versus Operating Expense

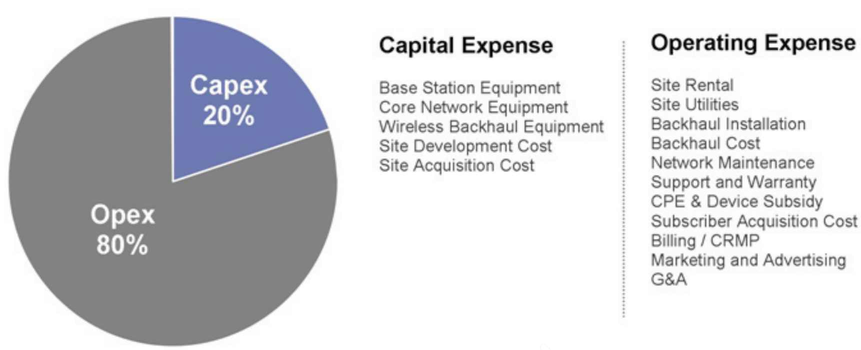
As in any major network deployment, the total cost of ownership of a WiMAX network will be comprised of both the initial capital outlay to procure the WiMAX equipment as well as the ongoing operational expense of managing and maintaining the WiMAX service.

While evaluation of the components contributing to the capital expense often consumes a large percentage of the operator's WiMAX consideration, the operating expenses will over time far outweigh the initial capital outlay.

This is due to both the nature of telecommunication operations as well as to the significant capital cost reductions engineered in leading WiMAX vendor solutions. Such solutions may offer light infrastructure approaches that benefit from an integrated design reducing real estate requirements and allowing for simple connections between components. Flexible hardware and software programmable radios provide the benefit of no-touch software updates. Integrated RF antenna design eliminates the need for costly and heavy coaxial cables between antennas and baseband modules and avoids power losses associated with heavy RF coaxial cables. Additionally, the WiMAX network architecture can be realized as a simple, peer-to-peer network based on a flat, all IP design. Such architectures can be significantly lighter and easier to install and maintain than traditional cellular based network designs and can substantially reduce the capital expense by leveraging IP networking equipment.

Over the course of seven years, the capital expenses including components such as base station, core, and wireless backhaul equipment will contribute roughly 20% of the total cost of ownership while the operating expenses including maintenance, support, device subsidies, and administration will contribute roughly 80%.

This underlies the importance of designing and deploying the end to end service network with strong consideration to the ongoing management and service support requirements. A well designed WiMAX network must include a scalable approach to the infrastructure supported by common management elements to accommodate subscriber growth and usage over time, strong integration between network and systems architectures to support operating procedures throughout customer care and point of sale, effective backhaul strategies limiting ongoing lease costs traditionally encountered with wireline solutions, and versatile deployment options to reduce site costs.



Cost of Ownership Contributions

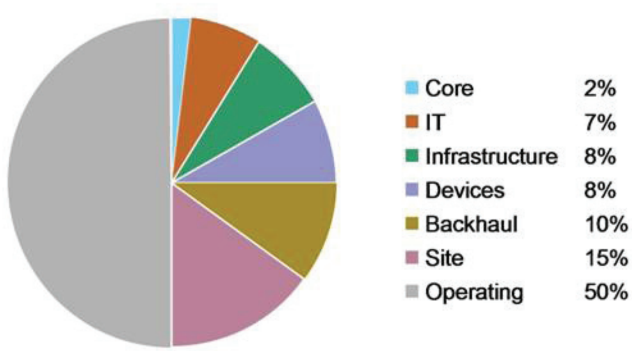
The cost categories contributing to the overall WiMAX cost of ownership model will have varying impact to the operator's financials. While identifying strong infrastructure solutions is an imperative to assure the performance, capabilities, and scalability necessary to deliver a differentiated service offering, WiMAX infrastructure may comprise less then 10% of the cost of ownership in many cases. It is equally important that the infrastructure solutions offer good flexibility in deployment approaches to reduce the larger contribution site costs pose on the cost of ownership model. Having access to infrastructure solutions with flexible deployment options including outdoor and indoor, wall mounted for on-building installation, pole mounted for existing towers, base mounted for rooftop or ground based systems, and rack mounted where existing sheds are available can allow the operator strategic options for managing the over 15% contribution site costs typically pose on the cost of ownership.

Backhaul contributions can vary dramatically depending upon the technology employed to manage the aggregate bandwidth. When using traditional wireline backhaul, operators may expect to have as much as 20% of the cost of ownership dedicated to backhaul. On the other hand, by leveraging advanced wireless point-to-point solutions, backhaul costs can be reduced to less than 2% of the cost of ownership. Adopting similar attributes to the WiMAX access technology, these wireless point-to-point solutions utilize OFDM and MIMO technology with strong interference mitigation capabilities when operating in unlicensed spectrum and offer licensed spectrum products where demanded. The backhaul contribution shown in the figure below represents a mix of wireless and wireline backhaul installations.

Core and IT projects associated with the WiMAX service will benefit from the all IP based architecture of the WiMAX technology platform. Operators have the opportunity to consider how the introduction of a WiMAX access solution may be paired with a converged IP core and service delivery platform to further enhance the service capabilities as well as introduce design efficiencies into the architecture benefiting from the steep cost curves of IP.

Operating costs can be expected to comprise the largest share of the cost of ownership. Operators will need to pay due attention to deploying a WiMAX service network that can be readily operationalized with effective management capabilities and strong integration to the systems architecture.

Operators planning investment into WiMAX installations will need to be certain that their front-end strategy and planning efforts consider the end-to-end proposition of the network, systems, and service to truly reap the cost benefits of WiMAX and the revenue potential of WiMAX services.



WiMAX Service Revenue

Service revenue from WiMAX networks will be benefited by a host of differentiable, value-added offerings that take advantage of the high-performing, wireless connections. Developing a portfolio of services that address the various needs across the operator's end-user segments including basic residential, high spend residential, small to medium business, enterprise, and government will allow the operator to realize swift return on the WiMAX investment, generate strong revenue, and grow market share.

With WiMAX providing the connections across a landscape of devices, operators can realize a host of rich services across an applications framework that may include Personal Communications, mCommerce, Mobile Entertainment, and Enterprise applications. With the IP foundations of the WiMAX architecture, operators can readily deliver the next wave of both fixed and mobile broadband applications emerging from all corners of the Internet.

By providing the right mix of value added services over next generation IP core and access networks, operators can differentiate themselves over the crowd of encroaching competitors and position themselves as the clear provider of choice for future applications and services.

In addition to subscription revenue, many operators are considering innovative revenue models that benefit from an open access model where eligible devices accessing the WiMAX network will be charged fees on a usage basis rather than through a monthly contractual obligation. This model offers the opportunity to harvest revenue from a broad ecosystem of consumer electronics enabled with WiMAX capabilities.

The adoption of IP in all aspects of the service delivery value chain is dramatically altering the relationships that have traditionally existed between the operator and the end-user. Increasingly, the operator is sharing an expanded ecosystem with content providers and advertisers. Operators are recognizing that content, applications, and personalization are driving differentiation. By engaging and encouraging the participation of content providers and accelerating the introduction of compelling applications and services, operators can be well positioned to develop the strong relationships with their customers and accrue the full value of their network.

Fixed Today, Mobile Tomorrow

A distinct advantage of the IEEE 802.16e-2005 WiMAX technology standard is its ability to deliver powerful connections across fixed, nomadic and mobile applications. Operators can consider a strategy of utilizing the 802.16e-2005 equipment to deliver a fixed and nomadic offering at the very onset of their service launch to speed time-to-revenue. With each WiMAX site that is turned up, the service perimeter surrounding that site can be leveraged to deliver fixed connections analogous to traditional wireline broadband such as DSL or Cable Modem service as well as nomadic, hot spot coverage similar to Wi-Fi but with greater reach. As the number of sites in the operator's deployment grows to provide more pervasive coverage over a greater geography, operators will have the opportunity to introduce mobile WiMAX services in addition to the existing fixed offering.

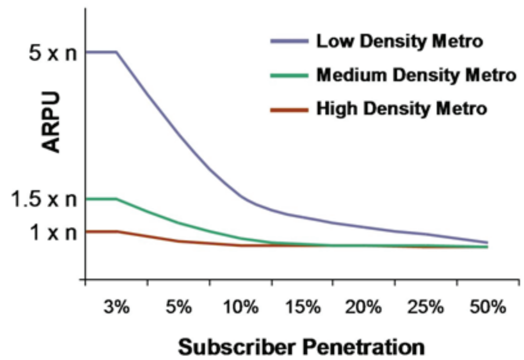
The flexible, software definable radios incorporated into leading 802.16e-2005 WiMAX equipment allows for simple software updates to enable full mobility application - giving operator's the confidence to deliver fixed, nomadic applications today and to evolve into fully mobile applications as their offerings strategy and market requirements demand the capability.

Return on Investment

At lower subscriber penetration rates, as one may find at the onset of a WiMAX service launch, a smaller base of end-users will be supporting the cost for a WiMAX network engineered to deliver coverage but perhaps underutilizing the inherent capacity built into the system. As subscriber penetration grows and the capacity built into the network becomes better utilized, the ARPU requirement per subscriber will drop rapidly. As we increase beyond a particular threshold of subscriber penetration, the ARPU requirement can be expected to reach a steady state. At this stage of the WiMAX service, the already established base of subscribers are generating the necessary revenue to support the initial coverage focused deployment; additional subscribers brought onto the network will provide the service revenue to support capacity focused network expansions.

The chart below shows the ARPU requirement for a seven year payback on the WiMAX investment for three different metro environments: High, Medium, and Low Population Density. Population density is measured as the number of addressable users within a given coverage area. The ARPU requirements for each of the three metro environments are represented on the chart across varying subscriber penetration rates.

As we see, the low density metro area may have a five-fold higher ARPU requirement than the high density metro area at low subscriber penetrations. In this scenario, fewer addressable subscribers are available in the low density metro area to support the broader network deployment needed to provide pervasive coverage. However, over time, as the subscriber loading increases and the penetration rate grows we see that each of the market profiles converge toward a much lower, steady-state ARPU threshold.



Metro Category	Subscriber Density	Example Cities
Low Density Metro	~1,500 Pop/km2	Atlanta, Prague
Medium Density Metro	~5,000 Pop/km2	Chicago, London
High Density Metro	~10,000 Pop/km2	New York City, Moscow

Spectrum

As a licensed spectrum technology platform, WiMAX investment decisions are predicated by access to appropriately regulated spectrum. Recognizing the virtues of WiMAX, regulators around the globe have allocated considerable portions of spectrum amenable to WiMAX and continue to allocate new spectrum channels to account for interest from multiple providers as well as to address the need for scaling these networks over time. The global WiMAX community has had good success in achieving some harmonization of the frequencies allocated for WiMAX. Almost three quarters of the spectrum allocated for WiMAX globally is focused in the 2.5 GHz and 3.5 GHz bands. Focusing development and deployment to a few, select bands offer greater design efficiencies as well as benefits in economies of scale – allowing steeper cost declines over time.

WiMAX Spectrum Comparison

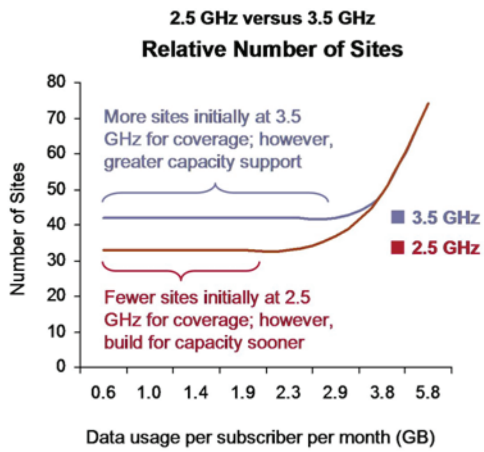
The physics of RF propagation demonstrate that as the frequency of operation increases - the coverage radius reduces for a given output power. Traditional cellular networks operate at frequency bands much lower than 2.5 GHz offering advantages in network dimensioning. However, the enhanced air interface and advanced, multi-antenna techniques offered with WiMAX allows the platform to overcome many of the disadvantages of the higher frequency of operation.

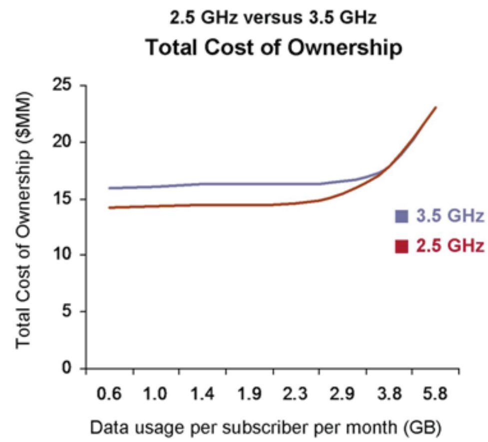
WiMAX networks deployed at 3.5 GHz may require almost 30% more sites for a given coverage area than a 2.5 GHz installation (Figure 10). This is a directional estimation that considers similar system margins contributed from penetration loss and fade margins for 2.5 GHz and 3.5 GHz systems. In actual application, the system margins are likely to be somewhat higher for a 3.5 GHz system and would be accounted for in detailed RF propagation modeling.

However, in deploying those additional sites, the 3.5 GHz network will also have 30% additional capacity inherently built into the system. As a result, the 3.5 GHz network will be able to absorb a greater rise in data consumption on the network over time and forgo additional capacity focused build out longer than a 2.5 GHz system.

The increase in sites at 3.5 GHz results in approximately 13% increase in total cost of ownership for the system over 2.5 GHz (Figure 11). Fixed costs common to both a 2.5 GHz and 3.5 GHz network including such operational line items as subscriber acquisition, systems integration and network management results in the 30% increase of sites to contribute only a 13% increase in cost of ownership. It is important to note that over time as capacity increases and the 2.5 GHz system requires investments in new build out earlier than the 3.5 GHz system – both the 2.5 GHz and 3.5 GHz system will demonstrate parity in cost of ownership.

Figures 10 & 11 – Comparison of 2.5 GHz and 3.5 GHz systems based on number of sites and cost of ownership





Infrastructure Selection

An optimized WiMAX system design must address the operator's market-specific requirements including frequency planning, deployment geography and planned service offerings. Additionally, these requirements may vary throughout an operator's service perimeter and may evolve over time.

Operators can design the best-fit network – mixing and matching across a host of base station types - when they have access to a range of infrastructure options with varying capabilities that address diverse deployment scenarios and operate under common management and controls.

Tower Top versus Ground Based Architecture

Network operators engaged in infrastructure selection for WiMAX base stations will want to select between more traditional, ground based design or innovative tower top approaches. Where a tower top approach may offer advantages in operating costs given the light infrastructure design, a ground based approach is capable of delivering higher power transmission and may extend the downlink coverage area.

Ultimately, any architecture selection process will benefit from a thorough cost of ownership model that considers expenses related to equipment, site development, backhaul, and a host of operational considerations.

However, it is possible to offer general direction in the decision process between tower top and ground based approaches. An understanding of the data rates required at the cell edge for a given market, the system gains afforded by the various base station types, and whether a given site deployment is limited by the uplink or downlink cell edge data rate will determine the optimal approach.

The following example provides a high-level methodology for deciding between tower top and ground based solutions (Figure 1). In this diagram, a downlink cell edge data rate curve is drawn against cell radius for both a tower top and ground based access point. As expected, the ground based access point will deliver greater downlink throughput than the tower top access point for a given cell radius. Additionally, we have overlaid a line corresponding to the maximum cell radius that can be supported by a given uplink data rate.

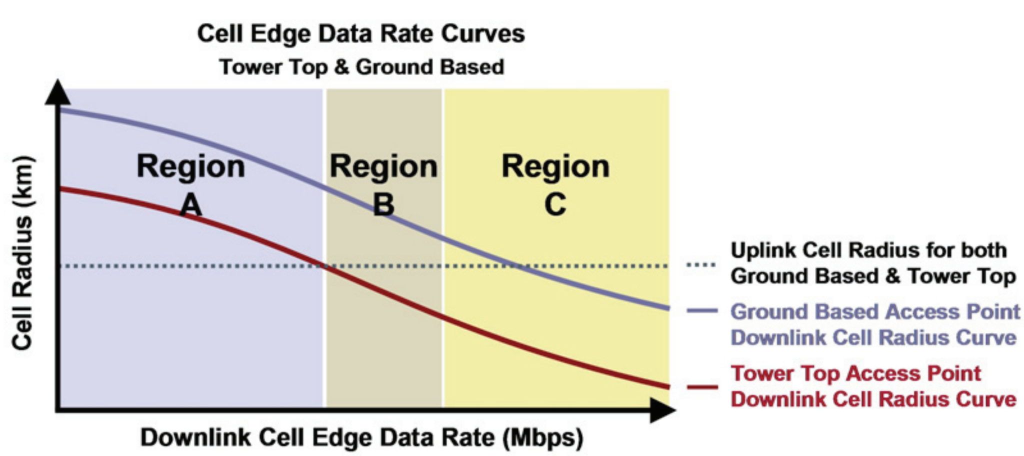


Figure 1 – Illustration of cell edge data rate curves for tower top and ground based access points

Three regions are considered within this diagram – Region A, Region B, and Region C.

In Region A we recognize that the cell radius achievable by the installation is limited by the uplink data rate requirement. Region A may be most representative of many urban environments where the usage model tends to challenge the uplink capacity. In Regions B & C we recognize that the cell radius achievable by the installation is limited by the downlink data rate requirement – more clearly so in Region C. Region C may be most typical in more rural geographies where the usage models tend to demonstrate greater pull on downlink capacity.

Based on these distinctions, the following table offers the criteria that can be considered for base station architecture selection pertaining to each of these regions.

Region A	Region B	Region C
Architecture Choice: **Tower Top**	Architecture Choice: **Tower Top or Ground Based**	Architecture Choice: **Ground Based**
The WIMAX cell radius is limited by the uplink link budget in Region A	The WiMAX cell radius is nominally limited by the downlink link budget in Region B	The limitation on the WiMAX cell radius is dominated by the downlink link budget in Region C
Generally found in urban environments	*Generally found in suburban environments*	*Generally found in rural environments*
In this scenario, the operator will benefit from a tower top solution with a light architecture approach and low operating costs. The higher power, ground based solution providing increased downlink coverage at the cell edge will not offer any benefit to alleviate the uplink limitation of this deployment scenario.	For deployment scenarios focused in Region B, the operator will benefit from more extensive cost of ownership modeling. Comparative costing between tower top and ground based equipment, site development, backhaul, and operational considerations will contribute to highlighting the optimal technology decision.	Utilizing a higher powered, ground based architecture can provide clear advantage over a tower top solution in increasing the downlink coverage to achieve the required throughput profile.

Table 1 – Selection criteria for tower top or ground based architecture

Figures 2 & 3 represent simulated performance data for a WiMAX ground based and tower top design for both fixed and mobile application. The access points represent 2x2 MIMO systems operating at 10 MHz channel bandwidth at 2.5 GHz. The maximum cell radius corresponding to uplink cell edge data rates are shown for 250 kbps and 1 Mbps.

The cell radius is offered as a normalized representation from r1 to r10 and corresponds to the maximum cell radius achievable by the system gain offered with each base station technology. Geography and market specific variables such as propagation environment and penetration losses will contribute to defining a specific coverage range.

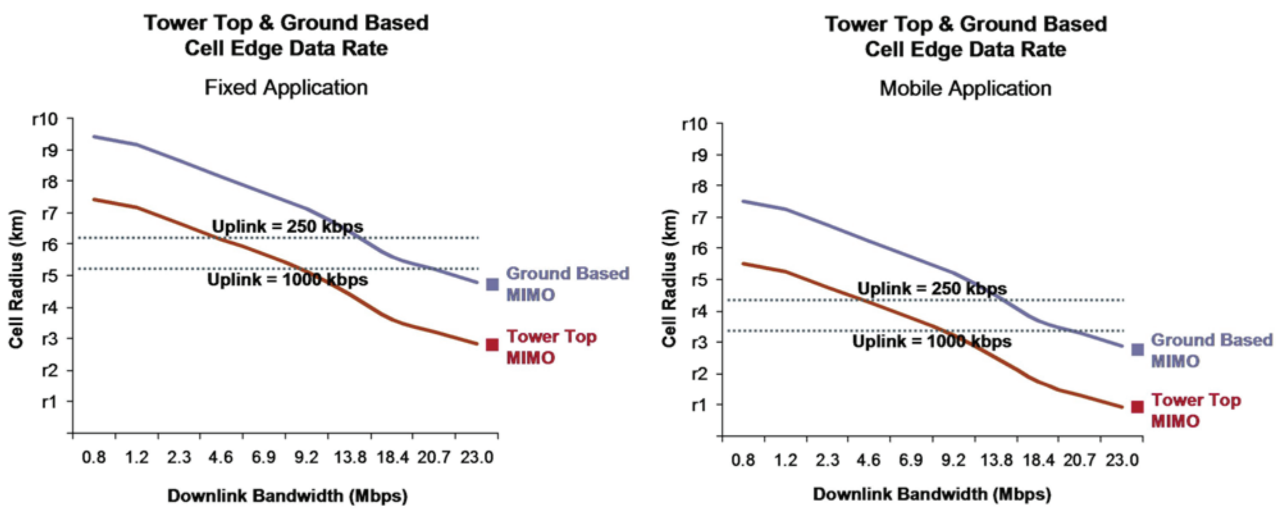


Figure 2& 3 – Simulated performance curves for tower top and ground based access points with fixed and mobile application

MIMO

The WiMAX standard considers two versions of MIMO capability referred to as MIMO Matrix A (STBC) and MIMO Matrix B (SM-MIMO).

With MIMO Matrix A, a single data stream is replicated and transmitted over multiple antennas. The redundant data streams are each encoded using a mathematical algorithm known as Space Time Block Codes (STBC). MIMO Matrix A is fundamentally used to enhance system coverage.

With MIMO Matrix B, the signal to be transmitted is split into multiple data streams and each data stream is transmitted from a different base station transmit antenna operating in the same time-frequency resource allocated for the receiver. MIMO Matrix B provides a very capable means for increasing the channel capacity.

An ideal WiMAX system employing MIMO techniques will support both Matrix A and Matrix B, dynamically shifting between the two approaches to offer the necessary coverage or capacity gains demanded from the network at any given time or location.

Beamforming / TX-AA

WiMAX systems that use TX-AA or "beamforming" as a means to further increase system coverage and capacity can in many instances surpass the capabilities of MIMO techniques. Beamforming techniques such as Statistical Eigen Beamforming (EBF) and Maximum Ratio Transmission (MRT) are optional features in the 802.16e WiMAX standard, but leading vendors are taking advantage of its strong performance characteristics.

Beamforming techniques leverage arrays of transmit and receive antennas to control the directionality and shape of the radiation pattern. The antenna elements have spatial separation dictated by the wavelength of transmission and are supported by sophisticated signal processing. By leveraging constructive and destructive interference, the radiation pattern is steered and formed to provide an optimal radiation pattern focused in the direction of communication.

Advantages of MIMO & TX-AA

Revolutionary multi-antenna techniques such as MIMO and TX-AA at the base station and end-user device, paired with sophisticated signal processing, can dramatically improve the communications link for the most demanding application scenarios including heavily obstructed propagation environments and high speed mobility service. Where conventional wireless network design has long used base site sectorization and single, omni-directional antennas at the end-user device to serve the communications link, with advanced multi-antenna implementations operators have a new suite of tools to develop the robust wireless networks of the future.

WiMAX has offered the industry a very capable platform by which to deliver the demanding service requirements for wireless access today and tomorrow. With the added support for a variety of advanced multi-antenna implementations, WiMAX offers the wireless operator considerable relief in meeting their growing network demands with higher performance, fewer sites, less spectrum, and reduced cost.

Using MIMO & TX-AA for Maximum Advantage

A MIMO system will demonstrate the greatest capacity gain over a SIMO (Single Input Multiple Output) system in environments that offer high scattering conditions such as urban locales. However, as interference levels increase, the capacity gain that can be realized from a MIMO system diminishes. In contrast, a TX-AA system provides the greatest performance advantage over a SIMO system in high interference environments.

Any network deployment must consider an evolving architecture designed to meet the needs of today while providing flexibility to optimally scale for future network growth. When a network deployment is primarily focused on coverage, a TX-AA system may be a preferable option given the large coverage radius that can be supported. Such a scenario may be likely at the early stages of a network deployment where there is interest in providing broad coverage but subscriber adoption has not yet warranted further capacity focused build out.

As subscriber adoption and user data consumption increases, as might be expected in urban environments, the MIMO system offers a way to provide additional capacity benefiting from the high scattering profiles of these areas.

In later years, as the concentration of sites increases, the interference level in the service perimeter may increase to where the MIMO capacity benefit begins to degrade. At this point in the network evolution, a TX-AA system may again be considered as a preferable way to provide increased performance in the high interference environment.

Frequency Reuse with MIMO and TX-AA

The selected frequency reuse scheme for a given installation can have a strong bearing on the technology decisions for the WiMAX base stations. In Figures 4 & 5 we demonstrate the sector throughput improvement using either TX-AA or MIMO for various frequency reuse schemes.

We find that a 2x2 MIMO system offers the best performance in a frequency reuse pattern of 1x3x3 where interference is lowest. The MIMO system can offer strong performance advantages to operators who have sufficient spectrum allocations to deploy with a 1x3x3 frequency reuse scheme. The MIMO system offers the least advantage in a 1x3x1, single frequency network where high interference can be expected.

Alternatively, the TX-AA system which provides the best advantage over SIMO systems in high interference environments, demonstrates the greatest advantage with a 1x3x1 system and the least advantage in the 1x3x3 system.

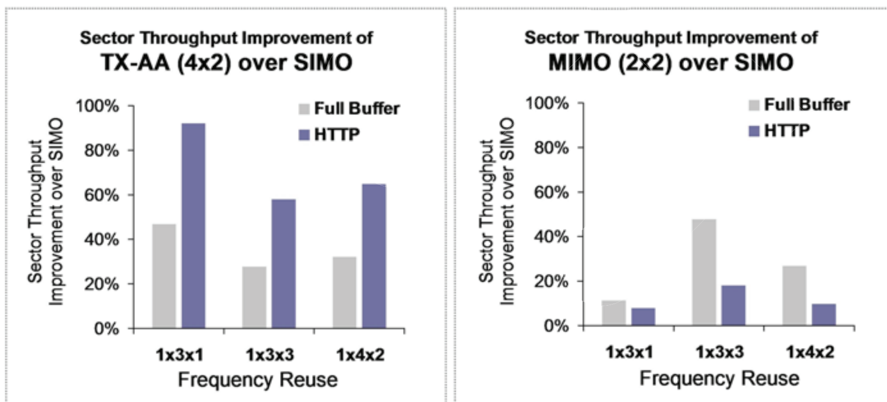


Figure 4 & 5 – Advantages of TX-AA and MIMO over SIMO for various frequency reuse schemes

Tables 2 & 3 represent both the downlink and uplink throughput improvement offered by MIMO & TX-AA over SIMO systems

Downlink Throughput Improvement MIMO & TX-AA over SIMO

	WiMAX 1x3x1	WiMAX 1x3x3	WiMAX 1x4x2
MIMO (Using MMSE Receiver)	11%	48%	27%
MIMO (Using MLD Receiver)	27%	70%	56%
TX-AA	47%	28%	32%

Uplink Throughput Improvement TX-AA over SIMO

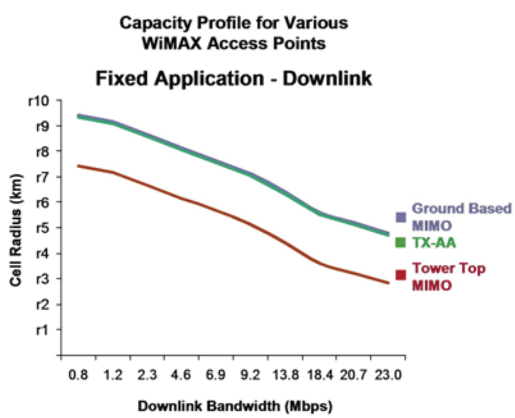
	WiMAX 1x3x1	WiMAX 1x3x3	WiMAX 1x4x2
TX-AA (Using MRC Receiver)	63%	2%	23%
TX-AA (Using SDMA Receiver)	95%	91%	79%

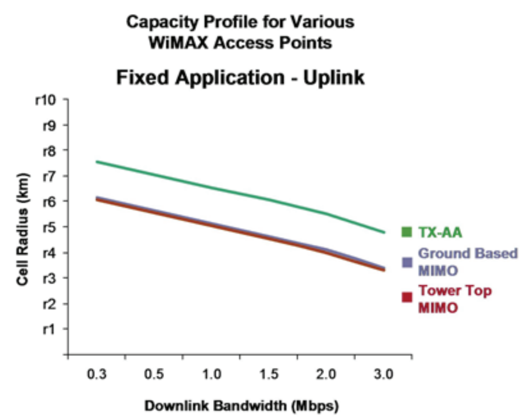
Tables 2 & 3 – Downlink & uplink improvement of MIMO & TX-AA over SIMO systems

Of course, the throughput and coverage capabilities of WiMAX systems are highly influenced by the radio environment, the profile of data and voice traffic on the network, frequency planning, and subscriber loading. Careful profiling of the service requirements for the WiMAX network combined with sophisticated RF modeling using detailed topological information of the service geography are a critical component for planning a deployment approach. Experienced analysis can provide the necessary insights as to the optimal combination of RF solutions and multi-antenna techniques on a site-per-site basis - ultimately resulting in an optimized business model.

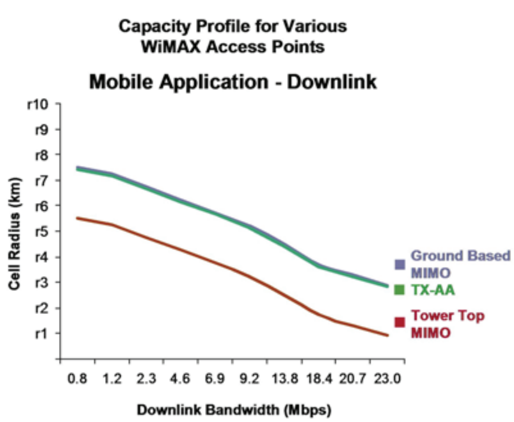
Performance Comparison – Tower Top MIMO, Ground Based MIMO & TX-AA

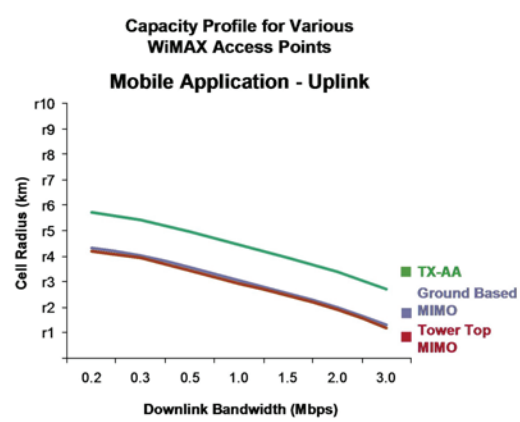
The following graphs represent the performance capabilities of tower top MIMO, ground based MIMO, and TX-AA WiMAX access points for fixed, mobile, downlink, and uplink scenarios.





Figures 6, 7, 8 & 9 – Advantages of TX-AA and MIMO over SIMO for various frequency reuse schemes





Operator Deployment Considerations

WiMAX offers significant cost advantages in either greenfield or overlay installations over traditional cellular or broadband alternatives. The economics of WiMAX deployment has been demonstrated as favorable to markets as diverse as emerging markets with challenging price constraints seeking access to basic voice and data connectivity to mature markets seeking to enhance existing broadband services with mobile broadband applications.

Operators seeking to make investments into WiMAX installations will need to consider the end to end implications of deploying the WiMAX service including all aspects of capital outlay and ongoing operational expenses. By garnering support from vendors with the capability to navigate through the end to end concerns and capability to support the technology and business modeling efforts will help ensure that a best fit strategy is achieved at the front end of the planning process.

With a rich history of delivering advanced wireless communications systems and significant global experience in deploying WiMAX solutions to markets around the world, Motorola understands the importance of tailoring an operator's deployment objectives and has strong capabilities in WiMAX network dimensioning and business modeling. Motorola looks forward to working with operators to further explore how the performance and economics of WiMAX can position them to reap the benefits of next generation technology and service.

wi4 WiMAX

Motorola's wi4 WiMAX portfolio of 802.16e products and services offers industry leading breadth and depth, allowing us to map the right architecture to meet an operator's specific deployment issues. Recognizing that a true end-to-end solution extends beyond the access network, Motorola's wi4 WiMAX solutions deliver an extensive portfolio of compelling devices and handsets, operations and management tools, integration and optimization services and, most important, the confidence to bring WiMAX to market.

Motorola's wi4 WiMAX infrastructure solutions offer unmatched flexibility for designing the optimal solutions for service providers from all corners of the globe. Our WiMAX solutions follow a design philosophy focused on high performance, reduced cost, rapid deployment and ease of management. The all IP distributed architecture lowers network costs, eases integration and supports better service delivery. Our light infrastructure solutions leverage low profile, reduced cost designs and are ideal for emerging markets. We offer substantial capacity and coverage gains with deep indoor coverage and full MIMO and Smart Antenna solutions for fixed and mobile applications. Operators are benefited by considering the broad wi4 WiMAX portfolio of tower top, ground based, MIMO, and Smart Antenna solutions to deploy a hybrid network that maximizes the coverage and capacity to specific locations and usage requirements throughout the service area while tuning the investment to realize the optimal business model.

Bottom line, our versatile wi4 WiMAX solutions help you give your customers truly personal broadband: uninterrupted, always on access to information, entertainment and communication.

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