WiMAX: The Business Case

Introduction

The term WiMAX[1] (Worldwide Interoperability for Microwave Access) has become synonymous with the IEEE 802.16 Wireless Metropolitan Area Network (MAN) air interface standard. In its original release the 802.16 standard addressed applications in licensed bands in the 10 to 66 GHz frequency range. Subsequent amendments have extended the 802.16 air interface standard to cover non-line of sight (NLOS) applications in licensed and unlicensed bands in the sub 11 GHz frequency range. Filling the gap between Wireless LANs and wide area networks, WiMAX-compliant systems will provide a cost-effective fixed wireless alternative to conventional wire-line DSL and cable in areas where those technologies are readily available. And more importantly the WiMAX technology can provide a cost-effective broadband solution in areas beyond the reach of DSL and cable.

This paper will provide a detailed business case analysis for the WiMAX technology in the sub 11 GHz frequency range. Two demographic scenarios are analyzed and two market models, one in which the operator only elects to offer services to residential customers and the second in which both residential and small to medium business customers are addressed.

WiMAX Architecture and Applications

A wireless MAN based on the WiMAX air interface standard is configured in much the same way as a traditional cellular network with strategically located base stations using a point-to-multipoint architecture to deliver services over a radius of several kilometers. The base stations are typically backhauled to the core network by means of fiber or point-to-point microwave links to available fiber nodes or via leased lines from an incumbent wire-line operator. The range and NLOS capability makes the technology equally attractive and cost-effective in a wide variety of environments. The technology was envisioned from the beginning as a means to provide wireless “last mile” broadband access in the Metropolitan Area Network (MAN) with performance and services comparable to or better than traditional DSL, Cable or T1/E1 leased line services. The market segments that will be addressed in conjunction with the business case analysis are:

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[1] The WiMAX Forum is an organization with more than 150 member companies with the goals of promoting worldwide adoption of the IEEE 802.16 air interface standard and to develop a suite of conformance tests to ensure equipment interoperability.

1. **Residential and SOHO High Speed Internet Access.** Today this market segment is primarily dependent on the availability of DSL or cable. In some areas the available services are not acceptable and/or are too expensive. In many rural areas residential customers are limited to dial up. In developing countries there are many regions with no available means for internet access. The analysis will show that the WiMAX technology will enable an operator to economically address this market segment and have a winning business case under a variety of demographic conditions.

2. **Small and Medium Business.** This market segment is very often underserved in areas other than the highly competitive urban environments. The WiMAX technology can cost-effectively meet the requirements of small and medium size businesses in low density environments and can also provide a cost-effective alternative in urban areas competing with DSL and leased line services.

3. **WiFi Hot Spot Backhaul:** WiFi hot spots are being installed worldwide at a rapid pace. One of the obstacles for continued hot spot growth however, is the availability of high capacity, cost-effective backhaul solutions. This application can also be addressed with the WiMAX technology. And with nomadic capability, WiMAX can also fill in the coverage gaps between WiFi hot spot coverage areas.

The WiMAX architecture and applications are illustrated in figure 1.

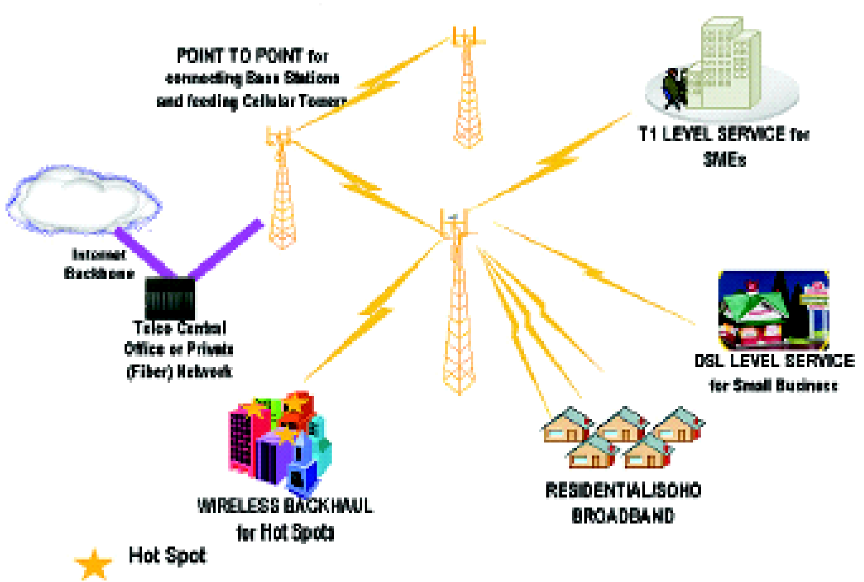


Figure 1: The WiMAX Wireless Architecture

The following applications are not included in the business case analysis; nevertheless they are worthy of mention in that they represent additional potential revenue sources for the wireless operator.

1. **Cellular Backhaul:** In the US the majority of backhaul is done by leasing T1 services from incumbent wire-line operators. With the WiMAX technology cellular operators will have the opportunity to lessen their independence on backhaul facilities leased from their competitors. Outside the US, the use of point-to-point microwave is more prevalent for mobile backhaul, but WiMAX can still play a role in enabling mobile operators to cost-effectively increase backhaul capacity using WiMAX as an overlay network. This overlay approach will enable mobile operators to add the capacity required to support the wide range of new mobile services they plan to offer without the risk of disrupting existing services. In many cases this application will be best addressed through the use of 802.16 based point-to-point links sharing the PMP infrastructure.

2. **Public Safety Services:** Support for nomadic services and the ability to provide ubiquitous coverage in a metropolitan area provides a tool for law enforcement, fire protection and other public safety organizations enabling them to maintain critical communications under a variety of adverse conditions.

Business Case Considerations and Assumptions

An accurate business case analysis must take into account a wide variety of variables. These will be described in this section along with the assumptions used in the business case analysis.

Demographics

Demographics play a key role in determining the business viability of any telecommunications network. Traditionally, demographic regions are divided into urban, suburban and rural areas. In our analysis a fourth area has been added called exurban. Exurban areas are primarily residential and compared to suburban areas are further from the urban center with lower household densities. DSL availability is limited due to the distance between the end-user and the switching center and cable in many cases is simply too expensive.

Rural areas for the purpose of the business case analysis are defined as small cities or towns that are located far from a metropolitan area. Customer densities can be fairly high in these areas but they tend to be underserved due to their remote location. The following table summarizes the characteristics that will generally be encountered in each of the four geographical areas under consideration for a new wireless service provider.

Area	Characteristics
Urban	• Highest density of potential WiMAX customers • Many multiple tenant office and residential buildings • Smaller WiMAX cell sizes to meet capacity requirements • Strong competition: Drive by market size and availability of alternate access technologies New operator can expect: • Lower market penetration • Higher marketing and sales expense Other considerations: • Licensed spectrum would be desirable to minimize potential for interference
Suburban	• Moderate density of potential WiMAX customers • Higher percentage of single family residences also... • Business parks, strip malls, etc • Cable and/or DSL may not be available universally • Increase in WiMAX cell radius but still capacity limited with limited spectrum assignments New operator can expect: • Somewhat higher market penetration compared to urban
Exurban	• Upscale residential neighborhoods with moderate to low household density • Fewer business establishments • High concentration of computers, cell phones, etc. • Cable and/or DSL not universally available • Larger WiMAX cell sizes, more likely terrain & range limited • Requirements of architectural boards, environmental impact studies, etc. may add to BS site development costs • High percentage of commuters to suburban & urban areas • Expect higher market penetration for fixed BB internet access

Area	Characteristics
Rural (small, relatively isolated small cities and towns)	• Distant from major Metro Areas • Residential and small business • Very little if any, cable or DSL (rely on dial-up or satellite) • High pent-up demand for internet access • Limited competition New operator can expect: • Very high WiMAX market penetration and rapid adoption rate Other considerations: • High capacity backhaul may be a challenge

Table 1: Demographic Characteristics

Services

Following is a description of the services used in the business case with the first year ARPUs that are assumed. These ARPUs are competitive with or below current cable, DSL, and leased line services in most developed countries. For the business case analysis the ARPUs are assumed to drop 5% per year after the first year. Wire-line operators generally offer several types of services for SME but for the sake of simplicity only two service levels have been assumed for this analysis.

In addition to high speed internet access, it is assumed the operator will also offer voice services to residential and SME customers. Other revenue sources include one-time activation fees and equipment rental fees for operator-supplied customer premise equipment. These fees are assumed to stay constant over the business case period.

Regulator imposed taxes and tariffs are not included in the analysis since these costs are generally passed through to the end-customer and will have little or no impact on the business case.

End Customer	Service Description	1st Year Monthly ARPU	Other Revenue
Residential			
Residential Internet	A best effort service	$30	$10/month for equipment lease and one-time $50 service activation fee
Residential POTS	VOIP Service	$20 Option	
Small Medium Business			
Basic Service	0.5 Mbps CIR, 1 Mbps PIR	$450	$35/month equipment lease fee and one-time $500 service activation
Premium Service	1.0 Mbps CIR, 5 Mbps PIR	$550	
Local Access (POTS)	T1/E1	$250 Option	
WiFi Hot Spot Backhaul	1.5 Mbps CIR, 10+Mbps PIR	$650	$25/month equipment lease fee and one-time $500 activation fee

Table 2: Services and ARPU

Market Adoption Rate

It generally takes some period of time for consumers to "buy-in" to a new technology, a new service or a new provider of that service. For some the technology, service and/or provider have to be well-tested before they will sign up for the service. Mobile phones and more recently, WiFi (IEEE 802.11) has helped establish a general acceptance of wireless access so it is reasonable to expect that WiMAX technology will have a fairly rapid adoption rate. The rates charged for services by the operator will also have a marked effect on how quickly the technology and services will be adopted and regions that are currently underserved will have a quicker adoption rate than areas that are currently well served. Figure 2 shows the market adoption rate[2] to reach 90% of the expected mature market penetration for a 3, 4 and 5 year adoption curve respectively. In the business case scenarios that follow we will assume a 4 year adoption rate for a metro area deployment, where competition is likely to be the strongest and a 3 year adoption rate in rural areas where there is likely to be high pent-up demand due to the lack of suitable broadband access alternatives.

[2] The adoption rate curve roughly follows the shape defined by the Rogers Innovation Adoption Curve. For more information see www.valuebasedmanagement.net

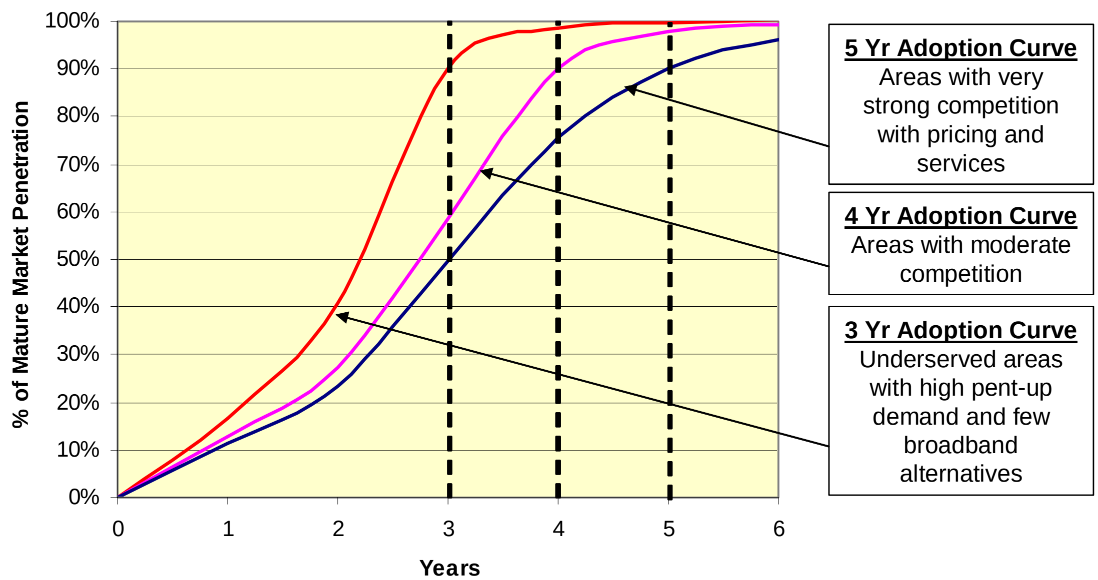


Figure 2: Market Adoption Rate Used for Business Case Analysis

Frequency Band Alternatives

A key decision with regard to spectrum choice is whether to use licensed or unlicensed spectrum. The use of licensed spectrum has the obvious advantage of providing protection against interference from other wireless operators. The disadvantage is dealing with the licensing process. This process varies depending on local regulations from either being very simple and quick to complex and lengthy and in countries where auctions are used, it can be expensive in highly sought-after regions.

The use of unlicensed spectrum gives the wireless operator the advantage of being able to deploy immediately but runs the risk of interference from neighboring wireless operators in the future. In general our feeling is that the use of licensed spectrum is desirable in major metropolitan areas where multiple wireless operators are more likely. License-exempt spectrum on the other hand, is often a good choice in rural areas where there are likely to be fewer operators. In these areas interference mitigation is easily accomplished through frequency coordination between the operators. A good practice when deploying with unlicensed spectrum is to size hubs such that no more than half the available band is used. This enables the use of automatic channel selection to enable auto-selection of channels that are not subject to interference from other wireless operators.

The three frequency bands that are of primary interest with today's prevailing regulations are:

- The license-exempt 5.8 GHz Universal National Information Infrastructure (UNII) Band
- The licensed 2.5 GHz Microwave Multi-channel Distribution Service (MMDS) Band
- The licensed 3.5 GHz Band

A summary of these bands and relevant considerations for the WiMAX business case is provided in the following table. In our analysis we will use the 3.5 GHz band for metro area deployment and the 5.8 GHz unlicensed band for rural area deployment.

Band	5.8 GHz UNII	2.5 GHz MMDS	3.5 GHz Band
Licensing	License-exempt spectrum	Licensed spectrum predominantly in US	Licensed spectrum in Europe, Latin America and Asia
Cost	n/a	Cost will vary from country to country depending on regulations, may also lease from existing license holder. Cost therefore, could be CAPEX or OPEX	
Spectrum	Up to 125 MHz available	Up 22.5 MHz (16.5 MHz + 6 MHz) per license	Assignments vary but typically no more than 28 MHz (2x14MHz)
Interference Control	Restrict deployment to < 1/2 the available spectrum, use auto channel select & coordination between operators	Protected by license assignment, no two operators assigned the same frequency in the same geographic area	
Base Stations Required	Fewer base station sites to achieve area coverage	More base station sites to meet capacity requirements due to limited spectrum assignment	
Indoor and Outdoor CPEs	Will only support indoor CPEs at customer sites very close to the base station, outdoor CPEs must be deployed elsewhere. Result: Higher average CPE cost and higher average installation costs	Will support a high percentage of indoor CPEs in capacity limited deployments. Result: Lower average CPE cost and lower average installation cost.	

Table 3: Comparison of Relevant Frequency Bands

Geographic Scenarios for Business Case Analysis

For the business case analysis three different scenarios are analyzed, the characteristics of which are summarized in table 4.

	Scenario 1:	Scenario 2:	Scenario 3:
Geographical Area Description	Major City/Metropolitan Area		Small Rurally Located City or Town
Market Segment	Residential	Residential, SME & WiFi Backhaul	Residential & SME
Size	125 sq-km		16 sq-km
Population	~1,000,000		~25,000
Residential Density	6000 HH/sq-km in urban center, 1500 HH/sq-km in suburban area, 500 HH/sq-km in exurban area		600 HH/sq-km
Total Households	~390,000		~9,600
Total SME	n/a	~24,000	n/a
Adoption Rate	4 years		3 Years
Frequency Band	Licensed 3.5 GHz Band		Unlicensed 5.8 GHz UNII Band
Channel BW	3.5 MHz FDD		10 MHz, TDD

Table 4: Summary of Business Case Scenarios

Capital Expense (CAPEX) Items

Base Station, Edge and Core Network

The business case assumes a green field deployment and as such it must include an allowance for core and edge network equipment in addition to WiMAX-specific equipment. Most of this equipment must be in place prior to offering services. Base stations and base station equipment need not be installed in totality at the outset, but can be deployed over a period of time to address specific market segments or geographical areas of interest to the operator. Nevertheless it is desirable to install some minimal number of base stations to reach a critical mass and have an addressable market sufficient to quickly cover the fixed infrastructure costs. It is also desirable in the case of fixed services involving operator-installed outdoor CPEs with directional antennas, to locate and deploy base stations in such way so as to minimize the possibility of having to insert other base stations within the same coverage area to add capacity. This would generally require potentially expensive truck-rolls to redirect CPE antennas. If sufficient spectrum is available, base station capacity can be increased by simply adding additional channels to all or selected base stations as required to meet growing demand. This is an ideal way to phase the deployment and grow the wireless network capacity to match customer growth. Base station capacity is determined by using a 20:1 over-booking factor for “best effort” residential services and 1:1 for SME committed information rate (CIR) services. In each of the business case scenarios it is assumed that all of the base stations needed to meet long term capacity requirements would be deployed prior to offering services. In very large metropolitan areas an operator may choose to deploy base stations over several years by dividing the area into geographic sections and fully covering one section prior to moving on to the next.

The business case also assumes the deployment of a high capacity point-to-point wireless backhaul connection for each base station to a point of presence or fiber node for connection to the core network. This can also be accomplished by means of leased T1/E1 lines in which case, rather than a capital expense there would be an operating expense. Table 5 summarizes the base station and infrastructure costs that have been assumed for the three business case scenarios in addition to the WiMAX equipment. For scenarios 1 and 2 it is assumed that a spectrum license is obtained through an auction process at a cost of $.01 per MHz pop. In some countries licenses can be obtained at no initial cost but with an annual “rental” fee. In these cases the cost to the operator would be entered as an operating expense rather than a capital expense.

Description	Scenario 1	Scenario 2	Scenario 3	Comments
Backhaul Link	$25K for a PtP microwave link		$200K total for 5 base stations	Allows for at least one multiple hop in rural areas
Other Base Station Equipment	$15K			Covers any necessary cabinets, network interface cards, etc.
Core & Edge Equipment	$400K	$500K	$100K	Router or ATM switch, Network management server, etc.
Spectrum License	Assume $.01 per MHz Pop		n/a	Assumes license is acquired via an auction process or other up-font investment

Description	Scenario 1	Scenario 2	Scenario 3	Comments
Base Station Acquisition & Civil Works	$50K Average per base station		$25K Average per base station	Includes indoor and outdoor site preparation, indoor to outdoor cabling, etc.

Table 5: CAPEX for Network Infrastructure

CPE Equipment

WiMAX equipment manufacturers will be providing CPE hardware in a variety of port configurations and features to address the needs of different market segments. Residential CPEs are expected to be available in a fully integrated indoor self-installable unit as well as an indoor/outdoor configuration with a high gain antenna for use on customer sites with lower signal strength. In the business case analysis a percentage breakdown of each is assumed in accordance with the frequency band, cell radius and propagation conditions that are likely to be encountered in the different geographical areas.

CPEs for SME will generally be configured with T1/E1 ports in addition to 100BT Ethernet ports. These units are priced higher for the business case, consistent with the added performance.

For both the residential and SME market segment it is assumed that a percentage of customers will opt to supply their own equipment rather than pay an equipment lease fee to the operator. This has the effect of reducing the CPE CAPEX and CPE maintenance expense. It also however, reduces operator revenues derived from equipment lease fees. Because of this interrelationship the impact on the payback period not significant.

The business case analysis assumes that the price of residential terminals will drop by about 15% per year due to growing volumes and manufacturing efficiencies and lower volume business terminals will drop by about 5% per year.

Operating Expense (OPEX) Items

A summary of the OPEX items that are used in the business case analysis are summarized in table 6.

OPEX Item	Business Case Assumptions	Comments
Sales and Marketing Expense (including customer technical support)	20% of gross revenue in year 1 dropping to 11% in year 5	Higher % or revenue in early years to reflect the fixed costs associated with these expenses, 5th year levels are consistent with levels for a mature stable business
Network Operations	10% of gross revenue in year dropping to 7% in year 5	
G & A	6% of gross revenue in year 1 dropping to 3% in year 5	
Equipment Maintenance	5% of CAPEX for Base Station Equipment 7% of Operator owned CPE CAPEX	Reflects higher maintenance costs associated with maintaining remotely located equipment
Base Station Installation & Commissioning	~$3K for 4-sector Base Station	One-Time expense
CPE Install & Commissioning	Varies with market segment	Offset by One-time activation fee charged to customer
Base Station Site Lease Expense	$1,500 per month per base station	Space for indoor equipment plus per antenna lease fee for outdoor units
Customer Site Lease Expense	$50 per month average for SME market segment	Not applicable for residential market segment
Allowance for Bad Debts & Churn	12% for residential segment 3% for SME segment	

Table 6: OPEX Summary

The Business Case

Scenario 1: Residential Market Segment in a Metro Area Environment

A market financial summary for scenario 1 is provided in table 7. The financial details are provided in the graphs shown in figure 3. The spectrum available to the operator is assumed to be limited to 28 MHz (two 14 MHz channels). The WiMAX base station equipment uses 3.5 MHz channels with frequency division duplexing. A 4-sector base station therefore, can be deployed using one channel pair per sector. Due to the limited spectrum, the base stations in each of the three geographical areas are capacity limited rather than range limited and 26 base stations are required to provide services to approximately 7% of the addressable residential market. With a 4 year market adoption rate (see figure 2) to reach 90% of the target market penetration, installation and commissioning cost peak in years 3 and 4 This contributor to OPEX plays a lesser role in the 5th year as the annual rate of customer growth slows.

The CAPEX is dominated by WiMAX CPEs since it is assumed for this scenario that 80% of the equipment would be provided by the operator. This of course is offset by the $10 per month equipment rental fees. As CPE prices decline we would expect a higher percentage of CPEs to be purchased by the customer to avoid the rental expense.

Scenario 1 Summary: Residential Market Segment in Metro Area			
Spectrum		**Deployment Data**	
Frequency Band	3.5GHz	WiMAX Base Stations Deployed	26
Channel BW in MHz	3.50	Aggregate Payload in Mbps	1,005
Spectrum Required in MHz	28	Coverage Area in sq-km	125
Addressable Market		Average Data Density Mbps/sq-km	8
Households Covered	388,254	Population in Coverage Area	1,009,461
Businesses Covered	n/a	**Assumed CPE Mix**	
		% of Indoor Residential CPEs	60%
Market Penetration (5th yr)		% Res CPEs Supplied by Operator	80%
Market Adoption Curve	4 Years	% SME CPEs Supplied by Operator	n/a
Residential Market	6.3%	ARPU Price Erosion	5%
Residential Voice Services	23%	**Avg # Subscribers per BS**	946
SME Market	n/a	**Total CAPEX per Subscriber**	$328
SME Voice Services	n/a	**Total CAPEX in $M**	$8.1
WiFi Hot Spots Backhauled	n/a	**Net Present Value (5 yrs) $M**	$3.6

Table 7: Market Summary for Scenario 1

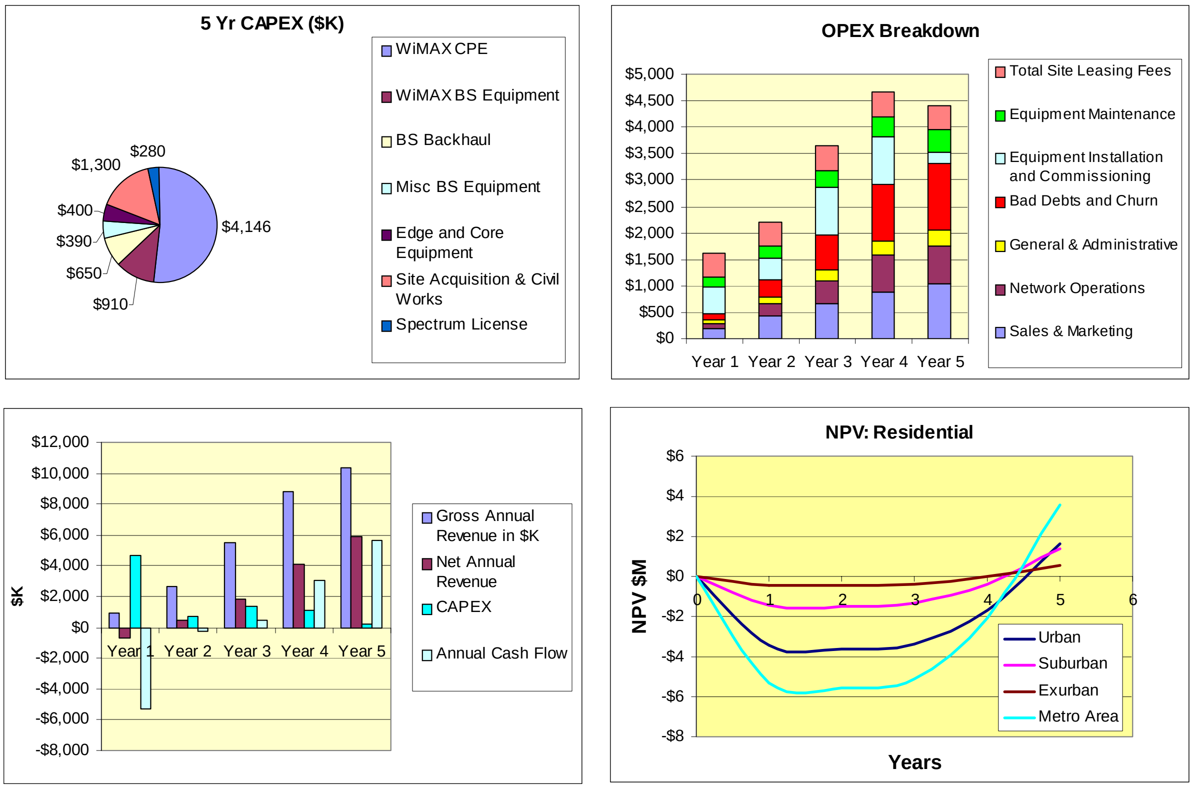


Figure 3: Financial Summary for Scenario 1

Scenario 2: Residential, SME and WiFi Backhaul Market Segment in a Metro Area Environment

The business case for scenario 2 is summarized in table 8 and in figures 4 and 5. This deployment scenario covers the same geographical area as scenario 1 but requires 37 additional base station sites to provide the added capacity necessary to address the SME market and to provide backhaul connections for 30 WiFi hot spots in addition to the residential market segment. Even though the number of business customers is less than one-tenth the number of residential customers the higher ARPU more than doubles the gross revenue (see graphs in figure 5) and improves the payback by more than six months as compared to a residential-only market segment.

With the resulting smaller average cell sizes an increased number of indoor residential CPEs can be supported as compared to scenario 1. These units being lower cost it is reasonable to conclude that more customers will choose to buy rather than rent their equipment. This, coupled with the assumption that a higher percentage of business customers will buy their own equipment, lowers the CPE contribution to less than 30% of the total CAPEX.

Scenario 2 Summary: Residential & SME Market Segment in Metro Area			
Spectrum		**Deployment Data**	
Frequency Band	3.5GHz	WiMAX Base Stations Deployed	63
Channel BW in MHz	3.50	Aggregate Payload in Mbps	2,470
Spectrum Required in MHz	28	Coverage Area in sq-km	125
Addressable Market		Average Data Density Mbps/sq-km	20
Households Covered	388,513	Population in Coverage Area	1,010,134
Businesses Covered	24,312	**Assumed CPE Mix**	
		% of Indoor Residential CPEs	80%
Market Penetration (5th yr)		% Res CPEs Supplied by Operator	60%
Market Adoption Curve	4 Years	% SME CPEs Supplied by Operator	50%
Residential Market	6.4%	ARPU Price Erosion	5%
Residential Voice Services	23%	**Avg # Subscribers per BS**	423
SME Market	7.8%	**Total CAPEX per Subscriber**	$456
SME Voice Services	52%	**Total CAPEX in $M**	$12.2
WiFi Hot Spots Backhauled	30	**Net Present Value (5 yrs) $M**	$17.4

Table 8: Market Summary for Scenario 2

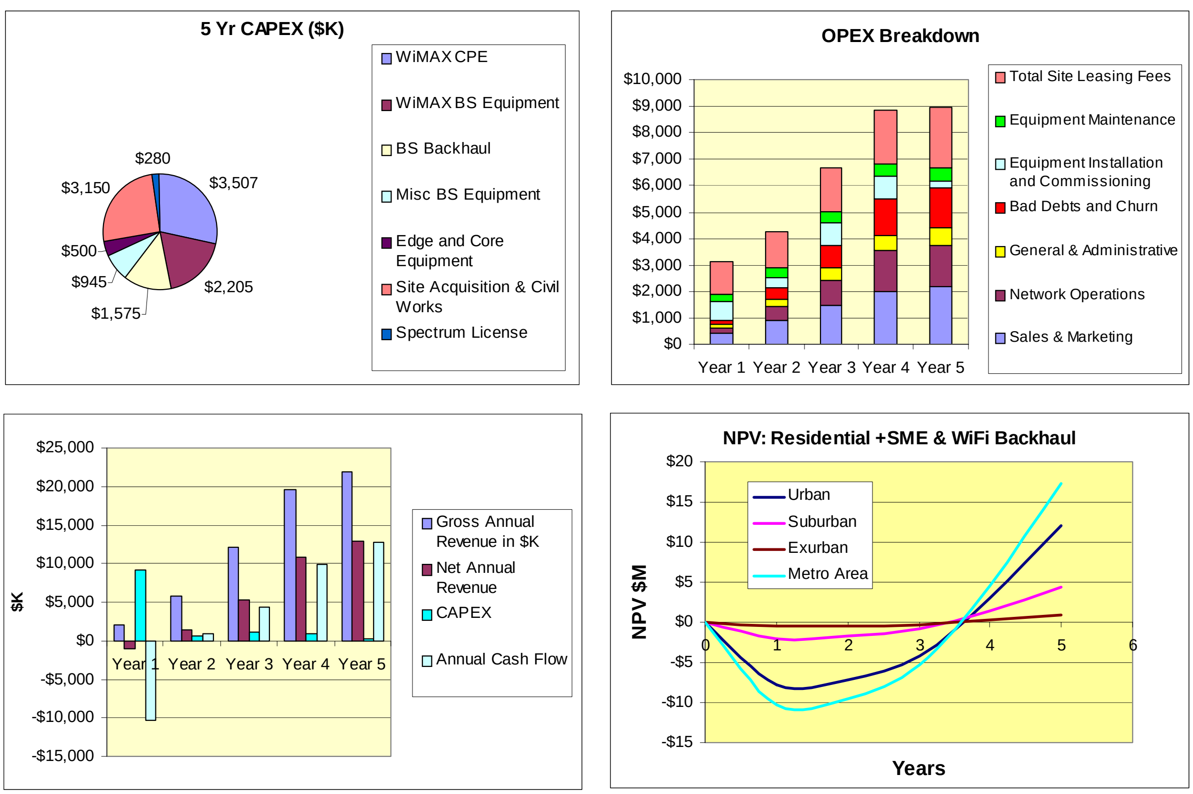


Figure 4: Financial Summary for Scenario 2

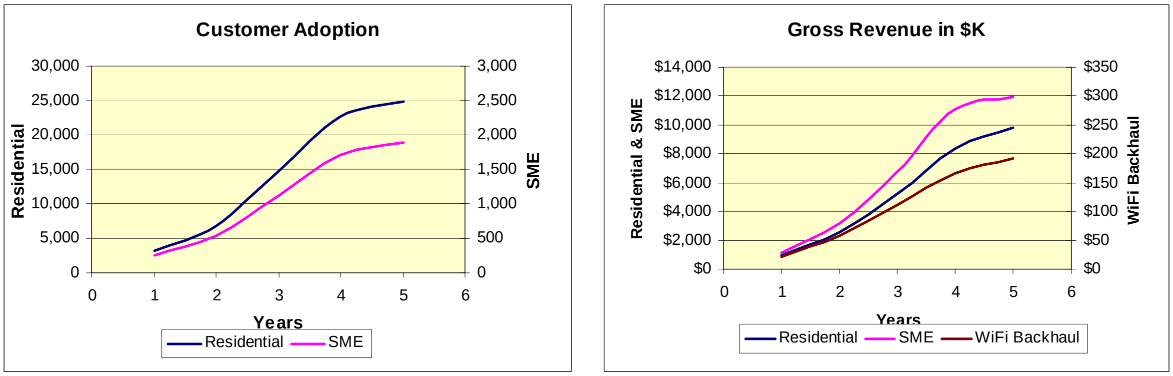


Figure 5: Customer Adoption and Revenue Contribution

Scenario 3: Residential Market Segment in a Rurally Located Small City or Town

Scenario 3, summarized in table 9 and figure 6, is representative of many small cities or towns throughout the world. Geographically distant from a major metropolitan area, these areas are among the most underserved insofar as broadband access is concerned. A wireless operator should be able to quickly achieve high market penetration in these venues. Therefore, a 3-year market adoption rate is assumed for this case with a residential market penetration at 5 years reaching 40% and a SME penetration reaching 30%.

The use of spectrum in one of the license-exempt bands is also acceptable since it is not likely that more than a few operators would elect to address these types of markets. With only 2 to 3 operators, coordination for interference control is very straightforward since it is to the advantage of each operator to mitigate the potential for interference in order to maintain quality of service.

One of the key challenges in remotely located deployment areas is the establishment of a suitable high capacity backhaul connection. In this case a 2 xOC-3 connection would be necessary to match the aggregate base station capacity. In the analysis it is assumed that a multi-hop point-to-point microwave link would be necessary to connect a "master" base station to a distant fiber node or switching center. The remaining base stations (four in his case) are backhauled from the "master" base station. In the 5.8 GHz UNII band it is assumed that all CPEs would be of the outdoor type and that 80% of the residential units would be operator provided.

Scenario 3 Summary: Residential Market Segment in Metro Area

Spectrum		Deployment Data	
Frequency Band	5.8GHz UNII	WiMAX Base Stations Deployed	5
Channel BW in MHz	10	Aggregate Payload in Mbps	280
Spectrum Required in MHz	40	Coverage Area in sq-km	16
Addressable Market		Average Data Density Mbps/sq-km	17
Households Covered	9,734	Population in Coverage Area	25,309
Businesses Covered	730	**Assumed CPE Mix**	
		% of Indoor Residential CPEs	0%
Market Penetration (5th yr)		% Res CPEs Supplied by Operator	80%
Market Adoption Curve	3 Years	% SME CPEs Supplied by Operator	n/a
Residential Market	40.1%	ARPU Price Erosion	5%
Residential Voice Services	50%	**Avg # Subscribers per BS**	826
SME Market	31.5%	**Total CAPEX per Subscriber**	$402
SME Voice Services	80%	**Total CAPEX in $M**	$1.7
WiFi Hot Spots Backhauled	n/a	**Net Present Value (5 yrs) $M**	$3.3

Table 9: Market Summary for Scenario 3

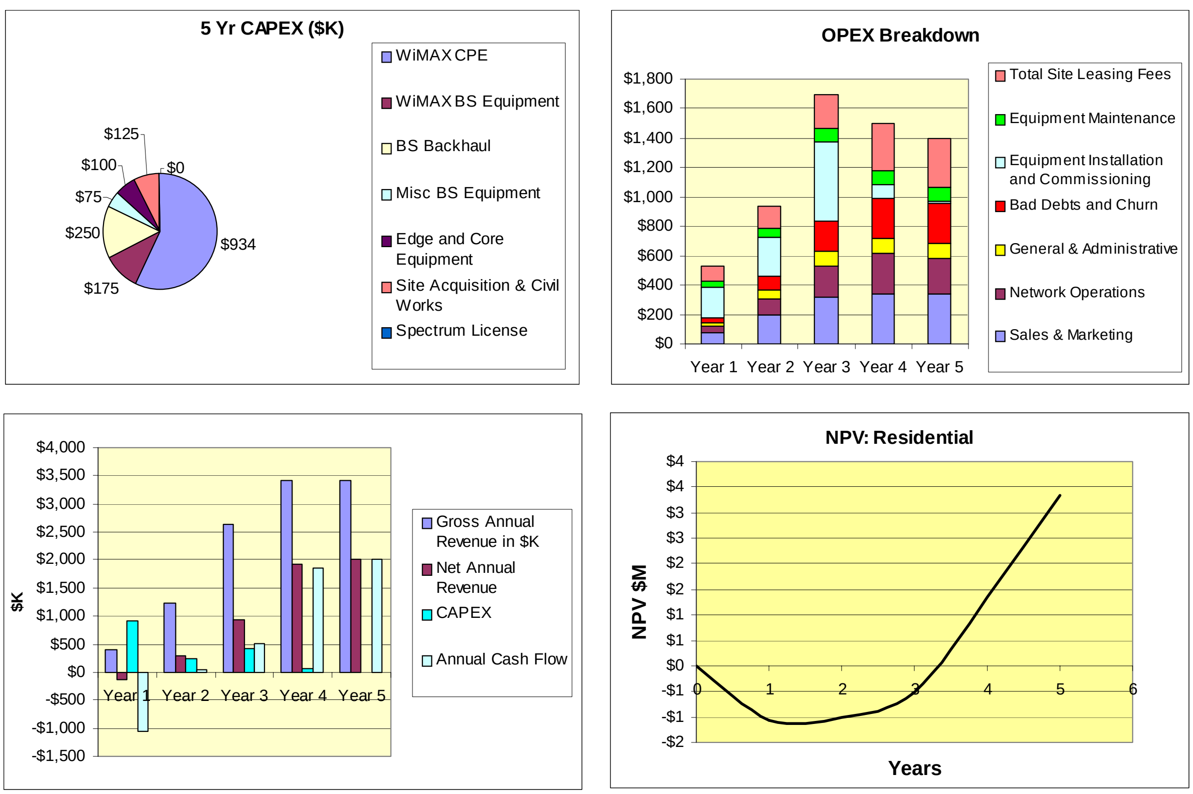
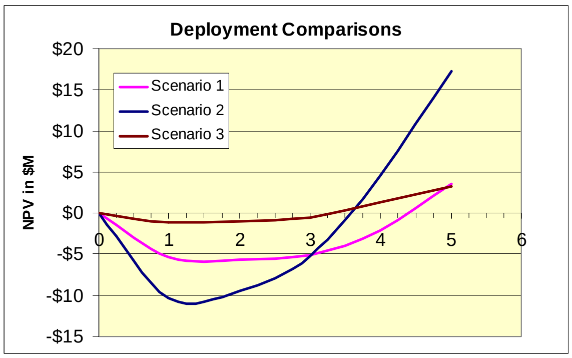


Figure 6: Financial Summary for Scenario 3

Comparing the Three Business Case Scenarios

A NPV comparison of the three scenarios is shown in the graph in figure 7. The accompanying table in figure 7 provides a summary of the WiMAX base stations required to meet the capacity requirements in each of the three business case scenarios. The chart clearly shows the business advantage of adding the SME market segment to the residential-only scenario.



Base Station Deployment Summary				
Scenario		**1**	**2**	**3**
Frequency Band		3.5 GHz		5.8 GHz
Urban	**# BSs**	17	48	
	Range	1.0 km	0.6 km	
Suburban	**# BSs**	7	12	
	Range	1.6 km	1.2 km	
Exurban	**# BSs**	2	3	
	Range	2.1 km	1.7 km	
Rural	**# BSs**			4
	Range			1.2 km

Figure 7: Comparison of Scenarios 1, 2 and 3

Payback Sensitivity

The market related parameters selected for the business case analysis will fit many specific markets but obviously not all markets. The three scenarios already provided some insight as to the impact of market penetration variation. Other variables that are likely to vary from one situation to another are the market adoption rate and the initial ARPU necessary to attract customers or to entice customers to switch from their current provider to a new wireless access provider. In actual practice these two parameters are not independent but for this exercise they are assumed to be so. The two graphs in figure 8 shows the NPV sensitivity for the scenario 2 business case to both a longer and shorter market adoption rate and to a 25% reduction in the initial ARPUs.

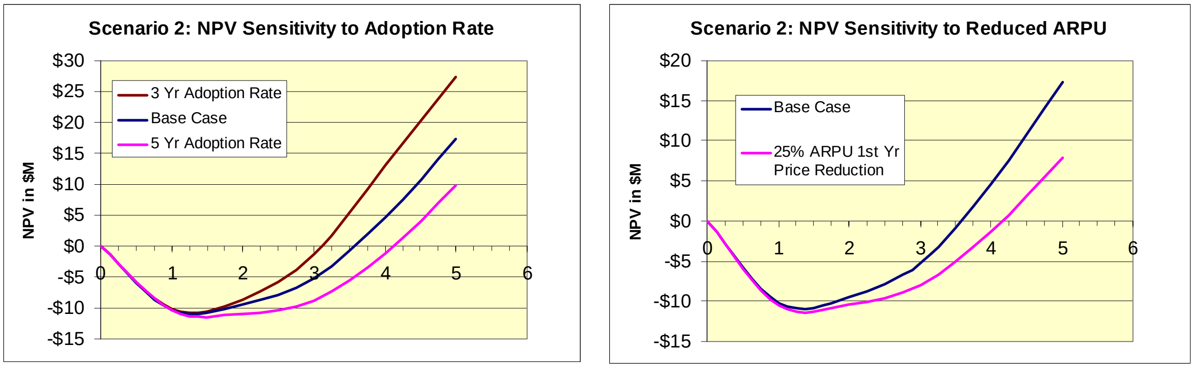


Figure 8: Sensitivity Analysis for Scenario 2

Conclusions and Summary

There are many other demographic situations that can be analyzed and a host of alternative assumptions that can be made. Hopefully the scenarios and assumptions selected for the business case analysis in this paper will provide the reader with a good perspective regarding the attributes and business opportunities will be realized when deploying a wireless MAN using the WiMAX IEEE 802.16d technology.

Some conclusions that can be drawn from the analysis are:

1. A winning business case can be realized with a WiMAX based network in a wide variety of demographic environments.

2. Addressing the SME market along with the residential market is a good business decision; it not only reduces the payback period by about 15%, but also reduces the investment risk since competitive forces in the two market segments are relatively independent.

3. Providing backhaul for WiFi hot spots is not a viable standalone business and does not contribute a great deal to the business case in conjunction with the residential and/or SME market. It does however represent a good source of additional revenue with little additional capital investment. It is also a business that is efficient to sell and manage in that long term agreements would generally be made with WiFi operators to cover an entire geographic region.

4. If an operator chooses to cherry-pick regions for deployment, the lower density and underserved areas require less initial investment, provide a faster payback and can be deployed with license-exempt spectrum with minimal risk of interference.

This also provides a new operator the opportunity to build a reputation for quality of service in a low risk environment before deploying in the more highly competitive urban areas. A caveat to this strategy however is that the longer the highly competitive areas are ignored the more entrenched the existing providers of DSL and cable services become.

As mentioned earlier in this paper, the infrastructure deployed to address the residential and SME market segments can also be shared with other wireless access applications such as cellular backhaul and public safety services. Public safety services would make use of the nomadic capability of IEEE 802.16d. These applications provide additional revenue opportunities for the WiMAX operator with minimal added CAPEX and OPEX.

An application that has not been mentioned in his paper is mobile applications. IEEE 802.16d covers fixed and nomadic operation; IEEE 802.16e will cover mobile applications. The availability of IEEE 802.16e compliant equipment in the near future will provide additional business opportunities for the WiMAX operator. A further description of this application and the associated business case will be the subject of a future white paper.