To Beamform or Not to Beamform:

Can Beamforming Help WiMAX Operators to Lower Deployment and Operating Costs?

As WiMAX operators deploy new networks or expand existing ones, they face multiple choices in the selection of base station equipment. How can WiMAX operators choose the hardware solution that is most cost effective and has the faster return on investment (ROI)?

We addressed this question by analyzing the capex and opex requirements for a five-year period, using radio access network (RAN) equipment with multiple input, multiple output (MIMO), beamforming (BF), and a combination of MIMO and BF.

MIMO equipment is less expensive, but requires a higher number of base stations. BF and BF+MIMO equipment costs more, but requires fewer cell sites to provide the same coverage and capacity.

Despite the higher RAN equipment costs, BF lowers the overall capex and opex as it requires fewer cell sites. In the BF case, 49% fewer cell sites are required in Year 1, and 20% in Year 5. For the BF+MIMO case, the reduction in cell sites is even larger, ranging from 57% in Year 1 to 34% in Year 5.

Fewer cell sites result in a 20% reduction in the discounted RAN costs over five years in the BF case, and in a 34% reduction for the BF+MIMO case.

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Introduction

WiMAX operators are busy building or expanding their networks. Greenfield operators need to determine their coverage and capacity requirements, and select the solution that best meets their financial and performance requirements. Fixed Institute of Electrical and Electronics Engineers (IEEE) 802.16d WiMAX or broadband wireless access (BWA) operators have started to transition to IEEE 802.16e WiMAX, with the expectation that the new equipment is affordable and delivers the expected performance improvements in both fixed and mobile networks. Mobile WiMAX operators are expanding their coverage to new areas and adding cell sites to support the rapidly growing subscriber traffic.

Today, tighter funding and growing expectations in terms of coverage and capacity from their subscribers have increased the pressure on WiMAX operators to extract maximum performance from their investment in network deployment. Support for mobility is also raising the bar for coverage requirements as handoffs require a higher level of coverage than is needed for fixed or nomadic access.

Individual subscribers' traffic levels are also growing very fast, making network congestion a current or impending issue. In Russia, at Yota the average subscriber traffic is growing by 1 GB/month, with an average of 13 GB/month. In Indonesia, WiMAX operator P1 sees 7 to 9 GB/month of traffic on average per subscriber. With a throughput of 7 to 12 Mbps per 10 MHz sector in a WiMAX base station, network capacity quickly becomes critical.

What is the best way for operators to choose a solution that both maximize coverage and capacity within their tight financial constraints and shorten their path to profitability? This paper analyzes the choices that operators face as they plan new networks or extend existing ones. Our analysis is based on a model that looks at two radio access network (RAN) technologies: beamforming (BF) and multiple input, multiple output (MIMO). We discuss the tradeoffs associated with choosing among options that vary in both performance and cost, and we outline how WiMAX operators can select the most cost-effective solution for the services they intend to offer and within the environment in which they operate.

One standard, many options: how to decide?

All WiMAX equipment is based on the same standard, IEEE 802.16—and typically the IEEE 802.16e version that supports mobility as an option. As a standards-based technology, WiMAX facilitates interoperability among vendors so that devices from different vendors work on the same network.

A common assumption is that, within a standards-based technology, performance across products does not vary significantly because all vendors need to conform to the same specifications. This is typically not the case. While the core technology is the same across all IEEE 802.16e-based equipment, the standard allows sufficient flexibility for vendors to diversify their products and for operators to choose a product that is well suited to their needs.

One example is the selection of antenna technologies. Many WiMAX networks still operate using a single-input, single-output (SISO) system with a single antenna. The trend is clearly toward multi-antenna technologies like MIMO and BF. WiMAX-certified base stations may support SISO, MIMO, BF, or a combination of MIMO and BF (BF+MIMO). WiMAX-certified subscriber devices have to support all three technologies to ensure that they are interoperable with WiMAX base stations from different vendors.

In terms of performance, the choice for WiMAX operators among alternatives is straightforward. SISO systems are easier to set up, but they have more limited coverage and capacity. IEEE 802.16e WiMAX base stations support two versions of MIMO, MIMO A and MIMO B. MIMO A provides improved coverage through a diversity transmission scheme that lowers the impact of interference. MIMO B works better in dense, multipath environments, where it increases capacity. BF base stations are less prone to interference and provide even better coverage and capacity by directing the signal directly to the subscriber's device. Combining BF and MIMO further improves performance.

The improvement in performance due to BF, however, carries a higher price tag: BF base stations use eight antennas, while MIMO uses two or four, and BF signal processing is more complex.

How should operators evaluate the tradeoff between performance and price in MIMO and BF base stations? Under which circumstances does it make sense for an operator to choose the more expensive equipment that provides better performance? And when is it better off choosing to spend less money? How does the impact on the short term (i.e., the capex in Year 1) compare to the impact on the long term (i.e., the cumulative capex and opex over a five-year period)?

We explore these questions with a financial model that analyzes the impact that the choice of antenna technology has on the operator, on the basis of assumptions on the relative performance of MIMO and BF as well as the overall cost of deploying and operating a WiMAX network (Table 1).

Cell site	MIMO	BF	BF + MIMO
Coverage (km^2)	0.26 – 0.77	1.48 – 4.79	1.78 – 5.75
Capacity (Mbps)	22.8	28.5	34.5
Price	$30,000	$70,000	$70,000

Table 1. Assumptions about performance and prices for cell sites with three-sector 10 MHz base stations. Coverage area value depends on the environment (urban, suburban, rural). The addition of MIMO to a BF base station does not increase the price as the hardware is the same. Source: WiMAX operators and vendors.

Model overview

The model explores the impact of the choice among MIMO, BF, or BF+MIMO base stations for a greenfield WiMAX operator over a period of five years on the RAN capex and opex. The model assumes that the greenfield operator has no legacy cell sites.

The model is initially driven by the need to establish consistent outdoor and first-wall indoor coverage. As the number of subscribers and their traffic grows through time, new cell sites have to be added to meet demand in traffic growth. Our assumptions about frequency reuse, spectrum requirements, uplink/downlink ratio, and oversubscription reflect current best practice and prevailing preferences among WiMAX operators (Table 2). Peak-hour assumptions and network utilization are based on extensively used benchmarks from cellular networks. The network is designed to have sufficient capacity to meet subscriber traffic demand during peak hours.

The network utilization level reflects the fact that not all the capacity available on the network can be utilized due to factors like geography, subscriber and traffic distribution, and constraints on cell site location.

The network can accommodate traffic from a growing number of subscribers. The network allocates 1.3 Mbps per residential subscriber and 3.0 Mbps per business subscriber, with a contention ratio of 25:1 and 15:1, respectively. This translates to a committed downlink rate of 53 kbps for residential subscribers and of 200 kbps for business subscribers. When assessing the ability to meet traffic demand and when computing the delivery cost per MB, we use the monthly traffic

Model assumptions	
Operator	Greenfield operator, new leased sites
Base stations	Three 10 MHz sectors, with a frequency reuse of 1/3/3
Spectrum	3.5 GHz band, 30 MHz allocation
Devices	Laptop dongles
Coverage area	1,000 km^2; 20% urban, 70% suburban, 10% rural
Population density	8,000 (urban), 5,000 (suburban), 1,000 (rural)
Subscribers	Residential: Y1: 40,000; Y5: 160,00 Business: Y1: 6,000; Y5: 24,000
Throughput per subscriber	Residential: 1.3 Mbps Business: 3.00 Mbps
Monthly traffic	Residential: Y1: 2 GB; Y5: 8 GB Business: Y1: 3 GB; Y5: 32 GB
Oversubscription (contention ratio)	Residential: 25:1 Business: 15:1
Downlink/uplink ratio	32:15
Network utilization	Sustainable maximum: 60%
Peak hour traffic	200% of average traffic
Opex per cell site	$38,000 per year
Capex per cell site	$110,000 for installation, plus $30,000–70,000 for the equipment
Depreciation	Five-year period, straight line
Discount rate	12%

Table 2. Model assumptions. Source: Senza Fili Consulting, WiMAX vendors, WiMAX and cellular operators.

figures listed in Table 2. We expect traffic per subscriber to grow quickly over the next few years on the basis of current usage trends from WiMAX and cellular operators.

We have also tested the model under a variety of realistic scenarios by changing these assumptions. We found consistent conclusions and expect the results of our analysis to be valid for a wide range of operators, even though their requirements and demographics may be different.

Cost analysis

Cell site count. Improvements in base station coverage and capacity with BF and BF+MIMO translate into fewer cell sites needed to cover the same area and to serve the same number of subscribers. During Year 1, the cell site count is driven by coverage requirements. BF requires 49% fewer cell sites (392) than MIMO alone (765), and the combination of BF and MIMO (BF+MIMO) results in a 57% reduction of cell sites (327) (Figure 1). As a result, BF can support 95% more subscribers (117 versus 60) and BF+MIMO 133% more subscribers (140).

As subscriber demand grows, capacity requirements determine the number of cell sites. The switch from coverage to capacity happens in Year 3 for MIMO base stations, and in Year 2 for BF and BF+MIMO base stations. The difference is due to the fact that the increased coverage benefit of BF is larger than the capacity benefit within the specific coverage and traffic requirements of the operator.

In Year 5, BF requires 20% fewer cell sites than MIMO alone (768 versus 960), and BF+MIMO 34% fewer cell sites (634). The number of subscribers per cell site is 25% higher with BF (239 versus 191) and 52% with MIMO+BF (290).

Installation cost per cell site. The cost for the initial installation on a three-sector cell site ranges from \$130,000 (MIMO) to \$170,000 (BF or BF+MIMO). Even though the cost of a three-sector BF base station is higher than that of a MIMO-only base station (\$70,000 for BF versus \$30,000 for MIMO-only), the cost to install a cell site with BF is only 31% higher than one that supports just MIMO. This is because installation costs, which also include planning, permitting and backhaul, account for 77% (MIMO) to 59% (MIMO+BF) of the capex (Figure 2).

Network deployment and operation costs. Capex and opex for the network buildout and operations are shown in Figure 2 with additional metrics for Year 5 in Table 3. Figure 3 shows the capex and opex per km^2; because the network is 1,000 km^2, the cost for the entire network can be calculated as the price per km^2 multiplied by 1,000. In this section we cite costs for the entire network, unless otherwise specified.

The capex is concentrated in Year 1 when the operator installs the cell sites needed for coverage. During Year 2 there is no need to install additional cell sites. From Year 3, new cell sites are installed to meet capacity requirements driven by a higher number of subscribers. The cumulative capex costs for MIMO and BF are very similar, but the combination of BF and MIMO leads to cost savings due to the improved performance (Table 4).

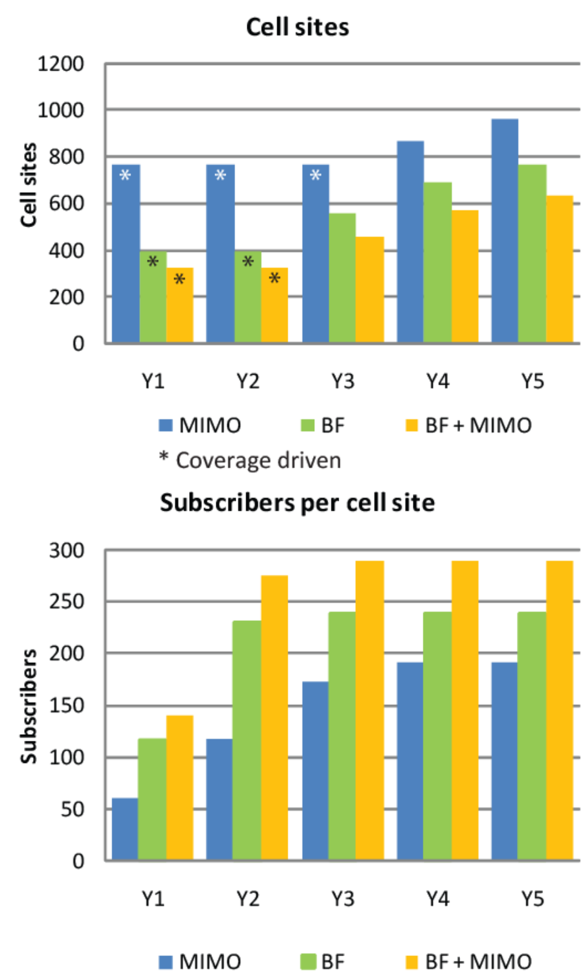

Figure 1. Cell sites and subscribers per cell site.

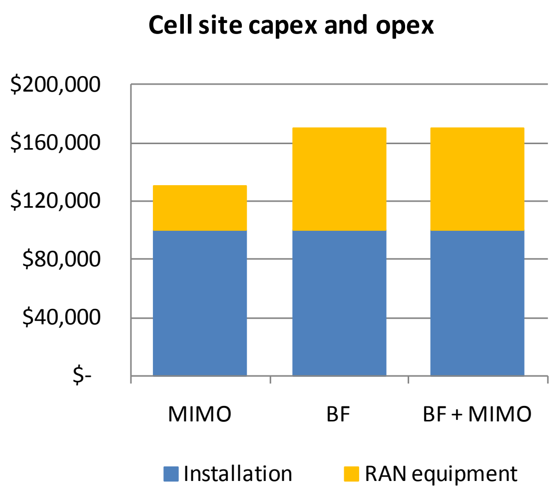

Figure 2. Cell site capex and opex.

The distribution of capex expenditure through time, however, is different, with the MIMO solution requiring more upfront capital because it needs more cell sites to establish coverage. With BF and BF+MIMO the operator can shift some of the capex to the second half of the period, when BF and BF+MIMO require the installation of additional cell sites.

Year 5 metrics	MIMO	BF	BF + MIMO
Cumulative capex per covered pop	$25	$24	$20
Cumulative capex per sub	$96	$94	$77
Opex per sub	$215	$172	$142

Table 3. Year 5 metrics.

Capex	MIMO	BF	BF + MIMO
Cumulative capex (million)	$145	$143	$128
Savings over MIMO		1%	18%
Y1 capex (million)	$99	$67	$56
Y1 capex as a percentage of cumulative capex	69%	47%	47%
Savings over MIMO in Y1 capex		33%	44%

Table 4. Capex.

The delayed installation of cell sites has several advantages:

- **A lower initial capital requirement.** Operators need to raise less money to deploy their networks and can use some of the revenues from subscribers to fund the network growth.
- **Lower opex.** Fewer cell sites mean lower opex, due to a reduction in backhaul, site rental and maintenance costs.
- **Faster network rollout.** Fewer cell sites allow operators to launch their network faster, as permitting, cell site acquisition and installation become less demanding. Fewer resources are needed, which is a valuable benefit in regions where hiring qualified staff is difficult.
- **More efficient use of network capacity and better targeted network upgrades.** Any coverage-driven network has more capacity than required, due to the unavoidable uneven distribution of demand across the coverage area. A lower number of base stations installed for coverage reduces the unused capacity and brings the operator in a shorter time to a more efficient capacity-driven stage, in which the location of new cell sites is determined by subscriber concentration.

The differences among solutions have even a larger impact on the operator's opex. The model assumes a RAN opex of $38,000 for a cell site, including maintenance, site rental, backhaul, and power. The RAN opex typically represents over half of the overall opex for a WiMAX operator. Fewer cell sites make the business case stronger.

The cumulative opex over the five years represents 53% of the total RAN costs (capex plus opex) for the MIMO solution, and 44% for the BF and the BF+MIMO solutions. In Year 5, when capex levels are lower, opex represents 69% of annual network costs with MIMO, and 65% with BF and with BF+MIMO.

With a BF solution, the WiMAX operator in the model can save from $51 million to $71 million over five years in opex (Table 5). Year 1 shows the highest difference in opex between MIMO, and BF or BF+MIMO. That difference decreases in Year 5. This reduction in the annual opex savings is tied to a decrease in the ratio of MIMO cell sites to BF and BF+MIMO cell sites. In general, opex savings are highest in the earlier years when the network is coverage-driven (and BF brings more substantial cost savings), and then they gradually reach a stable level when the network becomes capacity-driven.

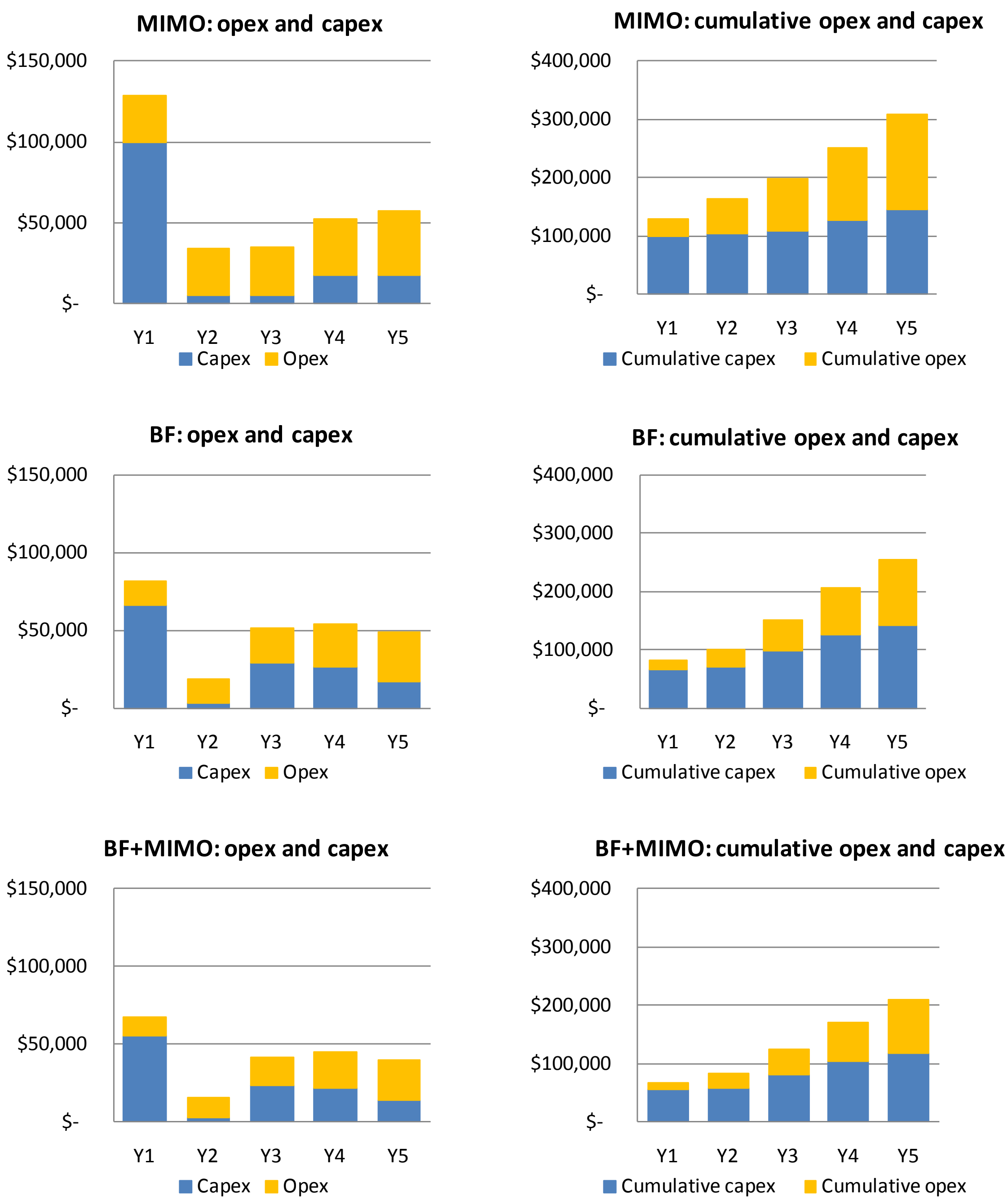

Figure 3. Opex and capex for MIMO, BF, and BF+MIMO.

Opex	MIMO	BF	BF + MIMO
Cumulative opex (million)	$163	$112	$92
Cumulative opex savings over MIMO		32%	43%
Y1 opex (million)	$29	$15	$12
Y1 opex savings over MIMO		49%	57%
Y5 opex (million)	$39	$32	$26
Y5 opex savings over MIMO		20%	34%

Table 5. Opex.

When we combine capex and opex, the cumulative RAN costs are $308 million for MIMO, $255 million for BF (a 17% decrease over MIMO), and $211 million for BF+MIMO (a 32% decrease over MIMO). This represents savings ranging from $53 million to $97 million for a 1,000 km^2 deployment.

Discounted RAN costs. The discounted opex and capex calculated over the five-year period shows that savings over MIMO are $53 million with BF, and $88 million with BF+MIMO (Figure 4 and Table 6).

Delivery cost per MB. The delivery cost per MB has become an important metric as wireless operators have to support massive increases in traffic from subscribers while keeping healthy profit margins.

Discounted RAN costs (million)	MIMO	BF	BF + MIMO
Capex	$129	$86	$71
Opex	$132	$123	$102
Total	$261	$209	$173
Savings over MIMO capex		$9 (7%)	$30 (23%)
Savings over MIMO opex		$44 (34%)	$58 (45%)
Total savings over MIMO		$53 (20%)	$88 (34%)

Table 6. Discounted RAN costs. The savings over the MIMO solution are shown in parentheses.

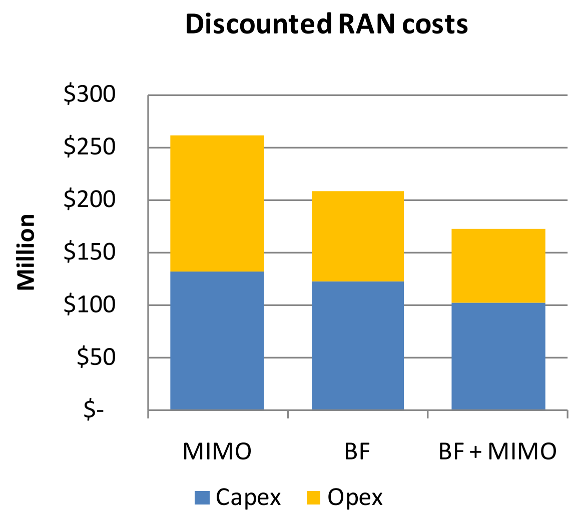

Figure 4. Discounted RAN costs.

In line with the previous results, the delivery cost per MB is higher for MIMO, and it ranges from $0.042 in Year 1 to $0.002 in Year 3. For BF, the cost ranges from $0.024 in Year 1 to $0.003 in Year 5. For BF+MIMO, the cost ranges from $0.020 in Year 1 to $0.002 in Year 5 (Figure 5). The data only include RAN costs (opex plus depreciation) and therefore the end-to-end cost to provide the service to the subscriber is higher.

As the model does not assume performance improvements over the five-year period, the decrease in delivery costs is due to a more efficient, higher network utilization—that is, by Year 5 the network transports more traffic, generated by a larger number of subscribers, each contributing higher traffic levels—in relation to its overall capacity.

In the initial phase, the delivery cost per MB is high because the network is still coverage-driven, and the overall network utilization is lower. The higher number of cell sites in a MIMO network raises the delivery cost further relative to the BF and BF+MIMO solution. As a result, in Year 1 when all solutions are still coverage-driven, the delivery cost per MB is 42% lower for BF, and 52% lower for BF+MIMO when compared to MIMO. In Year 5, these figures drop to 12% and 27%, respectively, as the networks become capacity-driven.

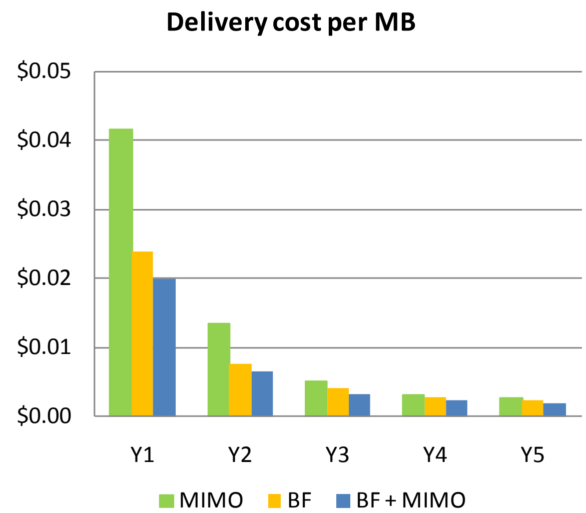

Figure 5. Delivery cost per MB.

Evaluating options

In the model base case, we consider a mix of urban (20%), suburban (70%), and rural (10%) areas, and we assume that subscribers are evenly distributed across cell sites throughout the network[1]. In this case, BF brings a net economic benefit to the operator. How does this benefit carry over to networks deployed in different environments?

To address this question, we look at three borderline scenarios in which the network is located entirely in an urban, suburban, or rural area. Operators typically have a mix of environments within their coverage area. These three scenarios do not attempt to model realistic network deployments—as the base case does—but they allow us to delve into the impact of antenna technologies in different environments.

The subscriber penetration level (as a percentage of the population) is the same as in the base case for the urban and suburban scenarios. This figure is doubled it for the rural scenario (Table 7), because we assume that an operator would only deploy a network in a rural area with low competition with the expectation of a higher market share. The results for the suburban scenario are similar to those of the base case, as the suburban environment is dominant (80% of the coverage area).

Cell site count. As expected, more cell sites are required in the urban scenario, both because the coverage radius of cell sites is smaller and because the density of subscribers (and correspondingly the traffic level) is higher (Figure 6). To establish coverage in Year 1, 1,266 cell sites are needed for MIMO, 676 for BF, and 564 for BF+MIMO. The network is coverage-driven until Year 4 for MIMO, and until Year 3 for the two BF solutions. As in the base case, this is due to the fact that the overall network capacity is higher for MIMO as more cells are required for traffic alone, but this capacity is not needed initially.

In the suburban scenario, the network is also coverage-driven until Year 4 for MIMO, but it becomes capacity-driven in Year 2 for the BF solutions. This is because the suburban environment hits a sweet spot: the density of subscribers and the cell site radius make it possible for the network operator to use the network resources more efficiently in the initial years and to transition earlier to a capacity-driven network when using a BF solution.

In the rural scenario, with MIMO coverage drives the network deployment throughout the period: 435 cell sites are required in Year 1 and are sufficient to meet traffic demand until Year 5. With BF and BF+MIMO, the number of cell sites grows from 209 to 296 (BF) and from 174 to 244 (BF+MIMO). In both cases, the network becomes capacity-driven in Year 3, as in the urban scenario.

The delivery cost per MB. Figure 7 shows the positive effect of suburban environment in terms of cell site and demand density on the network cost efficiency. In Year 1, the delivery cost per MB is the lowest in the suburban scenario regardless of the solution used. The overall network utilization is higher—i.e., less capacity is left unused. In the urban

Subscribers	Urban	Suburban	Rural
Y1 Residential	61,538	38,461	15,384
Y1 Business	9,230	5,769	2,306
Y5 Residential	246,153	153,846	61,538
Y5 Business	36,923	23,076	9,230

Table 7. Number of subscribers in the urban, suburban, and rural scenarios.

1 A base station in an urban area has as many subscribers as one in a suburban or rural area, but it covers a smaller radius. As a result, the density of subscribers is higher in urban areas due to the higher population density, other factors being equal.

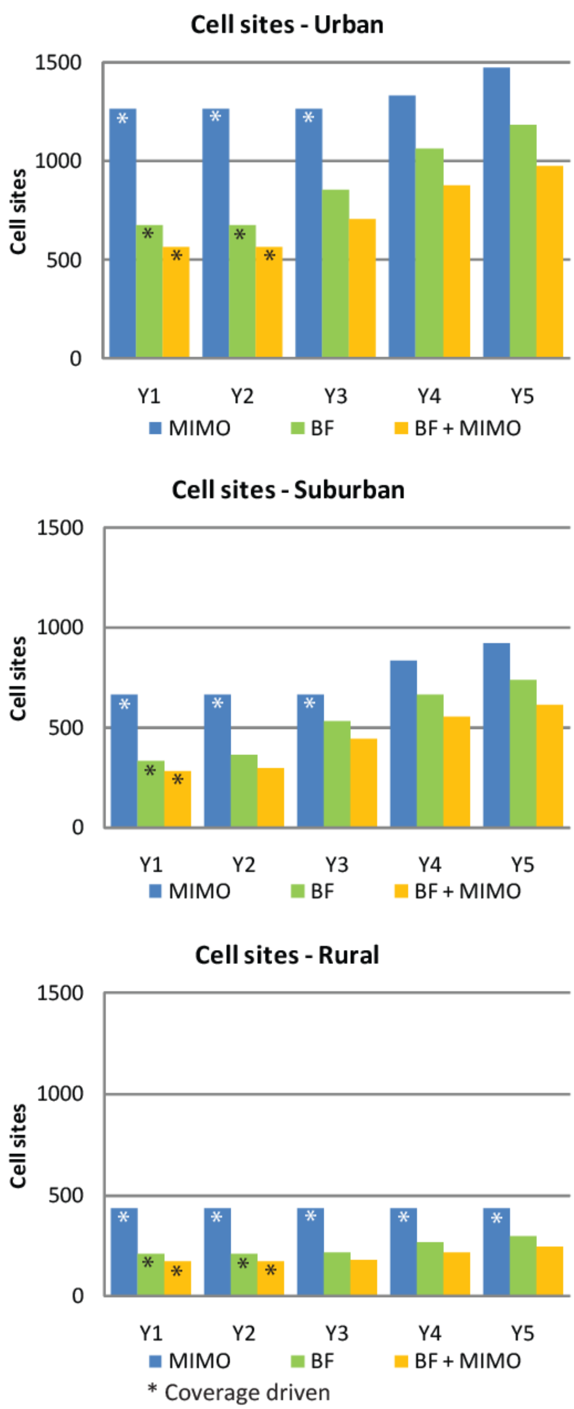

Figure 6. Cell sites in the urban, suburban, and rural scenarios.

scenario, the delivery cost per MB is slightly higher ($0.022 versus $0.018 for the suburban scenario for BF+MIMO) due to the fact that more cell sites must be initially deployed to meet the same level of demand. In the rural scenario, despite the higher market share, the coverage requirements put even further pressure on the operator and the corresponding delivery cost per MB reaches $0.028 for the BF+MIMO solution.

In Year 5, the cost per MB converges to the approximately the same value in the urban, suburban, and rural scenarios as the network is capacity-driven in all cases. The only exception is the MIMO deployment in the rural scenario, which is still coverage-driven and has a slightly higher delivery cost per MB compared to the suburban and urban scenarios.

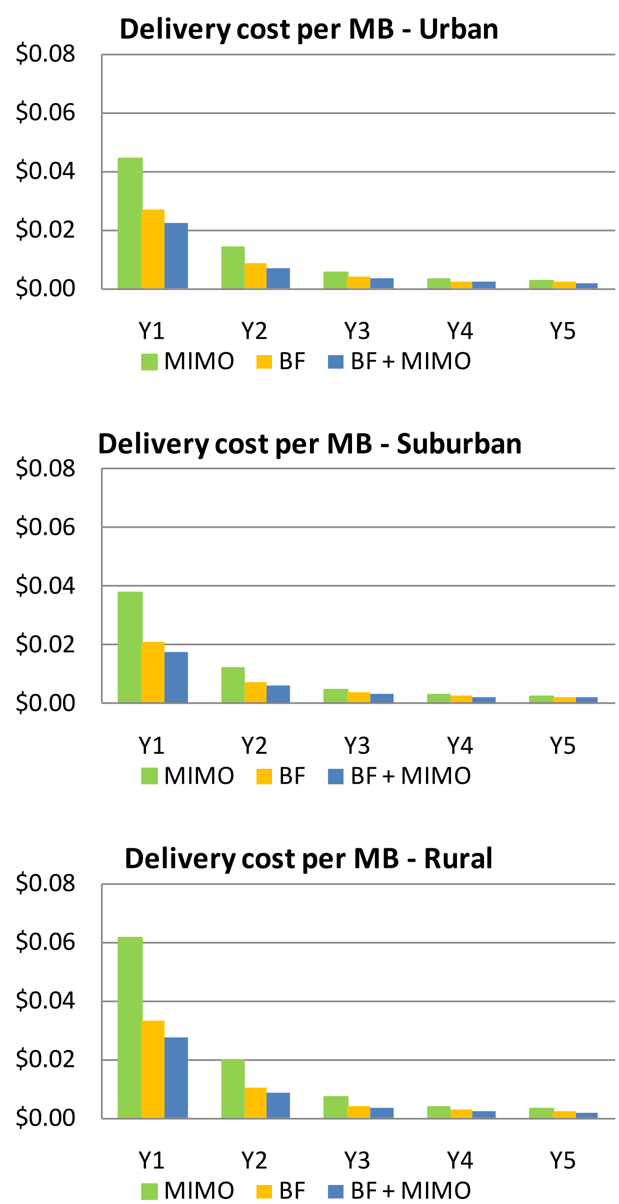

Figure 7. Delivery costs per MB in the urban, suburban, and rural scenarios.

RAN capex and opex. As both capex and opex are linearly dependent on the number of cell sites, the overall investment required is highest for the urban scenario and lowest for the rural scenario (Figure 8).

The three scenarios display different capex and opex trends through the five-year period. As noted in the base case, the requirement of fewer cell sites translates into many advantages for the operator. The suburban scenario presents the lowest Year 1 capex as a percentage of the cumulative capex, for all solutions (MIMO, BF, MIMO+BF) (Table 8).

If we compare the cumulative capex and opex, and examine the relative advantage of BF and BF+MIMO solution over MIMO (Table 9), the more challenging rural environment translates into bigger savings for the operator that chooses BF or BF+MIMO. The increase in cell site radius from BF and BF+MIMO is the main reason for the increased savings on both opex and capex. In the urban and suburban scenarios, the savings are approximately the same: in both cases the networks are capacity-driven (this is not the case for rural networks using MIMO).

Year 1 capex as a percentage of cumulative capex	Urban	Suburban	Rural
MIMO	73%	52%	52%
BF	63%	42%	42%
BF+MIMO	83%	62%	62%

Table 8. Year 1 capex as a percentage of cumulative capex.

Cumulative opex and capex (million)			
MIMO	Urban	Suburban	Rural
Capex	$225	$138	$145
Opex	$261	$149	$163
Total	$486	$287	$308
BF	Urban	Suburban	Rural
Capex	$222 (1%)	$137 (1%)	$143 (16%)
Opex	$177 (32%)	$105 (30%)	$112 (45%)
Total	$399 (18%)	$242 (16%)	$255 (32%)
BF+MIMO	Urban	Suburban	Rural
Capex	$184 (18%)	$133 (18%)	$118 (31%)
Opex	$147 (44%)	$87 (42%)	$92 (54%)
Total	$331 (32%)	$200 (30%)	$210 (44%)

Table 9. Cumulative capex and opex in the urban, suburban, and rural scenarios. Savings over the MIMO solution are shown in parentheses.

WiMAX networks in urban areas benefit more from BF than those in suburban areas. While the cumulative capex and opex savings from BF and BF+MIMO are very similar, the urban scenario requires a larger upfront investment for coverage for all three antenna solutions. In this situation the savings from BF and BF+MIMO are higher because the BF and BF+MIMO solutions are particularly effective at reducing the initial capex for the reasons discussed above.

Discounted RAN costs. The discounted opex and capex for the RAN summarizes the results of the analysis of the urban, suburban, and rural scenarios (Figure 9, Table 10). Rural WiMAX operators stand to gain the highest percentage savings from the adoption of BF or BF+MIMO. Fewer cells sites are needed when using BF or BF+MIMO to establish coverage initially, and to provide additional capacity in the second part of the five-year period.

Discounted capex and opex			
MIMO	Urban	Suburban	Rural
Capex	$207	$123	$65
Opex	$209	$117	$69
Total	$416	$240	$134
BF	Urban	Suburban	Rural
Capex	$193 (7%)	$116 (5%)	$51 (22%)
Opex	$137 (34%)	$81 (31%)	$37 (46%)
Total	$330 (21%)	$197 (18%)	$88 (34%)
BF+MIMO	Urban	Suburban	Rural
Capex	$160 (23%)	$96 (22%)	$42 (36%)
Opex	$114 (45%)	$67 (43%)	$31 (55%)
Total	$274 (34%)	$163 (32%)	$73 (46%)

Table 10. Discounted RAN costs comparison for MIMO, BF, and BF+MIMO in the urban, suburban, and rural scenarios. Savings over the MIMO solution are shown in parentheses.

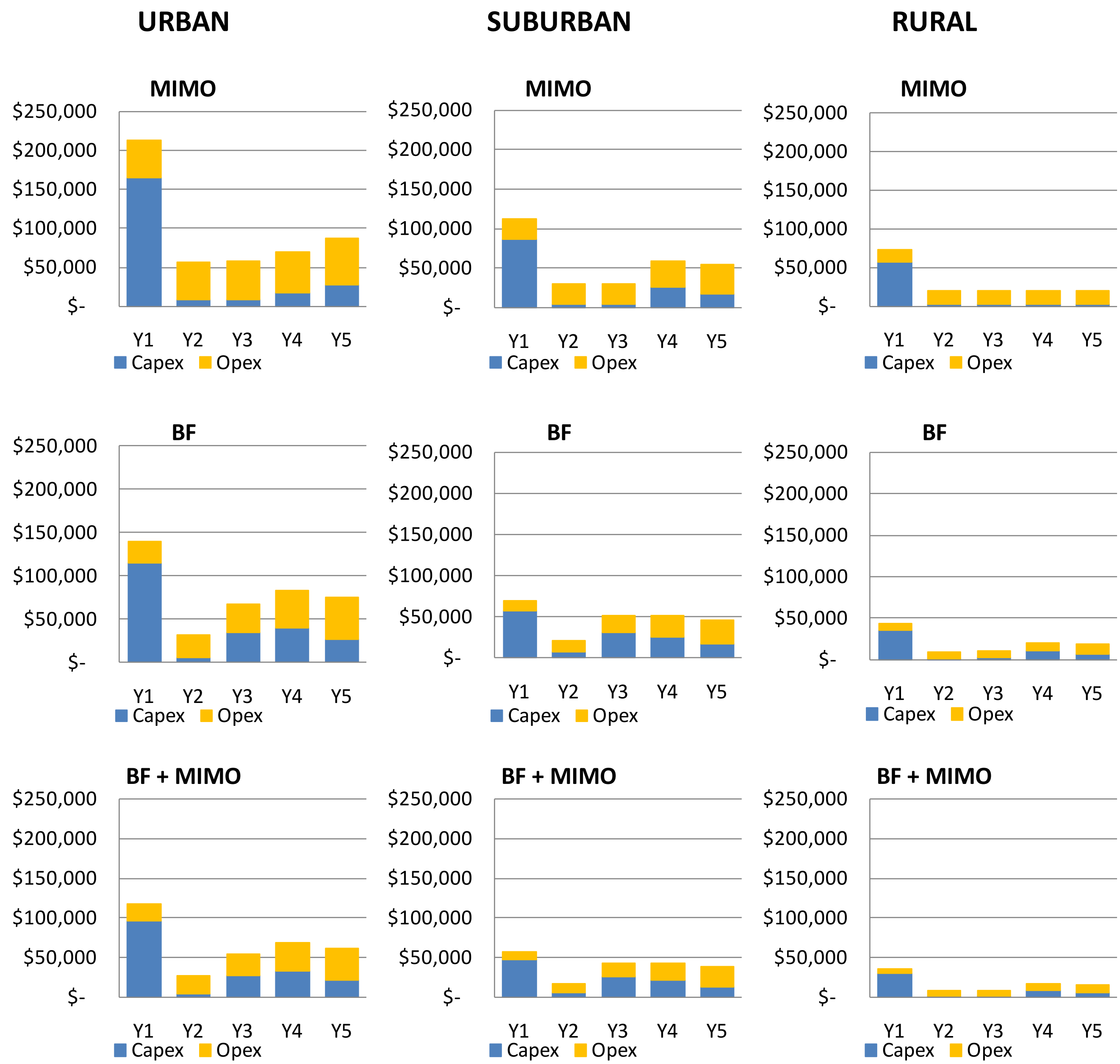

Figure 8. RAN capex and opex per km^2 in urban, suburban, and rural scenarios.

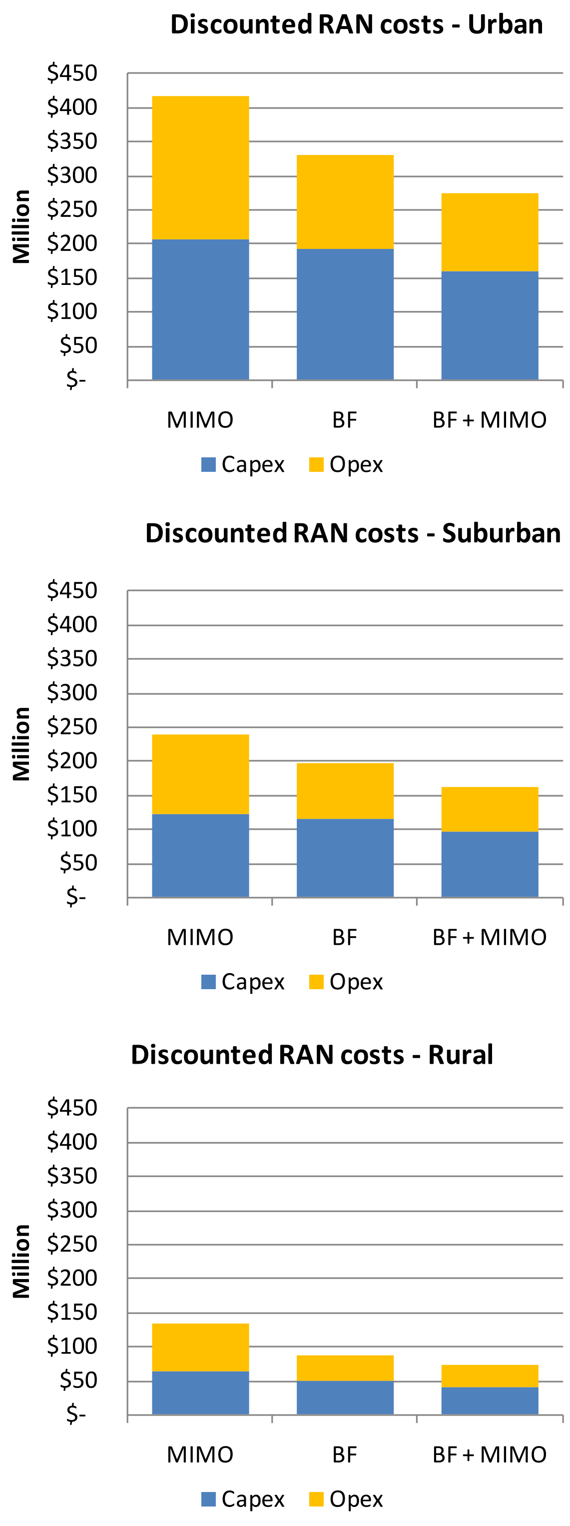

Figure 9. Discounted RAN costs for the urban, suburban, and rural scenarios.

Conclusions

When planning the construction of a network, operators are under intense pressure to keep costs down. Often the first step in trying to minimize costs is the selection of RAN equipment. A choice based purely on price per base station can hurt the operator in the long term for many reasons that are not exclusively financial—hardware reliability, timely delivery, performance, support, interoperability, upgradeability, equipment size, and power consumption, to name a few.

From a strictly financial perspective, equipment price is an important decision factor for WiMAX operators, but its impact should be evaluated within the wider perspective of overall deployment and operating costs. As installation costs are substantially higher (from 59% to 77% of the total capex in our model) than equipment costs, operators may reduce their overall network capex by using more expensive hardware, if this solution allows them to deploy fewer cell sites to meet their coverage and capacity requirements. Furthermore, fewer cell sites reduce the cost of operating the network and this accelerates the path to profitability as opex is typically higher than capex after the initial deployment.

At the same time, operators should also assess their capex choices within their profitability targets—i.e., on the basis of their revenue expectations and forecasted traffic demand—to ensure that their network can profitably sustain the traffic that subscribers are expected to generate.

In this paper we show a case in which higher equipment costs can deliver substantial cost savings during the initial network deployment and in the longer term. Our results rely on the assumption that BF and BF+MIMO solutions can deliver coverage and capacity improvements over MIMO-only solutions.

WiMAX as well as Long-Term Evolution (LTE) vendors have shown a high level of interest in adding BF support to their products in order to boost performance. However, to date, there is relatively little data on the performance of BF WiMAX networks—or, for that matter, on MIMO networks. Many operators still use SISO base station in their initial deployment phases. Further validation from commercial networks with MIMO and BF supporting high traffic levels will lend support or rectify the results presented here.

Xanadoo, a US WiMAX operator in Texas, Oklahoma, and Illinois, has been impressed with the performance of its recently installed BF network. Mark Pagan, Xanadoo's CEO, explains that "a better link makes it possible for a higher modulation, which translates into a higher revenue capacity." The additional capacity afforded by BF means fewer cell sites where traffic levels are lower and more capacity where demand is higher. This strategy has led to a network that is more efficient, and less expensive to deploy and operate.

There is wide agreement that BF will deliver improved performance, even though such improvements may depend on how BF is implemented, or on the environments in which it is deployed. Our analysis shows that the performance enhancements from BF can have an extensive impact on WiMAX operators, whether they operate in mixed environments or in primarily urban, suburban, or rural environments.

The model presented here shows that a BF solution can provide capex and opex cost savings of $53 million (BF) to $88 million (BF+MIMO) to a WiMAX operator over a period of five years, assuming a 20% to 34% reduction in cell sites. This is despite the fact that the cost of a BF base station can be over twice as high as that of a MIMO-only base station.

These are robust results that hold even when we change the assumptions made in terms of performance, traffic demand, or number of subscribers. Improved coverage and capacity lead to fewer cell sites, and fewer cell sites means more efficient network utilization, lower capex and lower opex, and eventually a faster path to profitability.

About Senza Fili Consulting

Senza Fili Consulting provides advisory support on wireless data technologies and services. At Senza Fili we have in-depth expertise in financial modeling, market forecasts and research, white paper preparation, business plan support, RFP preparation and management, due diligence, and training. Our client base is international and spans the entire value chain: clients include wireline, fixed wireless and mobile operators, enterprises and other vertical players, vendors, system integrators, investors, regulators, and industry associations.

We provide a bridge between technologies and services, helping our clients assess established and emerging technologies, leverage these technologies to support new or existing services, and build solid, profitable business models. Independent advice, a strong quantitative orientation, and an international perspective are the hallmarks of our work. For additional information, visit www.senzafiliconsulting.com or contact us at info@senzafiliconsulting.com or +1 425 657 4991.

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This paper was written by Monica Paolini. Monica Paolini is the founder and president of Senza Fili Consulting. She is an expert in wireless technologies and has helped clients worldwide to understand technology and customer requirements, evaluate business plan opportunities, market their services and products, and estimate the market size and revenue opportunity of new and established wireless technologies. She has frequently been invited to give presentations at conferences and has written several reports and articles on wireless broadband technologies. She has a PhD in cognitive science from the University of California, San Diego (US), an MBA from the University of Oxford (UK), and a BA/MA in philosophy from the University of Bologna (Italy). She can be contacted at monica.paolini@senzafiliconsulting.com.