

CABLE'S MOBILE FUTURE: WHICH TECHNOLOGY AND WHY?

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Abstract

This paper examines the wireless market and network technology, WiMAX or Long Term Evolution (LTE), cable operators will likely deploy in the not too distant future. Key market trends such as wireless growth, competitive threats and incumbent carrier landline erosion are explored. Technologies are compared based on expected mobile device availability, access technology, core network architecture, and roaming capability. The value of converged services is identified as a cornerstone to cable operators' wireless strategy. Finally a network technology recommendation is made based on the previous market and technology analysis.

INTRODUCTION

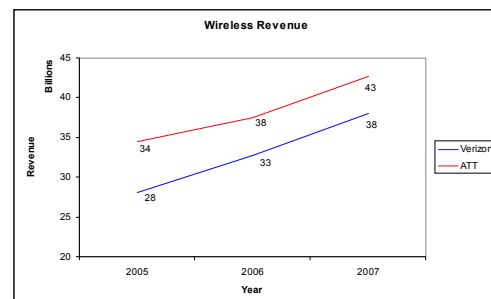
Over the past 3 to 5 years North American cable operators have invested significant resources to add cellular service to their portfolio with varied results. The first major step was the announcement of the SPRINT Joint Venture in November of 2005. This was a very celebrated development, but it hasn't provided an effective Quad Play offering. The next step was when major cable operators in the US, via Spectrum Co, purchased a nationwide footprint of AWS spectrum in September of 2006. This was again a major development, but the companies have yet to officially announce plans for the use of this spectrum. More recently, several major MSOs have entered the January 2008 FCC 700Mhz auctions with Cox, Charter (via Paul Allen /

Vulcan Ventures), and Bend Broadband winning additional spectrum. On March 26, 2008, the Wall Street Journal reported Comcast, Time Warner, Brighthouse and others are considering a WiMAX joint venture with SPRINT and Clearwire.

The previous events are noteworthy because they highlight a clear interest from the MSO community in bringing a credible wireless offering to market. This paper examines the prevailing market trends and concludes with a solution recommendation.

WIRELESS GROWTH

According to recent press, and the latest Quarterly reports from AT&T and Verizon, wireless subscriber growth is driving their overall company revenue growth. The graph below shows the revenue growth of the wireless organizations within Verizon and AT&T. Each of these corporations have experienced year over year growth in excess of 11.8% for the past 3 years.



Over the past few years revenue growth within wireless business units has been driven by voice, but as this market matures, revenue growth will be driven by value added data services such as SMS, email, and MMS. For instance, AT&T wireless has experienced exponential growth rates of mobile data usage. Usage of this service on their network has at least quadrupled for each of the last 4 years.

According to CTIA-The Wireless Association®, the average US cellular subscriber spends \$50 per month and there were 243.4M wireless subscribers in June of 2007. This is a staggering \$146B dollar annual revenue source for carriers. Comparing this to MSOs' most popular and highest ARPU service today, the National Cable Television Association (NCTA) reports US cable operators have 65.1M video households as of September 2007 with an approximate ARPU of \$60 for video service (Comcast 2007). This represents a market of \$46.9B. The point of this comparison is to illustrate, using current statistics, that offering a cellular service is a potential growth opportunity for MSOs. Cable Operators are already reaping the fruits of their landline efforts, but this opportunity will certainly diminish in the coming years. A viable and even obvious next step is to target a sliver of the wireless market representing a powerful new ARPU growth engine. This growth engine for MSOs will also serve to neutralize the predicted negative growth due to competition from the wide deployment of carrier-based services such as AT&T U-verseSM and Verizon FiOSTM.

In recent years subscribers have been transitioning to a wireless only voice communication paradigm. This transition is fueled by the improved reliability and affordability of wireless communication and subscribers' passion for mobility. As shown in the graph below from OECD, the European average for wireless only households is 22%

with Finland leading the charge at an incredible 54%.

Wireless Only Households	
Europe average	22.0%
Italy	38.0%
Austria	39.0%
Finland	54.0%
UK	13.0%
France	18.0%

Source: OECD

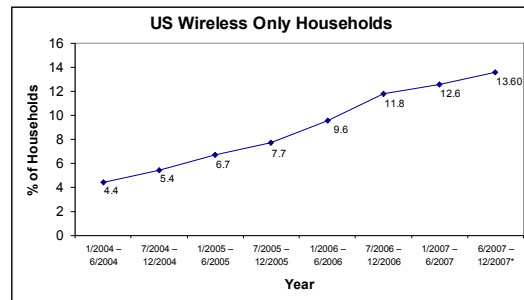
In recent mobile history, Europe has been a leading indicator for wireless trends in the US for services such as SMS and data. Assuming this applies to users cutting the cord as well, the US is going to follow the European trend that is taking place today. To back this theory the table below from In-Stat⁴ shows very strong interest in users migrating to a wireless only paradigm in the US.

Interest in Going All Wireless	US	France	UK
Extremely/Very Interested	45.0%	44.3%	44.2%
Somewhat Interested	33.5%	31.9%	27.1%
Total WITH Some Interest	78.5%	76.2%	71.3%

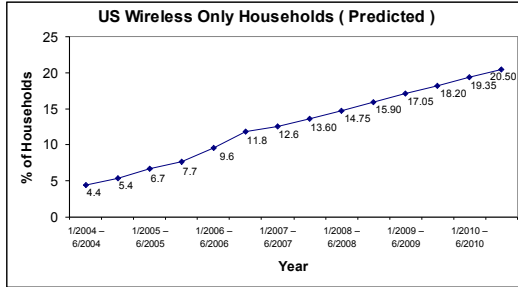
Source: In-Stat, 7/07

n=2,049

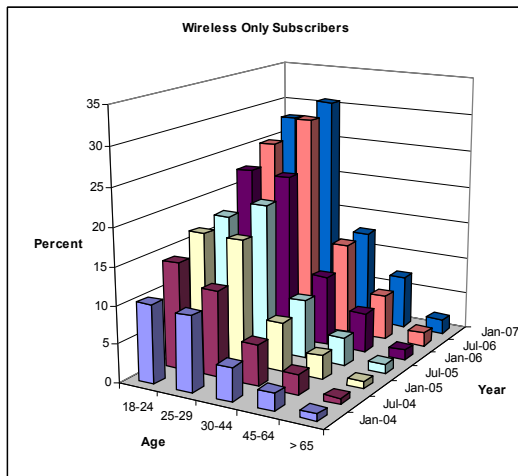
According to NCHS National Health Interview Survey, there were 13.6% wireless only households in the United States in 2007.



Assuming a continued average of 2.25% growth per year until 2010, the US will have approximately 20% wireless only households. This prediction will directly impact the wireline market going forward. Below is a chart of this prediction.

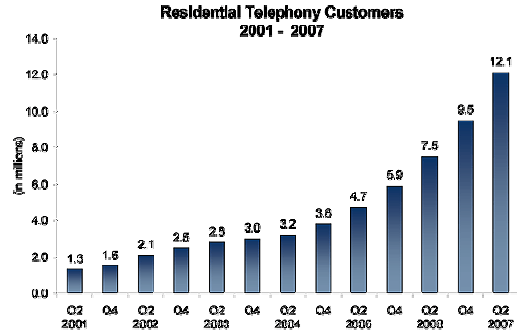


The predictions above are a conservative estimate when the following trend is considered. The younger a subscriber is, the more likely he or she is to be a wireless only consumer. The key message in the next graph is this trend will likely shift to the right as each demographic grows older versus remaining as an age-defined wireless only demographic. The younger generations will be more comfortable with mobile technology and thus more willing to rely on it as their sole communication device, but as they grow older their demand for mobile services will not diminish.

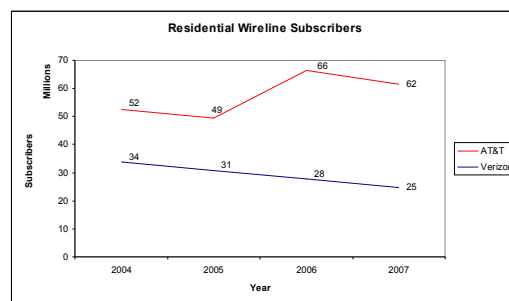


LANDLINE MARKET

In recent years cable operators have benefited significantly from strong subscriber landline growth as shown in the graph below from NCTA.

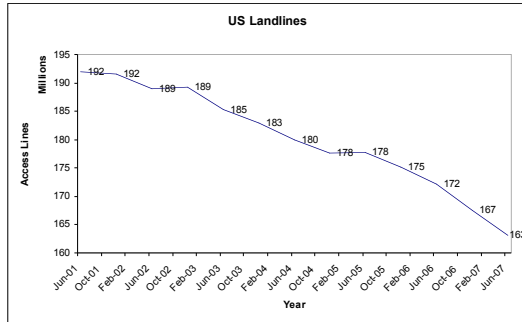


This growth has been the result of the significant landline erosion that has been a market force over the last few years in the traditional fixed line operator space. The traditional landline incumbents have taken the brunt of landline erosion as well as market competition from cable operators and pure play VoIP providers such as Vonage. The graph below shows the landlines lost by the traditional landline carriers over the past 4 years. One detail to notice in the graph is the only growth realized by either of the major carriers in the United States was via acquisition. In particular SBC acquired Bellsouth in 2005 which resulted in significant landline growth for the new corporation, but it is still very clear that the overall trend is landline erosion within the incumbent landline carriers. For instance, Verizon has lost 26.5% of its residential landline subscriber base over the analyzed time frame below.

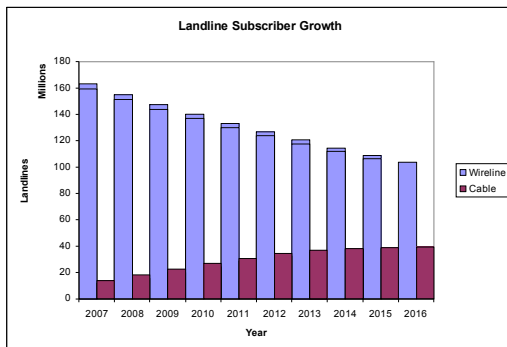


Despite cable operators' significant landline growth in the last couple of years the overriding industry trend is landline erosion as shown in the diagram below. As shown by March 2008 data from the FCC Wireline

Competition Bureau, during the past 5 years, the total landline market compressed by 15.1%. This doesn't highlight other overriding trends such as price erosion, but it certainly shouldn't be ignored.

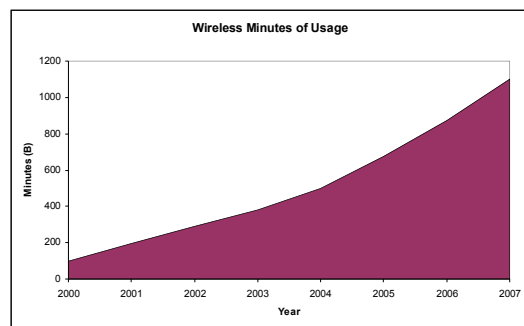


Using the data from the growth plot above and assuming continued -5% annual growth, the projected carrier landline market is shown in the next graph. On this same graph an annual growth rate of 15% for MSO landline growth is assumed for the next 2 years. After this period the growth rate reduces 2% per year until the MSOs reach 40% penetration of their 123M current homes passed. Based on the previous assumptions cable operators will likely experience flat landline growth in the 2012 timeframe.



The key takeaway from this analysis is as follows: Once MSO landline growth stops it is likely that the overriding trend of landline loss will then start to affect cable operators as it has affected the incumbents for the last few years.

These trends are being driven by the consumer's passion for wireless connectivity and continuous connectivity to friends, family and associates. Wireless Minutes of Use actually surpassed residential landline usage in 2003 and the population continues to become more and more reliant on wireless devices. The diagram below shows current and historical and wireless Minutes of Use (MOU). There is certainly a peak to this trend, but for the foreseeable future landline erosion and wireless MOU growth will continue.



To further accelerate the previously discussed trends, incumbent wireless operators are increasing the pressure on landline Minutes of Use and thus the profitability of landline operators' business. Verizon Wireless, AT&T, T-Mobile, and SPRINT all announced unlimited calling plans early in 2008. These unlimited plans will likely drive further growth of wireless MOUs and further commoditize landline voice.

T-Mobile is the most aggressive in its offering of the Hotspot@Home™ and Talk Forever™ services. The T-Mobile Hotspot@Home service is a \$9.99 per month service add-on to a minimal wireless plan that provides unlimited voice and data using UMA enabled dual-mode handsets over Wi-Fi. The Talk Forever service is a UMA enabled Analog Terminal Adapter that offers a Vonage-like service to T-Mobile customers. This service is available in limited markets at the time of this writing, but is planned for a nationwide launch at \$9.99 as an add-on to an existing wireless plan.

The goal of these new services is best stated by T-Mobile USA CEO, Robert Dotson in a June 27, 2007 release, “More people than ever are looking to drop their home landline phone and pocket the savings. However, they don’t want to use all their wireless minutes talking from home. Our new service solves this dilemma once and for all. T-Mobile’s HotSpot@Home is a first-of-its-kind service that helps people simplify their lives, save money, and enjoy great call quality on one device — their mobile phone — at home”. Joe Sims, VP of T-Mobile Broadband Products was quoted by Wi-Fi Net News stating “T-Mobile is looking to address the remaining reasons people were reluctant to cut the cord.”

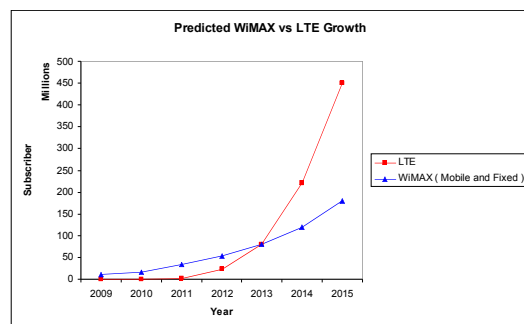
The expectation is that unlimited calling plans will force the major wireless operators to offer solutions similar to the ones T-Mobile has in its portfolio for various reasons. With unlimited calling plans, subscribers will become more and more reliant on their mobile devices, thus demanding better in-home coverage and bandwidth. Assuming uptake is high, the unlimited services will require operators to add additional network capacity to keep customer satisfaction at high levels. Another key driver of these new converged services is the undeniable cost advantage of landline vs. mobile MOUs.

NETWORK TECHNOLOGY

The key consideration during the selection of a new mobile access technology is the future expectations of access device cost and availability. Both of these factors are typically tied to subscriber bases with the capability to drive the largest handset volumes. Today GSM and CDMA are the prevalent network technologies and handset costs and varieties follow the afore-mentioned trend. According to 3G Americas.org, as of 3Q2007, there are 2.7B GSM subscribers in 220 countries resulting in 86% of the global wireless market share. In

contrast the CDMA Development Group reports 431M CDMA subscribers in 97 countries resulting in approximately 13% of the global wireless market share in 4Q2007.

The above comparison can then be applied to the current handset market for each of these network technologies. The CDMA Development Group reports that 1,950 devices have been introduced in to the market including 509 1xEV-DO Rel. 0 and 48 1xEV-DO Rev A devices. This is a historical figure over the lifetime of CDMA 2000 technology. GSM Arena reports current GSM device availability at 1159 in March 2008. This shows that the current number of commercially available GSM handsets in the market today is over half of the lifetime total number of CDMA2000 devices. This comparison is very useful when thinking about the next technology choices that MSOs will make or are already making. 3GPP Long Term Evolution (LTE) and WiMAX handset availability, variety, and cost will clearly be driven by the addressable market size. Below is a subscriber growth prediction using data from Senza-Fili and Analysys. The Senza-Fili data was extended to project 2014 and 2015 for this paper. The current projection is LTE will quickly overtake WiMAX (including Total Fixed and Mobile) deployments in the beginning of 2013.



Technology decisions will also affect roaming relationships that are possible between networks and operators. LTE has a clear advantage over WiMAX in this area because of the clear evolution path as technologies evolve.

3GPP GSM networks are evolving from GPRS to EDGE to HSPA today and the next evolution to LTE is an extension of that experience. The primary enabler of this evolution is a healthy handset ecosystem that will build handsets that support the upcoming network deployments. A handset that supports EDGE, HSPA, and LTE will be able to get network access virtually anywhere in the world in the coming years. This is a critical capability that must not be ignored as operators build out “greenfield” networks that have limited coverage areas. Technology inclusion and thus roaming relationships for WiMAX devices are very unclear. SPRINT and Clearwire have announced WiMAX network(s) in the US but primarily for laptops and fixed wireless access with a transition to mobile devices. The next step is offering mobile WiMAX in portable devices. Given the limited WiMAX coverage areas, a combination WiMAX/ CDMA2000 handset will likely be required. This combination will have far less volume and a much smaller ecosystem than the 3GPP driven LTE standard. This is driven by the uncertainty or non-linearity in the technology evolution path. Because SPRINT has an existing CDMA2000 network they will require a CDMA2000 /WiMAX handset solution until a nationwide WiMAX network is in place. This is in direct contrast to the recent decision that Verizon has made to utilize LTE technology in its next generation network upgrade. This decision will divide the US CDMA2000 subscriber base between WiMAX/CDMA2000 and LTE/CDMA2000 in the United States. There are many other potential handset technology combinations such as WiMAX/EDGE/HSPA that could be deployed by existing 3GPP or greenfield operators. This decision again would result in a divided market in comparison to the clear 3GPP evolution path and global scale.

The technology decision made by MSOs will also affect the opportunity for inter-carrier

roaming. For example, if WiMAX devices are deployed by SPRINT they will be the only established US operator deploying a WiMAX/CDMA2000 technology combination. As previously mentioned, Verizon Wireless has made public commitments to deploying a LTE network in its next round of technology upgrades. This implies SPRINT will not have an established nationwide WiMAX roaming carrier with a large network footprint or the subscriber base to support a nationwide network deployment. SPRINT will have to rely primarily on its network deployments for WiMAX coverage or utilize CDMA2000 based roaming. This also implies SPRINT will receive little WiMAX based roaming revenue from other US based operators except Clearwire. On the other hand, Verizon’s LTE approach will immediately expand its roaming partner ecosystem in North America and abroad. Verizon Wireless’ 50% owner, Vodaphone, has announced intentions of deploying LTE as have AT&T, China Mobile and NTT DoCoMo. It is likely that many of the over 200 3GPP operators will follow this clear evolution trend. This roaming ecosystem will provide Verizon access to a worldwide roaming based revenue engine as well as offer its customers a much better service availability. Verizon isn’t a true greenfield operator as most cable operators are today, but its decision to deploy LTE technology makes it very similar because of the technology discontinuity.

Technically speaking, WiMAX and 3GPP’s LTE are very comparable access technologies. Some of the access technology highlights are as follows: OFDM-based, similar modulation techniques, theoretical throughput and capacity. One notable exception to this rule is that WiMAX is typically a TDD solution whereas LTE is typically a FDD solution. WiMAX does have a FDD profile, but this hasn’t been deployed. The data in the table below gives a more thorough comparison.

	3GPP LTE	WiMAX
Bit-rate/site(DL)	100Mbps(MIMO 2TX, 2 RX)	75Mbps(MIMO 2TX, 2RX)
Bit-rate/site(UL)	50Mbps	25Mbps
Base Standard	E-UTRAN	IEEE 802.16e
Duplex Method	FDD	TDD(FDD optional)
Downlink	OFDMA	OFDMA
Uplink Multiple Access	SC-FDMA	OFDMA
Channel BW	1.25 - 20Mhz	Scalable:4, 3.75, 5, 7.8, 7.5, 10 Mhz
Modulation DL	QPSK/16QAM/64QAM	QPSK/16QAM/64QAM
Modulation UL	QPSK/16QAM/(64QAM opt)	QPSK/16QAM
Cell Radius	5km	2-7km
Spectral Efficiency	5[bits/sec/Hz] >200 users @ 5Mhz	3.75[bits/sec/Hz]
Cell Capacity	>400 users for larger BW	100-200 users

From a core network architecture perspective both WiMAX and LTE have been designed to be very flat IP-based solutions that interconnect with an IP Multimedia Subsystem, but there is a key difference. LTE has been architected from the beginning to support seamless handover and global roaming to LTE/2G/3G networks. WiMAX mobility is based on mobile IP and hasn't addressed inter-Radio Access Technology handover or global roaming scenarios.

The current standardization, deployment and mass market timelines show WiMAX reaching market in 2007, which has already happened. WiMAX mass market adoption is to begin in 2009. LTE is trailing WiMAX with expected deployments to start in 2010 with mass market adoption in 2012.

CONVERGENCE OPPORTUNITY

As cable operators become more serious about bringing a wireless offering to market, they must consider the clear advantage of adding a flavor of either device or service convergence to their solution. They must leverage the next generation access and transport networks that have been put in place to serve their other business needs. This investment can be further exploited with an offering that addresses both device and service layer convergence. This need becomes obvious when examining the calling patterns of wireless subscribers. In the US the average consumer makes at least 40% of calls from an indoor home or work environment. This doesn't even consider continuous data usage for services such

as Email, IM/presence, Web browsing, etc. This single statistic puts the cable operator with a wireless offering in a very good position to offer compelling new service bundles and capabilities required to compete in a hyper-competitive marketplace. In 2007 there were 123 Million households passed by cable operator networks. If we assume an average of 2 persons per household, MSOs have the ability to offer converged services to 246 Million subscribers. Compelling new services such as these will be required to create an impetus for change and drive the current 50% service penetration enjoyed today even higher.

Device convergence is the concept of embedding both Wide Area Network and Local Area Network technology in mobile devices. The most common example today is Wi-Fi+GSM in a single handset, but in future deployments this will likely become Wi-Fi+WiMAX+CDMA2000 or Wi-Fi+LTE+GSM. Femtocells can also be viewed as device convergence at a slightly different layer. The femtocell combines traditional Wide Area Network technology such as CDMA2000 with high speed local area network backhaul. The purpose of all Device Convergence is to make use of high bandwidth, low cost local area networks when they are available, but make the user experience very simple, cost effective, and truly next generation.

Service Convergence is the idea of blending physically independent device types on one or multiple carrier networks utilizing intelligent core networks. This blending occurs through simultaneous ringing of the independent device types and allows the call to be moved between different terminals very easily. For example, imagine walking into your home on an active AT&T cell call and with a single key press moving that active call from your mobile device to your cable operator managed landline. This would allow the user to select the current device of convenience, best performance, least

cost, or comfort as they prefer. This type of blending would offer a compelling reason for consumers to keep a landline in the home and thus reduce the current trend of landline erosion.

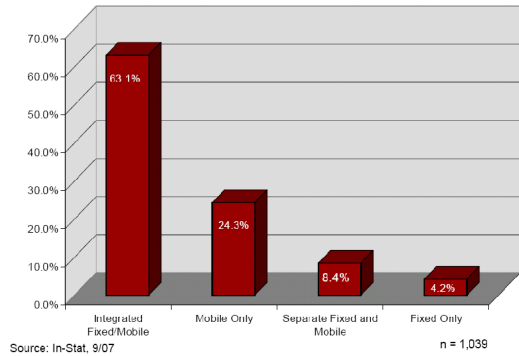
Demand for these services has been shown by recent studies. Of those surveyed, 49% of subscribers rate coverage at home and 42% rate voice plan pricing as the most important factors when selecting a cellular carrier. These are the top two factors which drive a consumer's wireless decision. This clearly shows that a device convergence strategy which attacks both of these issues head on, is a win-win offering for the consumer and operator.

One of the key issues in deciding to deploy a wireless network is developing an offering that is going to be compelling enough to entice a subscriber to switch providers. Based on a recent report, a converged solution is extremely or somewhat interesting to 92.7% of subscribers.

How interested would you be in moving your existing service bundle to another service provider in order to purchase an integrated fixed/mobile voice service?	
Extremely/Very Interested	50.4%
Somewhat Interested	42.3%
Not Very/Not At All Interested	7.3%

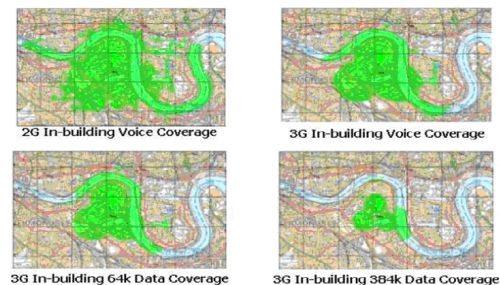
Source: In-Stat, 8/07 n = 1,039

From this same report subscribers are demanding a converged voice experience. Of particular interest to the cable industry is the perception that a fixed-only life is very undesirable to the study group. This indicates a user faced with a forced selection would prefer a mobile-only life rather than a tethered one, but the most desirable solution by far is a mixed offering.



DOCSIS 3.0 has shown the ability to improve download speeds at least 4X (40 Mbps to 160 Mbps) over the current DOCSIS 1.x/2.0 technology that is deployed in today's networks. This is proving to be a competitive advantage because of the relatively low capital investment required to deliver this level of bandwidth to a consumer's door. In the not too distant future converged devices play a significant role to further leverage this investment as part of the cable operator's wireless strategy. Using their HSD infrastructure cable operators can vastly improve the user experience and decrease the cost per bit significantly.

A device convergence strategy addresses an obvious problem MSOs will encounter with indoor coverage as they deploy their new networks. As an illustration of the issue the diagrams below show indoor penetration of 2G Voice, 3G Voice, 3G 64K data, and 3G 384K data by cellular base stations.



Notice the higher the data rate the less effective in-home coverage becomes. This is a well known characteristic of higher bandwidth

and/or higher frequency channels driven by the laws of physics. It may not be intuitive but this phenomenon will also affect outdoor users in terms of effective available bandwidth. The indoor users will consume more of the cell site's resources because adaptive modulation techniques are utilized in mobile networks. The indoor user's device will be using lower modulation schemes and hence require more of the available bandwidth than outdoor users to transmit the same amount of data. These facts show a converged solution will alleviate pressure on the outside network, therefore reducing the network capital investment required to offer best in class coverage and bandwidth to the end user.

CONCLUSIONS

From the market analysis above it is clear that cable operators must enter the wireless space to, at a minimum, prevent contraction of their existing business. Furthermore a much larger opportunity exists to accelerate revenue growth by entering and capturing a small portion of the wireless subscriber base that is searching for a true Quad-Play service offering. Cable operators have a lead in bandwidth to the home and a best in class content offering today, but the carrier community is attacking this safe haven with relentless vigor. With the addition of wireless it is quite clear that the MSOs will continue to be a formidable competitor.

Analyzing market data and comparing technology capabilities leads to a recommendation of LTE as the network technology best fit for MSO deployment. It is evident that the global scale of LTE insures competition as well as innovation in the handset and network equipment space via a vast vendor ecosystem. Its technical capability is second to none with the key element being handover and global roaming capability with not only LTE but legacy 3GPP and even CDMA EV-DO Rev-A networks. This is paramount when it comes to

customer satisfaction and revenue generation capability. One potential path to LTE to satisfy operators need for accelerated deployment is a staged approach of deploying 3G HSPA today and upgrading that network to LTE in the coming years. This strategy would allow for early market entry with field proven technology that is comparable in performance to today's WiMAX solutions.

Finally, a convergence strategy is a differentiator that will help insure a successful market entry for MSOs by significantly reducing capital expenditure and providing subscribers with yet another reason to migrate to cable operators' networks.

References:

1. "Statistical Trends in Telephony 2007 Report", FCC
2. "A Comparison of Two Fourth Generation Technologies: WiMAX and 3GPP LTE", <http://www.comsysmobile.com/pdf/LTEvsWiMax.pdf>
3. "2008 Corporate Brochure", GSMA
4. "HSPA and mobile WiMAX for Mobile Broadband Wireless Access", gsmworld
5. "EDGE, HSPA and LTE The Mobile Broadband Advantage", http://www.rysavvy.com/Articles/2007_09_Rysavy_3G Americas.pdf
6. CTIA mid year survey 2007, CTIA
7. "Wireless Quick Facts", CTIA
8. "Industry Statistics", NCTA
9. "Verizon Communication Inc., Form 10-K"
10. "AT&T Inc. Form 10-K"
11. "Comcast Corporation. Form 10-K"
12. "Time Warner Cable Inc. Form 10-K"
13. "Wireless Substitution: Early Release of Estimates From the National Health Interview Survey, January-June 2007, NCHS
14. "T-Mobile's VoIP Home Service: Goodbye to the PSTN", In-stat
15. "3G Femtocell, Fixed-Mobile Convergence", Light Reading Femtocell Webinar.
16. "Global Mobile Broadband: Market potential for 3G LTE", Analysys