Arthur D Little

Arthur D. Little Mobile Broadband Wireless Report 2004

Mobile Data

Handoff for Continuous Coverage

Complementary Local Loop

WiMAX vs. WiWAIT: Will Mobile Also Dominate Broadband?

Dear Readers,

We believe the rapid emergence of Mobile Broadband Wireless Access systems pose fundamental challenges to the current telecom landscape. Arthur D. Little forecasts that the global mobile broadband wireless industry could attract 10 million customers by 2008. The core businesses of both fixed line and mobile providers are at significant risk from this potentially disruptive technology with its promise of a complementary last mile solution capable of catering to both voice and data, combined with mobility.

Operators need to determine their approach to these technologies in their own markets, decisions given added urgency with the rash of recent technology trials and network launches. However, potential customers of these technologies (fixed, mobile and new entrants) have found it difficult to obtain balanced information on available systems, and to accurately interpret the often conflicting advice coming from strongly competing interest groups and vendors. We hope that this report provides a balanced and independent view, while also further stimulating some useful debate within the industry, particularly concerning the value of standards in what we see as a highly fragmented market. In this report, we identify the leading technologies in the market, the key features to consider when choosing a particular technology, and examine the strategic challenges faced by industry players in regards to MBWA.

In the course of preparing this report, we have relied on the knowledge and experience of our staff, clients, and also on the skills and insight of key independent consultants and industry players, whose collective insights have been formed from day to day involvement with actual system rollouts. We would like to take this opportunity to extend our thanks to all of these contributors.

Yours sincerely,

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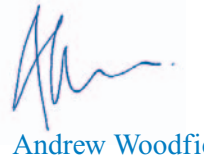
November 2004



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Executive Summary

Mobile Wireless Broadband Access (MBWA) systems, which are currently being tested and rolled out worldwide, offer customers broadband connectivity on the move. The development of MBWA presents market opportunities as well as real strategic challenges to companies that own and operate fixed and mobile telecommunications networks, with the possibility of a disruptive change in the competitive landscape. Arthur D. Little's goal in this report is to provide a balanced and independent view, while also further stimulating some useful debate within the industry.

What is MBWA?

- Mobile broadband wireless access (MBWA) systems permit the delivery of data at speeds from 384 kbps to 4 Mbps or above, with customers free to move over wide areas while remaining connected to the service at all times.
- MBWA systems can offer much more cost-effective solutions than current fixed or wireless technologies to meet the broadband and voice needs for various customer groups.
- MBWA offers significant advantages over current 3G mobile systems due to advances in technology, such as the use of smart antennas, which enable more efficient use of the spectrum.
- MBWA systems can offer attractive opportunities for all telecom players:
  - For incumbent fixed operators, MBWA can enable the delivery of basic broadband services to areas that can not be economically served with DSL or fibre.
  - Mobile operators can leverage MBWA to meet their customer needs for reliable and cost-effective fixed and mobile high bandwidth data.
  - Alternative operators and new entrants can use MBWA to bypass the incumbent's local loop and thereby compete more effectively.
- Arthur D. Little forecasts the global MBWA market potential to be 10 million customers in 2008, two-thirds of which are expected to be business customers and one-third residential.
- Demand for MBWA has been driven by vendors' effort to meet increasing demand for broadband access on the move, by mobile operators looking to repeat the success of mobile telephony and by alternative operators seeking to use MBWA to unbundle the local loop.
- MBWA networks provide transparent access for the delivery of a wide variety of fixed or mobile broadband services, including Voice over IP.
- All major MBWA vendors currently have a variety of customer devices available and several already plan to offer a VoIP handset device.
- 3G operators are reacting to emerging MBWA competitors by reducing the cost for their current lower speed data products while UMTS vendors are focusing development efforts on increasing data speeds (HSDPA) and smart antennas (MIMO).

MBWA Solutions

MBWA systems are under development by many leading companies, and include both proprietary and standard-based technologies.

- Four companies, ArrayComm/Kyocera (i-Burst), Flarion Technologies, IP Wireless and Navini, are currently leading the development and commercial deployment of proprietary MBWA solutions. More than 40 trials and commercial launches have taken place since 2002.
- There are four primary groups working on a MBWA standard: UMTS TDD, 1x EV-DO, WiMAX and 802.20 (MobileFi).
- Five main factors to consider when evaluating an MBWA technology are capacity, coverage, spectrum, cost and degree of commercialisation. In addition, issues such as interoperability, scalability, latency performance and industry commitment should be considered.

Challenges Faced by Industry Players

As MBWA solutions are now being tested or rolled out, it is critical that both incumbent and alternative fixed and mobile operators begin to address some critical strategic issues related to the market potential, regulation, likely competitive response, and timing and size of a potential investment into MBWA.

- Strategic Challenge #1 What is the best approach to take with the national regulators to either enable or block the deployment of MBWA technologies?
- Strategic Challenge #2 Is there sufficient demand for services delivered over MBWA in order to justify the necessary investment?
  - Incumbent fixed network operators need to assess the opportunities that MBWA provides, while protecting their current market position.
  - Mobile operators need to assess the impact of MBWA on current 3G plans and decide whether MBWA is an attractive complementary option.
  - New challengers and ISPs need to address the possibility of using MBWA to unbundle the local loop, and offer new broadband fixed and mobile services at reasonable prices.
- Strategic Challenge #3 Given the current and expected availability and cost of various MBWA solutions, when is the right time to invest in MBWA?

Conclusion

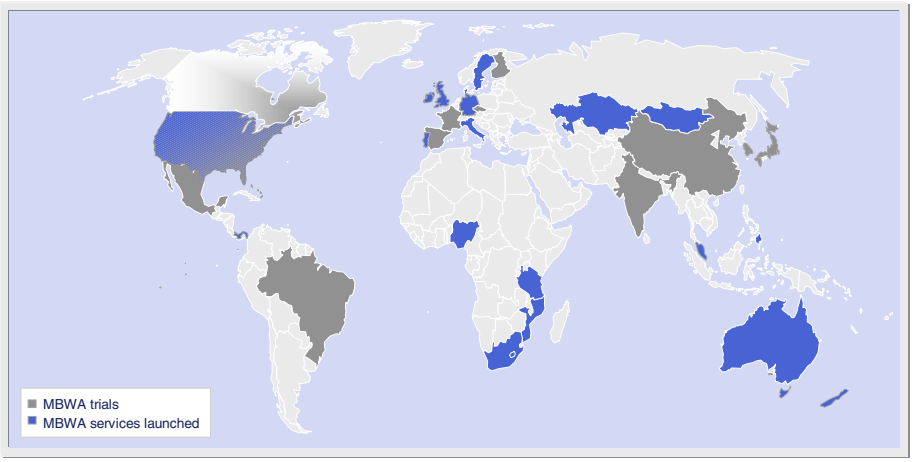
- We believe that broadband wireless access technologies could have a disruptive impact on telecommunication markets in the medium term.
- We feel that there are several reasons to be cautious regarding WiMAX's promises, given the challenges yet to be overcome in terms of market and vendor fragmentation, and the availability and cost of spectrum in many markets. It will take several years before the mobile WiMAX standard gains any real traction.
- Operators, whether fixed or mobile, incumbent or alternative, are facing difficult choices, given the wide range of MBWA technologies currently available or under development. There is a risk to investing too early, before these solutions are commercially-proven and an MBWA standard has been finalised. However, a wait-and-see approach may present a greater risk, and in many markets may not be a feasible option.

Introduction

Mobile Wireless Broadband Access systems are currently being tested and rolled out worldwide, offering customers broadband connectivity on the move, providing market players with both market opportunities and strategic challenges.

Between 2000 and 2004, the global broadband market experienced spectacular growth, growing from USD 6.2 billion to USD 54 billion. This growth in broadband demand has begun to also impact the mobile market; mobile broadband wireless access (MBWA) technologies are developing quickly. More than 40 trials and commercial launches have been started since 2002, and commercial rollouts have begun in Australia, Germany, Portugal, the Netherlands, New Zealand, South Africa, United Kingdom and USA (Figure 1).

Figure 1 **MBWA Trials and Commercial Rollouts**



Source: Arthur D. Little analysis, as of October 2004

Four leading proprietary MBWA vendors, ArrayComm/Kyocera (i-Burst), Flarion, IP Wireless and Navini, are dominating these trials and, more importantly, the full-scale commercial deployments.

With broadband wireless access technologies becoming available at prices affordable for both operators and customers, it presents current market players and new entrants with radically new market opportunities and threats. These further stimulate competition and contribute to global broadband growth.

For incumbent fixed operators, MBWA can enable the delivery of basic broadband services to areas that can not be economically served with DSL or fibre. Likewise, mobile operators can leverage MBWA to meet their customer needs for reliable and cost-effective, fixed and mobile broadband data. However, with the substantial investments into UMTS, most of which still weigh heavy on many balance sheets, investors will want to see solid justification for investing into yet another technology.

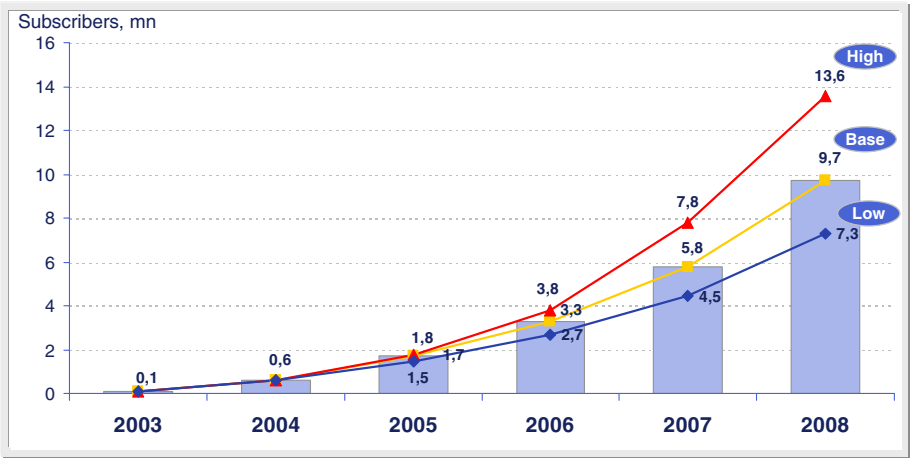
Importantly, alternative operators and new entrants can use MBWA to bypass the incumbent's local loop and thereby compete more effectively. MBWA may also permit these operators to wrest control of key segments of the addressable broadband market, such as business users and road warriors.

In light of this important new threat, incumbents will therefore need to consider their position, as well as that of any mobile subsidiaries, in the light of them both being able to offer broadband services based on this new technology.

The regulators in any market play a critical role in the development of MBWA services as they ultimately determine the allocation of spectrum. In doing so, they decide whether to license spectrum to particular operators or particular technologies, thus determining the level of competition on the market.

Based on our analysis of the broadband market, the demand for MBWA services already being seen in markets where there have been commercial launches and the number of trials taking place around the world, Arthur D. Little forecasts the global MBWA market potential to be 9.7 million customers in 2008, two-thirds of which are expected to be business customers and one-third residential. It is important to note that much of the fixed BWA market can be readily addressed by most MBWA systems. Therefore, the addressable market for MBWA could be at least 30 percent greater than this estimate by 2008; this additional market potential is taken into account in the «High» forecast.

Figure 2 **Potential Global MBWA Market Forecast**



Source: Arthur D. Little analysis

The development of MBWA presents real strategic challenges to companies that own and operate fixed and mobile telecommunications networks, with the possibility of a disruptive change in the competitive landscape. However, many operators have yet to address the impact of this new technology.

As MBWA solutions are now being tested or rolled out, it is critical that incumbent and alternative, fixed and mobile operators begin to address some critical strategic questions, such as: What are the possibilities to deploy this technology on the market? What is the position of the regulator on these technologies? Is spectrum available? If not, when is it likely to become available?

What is the likely response of the other market players? How could this new technology impact revenue forecasts? Given the proprietary systems currently being rolled out and the standardisation work being done, should a company adopt a wait-and-see approach? Or is there a real and credible threat of being left behind in the market? How should MBWA be considered in overall capital expenditure plans, especially for incumbents offering fixed and mobile services?

Our purpose in this report is to assess this new and dynamic technology, the MBWA systems that are currently being tested and deployed, and the strategic implications for market players. This includes an evaluation of:

- The MBWA market, including key demand drivers, services to be offered, and customer devices that are currently available and under development;
- MBWA solutions currently being deployed or under development and the criteria which should be used to evaluate them; and
- An assessment of the key strategic challenges to be addressed by market players when assessing a potential investment into MBWA

Part 1 The Dynamic MBWA Market

In order to understand the full potential impact MBWA may have on their local markets, operators need to have an understanding of what the technology can offer, its market potential and how it compares to the 3G systems currently being developed.

In order to understand the market for MBWA and the opportunities and threats it presents, we need to first understand the MBWA technology. To achieve this, we will address five key questions:

- What is MBWA?
- What are the main drivers fuelling the demand for MBWA?
- What services can be delivered using the MBWA technology?
- What MBWA equipment and customer devices are available or under development?
- How does MBWA compare to 3G mobile systems currently being developed?

1.1 What is MBWA?

Mobile broadband wireless access (MBWA) systems permit the delivery of data at speeds from 384 kbps to 4 Mbps or above, with customers free to move over wide areas while remaining connected to the service at all times.

Mobile broadband wireless access (MBWA) systems permit non-line-of-sight data transmissions at speeds between 384 kbps and 4 Mbps or above (peak downlink rate), enabling the customer to download or upload email, surf the web at broadband speeds, and transfer files continuously, regardless of location and movement. With MBWA, broadband services become accessible anywhere within the wide coverage area of the service, which can be tens or even hundreds of square kilometres. Leading systems support roaming between cities, while others already provide full mobility with handoff.

Fixed wireless broadband access (FBWA) systems employ an external outdoor unit with integrated antenna and an indoor unit with a phone jack and an Ethernet port. While supporting broadband data over large distances, FBWA installations are more costly and the customer location is fixed.

In contrast, MBWA systems feature simple one-piece compact customer devices, including small external modems with USB or Ethernet interfaces, or PCMCIA cards, each often with a small fold-up antenna. These devices are self-installed by the customer, often with a customer-driven, web-based system for accessing the initial service. Since these are mobile technologies, no change is required when a customer moves to another location.

The rollout of a MBWA network is similar to the rollout of a mobile network, and access to sites is a critical success factor for any operator. Especially in Europe, access to potential sites is rigorously regulated for environmental reasons. For that reason, mobile operators are in the best position when developing a MBWA network as they can utilise their current infrastructure.

As the devices become smaller and with the introduction of VoIP-enabled MBWA handsets expected in 2005, customers could soon have both a very low cost mobile voice service and high bandwidth data access in a single device, which is a very compelling wireless access product.

1.2 Key Drivers of Demand for MBWA

Demand for MBWA has been driven by vendors' effort to meet increasing demand for broadband access on the move, by mobile operators looking to repeat the success of mobile telephony and by alternative operators seeking to use MBWA to unbundle the local loop.

There are three main players driving the development of MBWA: vendors, mobile operators and alternative operators.

Vendors and mobile operators are hoping to build on the growth in wireless LAN (WLAN) systems and repeat the spectacular success of mobile telephony by moving into mobile data. Alternative operators are interested in using MBWA to bypass the local loop barrier when delivering broadband services and to gain additional attractive revenue through the delivery of voice services.

The rapid growth in the WLAN market over the last several years has helped change customers' perception of data access. WLAN systems enable several computers in an office or household to be connected to the Internet via a wireless access point and a fixed broadband service. WLAN hot spots have become increasingly available in public areas such as hotels, cafes and airports. This freedom provided by WLAN has stimulated the demand for wider coverage and extended service provision of wireless broadband services, features unable to be adequately satisfied by these low-cost short-range WLAN systems.

In contrast to the limited 100-metre range of WLAN, MBWA systems provide roaming coverage over tens, and more often hundreds, of square kilometres, from a series of cellular-like base stations. Some of these systems support roaming between cities, others full mobility.

As was the case initially for mobile telephony, there is evidence from MBWA trials and the first commercial deployments that early adopters are willing to pay a premium of up to 25 percent for the freedom MBWA offers compared to DSL or HFC alternatives. In markets where existing fixed and mobile systems are constrained, for example by pair-gain or spectrum limits, the premium for MBWA has been up to 50 percent.

Demand from alternate carriers and operators, such as ISPs, is a critically important driver of the growing interest in MBWA systems. These operators recognise the strategic and cost advantages of these systems compared to conventional DSL. MBWA frees them from the local loop barrier, which is usually controlled by the incumbent operator. So far, the only alternative was to unbundle the local loop, a costly and risky venture. Without unbundling, alternative operators had to accept the incumbents' product specification and

nominal pricing margins. With MBWA, alternative operators can avoid many of these issues and still successfully compete in the broadband market. MBWA reduces capital expenditure needs; operators have more freedom to differentiate the product while retaining full customer ownership, all with lower production costs, which improves financial performance.

1.3 Services over MBWA

MBWA networks provide transparent access for the delivery of a wide variety of fixed or mobile broadband services, including Voice over IP.

MBWA systems offer a highly flexible access solution by serving customer needs, both fixed and mobile, over a common infrastructure. For example, MBWA networks can provide broadband data connectivity for:

- Broadband fixed data services – Serve customers in fixed locations who may be unable to obtain service from an incumbent or cable operator due to lack of DSL & HFC infrastructure coverage
- Broadband nomadic data services – Provide broadband data connectivity for mobile customers across wide areas and different locations

Some of these networks have the ability to support VoIP, which enables two new service opportunities for many operators:

- Fixed telephony – For example, voice services, possibly bundled with broadband data
- Mobile telephony – VoIP-based handsets with built-in broadband data connectivity

Where MBWA systems deliver high capacity, they may also be able to provide some limited fixed backhaul connectivity for WLAN systems.

Depending on the type of operator and their existing services, the new services that may be offered over MBWA networks, and their priority for the operator, can vary significantly (see Figure 3).

Figure 3 **MBWA Services and Stakeholders**

Service category	Services	Device Required at Customer Premises	Targeted Customers	Deployment priority for operators				
				Mobile Operators	Incumbents With cellular Subsidiary	ISPs	Start-ups	Incumbents & Operators without cellular Subsidiary
DATA	Broadband fixed data services	Wireless modem (Replaces usual DSL or cable modem), potentially with outdoor antenna	Residential or SOHO and Small companies	1st	2nd (mainly in rural areas)	1st	1st	3rd
	Broadband nomadic data services	PCMCIA card (replaces UMTS/EDGE/GPRS data card)	Business user, road warriors	2nd	1st	2nd	3rd	1st
	Backhaul for WLAN and to backbone	None (wireless connectivity)	WLAN Hot spot service providers, corporations, as well as operators	3rd	4th	3rd	5th	4th
VOICE	VoIP/fixed telephony	Wireless modem with VoIP ATA into which the fixed telephone (POTS) is plugged, potentially with outdoor antenna	Residential or SOHO, Small companies	4th	5th	4th	2nd	5th
	VoIP/mobile telephony	VoIP-enabled MBWA phone (with integrated BB data service facilities)	Residential and Business customers	5th	3rd	5th	4th	2nd

Source: Arthur D. Little based on completed projects

As illustrated above, the primary focus of mobile operators, ISPs and start-ups is in entering the broadband data business, while incumbents and other fixed net operators are rather interested in nomadic data services. Mobile VoIP is especially important to incumbents and operators without a mobile subsidiary, while stationary VoIP is of high importance for start-ups.

The primary end customer segments for these services are small and medium-size businesses (SMEs), SOHOs and residential customers primarily located in rural areas with no current access to broadband services. Road warriors, customers who spend much of their time travelling and need broadband connectivity on the road, are also an important customer segment for these services.

1.4 MBWA Devices

All major MBWA vendors currently have a variety of customer devices available, and several already plan to offer a VoIP handset device.

Several types of customer devices are currently available or being planned by vendors:

- **PCMCIA cards** have been released by several vendors, and more are becoming available. These usually offer slightly lower transmitter output powers than their fixed modem counterparts and this reduction can lead to slightly poorer performance or reduced service coverage in some deployments.
- **Fixed modems** typically feature an integrated antenna and either a USB or Ethernet interface for the user equipment. USB interfaces offer ready connection to customer computers, but increasingly, these devices have also been provided with Ethernet connectors to permit a small office or enterprise to connect such devices directly to their LANs similar to DSL modems.

- **Handsets** are being increasingly highlighted by MBWA vendors, and device functionality is expected to include VoIP or TDM-based voice codecs, full mobility with handoff, with similar size and functionality to low-end GSM handsets, and access to broadband data services via a USB cable, Bluetooth and/or infra-red (IrDA) interfaces. The first handsets for use with MBWA technology should become available in 2005.

Other devices are currently under development, including laptop-embedded modules, PDA interfaces, video-enabled handsets and tablet PCs. It is expected that some devices will become integrated within other products, such as an integrated device within gaming platforms that would permit access to multi-player games over the Internet without the barrier of cords and trailing cables.

1.5 A Comparison with 3G Mobile Systems

3G mobile operators are reacting to emerging MBWA competitors by reducing the cost for their current lower speed data products and focusing development efforts on increasing data speeds (HSDPA) and smart antennas (MIMO).

Existing mobile network operators are not ignoring this growth in demand for wireless broadband. While 3G systems are proving to be more costly than originally expected, with rollouts often limited to urban areas with complimentary coverage supported by upgrading 2G networks, operators have begun to offer low speed data services to utilise excess capacity due to lower than expected customer demand.

Current MBWA system advantages come about through a focus on the wireless delivery of simple high speed IP-based data. Avoiding the need to support each and every complex and often time-critical multi-service protocol required in 3G, and coupled with on-air coding improvements and, in some cases, smart antennas, MBWA systems are thus able to reduce hardware and software costs in a manner reminiscent of that of fixed IP technologies over the past decade.

One way that 3G operators are looking to improve performance is through the implementation of High Speed Downlink Packet Access (HSDPA). Network vendors promise HSDPA as a low cost upgrade for existing UMTS systems, delivering around five times better peak data rates on downlink paths. They also claim that the technology significantly improves network capacity.

HSDPA is expected to be launched commercially on a large scale during 2006, and a number of the most recently installed 3G networks only require a software upgrade to implement the technology. Handsets are yet to be announced, and are likely to represent the major delaying factor. Other issues include a lack of full mobility with HSDPA, and uncertain coverage quality in some current networks.

MIMO (Multiple Input Multiple Output) is a further approach being studied to enhance performance on 3G networks, improving coverage, capacity and data speeds through the use of multiple antennas on base stations and handsets. While offering valuable improvements for both current and future services, MIMO is unlikely to be available commercially before 2006. Cost and the complex installations required on existing sites pose additional challenges for 3G operators.

3G networks are unlikely to be able to offer a significant competition to MBWA systems in the near term due to the need for further network investment to upgrade the downlink bandwidth (via HSDPA or MIMO) to MBWA levels, limited mobility and the likely delay before adequate handsets and modems become available.

Part 2 MBWA Solutions

MBWA systems are under development by many leading companies, and include both proprietary and standard-based technologies; several vendors have already completed full commercial deployments around the world.

In this section, we will briefly highlight the capabilities of the proprietary and standards-based solutions currently available, as well as the key criteria to be addressed when evaluating these MBWA solutions.

2.1 Proprietary and Standards-Based MBWA Solutions

Currently, four proprietary systems are commercially available and four key standards are in development.

Four companies, ArrayComm/Kyocera (i-Burst), Flarion Technologies, IP Wireless and Navini, are currently leading the development and commercial deployment of proprietary MBWA solutions (Figure 4). Commercial launches have already taken place in Australia, Germany, Italy, Portugal, the Netherlands, New Zealand, South Africa, United Kingdom and the USA.

Figure 4 UMTS TDD and Proprietary MBWA Solutions Currently Being Launched

Company	ArrayComm/ Kyocera (iBurst)	Flarion Technologies	IPWireless	Navini
System	i-Burst	RadioRouter	IPWireless	Ripwave
Technology	TDMA/FDMA/SDMA	Flash OFDM	UMTS TD-CDMA	MC-CDMA
Spectrum	5 or 10 MHz TDD	2 x 1.25 MHz FDD	5 or 10 MHz TDD	5 MHz TDD
Per User Throughput (DL/UL)	1 Mbps/345 kbps (5 MHz bandwidth)	1.5Mbps/ 200-375 kbps	1.5 Mbps/450 kbps (5 MHz bandwidth)	2.5 Mbps/1.5 Mbps
Available Customer Devices	A compact PCMCIA card and a standalone Ethernet/USB modem	A desktop modem and a PCMCIA card.	A compact portable modem with USB or Ethernet interface, and a PCMCIA card modem.	A portable modem with Ethernet and USB ports and an optional internal battery. PCMCIA modems are promised Q4 2004.
Commercialization (limited selection)	Launched by PBA in Australia, and WBS South Africa; 8 more launches in pipeline being trialed during Q4 '04	Trials by Nextel, North Carolina, US; Vodafone, Japan; Telstra, Australia and T-Mobile, The Netherlands	Launched by Woosh, New Zealand, Possio, Sweden, PCCW's UK Broadband, UK. More than 15 ongoing trials.	Deployed in Panama, Sydney, Australia by Unwired, Italy by iBax, more than 11 ongoing trials
Standardization affiliation	802.20 and WiMAX	802.20	UMTS TDD	802.20 & WiMAX

Source: Vendor data, Arthur D. Little analysis, November 2004

In addition, several industry groups are developing standards-based MBWA solutions (Figure 5). IP Wireless's UMTS TDD based technology has been commercially launched in 10 networks of varying size since 2002. 1xEV-DO/DV is an evolutionary path for cdma2000 operators, with IPR and chipsets being supplied by Qualcomm. The most vocal group, WiMAX, is supported by leading industry players such as Intel, Siemens and Alcatel, as well as by innovators in broadband wireless technologies like Alvarion, Airspan and Navini. However, the mobile standard is incomplete and currently under review, several issues with the technology are still unresolved, and commercial rollouts are not expected until 2006. MobileFi, or 802.20, is a standard supported by major industry players such as Flarion,

ArrayComm/Kyocera (iBurst), Cisco and Motorola, but is also incomplete, while many of its members are continuing to develop and deploy their proprietary solutions.

Figure 5 MBWA Standards Groups

	UMTS TDD	1x EV-DO	WiMax 802.16a and 16e	MobileFi 802.20
Status	■ Published in 1999, with subsequent revisions 4 and 5 also completed ■ Commercially launched	■ Standards published beginning in 1998, with revisions to EV-DV in 2000 ■ Commercially launched	■ Standard incomplete ■ Initial fixed systems Q2/2005 ■ Commercial rollouts of fixed WiMAX expected during 2006	■ Standard incomplete
Technology	■ W-CDMA	■ CDMA	■ OFDM and CDMA	■ OFDM & FDMA/TDMA
Spectrum	■ IMT-2000 (3G) TDD bands ■ 1.9, 2.0, 2.5 and 3.4 GHz licensed bands	■ 450, 800, 1800 and 1900 MHz FDD bands	■ 2-11, 10-66 GHz (Main focus: 2.5 and 3.4 GHz licensed bands and unlicensed 5 GHz band)	■ 400MHz – 3.5 GHz
Available Customer Devices	■ UMTS TDD CPE is available in portable battery-powered form-factors. PCMCIA card promised. ■ VoIP handset expected Q1 2005	■ Variety of handsets available with regular arrival of new models ■ PCMCIA card available	■ Mainly fixed equipment expected to be available in 2005/2006 ■ Limited mobility (802.16e) likely mid-2006	■ Standardised products not expected before 2006
Mobility	■ Full mobility up to 120 km/hr	■ Full mobility, more than 150 km/hr	■ Fixed (802.16a) or limited mobility (802.16e) up to 100 km/hr	■ Full mobility up to 250 km/hr
Primary Supporters	■ IPWireless	■ Qualcomm	■ Intel, Siemens, Alcatel, Airspan, Navini, etc.	■ Flarion, Cisco, Lucent, ArrayComm and Motorola

Source: Arthur D. Little analysis

2.2 Evaluating MBWA Solutions

Five main factors to consider when evaluating an MBWA technology are capacity, coverage, spectrum, cost and degree of commercialisation. In addition, issues such as interoperability, scalability, latency performance and industry commitment should also be considered.

When considering an investment in MBWA, operators need to identify a system which can deliver the required capacity for today's market place, while also permitting a growth strategy into the near-future, with clearly identified milestones for technology upgrades. In addition, the selected technology must have adequate coverage capabilities to permit a swift and cost-effective deployment.

We have identified five factors to consider when evaluating wireless broadband technologies:

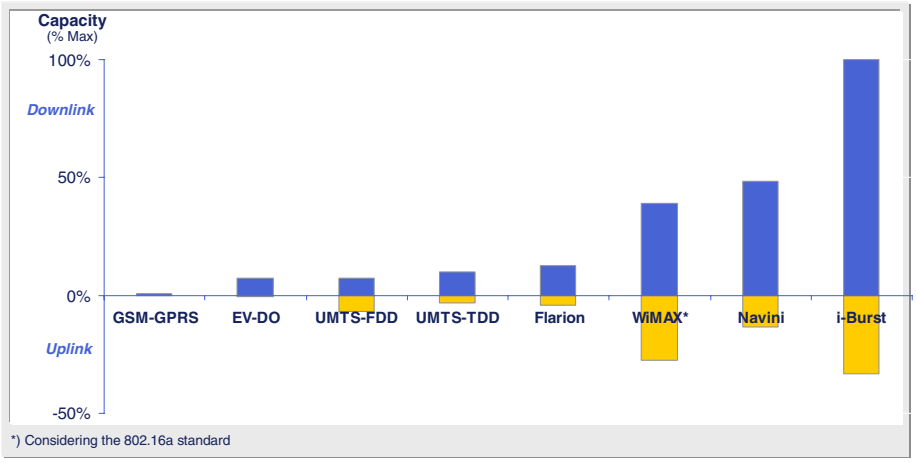
- Capacity
- Coverage
- Spectrum
- Cost
- Degree of Commercialisation

Capacity

The capacity of any MBWA technology depends on the capacity of each base station, as well as the capacity available to each modem.

The following Figure 6 compares the relative capacity of the various wireless broadband technologies. The maximum downlink capacity per sector for the most advanced MBWA systems commercially deployed today can reach 20 Mbps, compared to 3G systems such as W-CDMA (UMTS FDD) standard of about 2 Mbps and for CDMA EV-DO Rev. 0 of up to 2.4 Mbps.

Figure 6 **Average Cell and Site Data Throughput Performance**



Source: Company specifications, Arthur D. Little analysis

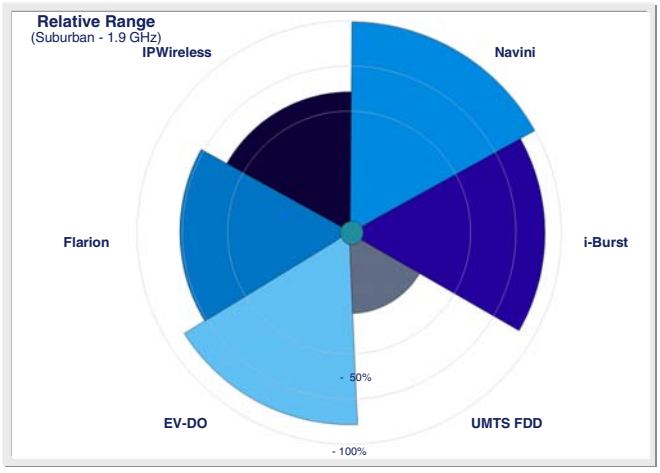
Note: Values shown assume typical sectored urban/sub-urban site deployments around 1.9 GHz, a random mix of customers with minimal interference, excluding system overheads. Performance in actual deployments may vary.

Coverage

Coverage is a critical element of any MBWA deployment as it affects the data speed, the base station's average throughput, as well as the cost of deploying the system.

A comparison of the range of the various MBWA systems is shown in Figure 7. While the range of these technologies can be affected by the terrain and buildings, the diagram gives an indication of each technology's ability to serve indoor users; systems with greater range enable improved indoor coverage.

Figure 7 **A Comparison of System Coverage**



Source: Vendor data, Arthur D. Little analysis

Note: Coverage data takes into account intelligent and smart antenna effects of proprietary vendor solutions. Coverage varies between cities depending on a variety of environmental conditions. Depending on the system, range may exceed 5 km in outdoor suburban areas but can be below 500m for dense urban indoor coverage, in some cases.

Importantly, system coverage also impacts the cost of system deployment. Since better coverage reduces initial capital expenditure (Capex) requirements, coverage can be a critical decision factor for a specific technology. In this case, there are two drivers to consider:

Coverage driven Capex	Number of systems required for initial geographic coverage, and
Capacity driven Capex	Equipment required at each site to meet capacity needs – a mix of number of customers on each site and their individual usage needs

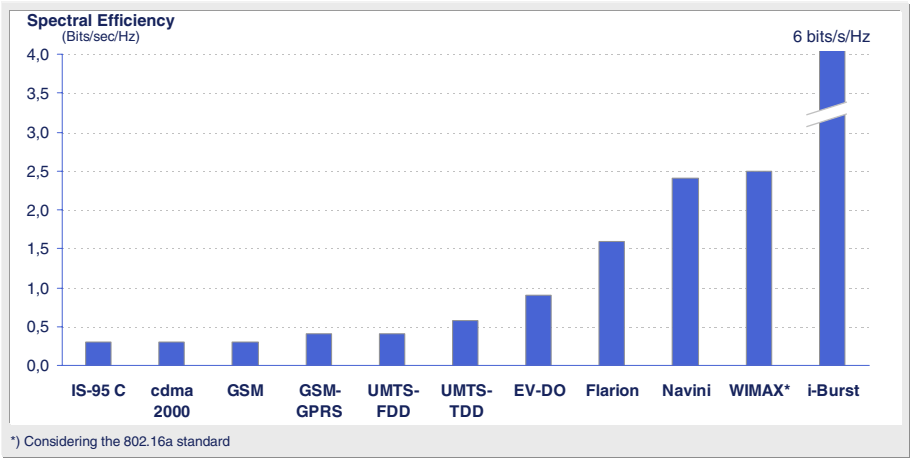
Spectrum

There are several issues to consider in terms of spectrum: spectrum requirements, spectral efficiency, and the availability of suitable spectrum in any particular market.

Spectrum requirements for MBWA systems vary from paired 1.25 MHz FDD assignments required for a Flarion system, and up to 21 MHz may be required for some of the WiMAX options.

Spectral efficiency is a key parameter to take into account when assessing spectrum (measured in bits/sec/Hz), and usually, the bigger this number is, the cheaper is the deployment, or the less spectrum that must be obtained. Figure 8 plots this parameter for a selection of wireless technologies.

Figure 8 **System Spectral Efficiency**



Source: Company data, Arthur D. Little analysis

Note: Figures shown in this graph are determined by different base station ranges, the spectrum used, and are based on currently available information on vendor system performance. For example, the UMTS-FDD performance is for a typical 3G W-CDMA network deployment, while the UMTS-TDD performance is for a typical IP Wireless system. The WiMAX result is from a coverage simulation for a multi-site deployment of a 3.5 MHz bandwidth WiMAX system, and the ArrayComm/ Kyocera (i-Burst) performance is from vendor reported results at a recent industry forum.

While it may appear that spectrum requirements are less for technologies such as WiMAX, Navini and i-Burst, it is important to also consider the availability of suitable spectrum for these technologies in any particular country.

For example, while the national legislation regarding spectrum needed for cdma2000 or GSM is bound to internationally-agreed spectrum standards, this is not the case for WiMAX or many of the proprietary MBWA systems. These systems, therefore depend on operator acquisition of spectrum, potentially in many different and largely incompatible country specific assignments.

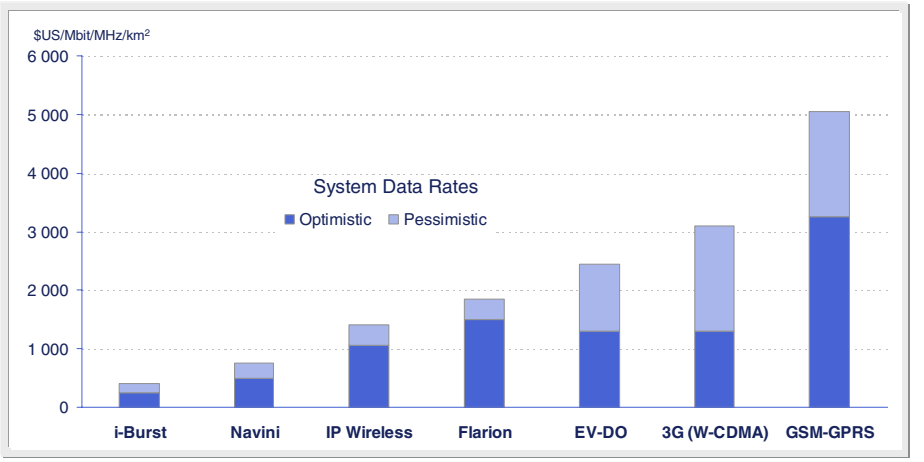
Cost

When assessing an MBWA technology, it is important to consider the costs of the data delivery, the costs of the devices and the access network, as well as the deployment density.

One method that can be used to evaluate the relative costs of such widely differing technologies is a comparison based on the ability of each system to deliver a specific bits-per-second data rate over a given area. By dividing the delivered capacity by the required channel bandwidth for each system, the relative bandwidth efficiency of each technology can be included in the comparative evaluation. The comparison measure adopted is Delivered Mbps/km^2 on a per-MHz normalised

bandwidth basis. Figure 9 is the result of our analysis based on vendor system performance of the current leading mobile broadband wireless technologies.

Figure 9 **Comparative Delivery Costs for Broadband Wireless Data**



Sources: Vendor specifications, Arthur D. Little analysis

Note: Figures assume typical sectored urban/ suburban site deployment around 1.9 GHz, a mix of customers, minimal interference, allowing for system overheads. Costs and performance in specific deployments may vary.

The shorter the height of the bar in the graph above, the better is the cost-effectiveness of a technology. The graph also shows «pessimistic» and «optimistic» results, based on both the currently available or advertised performance of each system, and the best possible result if all vendor claims could be delivered by the technology.

Figure 10 provides a comparison of the device and access network costs for the three most commonly utilised broadband technologies: DSL, UMTS (3G) and MBWA.

Figure 10 **Per-user Capital Expenditure Comparison**

Item	DSL	UMTS (3G)	MBWA
Device Costs (without rebates)	$50 - $100	$335 - $600	$220 - $320
Access Network Costs	$130 - $230	$1,000 - $1,225	$270 - $700
Total	$180 - $330	$1,335 - $1825	$490 - $1,200
Notes:	Shelf-loading and line quality dependent	Broadband users without HSDPA	Broadband users for range of systems

Sources: Vendor data and Arthur D. Little analysis

Note: Costs assume systems are installed on existing operator networks making use of existing lines and sites. UMTS devices include handsets and PCMCIA data cards.

DSL costs assume a typical urban deployment with high DSLAM shelf utilisation and good quality lines. DSL in areas with lower customer densities or uptakes can quickly drive access costs close to, or above, MBWA costs.

A final issue to consider in terms of cost is one of deployment density. In general, the higher the spectrum utilised for MBWA solutions, the greater the network cost of the solution for serving a given area with a given service. Hence, acquiring spectrum at a lower range, for instance 450MHz, may be more attractive than in a 3.5 GHz band. With coverage and capacity differences between MBWA systems combined with this factor, the total number of base stations in an initial roll-out phase can vary up to 20 times in extreme cases.

Degree of Commercialisation

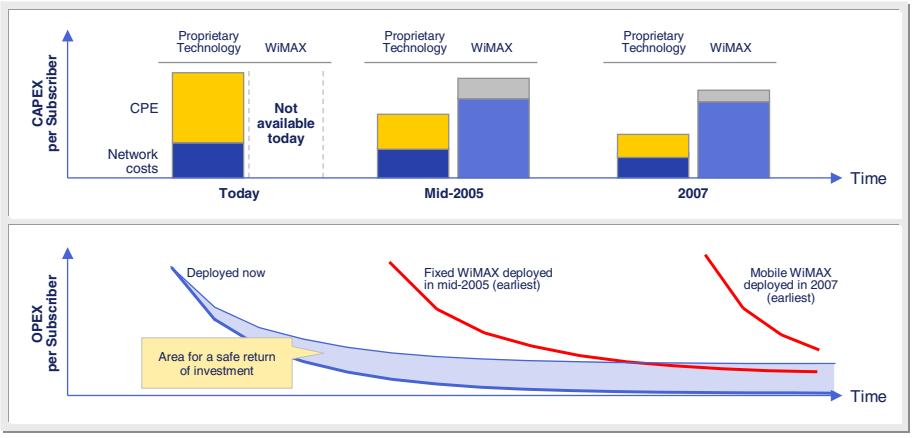
In order to assess the commercial viability of any MBWA system, it is important to address the 'time to commercialise', the impact it has on prices, spectrum availability and cost, and the availability of customer devices.

With any technology, there is a minimum time required to translate an initial technology release into an acceptable and commercially viable system. For systems such as cdmaOne, GSM and UMTS, WLAN, and the proprie-tary MBWA systems currently available, this 'time to commercialise' has ranged from 12 to 24 months. Based on this experience, a similar delay can also be expected with WiMAX (802.16e offering mobility) as well as HSDPA, MIMO and other UMTS enhancements.

Figure 11 below illustrates the effect of this 'time to commercialisation' delay on pricing. The graph on the top shows the development over time of per-subscriber capital expenditure costs for a proprietary MBWA system versus WiMAX. The graph on the bottom shows the typical development of operating expenses.

This typical development shows the impact of a delay in commercialisation of two years (an example of the time difference between the launch of most of the current proprietary technologies and fixed WiMAX) and a delay of a further year for a subsequent network, for example one based on 802.16e mobile WiMAX. The timing and sustainability of the cost advantage for a proprietary technology is not easily predicted. However, operators appear to have a window of opportunity to establish a market position by initially deploying a proprietary solution and then converting to a standardised solution (with its attendant procurement and interoperability advantages) once it delivers desired functionality and meets price points.

Figure 11 **Cost Comparison Between Proprietary Solutions and WiMAX**



Source: Vendor and operator data, Arthur D. Little analysis

An important issue that this highlights is the time required for WiMAX to reach the same level of market maturity as the existing MBWA systems. Although these proprietary technologies may be projected to have higher per-user costs due to lower volumes, their early entry into the market offers evidence of an ability to provide, and possibly maintain, a price advantage over later entrants such as WiMAX.

Another issue related to the time to commercialise is the availability of spectrum. The critical spectrum necessary to operate WiMAX systems in many markets may well have been already acquired by the operators deploying proprietary systems. An example of this may be seen in Australia, where Arraycomm/Kyocera (i-Burst) and Navini deployments are already being rolled out, and Telstra is in the advanced stages of trialing Flarion.

The availability of a broad selection of customer devices is also critical in order to make the technology commercially viable. The availability of modems, PCMCIA cards, and eventually, VoIP-enabled handsets or antenna-embedded laptops or gaming consoles, will increase the convenience for the customer and thus the demand for this new technology. Each vendor of MBWA devices has a roadmap of currently and expected customer devices (Figure 12). As shown below, the choice of devices available today is limited, however the roadmap seems to be promising and has the potential to compete with current 2.5 and 3G devices.

Figure 12 MBWA Vendors' Roadmap of Current and Planned Devices

Source: Vendor and operator data, Arthur D. Little analysis

Additional Issues to Consider

There are four additional issues that should be addressed when considering an investment into a mobile broadband wireless solution: interoperability, scalability, latency performance and industry commitment:

- **Interoperability** is the ability of one device to support a new technology while simultaneously supporting another existing technology. For example, current 3G mobile phones support existing 2G standards. Interoperability enables customers to achieve more cost-effective utilisation of a new device, and thus may improve demand.
- **Scalability** is the ability of a technology demonstrated on a small system size (i.e. a single site, or a few sites) to be expanded up to a full-scale network while retaining the same capacity and functionality.
- **Latency performance**, or the delay incurred when data is transferred by these systems, can also be an important issue when operators are targeting specific markets, such as internet gaming. Game players often require performance below 100ms to remain competitive with fixed line users. MBWA systems offer significantly improved latency performance, in the range of 50 to 100 ms, over other systems, especially cellular technologies which can produce latency performance more than twice these levels.
- **Industry commitment** is the ability of an MBWA supplier to license their technologies to a large number of well known and established infrastructure and device manufacturers to create competition and open new distribution channels with existing operators. Creating an eco-system with the right partners along the value chain (including operators) remains a key success factor for any MBWA system, hence a key selection criteria for operators.

Part 3 Challenges Faced by Industry Players

The introduction of mobile broadband wireless access technologies provides market players with opportunities to address new markets, as well as several strategic challenges.

Mobile broadband wireless access technologies represent a unique and important opportunity for operators; one that supports an independent cost-competitive local loop access system and creates a new wireless market for both operators not yet in the wireless business and mobile operators seeking to gain a share of the broadband market.

However, before investing into mobile broadband wireless technology, an operator needs to address several strategic challenges.

Strategic Challenge #1 What is the best approach to take with the national regulators to either enable or block the deployment of MBWA technologies?

The regulatory regime plays a critical role in the development of MBWA services in each market since regulatory bodies determine the allocation of spectrum, the service definition and choice of technology, thus determining the potential level of competition.

Opening up the spectrum for technology-neutral use could dramatically impact the competitive landscape on the market. This is especially true in Europe, where more than 90 percent of mobile operators hold a UMTS frequency license, which theoretically could be used for more state-of-the-art and more effective MBWA technologies than the currently available 3GPP/IMT-2000 standard.

In some markets, regulations are explicit about the provision of 'mobile services', i.e. allowing or forbidding 'handoff' between base stations in certain spectrum assignments. In some countries, such as the United Kingdom, alternative operators have come to an agreement with the regulator that they can use the spectrum for 'portable', but not 'mobile' broadband; MBWA can be deployed as long as there is no handoff. In Australia, Austria and Korea, full mobile operation with handoff is permitted.

In addition to the spectrum, service and technology-related regulatory requirements, the maximum absolute bandwidth that an operator can buy is crucial. If the limited available bandwidth is assigned across 5 licenses, the attractiveness of an MBWA network and its associated services may well be different than for spectrum assigned for just 2 or 3 licenses. The larger the number of players sharing the total available spectrum, the lower the capacity an operator can support, the poorer the service portfolio becomes, making MBWA less attractive to deploy.

Many national regulators have yet to fully evaluate the impact of, and the rationale for, deploying MBWA technologies and services on their markets. Depending on the situation in their specific market, market players need to

determine the best strategy vis-à-vis the regulator, the goals to be pursued, and the arguments which need to be presented to regulatory authorities for obtaining satisfactory spectrum allocations and licensing conditions. (See also Section 4 – Selected Case Studies)

Strategic Challenge #2 Is there a sufficient demand for services delivered over MBWA to justify the necessary investment?

The primary risk for an operator investing into MBWA is the lack of market size to justify the investment. As with any new technology, customer demand for MBWA is as yet largely unclear. However, based on the enormous growth experienced in fixed broadband services and the initial take-up seen in countries where MBWA is already being commercially launched, we believe there is reason to be optimistic.

Current operators concerned about the potential demand on their markets also need to consider the risk of not investing into MBWA to their current business. For incumbent operators, in particular, the absolute market size for MBWA services may not be as important as the impact on their business if MBWA is deployed by their competitors.

There are a host of strategic and marketing issues that need to be addressed when assessing an investment into MBWA, which vary by type of operator and individual market environments. Below, we highlight the critical issues faced by incumbents, mobile operators and new, alternative operators. (See also Section 4 – Selected Case Studies)

Incumbent fixed network operators need to assess the opportunities that MBWA provides, while protecting their current market position.

While MBWA provides an incumbent with an opportunity to improve coverage and expand services, it also represents a significant threat in the form of another mobile technology that has the potential to negatively impact their fixed line revenues. Considering that the uptake of broadband via DSL is the main growth area for most fixed incumbents, MBWA is a major threat with the potential to migrate a substantial number of customers from a "Fixed DSL" service to a "Portable DSL" offer enabled by MBWA networks. In addition, these technologies offer third parties, especially ISPs, the first genuine possibility to bypass the local loop, disenfranchising the incumbent from the customer, possibly permanently.

The primary focus of a fixed, incumbent operator, therefore, should be on assessing the opportunity for MBWA, while protecting the current market position from new entrants. For a large, fixed operator, MBWA can act as a complimentary technology to expand the broadband offer to include mobile services.

Key issues to be addressed include:

- Can such a technology be used to rapidly provide service in difficult to cover areas unable to be cost-effectively reached by DSL/cable offerings?
- Does the availability of a MBWA technology permit a fixed operator to enter the mobile space to offer "Portable DSL" service and mobile voice via IP?
- Is there a sound defence strategy which can be based on the existing product portfolio, if no spectrum is available, and start-ups and/or mobile operators start building MBWA networks attacking the DSL and broadband wholesale market?
- How shall MBWA be positioned within the organisation, particularly in the light of potential mobile subsidiaries' or existing DSL deployment strategies?

Mobile operators need to assess the impact of MBWA on current 3G plans and decide whether MBWA is an attractive complementary option.

A mobile operator needs to assess the potential to use MBWA to expand the mobile data offer, while determining the impact of MBWA and the potential introduction of VoIP over broadband wireless on the current business plan and any planned UMTS roll-out.

In general, there are five key questions that should be considered by a mobile operator including:

- Can the lower cost structure of mobile wireless broadband systems be leveraged to support a complementary mobile broadband data service alongside the existing 3G infrastructure?
- Can the existing assets (i.e. frequencies, base stations, customer access, etc.) be leveraged to deploy MBWA systems more cost-effectively than other operators, such as new entrants?
- Will the introduction of VoIP-enabled handsets by MBWA vendors impact the existing mobile cellular market?
- Is there a sound defence strategy to compete with new entrants and start-ups (e.g. AirData in Germany, PBA in Australia), as well as incumbents and other mobile operators, which begin offering MBWA services on proprietary systems?
- How should MBWA be positioned within a mobile operator, particularly in the light of the strategy of a potential incumbent parent company?

New challengers and ISPs need to address the possibility of using MBWA to effectively unbundle the local loop, and offer new broadband fixed and mobile services at reasonable prices.

MBWA provides a critical opportunity for ISPs and alternative operators to bypass the incumbent's local loop barrier. Unlike cellular, where initial costs limited system adoption by the mass market, proprietary MBWA system costs are rapidly becoming very competitive compared to DSL.

New entrants need to determine if, through a deployment of MBWA, they will be able to change the competitive landscape in their market and compete more effectively against existing players that are offering voice and data services. Some key questions include:

- Can a technology such as MBWA permit the delivery of cost effective data and voice services to fixed and mobile customers and avoid the traditional incumbent-controlled «last-mile» barrier?
- Can MBWA increase the range of services able to be offered today and enhance operator viability in highly competitive markets?

Strategic Challenge #3 Given the current and expected availability and cost of various MBWA solutions, when is the right time to invest into MBWA?

Depending on current trends globally and in the local market, operators need to determine the timing of any investment into MBWA or the launch of services in their market. Timing is also critical when deciding on which MBWA solution to deploy.

There is a risk to investing in MBWA too early. No single proprietary system has gained clear ascendancy, much of the work on standardisation remains unresolved, and many of the promised services and devices are not yet available. There are also many risks of entering too late – many of them outlined in this document.

In some markets, the success of an MBWA system requires the bundling of both voice and broadband data within a single device, such as a broadband handset. While a number of vendors are talking about such equipment at present, they may not be available until the end of 2005 at the earliest. The deployment of these devices also requires networks have an adequate quality of service functionality to ensure that voice quality is maintained, or an early significant excess of capacity. Currently, not all MBWA networks support this level of QoS functionality nor do all have high site capacity.

Part 4 Selected Case Studies

We present four case studies in order to highlight the key strategic challenges and how some operators have responded to them.

The case studies presented below illustrate possible strategies open to an operator when deploying MBWA solutions, including:

- Meeting broadband demand in the Australian market
- Building a wholesale MBWA business from scratch using partnering in Germany
- Fulfilling demand for nomadic broadband services and the important role of the regulator in the Czech Republic
- Strategies of a UMTS greenfield operator in Austria

Australia: Taking the lead in MBWA?

Australia is swiftly becoming one of the key international markets for observing the development of the MBWA industry. ArrayComm secured low cost UMTS TDD spectrum early to enable the launch of iBurst in Sydney in October 2003, with the support of system vendor, Kyocera, and key partners including Vodafone and a leading nation-wide ISP, Ozemail.

From the initial coverage of more than 100 square km and one million people served by just six sites, the network currently includes more than 70 sites in Sydney, Melbourne and Brisbane, with expansion in progress into other major regional capital markets.

This rollout has led rapidly to the deployment of two other competing MBWA systems in Sydney, including a US$50m rollout by Unwired and Navini, and a trial by the incumbent Telstra with Flarion. Hutchison's «3» UMTS network has also responded by introducing a «data only» tariff plan.

Unwired's network was launched in June 2004, and currently covers 95 percent of Sidney with 60 sites. Strong investor confidence was shown even before commercial launch; Unwired had an IPO in December 2003, and market capitalisation is $220 million as of October 2004.

Competition in this market has resulted in some sharp price reductions, with "3" reducing its 200 Mb data package from Euro 495/month (US$ 640) in May 2004 in favour of a 500Mb package priced at just Euro 60/month (US$ 75) in October 2004.

AirData, Germany: Toward a true partnership model?

AirData is a German wholesale business offering UMTS TDD services to carriers, online services, ISPs and mobile operators since October 2004. It positions itself as a "last mile carrier" and operates an independent infrastructure that was especially developed for the transmission of broadband data and voice. AirData utilises 10MHz of frequency in the 2.6GHz band.

AirData is offering a wireless Internet access product under the brand "PortableDSL" that is positioned as "fast and easy". Primary target customers are SOHOs, SMEs and residential customers. Speed plans (1024 K) are priced at approximately Euro 44/month (US$ 56), and basic plans (128 K) at approximately Euro 24/month (US$ 30). All tariff plans are based on flat-rates. The desktop modem costs Euro 149 (US$ 190). The service is currently available in Stuttgart and Berlin Centre with plans to eventually cover 30 German cities and surroundings (approximately 50 percent of the country).

As the first company to deploy UMTS TDD technology in Europe, AirData is getting a lot of attention; at the 2004 CeBIT conference, the company received the "Innovation of the Year" award for the Internet section from PC Professional.

The business model is based on an extensive partnering strategy including four different types of stakeholders:

- An infrastructure partnership with Telefonica to access an established backbone. AirData is already wholesaling its services to Telefonica, which is one of the largest IP providers in Germany.
- Two system technology partners, Alcatel and IPWireless, to build and run the network.
- AirData has partnered with three small Internet service providers, DNS, Next Generation Internet and Isomedia, to resell its services, and is focusing on extending its network of retail partners.
- AirData is also exploring a pontential partnership with a mobile operator to access sites.

Eurotel, Czech Republic: Taking advantage of effective spectrum

An example of the importance of actively negotiating with the regulator and the implications that this may have in a market is Eurotel's experience in the Czech Republic. Eurotel received the permission from the regulator to re-use its NMT 450 2x4.5 MHz spectrum, which supports three carriers with the CDMA-1xEV-DO standard, enabling Eurotel to launch a new broadband data service in August 2004. Within 5 weeks, 10,000 customers joined the service, around 10 percent of the broadband subscribers in the country (incl. DSL and CaTV users). Eurotel captured 50 percent of the gross adds of the total broadband market during this period. Although Eurotel paid over USD 120 million for a UMTS license and owns a spectrum with network roll-out obligations, according to the judgement and analysis of their network planning engineers, the EV-DO Rev.0 standard was the most suitable technology to launch broadband services for their customer base.

The lessons learned from this case study are two-fold. First, monitoring and negotiating desirable changes in the regulatory regime provides benefits for operators and customers. Second, this successful launch demonstrates the fulfilment of a latent demand for mobile broadband data services.

Hutchison's «3»: Right reaction of a 3G operator?

Hutchison's «3» has opted for an aggressive rollout of a "mobile broadband data package" in certain markets, such as Austria and Australia. For example, the package launched in October 2004 in Austria supports a 500 Megabyte per month data consumption for just $US 36, and is advertised as "Mobile DSL, 3Plus500MB». Knowing the performance and capacity of a UMTS (W-CDMA) network, 3 decided to speculate on managing the costs and network capacity risks associated with this service. If usage increases rapidly, there is a serious risk of impacting available network capacity for high value 3G services such as internet access, video telephony, streaming and gaming, and particularly voice services. Should the market be as attractive as Hutchison hopes and as we suspect, i.e. huge latent demand for affordable mobile DSL services, then deploying a "true" broadband access technology available from MBWA suppliers could have been an interesting complementary option to consider instead.

Competing prices in 3's Australian market have also fallen, with one MBWA vendor currently offering a 1,000 Megabyte service for $US42 per month against 3's local 500 Megabyte tariff of $US75.

Part 5 Conclusion: WiMAX vs. WiWAIT?

MBWA has the potential to become a disruptive technology on the market, and fixed, mobile and alternative operators alike need to assess the impact on their market, their strategies and their business plans.

We believe that broadband wireless access technologies have the potential to have a disruptive impact on telecommunication markets in the medium term. The technology can open up new markets for current players, and enable alternative operators to free themselves from existing fixed and mobile access providers. Once the service and devices are widely commercially available at a reasonable price to the end customer, MBWA could dramatically change the customer's perception of the convenience and flexibility of Internet access as demonstrated in Australia and Korea.

Several proprietary solutions are currently commercially available, and are in the process of being tested and rolled out world-wide. Leading companies currently offering proprietary solutions are Arraycomm/Kyocera (i-Burst), Flarion (RadioRouter), IPWireless (IPW), and Navini (Ripwave). Commercial launches and trials are now taking place in over 26 countries on 5 continents.

Meanwhile several groups, with participation of the companies currently offering proprietary solutions, are working to develop a standard technology for MBWA. The most vocal, WiMAX, has yet to finalise their mobile standard and are not expected to be ready to launch commercially until 2006 or 2007. We feel that there are several reasons to be cautious regarding WiMAX's promises, given the challenges yet to be overcome in terms of market and vendor fragmentation, and the availability and cost of spectrum in many markets. It will take several years before mobile WiMAX gains any real traction.

Operators, whether fixed or mobile, incumbent or alternative, are facing difficult choices, given the wide range of MBWA technologies currently available or under development. There is a risk to investing too early, before these solutions are commercially-proven and an MBWA standard has been finalised. However, a wait-and-see approach may present a greater risk, and in many markets may not be a feasible option. With a new, potentially disruptive technology, being a late entrant will leave an operator out of the market completely.

Operators have three alternatives in terms of MBWA:

- Deploy one of the readily available proprietary systems that are now being aggressively deployed, but risk selecting a technology that may be ultimately superseded by other standardised technologies, or
- Opt for a standards-based system such as WiMAX (802.16e supports mobility) or 3G with HSDPA or MIMO (next UMTS evolutionary steps) to avoid the risks associated with deploying a technology orphan, while accepting the delays before a commercial launch is possible, or

- Use cdma2000 1xEV-DO or FDD W-CDMA (the current UMTS platform) to quickly deliver modest broadband performance, but with the risk of a limited market uptake in the face of proprietary competitors with systems that deliver significantly better performance and lower cost structures, particularly under conditions of heavy network loading.

If operators have not already developed a strategy with regard to MBWA, there are three immediate actions to take in order to determine which alternative is the most appropriate for their particular situation.

First, they should perform a market assessment of the potential for MBWA services, as well as their competitors' likely strategies concerning MBWA. Second, they should determine a strategy for negotiation with the regulator regarding the availability and cost of spectrum, and the conditions attached to any allocation (i.e. functionality enabled, technologies supported). Third, it is critical that operators begin to test these systems, whether proprietary or standards-based, in order to gauge their strengths and weaknesses, the potential threats which they may pose in the hands of competitors, and the value they could bring to their particular market.

After completing these three steps, an operator will be able to actively move forward to address the challenges that MBWA presents.

Definitions and Acronyms

3G	Third generation wireless technologies including IMT 2000 and Universal Mobile Telecommunications System (UMTS)
ATA	Analog Telephone Adapter interfaces a standard analogue two-wire telephone to an Ethernet or USB port allowing customers to access VoIP services
Backbone	A segment of a network used to connect network nodes together. Backbones carry high concentrations of traffic between these network nodes
Bandwidth	The measure of the size of a communications channel. Wireless systems often measure capacity in hertz, the difference in the highest and lowest frequency of the channel. Digital systems usually measure bandwidth in bits per second.
Bits per second	Common measure of data speed for computer modem and transmission carriers in data communications, the number of bits transmitted or received each second
Broadband	Broadband typically refers to services or systems that are able to support data transfers at speeds usually above 256kbps. Services which occupy wider spectrum bandwidths are also sometimes referred to using this 'broadband' term
BWA	Broadband Wireless Access refers to a wireless access layer supporting broadband data speeds typically above 1Mbps
CDMA	Code-Division Multiple Access, mobile standard developed by Qualcomm, licensed to multi-vendors supported by more than 100 mobile operators around the globe
DSL	Digital Subscriber Lines. A technology that allows high-speed data transfer rates over twisted-pair copper wires (regular phone lines) between subscribers and the local telephone exchange.
DSLAM	Digital Subscriber Line Access Multiplexer, a mechanism at a phone company's central location that links many customer DSL connections to a single high-speed ATM line.
FDD	Frequency Division Duplexing. A method of separating two-way communication systems in frequency. FDD employs two separate spectrum blocks, one for each communication direction. Most common method used in wireless voice systems.
GSM	Global System for Mobile Communication is a technology that, like TDMA, uses time slots to distribute limited cellular spectrum among many users for both voice and data communications.
HFC	Hybrid Fibre Coax: Cable Television infrastructure technology
HSDPA	High Speed Download Packet Access, increases the throughput possible over UMTS systems.
Internet Protocol (IP)	The method or protocol by which data is sent from one computer to another on the Internet. Each computer (known as a host) on the Internet has at least one IP address that uniquely identifies it from all other computers on the Internet

ISP	Internet Service Provider – Connects end-users to the Internet via telephone lines or other method. The ISP provides connectivity to international Internet resources and supplies services such as voice mail, web-hosting and domain name registration
Latency	End-to-end delay in a data transmission caused by the network elements, such as buffers and routers, used to carry the data between users.
Local loop	The wired connection from a telephone company's local exchange to its customers' telephones at homes and businesses. This connection is usually on a pair of copper wires called twisted pair. With Integrated Services Digital Network (ISDN) or Digital Subscriber Line (DSL), the local loop can carry digital signals directly and at a much higher bandwidth than using analogue modems.
MBWA	Mobile Broadband Wireless Access. Radio system supporting simultaneous two-way broadband data services with mobile and fixed customers.
MIMO	Multiple Input Multiple Output. A system with multiple antennas at the base station and at each user terminal or handset to support multiple independent non-interfering wireless channels between the base station and each terminal.
Network	A network is an arrangement of devices that can communicate with each other.
OFDM	Orthogonal Frequency Division Multiplexing. A shared modulation system using many small overlapping non-interfering carriers to achieve high data rates
PCMCIA	Portable computer memory card industry association. An industry group that has developed a standard for peripheral cards for portable computers. PCMCIA cards are used for functions such as modems and for additional memory
QoS	Quality of Service
RF	Radio Frequency. A term that refers to alternating current having characteristics such that, if the current is input to an antenna, an electromagnetic field is generated suitable for wireless broadcasting and/or communications
SDMA	Spatial Division Multiple Access. Multiple base station antennas support multiple independent non-interfering wireless channels between a base station and each terminal in range in a common spectrum and timeslot assignment.
TDD	Time Division Duplexing. A method of separating two-way communication systems in time. TDD utilises the same frequency block for both directions and does not require paired spectrum blocks, as is the case for FDD systems. TDD systems are ideal for data only communications given the asymmetric nature of data traffic
TDMA	Time division multiple access is a technique that uses time slots to share limited cellular spectrum among many users for voice and data communications
ULL	Unbundled Local Loop is the unbundling the physical copper line circuit in the local access area network connecting the cus tomer's premises to the operator's exchange or switch.

UMTS	Universal Mobile Telecommunications System. Also more commonly known as «3G» or third generation mobile phone system. UMTS W-CDMA systems form the largest group of the IMT-2000 family of standards
VoIP	Voice over IP refers to a protocol which enables speech to be carried over a network between one or more users using Internet Protocol
WAN	Wide area networks connect computers that are located in different cities, regions or countries
W-CDMA	Wideband code-division multiple access, an ITU standard derived from code-division multiple access (CDMA), is officially known as IMT-2000 direct spread. W-CDMA is a third-generation (3G) mobile wireless technology offering higher data speeds to mobile and portable wireless devices than current cellular systems
WLAN	Wireless Local Area Network

About the Authors

Karim Taga is a Managing Director in the Vienna office of Arthur D. Little's German, Austrian and CEE operations. He specializes in telecommunications and he is a member of the TIME (Telecommunications, Information Technology, Media and Electronics) practice.

Besides his broad telecommunication background, he has been involved in Broadband Wireless Access strategy projects since 2001, when one of the first roll out plan was designed for mobile purposes. Not only has the operator successfully launched the service, but is belongs to one of the largest commercial services available on a global scale. Furthermore, due to the increasing relevance of the topic, in the first half of 2004 alone, Karim was director in charge of 7 projects conducted on behalf of Arthur D. Little covering business planning, bidding, due diligence, corporate strategies and access strategies.

Andrew Woodfield is a Senior Engineer with 20 years experience in the design and rollout of cellular, broadband wireless data, SMR/PMR and other wireless networks across Asia, Europe, the Pacific Rim and Latin America.

Andrew has been heavily involved in a variety of MBWA and BWA projects over the past three years including the design and implementation of the first large scale commercial MBWA network internationally, as well as with the high level design, modelling and implementation of a number of other fixed and mobile broadband wireless networks around the world. Recent projects have also included three new MBWA systems for international operators, and the design and deployment of a new 3G network in the Asia-Pacific region.

About Arthur D. Little

Arthur D. Little's Telecommunications, IT, Media & Electronics (TIME) Practice is a global network of world/class professionals. Together we offer an unparalleled combination of industry experience, understanding of the underlying technologies shaping the global digital industries and mastery of the business processes within these industries. We guide our TIME clients towards a deeper understanding of the strategic, operational and cultural determinants of technology, innovation and financial management, as well as transferring the skills to manage these determinants for the optimal benefit of all their stakeholders.

Arthur D. Little is the world's first management consulting firm, founded in 1886 in Cambridge, Massachusetts, USA. We are leading-edge innovators, combining industry knowledge, functional experience and technology skills to help our clients grow and create extraordinary value. We have spent 118 years renewing and reinventing ourselves continuously – we come to our clients with a fund of fresh knowledge and experience in leading industries around the globe. Arthur D. Little people bring curiosity, creativity, integrity and analytical rigor to every job, which means fast and dramatic performance improvements. Together with our partners Altran Technologies and Cambridge Consultants Ltd we have 16,000 professionals at your disposal in more than 40 offices worldwide.

Arthur D. Little's Qualifications

Arthur D. Little has been working, since the pre-standards phase in 2001, with incumbents and start-ups, fixed operators, mobile operators and ISPs, addressing strategic issues related to Mobile Broadband Wireless Access.

Some examples of recent projects include:

- Arthur D. Little has supported the rollout planning and design of the largest broadband wireless access networks in Australia and UK (i.e. design, radio network planning, business plan, info memo/bid book etc.). The first was launched commercially the first quarter of 2004 in Sydney the second launched its trial during the second quarter 2004.
- Arthur D. Little performed a due diligence (strategic, technical and financial) on behalf of an European Bank Consortium that was interested to finance a mobile operator planning to roll out a broadband wireless access services based on CDMA 2000 EV – DO/DV technology. In addition, ADL conducted a commercial due dilligence for an American private equity house, assessing an investment in one of the largest MBWA network roll-out deployments in Europe based on a proprietary platform.
- Arthur D. Little has finalised a corporate strategy for a mobile operator, considering Broadband Wireless Access as a new opportunity and as a main pillar for its future revenue growth competing against the fixed incumbent operator with broadband data services beyond voice substitution from fixed to mobile
- Arthur D. Little has developed a corporate strategy for an ISP who will offer BWA based services to its corporate business account by-passing the ULL wholesale offer of the incumbent
- Arthur D. Little has developed the access strategy of a Western European Incumbent leveraging MBWA as a complementary roll-out plan of its broadband footprint in rural areas as well as being in a position to offer mobile VoIP based services via MBWA networks in urban and sub-urban areas.

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Arthur D Little

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