GSM ASSOCIATION

how to realise the benefits of mobile broadband today

February 2007

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Section 1: Introduction

This review aims to evaluate the realities of different technologies promoted as enablers of mobile broadband services, including a realistic appraisal of their technical performance and commercial availability. The review will demonstrate why HSPA is the logical choice for operators wanting to offer mobile broadband services to both urban and rural consumer and enterprise users. Featuring first-hand experience from a number of different stakeholders, the review examines the huge impact HSPA technology is already having on the mobile broadband sector and how it will continue to dominate alternative mobile broadband offerings.

- **Mobile Market Review:** a mobile broadband market review highlighting the market size for the competing broadband technologies and the growth potential in terms of networks deployed, available devices and services.

- **Technology Evaluation – HSPA and WiMAX:** an independent comparison of HSPA against mobile WiMAX taking into consideration a number of factors such as the business models, spectrum availability, and costs. In addition, this section looks at the performance of competing technologies and their relative maturity as well as issues such as interoperability and the ability to secure competitive supply contracts.

- **Technical Benefits of HSPA:** explaining HSPA from a technology perspective, the technical specifications involved, and what is delivered in reality. Also, this section has a frank comparison from an operational perspective on the ease of upgrading for an already established 3G network compared to a 'greenfield' deployment.

- **User's Experience:** importantly, what's it like to use mobile broadband (HSPA), the impact of migrating from dial-up speeds to broadband and the benefits of new and exciting applications

- **An Operator's View:** examining the decisions that need to be taken to determine which technology should be used to deliver high-speed data and mobile broadband, whilst sharing the strategies to attract customers onto the new network

- **Regulatory Insight:** looking at the issues regulators should consider in order to ensure fair competition for both the operators (a fair and level playing field) and for consumers (the availability of services at reasonable prices)

- **Investment for the Future:** highlighting the pros and cons of a future-proof debate – from an initial investment standpoint and early RoI requirements and then from a longer-term perspective, extending the solution to offer enhanced services in a 5-to-10 year timescale.

Section 2: Mobile Market Review

As mobile operators worldwide look towards data services to contribute an increasing portion of ARPU and open new revenue opportunities, WiMAX proponents herald 802.16e as superior to 3G in terms of cost, performance and ecosystem. While confusion and hype abound concerning the real merits of WiMAX in the mobile environment, one key point receives less attention: true mobile broadband services are already here today.

Mobile Broadband Today

Mobile broadband services based on technologies standardised by 3GPP and 3GPP2 have already been launched by 145 operators in 68 countries/territories, covering more than one billion people worldwide[1]. At least another 113 operator networks are currently in deployment. To date, more than 475 devices have been launched or announced for these services. These devices include feature phones, smartphones, PDA's, PC Cards and Express Cards, USB 'thumb' drives, embedded notebooks and even desktop modems. Embedded notebook solutions alone number more than 91 models from 14 manufacturers, including Dell, HP, Lenovo, Panasonic, Sony and Toshiba.

What is Mobile Broadband?

Consistent with the prevailing industry view, and for the purposes of this paper, mobile broadband technologies include those that deliver typical end-user downlink data rates of 500 kbps or more while providing full mobility. Mobile broadband rivals the experience of wired broadband technologies, such as ADSL. It enables suitable user experiences for a broad range of data applications - including email with attachments, web browsing, multimedia streaming and file downloads – while stationary or on the go. This end user experience baseline has also become important for PC notebook manufacturers who decided to embed mobile data into their products only once it could deliver a broadband experience. Previous 2G and 2.5G solutions were simply not fast or efficient enough.

Current Mobile Broadband Technologies and Their Evolutions

There are a host of technologies enabling commercial mobile broadband services today. The two responsible for enabling the wide majority of these services at present are HSPA (High Speed Packet Access) and EV-DO (Evolution, Data Optimized). Other commercial technologies such as FLASH-OFDM (Orthogonal Frequency Division Multiplexing), UMTS TDD (Universal Mobile Telecommunications System Time Division Duplex) and iBurst have had commercial traction in certain markets and applications, and may continue to gain operator customers. These mobile broadband technologies also support a number of fixed and portable services, but the true prize in market potential is mobility.

According to research firm Strategy Analytics, there will be 518 million mobile broadband users worldwide by 2010; the competitors to HSPA and EV-DO will account for only 30 million of those.[2]

1 Sources: Global mobile Suppliers Association (GSA), January 18, 2007; 3G Americas, January 8, 2007; CDMA Development Group, January 2007.

2 "Beyond 3G: Looking for True Mobile Broadband," Strategy Analytics, November 2006

HSPA

HSPA is the set of technologies standardised by 3GPP[3] that defines the migration path for UMTS operators worldwide. HSPA includes HSDPA (High Speed Downlink Packet Access), HSUPA (High Speed Uplink Packet Access) and HSPA Evolved. These are also known as 3GPP Releases 5 through 8.

Unlike many other mobile broadband technologies, HSPA provides very efficient voice services in combination with mobile broadband data, enabling MNOs to continue to operate their traditional voice business models whilst at the same time driving revenue through increased uptake of high-speed data services.

Although HSDPA's theoretical downlink peak rate is 14.4 Mbps, commercial deployments support up to 3.6 Mbps. Several operators are rolling out HSPA with support for 7.2 Mbps, Telstra being one of them. Equally as important, HSDPA increases UMTS capacity approximately three fold and reduces latency substantially. HSDPA services were first deployed in 2005 by AT&T (formerly Cingular) in the United States and Manx Telecom in the UK.

According to the Global mobile Suppliers Association (GSA), 94 HSDPA operators had launched services in 51 countries/territories and an additional 46 operators are deploying or planning to deploy HSDPA.[4] As of January 2nd 2007, 128 HSDPA devices had launched, including 46 mobile phones. Over 40 embedded HSDPA notebook solutions have also been announced, with many of these already commercial in various markets.[5]

3 3rd Generation Partnership Project

4 "GSM/3G Market/Technology Update," Global mobile Suppliers Association, January 18, 2007; "Global UMTS and HSDPA Operator Status," Informa WCIS and 3G Americas, January 8, 2007.

5 Sources: Various press releases, public announcements and Qualcomm.

HSPA Embedded Notebooks

Notable HSDPA embedded notebook PCs, as of December 2006

Brand	Model	Operator(s) Supported	Announcement/ Press Release	Expected in Market
Acer	Aspire 5650	Vodafone	April 12, 2006	May 2006
	TravelMate 4260	Vodafone	April 12, 2006	May 2006
Asus	V2		December 14, 2006	December 2006
DELL	Latitude D420	Cingular	June 20, 2006	June 2006
	Latitude D620	Cingular, Vodafone	March 30, 2006	March 2006
	Latitude D820	Cingular, Vodafone	March 30, 2006	March 2006
	Precision M65	Vodafone	March 30, 2006	March 2006
Fujitsu-Siemens	CELSIUS H240	Swisscom Mobile, T-Mobile	March 9, 2006	April 2006
	LIFEBOOK E8210	Orange (France), Swisscom Mobile, T-Mobile (Germany)	March 9, 2006; April 18, 2006	April 2006
	LIFEBOOK Q2010	3 (Sweden), Mobikom (Austria), Orange (France), SmarTone (Hong Kong), Swisscom Mobile, T-Mobile	February 28, 2006; March 9, 2006; July 26, 2006	Q2 2006 and later
HP	Compaq nc6400	Cingular	May 9, 2006	End 2006
Lenovo	Thinkpad T60 / T60p	Cingular, Vodafone	January 31, 2006	Q2 2006
	Thinkpad X60 / X60s	Cingular, Vodafone	January 31, 2006	Q2 2006
	Thinkpad Z61t	Vodafone		
	Thinkpad R60	Vodafone		
LG	Xnote A1	KTF	November 1, 2006	January 2007
Panasonic	Toughbook CF-18	Cingular	April 7, 2006	Q4 2006
	Toughbook T5 / W5 / Y5	Cingular	September 13, 2006	October 2006; December 2006
Samsung	Q1	SK Telecom	November 1, 2006	2007
	Q40	SK Telecom	December 21, 2006	2007
Uniwill	X20		November 1, 2006	2007
	L51		November 1, 2006	2007

Source: Qualcomm

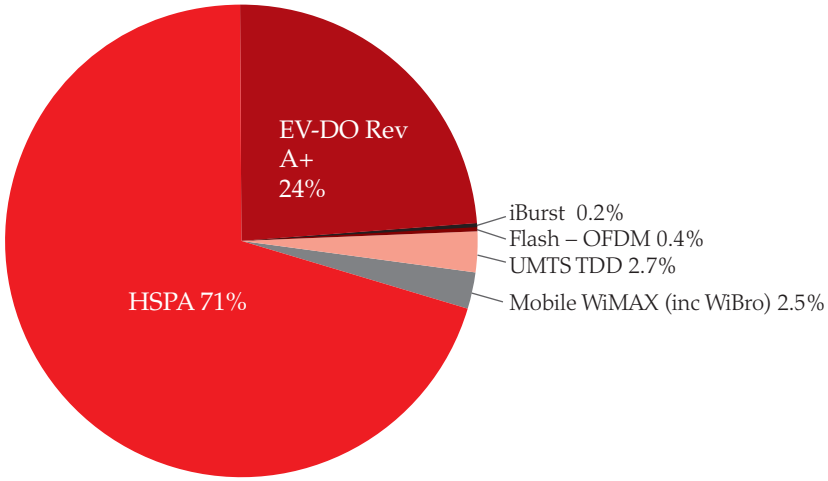
HSUPA vastly improves uplink peak rates and sector capacity over UMTS (WCDMA Release 99). It provides peak uplink rates of 5.7 Mbps and is expected to be launched by a number of UMTS/HSDPA operators during 2007. HSUPA also significantly improves the capacity as well as reduces uplink packet latency and enables efficient VoIP services.

HSPA Evolved introduces MIMO (Multiple-Input, Multiple-Output) capabilities and higher order modulation (64QAM). It also enhances the capacity for non-real time traffic as well as real-time services such as VoIP. HSPA Evolved is capable of delivering 42 Mbps peak bit rate in the downlink and above 11 Mbps peak bit rate in the uplink. The 3GPP standardisation activity is currently receiving a lot of attention and there is good alignment between the terminal industry and the network industry. Initial HSPA Evolved services are expected by H2 2008.

Of the various standardised and proprietary solutions, HSPA is expected to capture the large majority of the mobile broadband market.

A more detailed technical discussion of HSPA is provided in sections 3 and 4 of this paper.

Figure 1: Mobile Broadband Subscriptions, 2010



Source: Strategy Analytics, November 2006. Note: Strategy Analytics defines HSPA as HSUPA (3GPP Release 6) and future releases.

EV-DO

Similar to HSPA for UMTS operators, EV-DO is the upgrade path for the majority of CDMA2000 operators and is standardised by 3GPP2. EV-DO Release 0 supports downlink peak rates up to 2.4 Mbps, typical end user rates of 400 – 700 kbps and approximately 3 times the data capacity of CDMA2000 1X. SK Telecom and KTF in Korea launched the first EV-DO services in January and August of 2002, respectively.

According to the CDMA Development Group (CDG), 52 operators have launched EV-DO services and another 57 operators are deploying the technology.[6] A reported 395 EV-DO devices have been launched, according to the CDG. More than 50 EV-DO embedded notebooks have been announced.[7]

EV-DO Revision A improves downlink rates to 3.1 Mbps and more importantly, improves uplink peak rates to 1.8 Mbps. EV-DO Rev. A also improves capacity, lowers packet latency, and provides QoS controls for different IP streams, enabling very efficient VoIP services. Sprint Nextel, KDDI and Telecom New Zealand have launched commercial EV-DO Rev. A services.

EV-DO Revision B allows operators to aggregate multiple EV-DO Rev. A channels together to provide greater bandwidth to users. Representing a software upgrade to EV-DO Rev. A networks, Rev. B will support up to 9.3 Mbps downlink / 5.4 Mbps uplink peak rates in 5 MHz. EV-DO Rev. B commercial networks should be available as early as 2008.

FLASH-OFDM

Marketed by Flarion Technologies (acquired by Qualcomm in early 2006), FLASH-OFDM holds the distinction of being the first field-tested and deployed fully mobile OFDM technology. T-Mobile launched Flash-OFDM at 450 MHz across Slovakia in October 2005. The service offers end-user data rates of 1 Mbps downlink / 256 kbps uplink to PC cards and desktop modems. In November 2006, Digita in Finland announced it would launch a FLASH-OFDM network in the first half of 2007, supplied by Siemens. On December 18 2006, Siemens won the contract to build the T-Mobile Railnet broadband wireless network, providing Internet access for Germany's 200+ InterCity Express Train (ICE).

UMTS TDD

Championed by IPWireless, UMTS TDD leverages an unpaired 5 or 10 MHz channel to deliver mobile broadband services. A number of commercial UMTS Networks have launched, commencing with a January 2003 deployment in New Zealand. This launch, by Whoosh Wireless, is perhaps the most noteworthy UMTS TDD deployment. Offering broadband access through either PC Cards or desktop modems, the operator had approximately 25,000 subscribers throughout New Zealand by July 2006 after nearly three years of service.[8]

iBurst

iBurst, developed by Arraycom, is a mobile broadband system employing TDD (Time Division Duplex) and adaptive antennas to deliver end-user data rates of 1 Mbps downlink and 384 kbps uplink. A few operators, including Personal Broadband Australia and WBS in South Africa, have launched commercial iBurst services.

6 "Quick Market Statistics," CDMA Development Group, January 17, 2007.

7 Source: Qualcomm

8 Source: "Beyond 3G: Looking for True Mobile Broadband," Strategy Analytics, November 2006

WiBro

Initially begun as a proprietary technology developed by South Korean firms Samsung, LG, SK Telecom and the government organization, ETRI, WiBro has now become harmonized with 802.16e and is one of the certification profiles for mobile WiMAX. Using TDD spectrum at 2.3 GHz, WiBro was launched in Korea by both SK Telecom and KT in June 2006. Subscriber uptake has been lackluster, growing to only 1,500 users as of November 29 2006[9]. In fact, HSDPA services, launched in Korea during the same timeframe by both SK Telecom and KT's mobile arm KTF, have attracted nearly 150,000 subscribers[10], a hundred-fold difference versus WiBro. Limited device and coverage availability and lack of differentiated services compared to HSPA and EV-DO in Korea are some of the reported reasons for limited WiBro traction thus far.

Future Mobile Broadband Technologies

LTE

Long Term Evolution incorporates MIMO in combination with OFDMA in the downlink and Single Carrier FDMA in the uplink of GSM-based technologies to provide exceptional spectral efficiencies and end user data rates exceeding 100 Mbps coupled with very good capacity and latency figures. LTE will support channel bandwidths from 1.25 MHz to 20 MHz and both FDD and TDD operation. LTE is currently being standardised by 3GPP and several parties in the industry are aiming for commercial launches during 2009.

UMB

Ultra Mobile Broadband, previously known as EV-DO Rev. C, incorporates OFDMA and MIMO techniques. Like LTE, UMB is primarily targeted towards new spectrum opportunities or existing spectrum capable of supporting wider channel bandwidths. UMB supports channel bandwidths up to 20 MHz and is being standardised by 3GGP2.

Mobile WIMAX (802.16e)

802.16 was initially conceived within the IEEE as a fixed wireless access and backhaul technology. Certification profiles based on the 802.12-2004 revision of the standard defined the set of features, frequency bands and channels to be supported by all fixed WiMAX products. The 802.16 group later ratified the 802.16e standard and the WiMAX Forum then defined a set of profiles based on 802.16e for mobile WiMAX. The two standards are incompatible.

The WiMAX Forum has reported more than 250 trials to date, however the majority of them seem to have been either proprietary 'pre-WiMAX' or fixed WiMAX (802.16-2004). While WiMAX is the most hyped wireless technology over the last few years, just a few mobile operators have committed to launching mobile WiMAX, the most notable one being Sprint Nextel, using its 2.5 GHz spectrum.

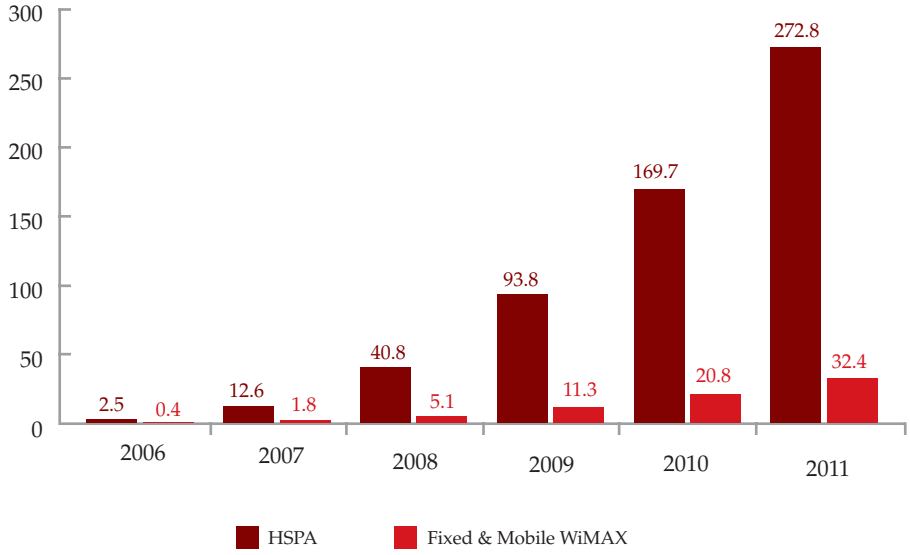
WiMAX certification profiles specify characteristics including spectrum band, duplexing, and channelisation. Several profiles exist for fixed and mobile WiMAX. All WiMAX-certified products to date (just 28 as of October 2006[11]) are for fixed WiMAX in the 3.5-GHz band. Vendors are waiting for mobile WiMAX certification to begin, starting in Q1 2007 for Wave I (WiBro / 2.3 GHz) and Q3 2007 for Wave II (2.5 GHz). Sprint Nextel plans to launch its services based on mobile WiMAX in late 2007 or early 2008.

9 Source: Yonhap News (November 29, 2006)

10 Source: ZDNet Korea (December 22, 2006)

11 Source: Maravedis WiMAX report

Figure 2: Subscriber Forecasts: HSPA vs. WiMAX



Sources: HSPA - Informa, June 2006 (includes HSDPA and HSUPA); WiMAX – Average of Pyramid Research, 12/06; Strategy Analytics 11/06 (for mobile WiMAX) and 6/06 (for fixed WiMAX); ABI, Q2'06.

Advantage HSPA

While WiMAX has gained considerable attention over the last few years, the mobile broadband market is expected to be dominated by HSPA. According to the latest forecasts from industry market research firms, HSPA subscribers are expected to outnumber WiMAX subscribers more than 8 to 1 in year 2011. With deployments or commitments from hundreds of operators, HSPA represents an efficient evolution path for UMTS and GSM networks serving more than 2 billion subscribers.

"We will be demonstrating .16e around the end of the year to show our customers we have this capability, but real deployments are two to three years out for most customers."

Majed Sifri, Chief Executive, Redline Communications Inc., EETimes.com, January 22, 2007

"While much of the attention on WiMAX has focused on its technical merits, much less has focused on the related commercial point that WiMAX has the freedom to implement such advanced technology because it does not have a significant installed base in the market. This is a major weakness relative to 3.5G systems, which can capitalise on the huge commercial scale and momentum of 2G, 2.5G and 3G networks currently serving over two billion end users worldwide."

Informa Telecoms & Media, June 2006

Section 3: Technology Evaluation – HSPA & WiMAX

A new report from Arthur D. Little – 'HSPA and mobile WiMAX for mobile broadband' – examines the roles of HSPA and WiMAX and brings clarity to decision makers. The following is an overview of the report's key findings.

Operators, regulators and vendors are developing their plans for mobile broadband access based on an incomplete picture of the technology choices available. In particular, the relative advantages and disadvantages of choosing HSPA vs. mobile WiMAX remain unresolved.

To help decision makers, Arthur D. Little conducted a qualitative research project amongst 31 HSPA and WiMAX equipment vendors, operators running the networks, government regulators and financial investors around the world.

The findings can be summarized as follows:

- HSPA will account for the majority of mobile broadband networks worldwide over the next five years;
- Mobile WiMAX is a competitive technology for selection by operators over this period in only a limited number of circumstances where conditions are favourable;
- There are 94 commercial HSDPA networks in operation today, while the first commercial mobile WiMAX networks are expected to enter service towards the end of 2007[12];
- In the long-term, mobile broadband wireless systems will be characterized by technologies such as OFDMA and MIMO, whose development is being actively pursued throughout the industry.
- While future mobile WiMAX systems could potentially achieve data transfer rates of 16.8 Mbps in urban areas, mobile WiMAX cells will tend to be significantly smaller than HSPA cells, at only half to a quarter the cell radius of the equivalent HSPA cell. HSPA bandwidth falls away slowly, which allows for larger cells. Typically, the radius of HSPA cells is 2-4 times larger than WiMAX, which means the cells range across an area 4-16 times greater; this gives HSPA a significant mobility advantage.
- Initial indications are that capex for current WiMAX technology can be up to 5- 10 times HSDPA capex on a like-for-like basis.

12 Sources GSA and WiMAX Forum - the first mobile WiMAX Forum Certified™ products are expected in early 2007.

A powerful momentum behind HSPA

Over the next five years many factors will lead operators to deploy more HSDPA networks than WiMAX.

Since 2005 more operators have either deployed or plan to deploy HSDPA ahead of WiMAX. HSDPA has gained a significant time-to-market advantage. With a large HSDPA base established, economies of scale have come into force, particularly on handsets and other user devices. A growing network of global suppliers of components, subsystems, equipment and network design and implementation services now support the HSDPA base.

HSDPA (and upgrades) form a natural migration path for the many GSM and UMTS operators who already operate commercial networks in 3G spectrum. For most operators HSDPA offers the least risky route to offering mobile broadband services, with speeds comparable with first generation DSL access services.

Today's powerful Internet-based interests (Google, Yahoo! and MSN) create demand for mobile broadband access, with operators coming under pressure to deploy available infrastructure and handsets capable of achieving similar speeds to those users experience with broadband at home.

WiMAX lags behind HSPA but has supporters

Over the past year WiMAX has made significant progress in building a comprehensive "ecosystem" of supply, albeit one which has not yet established the depth and breadth of the HSDPA equivalent.

A major factor which operators considering mobile WiMAX will have to take into account is the cost of WiMAX user terminals in certain markets. Because of low WiMAX volumes and the limited choice of devices, the prices of WiMAX handsets will remain significantly higher than those of other, much higher volume, cellular terminals, which are being developed and offered in increasingly lower cost versions.

In fact, WiMAX is in the difficult position of having to prove its business case in advance of proven performance. This is due to two key factors:

- Attractively priced notebooks and PDAs with WiMAX-embedded capability, coupled with acceptable power consumption, will not appear in quantity until 2008, with handsets arriving in 2009 or later.
- WiMAX lacks the economies of scale that benefits HSPA.

In addition, operators will have to note the cost of WiMAX handsets in price-conscious, emerging or developing economies where no significant voice revenue exists for them. That said, a small number of operators will choose WiMAX in certain situations where:

- The operator does not have access to 3G spectrum but does have spectrum at other frequencies such as 3.5, 2.3 GHz
- The fixed operator wishes to deploy broadband to areas where wired alternatives, such as DSL, are neither available nor economic to deploy
- The operator wishes to enlarge their 'hotspot' broadband

In this last example, the capex costs deter the operator from offering national or wide area coverage. However, an operator that possesses both a 3G network and TDD spectrum can do this. In the U.S., Sprint Nextel will have two broadband wireless networks deployed to concentrate the delivery of additional data services over WiMAX with fallback to CDMA/EV-DO when the user moves outside the WiMAX hotspot.

The impact of new, faster OFDMA/MIMO technologies in the next decade

Both WiMAX and 3G/HSPA are pursuing OFDMA-based technologies that will form the next step in access speeds in mobile broadband networks. The longer-term competitive question for equipment vendors and markets is whether either the mobile WiMAX or the LTE streams will achieve a significant time-to-market advantage over one another. It is possible that mobile WiMAX might enjoy a time-to-market advantage over LTE if the latter were delayed substantially. This opportunity for mobile WiMAX would only arise if it succeeded in building a solid niche installed base with proven performance and a credible upgrade path in coming years.

The bottom line is WiMAX faces huge risks. Its products may be too late to fill the gap in speeds between a few hundred kbps and the Mbps data rate HSPA achieves now. At the same time, they may be too early for the components technology and network capabilities (e.g. rapid cell handover) the new OFDMA/MIMO-based networks require for their success in the next decade.

Vendors and operators hold the key long-term

Market developments and pressure from the major operators may prompt collaboration between the two technology groups. This could lead to convergence of the separate technology systems. Or, the technologies may separate into two camps.

Vendors' priorities are driven by the realities of the broadband market.

This explains in part why vendors that failed to achieve leadership in 3G-network equipment now champion WiMAX. They are trying to grow their market share in the overall mobile broadband equipment market on the back of the hoped-for success of WiMAX.

Operators will also influence the shape of the wireless equipment market. They will pursue their influence as buyers rather than sellers of equipment. They already influence standards and specification procedures through consortia, such as The Next Generation Mobile Network (NGMN).

Towards a common agenda

A growing interest in the value of multi-node user devices and roaming capabilities across the technologies suggests a change in attitude towards WiMAX.

This drive to collaboration reflects a widespread belief that OFDMA and the other technologies involved in WiMAX and 3G LTE will all play central roles in future mobile broadband networks.

HSPA and WiMAX comparison chart		
	HSPA	Mobile WiMAX
Technical strengths		
High bandwidth:		
- Urban areas	✓	✓
- Non-urban areas	✓	
Mobility	✓	
Business base		
Support from operators	✓	✓
Considered low risk	✓	
Ease of upgrades	✓	
Niche opportunity		✓
Niche support		✓
Time-to-market advantage	✓	
Economies of scale	✓	
Ecosystem of suppliers	✓	✓
Influencing the future		
Pursuing OFDMA	✓	✓
Policy-making	✓	✓

For a full version of the report from Arthur D. Little, entitled 'HSPA and mobile WiMAX for mobile broadband', please contact Sandra Gilligan at the GSMA (sgilligan@gsm.org).

Section 4: Technical Benefits of HSPA

HSPA is state-of-the art technology that provides mobile and wireless broadband services with an unsurpassed performance. Already deployed worldwide by prominent operators, it supplies high bit rate transmissions, excellent system capacity and very low latency, combined with superior wide-area coverage. HSPA's technical capabilities and its global adoption will have a huge impact on society.

Operator and end user benefits with HSPA

A good broadband system has to fulfil some vital criteria. These include high data rates, high capacity at low cost per bit, low latency, sophisticated schedulers (that enable differential user or service levels) as well as good coverage. HSPA's high uplink and downlink data rates combined with low latency in a wide-area network gives end users an unparalleled data experience. Applications like web access, file download/upload, VoIP and streaming services used with HSPA rivals the experience with wired alternatives like ADSL. The HSPA solution also provides full mobility, and all-IP connectivity where the end user experiences seamless services without interruption when freely moving in the network.

For many existing UMTS/WCDMA networks, HSPA is a software upgrade, leveraging the existing hardware and minimising the complexity. HSPA uses the same frequency carrier as other traffic and supports service continuity across the network. This, together with existing dual mode GSM/HSPA devices, gives the operator full control during the introduction of new, high-quality mobile broadband services whilst maintaining a seamless service.

Even for a green-field deployment, HSPA offers a superior choice to WiMAX due to its availability, operationally proven superior coverage, spectrum efficiency and economies of scale.

While mobility is an inherent feature of 3GSM technologies, it is important to note that HSPA can actually offer a much more cost efficient solution for wireless (fixed) broadband applications than WiMAX without sacrificing any performance.

Performance superiority

With 94 commercially launched HSPA networks today, its performance and capabilities can be verified in live, operational environments. Measurements with 16QAM, 5 code devices capable of up to 3.6 Mbps under good radio conditions showed a throughput of 3.1 Mbps in the downlink. Measured throughput for a pedestrian end user was 2.1 Mbps and for an end user in a car driving at 60 km/h was 1.7 Mbps. Cell edge performance was still 1.5 Mbps, underlining the wide-cell coverage capabilities of HSPA. Latency as low as 60 ms has been measured. This performance was all achieved by simply installing new software in existing hardware and using currently available commercial devices with maximum achievable downlink speeds limited to 3.6 Mbps. A single cell can simultaneously support several devices offering a mixture of services all running at peak rate. It is also possible to run multiple simultaneous services to one user, e.g. voice telephony service and internet browsing at the same time.

Devices with support for 10 codes, capable of 7.2 Mbps on the downlink and HSPA in the uplink, and with more advanced receiver technologies significantly improve these already impressive results. Terminals with these capabilities are being introduced this year. To further minimise costs, a significant focus has been given to providing high coverage solutions.

HSPA Features

HSPA includes key features that improve the end user experience and provide the operator with the most competitive mobile broadband offering available.

- **High data rates**
  - **Higher order modulation**
    16 Quadrature Amplitude Modulation (16QAM) provides up to 14 Mbps peak rate in the downlink as well as 12 Mbps in the uplink. 64QAM modulation will enable peak downlink data rates of 21 Mbps[13].
  - **Downlink MIMO (Multiple Input Multiple Output)**
    Two antennas are used, effectively doubling the peak rate. In combination with 64QAM this enables a peak rate of 42 Mbps.
  - **Multi code transmission**
    Several codes can be used simultaneously, allowing the system to flexibly allocate resources per user, thus reaching the high peak rates described above.

- **Quality of Service and Latency**
  - **Fast scheduling**
    End user traffic streams are prioritised according to their service agreements by determining which user equipment the shared channel transmissions should be directed to.
  - **Short Transmission Time Interval (TTI)**
    With a TTI of 2 ms, roundtrip times are approaching wired equivalents such as DSL, having times of 20 ms.

- **Capacity**
  - **Shared channel and multi code transmission**
    More efficient use of available codes and power resources increases system capacity.
  - **Fast link adaptation (500 times per second)**
    Instantly optimises transmission parameters and thus data rates depending on the radio conditions reported back by the terminal.
  - **Fast scheduling (500 times per second)**
    Allows rapid resource re-allocation, increases system capacity as well as the likelihood for high end user data rates by selecting users with favourable radio conditions.
  - **Fast hybrid Automatic Repeat reQuest (ARQ)**
    Enables the rapid retransmission of missing data and soft-combining to significantly improve performance and provide robustness.

13 Dependent on proximity to transmitter.

- **Coverage**
  - **Macro-diversity**
  - Several base stations and sectors attempt to decode the data, increasing data reception, system capacity and cell edge bit rates.

Summary

HSPA enables mobile operators to cost-efficiently deliver a wide range of mobile broadband services today. It targets all end user segments and terminals and delivers an end user experience that was previously only available with fixed network technologies. In addition to that, HSPA also delivers full mobility and availability everywhere.

HSPA is clearly the undisputed choice for mobile broadband services today, providing:

- Significant benefits from the economies of scale uniquely available to a technology that is part the 3GPP family of standards, serving over 2 billion subscribers
- Exciting new applications and faster performance with transmission bit rates of up to 14 Mbps in the first phase and up to 42 Mbps in the second phase
- Highly economic urban and rural coverage, providing up to 200 km cell range and with measured speeds that exceed 2 Mbps at the cell edge
- A clearly defined and easily adopted evolutionary path

Finally, load calculations in an HSDPA network demonstrate an operator has a technology capable of cost efficiently delivering over 30 Gigabytes of data, plus 300 minutes of mobile TV and 1000 minutes of mobile voice per month, for everyone virtually anywhere – today!

Section 5: Influences on Choice

5.1 A User's Perspective

There's no question that the launch of 3G more than three years ago sparked a revolution in mobile data services. For the first time it became simple and practical to browse the Web, download presentations, and keep email flowing while out and about with a notebook computer. While on mobile handsets, services from search, mapping, video streaming, photo blogging, and content-sharing, to music downloads, and more, are now exploding into the mainstream.

The best thing about all this? It's only the beginning – and with the introduction of High Speed Packet Access (HSPA) technology, the end-user experience is being taken to a whole new level.

It's from day-to-day experience of using the technology that you really see the benefits of HSPA.

Initially, at least, there's no 'eureka' moment – you fire up the service and there it is, the Internet working as normal. That simplicity, in itself, is testament to the technology. Then with time you start to notice the benefits over regular 3G: web pages load faster, Internet video sites just work better, and large email attachments simply drop into your inbox.

The experience of HSPA in a laptop is almost like desktop performance gone mobile. In everyday usage situations (in meetings, at conferences, and the like) download speeds of around 1 Mbps while stationary are typical, and even in locations with poor signal strength – the 9th floor meeting rooms at Unstrung's London office, for example – you can stream 512 kbps video without a hitch. In markets where operators have deployed more advanced versions of HSPA, user's report peak data rates of almost 3 Mbps in good signal conditions.

Response times are also noticeably better. Response times are in the range of 100ms to 200ms, which is good enough for most Internet applications and, for enterprises specifically, this lower latency enables use of transactional, line-of-business applications. This means users can update and pull-down information in corporate databases in real-time, without having to rely on disconnected operation and time-delayed synchronization.

HSPA on a handset, for me, is more about having fun that it is about work. Sure I want email and IM, but it's browsing, video streaming, and remote access to my music collection that really makes the best use of the faster connection.

Verging on the geeky side of things, one the applications I've enjoyed playing with (just because I can!) is the ability to stream Internet radio while taking the train to work across London. Others include bit-torrent file-sharing (legal content only, of course!) and mobile VOIP. For sure there's work still to be done before these kinds of services 'just work', but it shows what could be coming down the pipe a year or two from now.

And that's the thing about this technology. It makes you greedy for more. What I want now is more coverage in-building and outside the city. Oh, and I need a new laptop – one with an integrated HSPA card.

Gabriel Brown,
Chief Analyst, Unstrung

5.2 An Operator's View

AT&T - Raising the bar for mobile broadband today

AT&T (formerly Cingular Wireless) operates in one of the world's most competitive and complex mobile markets. As the largest mobile operator in the USA, it strives to be first to market with successful mobile services. In 2005, the company launched the world's first large scale High-Speed Downlink Packet Access (HSDPA) service as an evolution of its existing data service EDGE. With an aggressive rollout during 2006, AT&T's HSDPA services were made available in 160 markets, including most of the top 100 major cities in the country

AT&T has initially focused on HSDPA, where the downlink speed is boosted to 1.8 Mbps, considerably faster than WCDMA, allowing AT&T to launch compelling next generation data services such as mobile television and broadband Internet access. For AT&T, the result is a rapid growth in data ARPU and increased customer loyalty. Data ARPU increased 53 percent in the fourth quarter of 2006. Churn has fallen from 2.4 percent in 4Q04 to 1.8 percent in 4Q06.

Businesses turning to mobile broadband

When AT&T's HSDPA services were launched in 2005, they were initially aimed at business customers. Early adopters were attracted to dual-mode HSDPA / EDGE data cards that plugged directly into laptops giving them super fast, unlimited connectivity anywhere within its nationwide 3G footprint. Later was to come the embedded devices that AT&T worked on with key notebook vendors. Many are also adopting HSDPA handsets that feature Bluetooth 2.0 capability, enabling the delivery of rich content services on their mobile, while also being used as a modem for their notebook.

Consumers turning on to mobile television

Mobile television is proving a hit with AT&T customers thanks to HSDPA. The fast download speeds allow video from favourite programmes from HBO, MTV, ESPN, CNN and Billboard to be streamed to a user's 3G handset. A combination of the compelling range of providers and prices, and a superior viewing, experience has helped AT&T to become one of the most successful mobile television providers, encouraging customers from other networks to join.

The next steps for exploiting the full potential of HSDPA will be AT&T's launch of live video share calling. This allows users to send a live video stream to a recipient during a standard voice call, with the click of just one button. This ability to link two communication streams is only possible with HSDPA and the IMS-based intelligent network that AT&T has built to power its future services.

Building tomorrow's network today

AT&T is the largest mobile operator in the USA and has 61 million active customers. Its nationwide GSM/GPRS network reaches 282 million people. In 2003, recognising the need to develop non-voice services while maximising its existing investment, AT&T began the process of upgrading the majority of its network to support EDGE. While EDGE offers the advantages of always-on connectivity and practical data rates up to 128 kbps, it only scratches at the surface of 3G potential. To provide its customers with genuine mobile broadband and keep abreast with its challengers, AT&T needed to look to HSDPA to power the network to multi-megabit speeds.

AT&T chose to roll out HSDPA, allowing it to offer market-leading data rates and service quality to support compelling content. What's more, HSDPA's superior spectrum efficiency meant that its data services could also be priced competitively.

By deploying HSDPA from the outset, AT&T's 3G network was fast, efficient and economic at launch. Rollout priority focused on metropolitan areas providing the service continuity outside of the 3G/HSDPA coverage area.

Critical acclaim for AT&T's mobile broadband

Walt Mossberg, a columnist with the Wall St Journal, tested the HSDPA service in January 2006. He reported: "I've been testing the AT&T BroadbandConnect service on a notebook around Washington and I like it. It's very fast. And it proved reliable, connecting properly every time. In tests in both downtown DC and a suburb 15 miles away, the AT&T service averaged 640 kbps, roughly 6-7 times the speed I have seen with EDGE."

Today fast, tomorrow even faster

AT&T continues to enhance the network, improving the speeds at which it can deliver media-rich content. In the deployment of HSDPA, the operator ensured that there would be a simple upgrade path to HSUPA, where the uplink speed is vastly improved. When this is deployed, it will be a benefit to users who send large files by email or use chatty enterprise applications like SAP. The improved uplink speed will also tap into the growing interest in user-generated content, such as home videos filmed on subscribers' 3G handsets and posted to the operators' portals.

Faster speeds for the downlink are also planned. The network has the capability of carrying HSDPA at 3.6 Mbps but is currently engineered for 1.8 Mbps. AT&T will increase the downlink speeds as more devices become available and as the market dictates. The current average speeds provided by HSDPA, 400-700kbps, are addressing customer needs.

The success of the HSDPA rollout has reinforced AT&T's commitment to their choice in GSM technologies and proven to be a cost efficient technology for providing mobile broadband services to urban and rural communities. The US is highly fragmented with incompatible technologies, so making the right technological choice is extremely important to any US mobile operator, irrespective of their size. Mobile broadband is an evolutionary process, and AT&T continues to evolve the next generation services that will keep it top of the US mobile market. With HSDPA, AT&T is delivering tomorrow's mobile broadband today.

The GSM Family
GSM – Global System for Mobile communications
GPRS - General Packet Radio Service
EDGE - Enhanced Data rates for GSM Evolution
UMTS - Universal Mobile Telecommunications System
HSPA - High-Speed Packet Access
HSDPA - High-Speed Downlink Packet Access
HSUPA- High-Speed Uplink Packet Access

5.3 Regulatory Insight

Establishing an Equitable Regulatory Context for HSPA Deployments

The demand by mobile users for faster data services is growing – with mobile broadband services a high priority for users all around the world. Evolved 3GSM technologies, specifically HSPA, are demonstrating in practice the high downlink and uplink data speeds, low latency and spectral efficiency that result in service benefits to consumers and enterprise users alike.

Throughout this white paper, no pretence is made that there is only one technology solution available to meet the high-speed data demands of mobile users. Alternative access technologies, some of which are operational and some of which are proposed, may offer solutions to form part of an operator's portfolio of product offerings. However, it is vital that the regulatory approach to licensing and spectrum management ensures a balanced and market based–methodology is used to determine which solutions become commercially available.

Investment in 3G licences is a pre-requisite for operators to develop new, fully mobile services offering rich data and mobile broadband applications, leveraging the evolutionary upgrade path of GSM. A reasonable assumption for business planning in this environment is that a competitive licensing environment is also an equitable one. Thus it is important that the investment balance is not skewed for different technology platforms.

Ensuring an equitable financial foundation to licensing

Regulators strive to create regulatory regimes that foster innovation, investment and affordable access to services. In achieving these aims it is important to ensure no unfair advantage is offered to any particular technology. For example, should a service, based on one set of licensing criteria, be commercially developed to extend beyond the original licensing terms, this can distort the market and result in unfair competition and potentially poor quality services for consumers. In a number of markets there have already been attempts by nomadic data service providers to evolve their market offerings into quasi-mobile solutions. This is done primarily to avoid regulatory fees and licence conditions associated with mobile spectrum and results in market distortions. In order to ensure consumers can continue to benefit from existing mobile services and can take advantage of new high- speed data services, it is critical that a consistent and predictable investment environment is secured.

Pressures on Spectrum

One of the benefits of HSPA is that it is a natural migration path for GSM operators to deliver high speed broadband services. For operators, this has many advantages. For regulators, operators adopting solutions in existing spectral allocations, especially in the 900MHz bands, give significant re-farming advantages especially in terms of providing rural coverage and helping to support activities aimed at providing universal access to high speed data services. Significant technical studies have been undertaken by 3G operators to plan approaches to refarming 900MHz spectrum for HSPA which show significant network cost advantages of supporting this policy that will result in lower consumer prices. Ensuring harmonised band planning in line with ITU recommendations will also help to ensure the clear benefits of handset economies of scale and handset choice can be leveraged to the advantage of consumers.

Summary

The benefits of HSPA in terms of delivering mobile broadband are numerous. It is important that operators and users around the world are free to make their choice of the best vehicle for delivering mobile broadband – based upon an accurate and balanced comparison between alternatives. Whilst many of the issues involved in determining the best choice may be truly commercial, some of them will be determined or greatly influenced by local regulatory positions. It is therefore important that all decisions affecting the regulatory position are made in the spirit of producing an equitable environment for customers to exercise their right of choice.

Section 6: Investment for the Future *– the Evolutionary Path*

The introduction of HSPA is the continued evolution of the 3GSM technology family. With multi-band HSPA terminals already available, HSPA offers a natural evolution path for GSM and WCDMA networks, as well as being the clear technology choice for green-field deployments, due to its operationally proven superior coverage, spectrum efficiency and economies of scale.

A number of key factors face operators today when deciding which technology will best ensure a profitable business and give an attractive future service offering:

- Time to market
- Economies of scale
- Range of end user devices
- Total cost of network ownership
- Level of future-proof protection

Time to Market

HSPA is at least two to four years ahead of many other mobile broadband technologies, such as WiMAX, LTE and UMB. More than 94 networks in the world have already launched commercial HSPA services (a continuously increasing number) and are all capable of delivering mobile broadband as well as fixed wireless broadband.

Economies of Scale

Though IPR costs are often mentioned, they are not a significant influence on the industry and are not a differentiator between WiMAX and HSPA. In fact, even WiMAX proponents admit WiMAX will not be free from IPR costs[14]. Instead, the principal factor for industry success is economy of scale. There are currently around 2.5 billion mobile subscriptions worldwide. It is predicted that there will be around 4 billion mobile subscriptions worldwide by the end of 2011, and the vast majority of these subscribers will make calls via the 3GSM family of standards (GSM/WCDMA/HSPA).

This substantial volume advantage is beneficial to both end user terminals and infrastructure equipment. It drives the manufacturing costs down, and generates sales income that can give an unrivalled investment into research and development. This maintains the competitive advantage of the 3GPP standards as the technology of choice for a wide range of devices.

14 Fierce Wireless interview of Ron Resnick, president and chairman of the WiMAX Forum, January 16, 2007

Range of Devices

The range of HSPA devices is extensive and is supplied by multiple vendors. Products include mobile phones, PDAs, notebooks, PC data cards, PCMCIA cards or embedded modules, USB modems, wireless routers and Personal Media Players. HSPA is the most cost effective solution available for mobile broadband connectivity on the market and there is an enormous ecosystem that guarantees a wide range of attractive and low cost end user devices.

Total Cost of Network Ownership

There are many variables to consider when calculating the total cost of ownership of a mobile network. Amongst others; equipment costs, site costs, network OPEX and, importantly, coverage. Up to 80% of the radio network costs are driven solely from the site costs: site equipment, site rental, power supply, civil works and transmission to the site. As HSPA delivers superior coverage, this directly leads to fewer sites being required and significantly reduces the total cost for the radio network. As an example, networks are being deployed with cell ranges of up to 200 km using standard, commercially available terminals and PC cards.

Level of Future – proof Protection

HSPA currently supports the delivery of mobile broadband and fixed wireless broadband services in nearly all of the mobile spectrum bands. HSPA covers the 850 MHz, 900 MHz, AWS (1700 MHz) 1800 MHz, 1900 MHz, 2.1 GHz and 2.6 GHz spectrum bands and during 2007 it is expected that at least five of these bands will carry commercial traffic.

Operators will offer subscribers 7.2 Mbps with full mobility at the beginning of 2007. However, HSPA's capabilities today are only the beginning for mobile broadband. Delivering peak rates of 14 Mbps in the downlink and 5.7 Mbps in the uplink, its evolution adds support for MIMO and 64QAM that can deliver up to 42 Mbps in the downlink and MIMO + 16QAM for up to 12 Mbps in the uplink. In parallel, LTE will deliver further enhancements in peak rates (exceeding 100 Mbps), in addition to scalable channel bandwidths using OFDMA and with both TDD and FDD duplex operation. LTE and HSPA Evolved offers maximum flexibility with regards to spectrum, while delivering true high-speed, high quality next generation performance.

Delivering mobile and wireless broadband services not only places demands on the radio interface, but on the entire network to be able deliver low latency, jitter free, high bandwidth multimedia services, with the quality of service and in-service performance end users expect from a public telecom network. Therefore, 3GPP's focus is not only on specifying the radio interface, but also on the requirements, interfaces and architecture for the end-to-end network.

Just as the radio interface improves at every step, so too is the network enhanced and optimised. In step with HSPA, the 3GPP reference architecture is enhanced with a One Tunnel Solution to optimise the delivery of Mobile and Wireless Broadband services.

The next step in the architecture evolution specified together with LTE in 3GPP, the System Architecture Evolution (SAE) will deliver optimised and flattened network architecture with simplified QoS for the delivery of IP services. Further, for operators evolving to LTE/SAE from GSM/WCDMA/HSPA, it will maintain full backwards compatibility with the legacy networks. In fact, the SAE architecture is so attractive that it has also been considered for non 3GPP access technologies.

Summary

There has been a truly superb development of the 3GSM technology track (GSM/WCDMA/HSPA). In a mere ten years there has been a factor 1000 increase in the data bit rates of mobile networks, while maintaining full backwards compatibility with the very first mobile phones released in the market. 3GPP technologies will continue to evolve and enhance its capability, with a clear roadmap of reaching 42 Mbps with HSPA Evolved and exceeding 100 Mbps in the near future with LTE.

As a public telecom operator, the technology choice of today will influence operations for many years to come. 3GSM technologies are the future proof choice to adopt, from an initial investment standpoint, economy of scale and the ability to extend and continuously enhance the solution for the next 5 to 10 years.

Section 7: Conclusions

As cited extensively throughout this review, it is evolutions on the foundation of proven and powerful existing technologies such as GSM that will dominate the future mobile broadband arena, despite all the hype surrounding alternative high-speed mobile technologies.

The points below summarise the review's findings:

- **HSPA is delivering mobile broadband today**
  - **Major commercial investment already in place**
    According to the GSA, as of early January 2007, 140 mobile operators in 64 countries/territories have committed to HSPA technology, with 94 commercial networks in 51 countries already live
  - **Proven high speed performance**
    Such networks currently support typical end user downlink data rates of 400 kbps to 1 Mbps
  - **Even higher speeds offered now**
    28 operators already currently support 3.6 Mbps
  - **Largest range of high-speed devices available**
    128 HSDPA devices have been launched from 39 suppliers, including 46 mobile phones and 32 datacards

- **HSPA benefits all**
  - **Benefits for all types of users**
    Business and consumer users in rural and urban communities are reaping the benefits of HSPA
  - **Cost effective use in emerging markets**
    HSPA is also an extremely cost effective way of bringing broadband to the developing world

- **HSPA has major technology advantages over other mobile broadband alternatives**
  - **Voice and data connectivity**
    Unlike other mobile broadband technologies, HSPA allows for simultaneous voice and data connections
  - **Proven investment mode**
    HSPA builds on the successful GSM business model, offering users secure network interoperability access and global roaming
  - **Easy upgrade path for existing installations**
    In many cases, HSPA is a software upgrade to existing 3GSM networks and operators are able to benefit from economies of scale and global experience of mobile network planning and deployment
  - **Overwhelming support from the industry**
    The majority of the world's mobile equipment vendors support HSPA technology, creating a huge ecosystem of market support. There is effective competition in this space with no one single dominant player
  - **Deployed and available already**
    HSPA has a significant headstart over WiMAX; vendor investment in R&D is being matched by operators deploying the technology

- **The window of opportunity for WiMAX is limited**
  - **Unequal scale of operations**
    WiMAX has made progress in building an ecosystem of supply, but one that has not yet established the depth and breadth of the HSPA equivalent
  - **A long wait for enabled devices at an affordable price**
    Attractively priced notebooks and PDAs with WiMAX embedded capability, coupled with acceptable power consumption, will not appear in quantity until 2008, with handsets arriving in 2009 or later
  - **Smaller market overall**
    WiMAX lacks the economies of scale that benefits HSPA
  - **Available as a choice for niche operations**
    A small number of operators will choose WiMAX in certain situations where spectrum conditions and/or internal business policies necessitate such a decision

- **The future direction of HSPA is clear**
  - **Fast, faster, fastest**
    HSDPA data rates will continue to improve; by the end of 2007 we can expect to see services supporting 7.2 Mbps
  - **Uplink high speed services launching in 2007**
    The introduction of HSUPA – expected to be launched by the end of 2007 – will provide peak uplink data rates of 5.7 Mbps
  - **Encouraging innovation and exciting new services**
    The introduction of HSUPA is likely to boost the amount of data uploaded over mobile networks, especially user-generated content. Jointly, downlink and uplink enhancements will further enhance user experiences and increase the use of application and activities, especially where data is shared between users, for example, interactive multi-player gaming
  - **The evolutionary path has steps to the future**
    In addition to enhanced capacity, HSPA Evolved will deliver a peak bit rate of 42 Mbps. Initial HSPA Evolved services are expected by H2 2008 or later

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