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Alternative migration paths to providing 3G services

Two approaches to delivering high-speed data on wireless networks

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ALTERNATIVE MIGRATION PATHS TO PROVIDING 3G SERVICES
Two approaches to delivering high-speed data on wireless networks

1. Executive summary

In recent years, third generation mobile systems (3G) have been identified as the next big thing to hit the wireless communications industry. However as 3G licences have been auctioned throughout Europe, at a vast cost to the mobile operators, the markets have become jittery. In Germany alone the six licence holders paid an average of $7 billion each ($90 per POP) for new licences and spectrum. Concern has been compounded by worries that network roll-out is behind schedule. As with many new technologies, rumours abound that standards or equipment and handsets will not be ready as scheduled.

Thoughts turn to return on investment, safety nets or exit strategies, should the rumours become reality. Consequently alternatives for delivering high-speed data on mobile networks gain piqued interest.

This paper introduces these two alternatives with a case study of a deployment of these technologies in the German market for an incumbent GSM operator that has purchased UMTS spectrum.

Key Points of Paper

- cdma2000 can provide two alternatives for GSM carriers to begin deploying 3G network equipment in 2002: complementing W-CDMA or as a substitute

  the first alternative is to deploy cdma2000 1xEV with peak rates of 2.4Mbit/s in 2002 to generate revenues with new emerging segments, followed by W-CDMA

  the second alternative is to deploy 1xEV and then deploy MC-MAP (IS-833, the cdma2000 1x air interface with GSM-MAP core network, or 1xMAP) for voice and high-speed data in 2003 if W-CDMA network equipment availability is delayed

- Consequently, two new markets can be addressed immediately with 1xEV

  the first is the fixed Internet market, in countries where prices are high, fixed PSTN speeds are slow, and access to broadband solutions is difficult. In these countries deployment by mobile operators can be relatively fast. In a fixed location, 1xEV offers average throughputs of 1.4Mbit/s

  the second is the emerging high speed mobile market, where 1xEV offers average mobile throughput of 880kbit/s.

This case study examines the second migration path, the deployment of 1xEV and 1xMAP which address the fixed and mobile markets. With this deployment an operator can increase mobile ARPUs by euro30 (euro78 total ARPU) with approximately 20% of its subscriber base by bundling high speed fixed services with an incremental capital cost of euro122 per subscriber. EBITDA margins can be increased by 500 basis points with the addition of the fixed segment.

1xEV will be commercial by the end of 2001 and 1xMAP will follow. All the key standards have been ratified. 1x is commercial today and 1xEV market trials are occurring in Korea, Japan and the US with commercial launches expected in late 2001.

2. Introduction

2.1 Introduction

In recent years, third generation mobile systems (3G) have been identified as the next big thing to hit the wireless communications industry. Supporting data speeds up to 2Mbit/s, they have the potential to converge the mobile and Internet worlds for the productivity of the business world and the entertainment and convenience of the consumer world, with particular appeal to the burgeoning youth culture.

During 2000, 3G licences had been auctioned throughout Europe at a vast cost to the mobile operators. In addition to the licence fees, they face network roll-out costs of between euro2.5-4 billion. These new networks are predicted to launch commercially in 2002 and consequently begin generating revenue in the medium term.

However, as with any new technology, there are inevitably rumours that the standards or equipment and handsets will not be ready as scheduled. Thoughts turn to return on investment and safety nets or exit strategies should the rumours become reality. This is symptomatic of the position the market currently finds itself in. As a result operators need to examine alternative migration routes.

There is no single approach to evolve from current 2G technology to a 3G technology. There are three widely acknowledged migration paths.

- GSM-based: GSM->GPRS->W-CDMA

  most of the market attention so far has focussed on GSM. It is the most widely publicised migration path and is well entrenched in Europe. There are GSM networks in over 160 countries worldwide

- EIA/TIA-95-based: cdmaOne (95A and 95B)->cdma2000 (1x and 1xEV)

  its installed base is in the Pacific Rim and US, but has permeated every geographical market except Europe. SK Telecom already offers 1x phones with 144kbit/s peak rates. 1xEV has been approved by 3GPP2 and submitted to the ITU as a 3G standard. It is currently in market trials.

- TDMA-based: UWC136->UWC136HS

  the TDMA-based migration path is losing ground. Its major proponent, AT&T Wireless, is now working with NTT DoCoMo on 3G technologies and moving towards the GSM-based evolution path.

Aside from these migration paths, there are further possibilities. This paper concentrates on two of them.

- The first is to install 1xEV on a GSM/GPRS core network. 1xEV is a data only air interface. Market trials show that it can provide 2.4Mbit/s peak rate per sector/cell at average throughput rates of 880kbit/s in a mobile environment and 1.4Mbit/s in a low mobility environment all in a 1.25MHz channel. It is positioned as complementary to the existing GSM->GPRS->W-CDMA migration path and it is able to address both mobile and fixed markets.

- The second solution allows a migration from1xEV to 1xMAP. It uses the GSM-MAP core network in conjunction with cdma2000 1x radio access network. It re-uses the infrastructure from the 1xEV deployment and the installed GSM network equipment. This network maintains roaming capabilities with current GSM networks

These options are made possible through the development of the IMT-2000 specification, which enables the combination of different core networks and air interfaces.

The purpose of this paper is to introduce the two alternatives outlined above. It also examines the market segments and economics of deploying 1xEV in parallel with GSM and migrating to 1xMAP.

2.2 Definitions

cdma2000 standards

1x: IS-2000

1x is a cdma2000 standard. It provides a path for operators of cdmaOne networks to achieve third-generation services.

1x nearly doubles the voice capacity of cdmaOne and enables higher data rates. It offers 144kbit/s data rates in Korea today with low end 1x phones and will offer 307kbit/s with higher end phones in 2002. 1x networks are frequency independent. They can be deployed in new or existing spectrum.

1xEV: IS-856

1x Evolution (EV) is a data-centric standard in the cdma2000 family. 1xEV has been standardised by 3GPP2 and TIA as part of cdma2000 and has been submitted to the ITU for approval.

1xEV accommodates the different needs of voice and data by using a separate 1.25MHz carrier channel for data. This simplifies system software development and avoids difficult load-balancing tasks. Voice and data do not need to compete for the same airlink resources.

As Figure 2.1 illustrates, voice and data have different characteristics. Data can tolerate delays of seconds- especially bursty Internet traffic. Voice on the other hand is intolerant of delays and current implementations of voice are circuit based to maintain a constant connection.

1xEV offers peak rates of 2.4Mbit/s per sector and average mobile throughput speeds of 880kbit/s, or pedestrian speeds of 1.4Mbit/s in a standard 1.25MHz channel. It is envisioned as an access method to compete with wireline technologies for 'always-on' high-speed Internet access. 1xEV is compatible with GSM, IS-95A, IS-95B and cdma2000 networks since it uses standard off-the-shelf IP elements. 1xEV is also frequency independent.

MC-MAP: IS-833

MC-MAP allows a cdma2000 1x air interface to work with a GSM MAP core network (also known as 1xMAP) It will allow high-speed packet data access, with all the additional benefits of GSM-MAP. Proponents believe that it could provide capacity relief for GSM 900 and DCS 1800 as well as for greenfield operators.

The MC-MAP standard was developed within TIA/3GPP2 and is an ITU standard. MC-MAP provides adaptation at the radio resource control layer with the upper layers from GSM-MAP networks receiving the same protocol services as in native mode.

Figure 2.1 **Optimising voice and data channel carriers for different services**

	Voice	**Data**
Traffic	Continuous	Burst packet traffic
Delay	Delay Intolerant	Delay Tolerant

2.3 Background

What is 3G?

There is no tight, unambiguous definition of a third generation mobile system; the term excites a variety of interpretations. In essence, the aim of the third generation system is to provide a leap forward in the transmission speed and capacity available on mobile communications networks. The ITU has stated that 3G standards should provide:

- 144kbit/s high mobility (vehicular) data transmission
- 384kbit/s low mobility (pedestrian) data transmission
- 2Mbit/s stationary (untethered) wireless data transmission.

The International Telecommunications Union (ITU) has identified the following bands for IMT-2000 3rd generation services:

- 806-960 MHz
- 1710-1885 MHz
- 1885-2025 MHz
- 2110-2200 MHz
- 2500-2690 MHz

According to the ITU, countries may also license 3G technologies in any other frequency band that is allocated to a mobile service.

In May 1999, the ITU approved a family of standards, known as IMT-2000, for third generation mobile systems. The family includes:

- W-CDMA
- cdma2000
- TDMA.

At the current time, two of these standards are developing as shown in Figure 2.2.

Figure 2.2 **Development of W-CDMA and cdma2000**

	Data rates supported (kbit/s)	**Commercial launch date**	**Channel width MHz**	**ITU approval**	**Applications**
W-CDMA	64 144 384 2,000	2002 2003 2003 2004 (unconfirmed)	3.84	Yes	Mobile/Fixed Voice and Data
cdma2000				Yes	
- 1x* (1xMAP)	144 307 614	2000 2002 2003 (unconfirmed)	1.25	Yes	Mobile/Fixed Voice and Data
- 1xEV	2,458	2001	1.25	Pending	Mobile/Fixed Data Only

** 1xMAP will use the cdma2000 1x air-interface*

What does 3G do?

Third-generation systems:

- increase the capacity available to cellular operators
- enable high-speed data applications up to 2Mbit/s
- enable users to take their service profile with them when they roam
- support circuit-switched and packet-switched services, such as Internet Protocol (IP) traffic and real-time video
- offer fixed line quality of service
- support global roaming, between different IMT-2000 operational environments.

Where is 3G available?

In Korea 1x services are currently available at 144kbit/s, so according to the ITU definition on data transmission speeds, this country is offering 3G services today in existing spectrum. Further commercial launches are scheduled this year in Japan and the US.

More publicity however has been directed at the European market, where countries have allocated spectrum in the 2GHz band for 3G services. Launches are expected to commence in 2002. The first 3G licence was awarded by beauty contest in Finland in February 1999. Exactly two years later, eight European countries had awarded licences - more than half, by auction. The unexpectedly high prices commanded in the UK and Germany, $30 billion and $50 billion respectively, have saddled many operators with huge debts even before they roll-out their networks. Vendor financing is increasingly difficult to secure. The last Euro-auction, taking place in France, has just two companies going for four of the $4 billion licences.

European carriers are currently supporting the W-CDMA standard, which initially is expected to roll-out in 2002 with 64kbit/s data transmission, but which will increase to 144kbit/s and 384kbit/s. Any delay in this plan will prolong the time servicing the debt without accruing new revenues. Consequently, this paper presents two alternatives:

- deploy 1xEV in 2002 in UMTS spectrum to address the high speed fixed internet market and then migrate to W-CDMA
- deploy 1xEV for the fixed opportunity, as above, and then migrate to 1xMAP if W-CDMA equipment availability is delayed.

This paper examines the economic case of deploying these technologies in the German market for a GSM incumbent who has purchased UMTS spectrum.

3 Market implications

3.1 As an operator, why would I consider deploying 1xEV or 1xMAP?

Deploying 1xEV as a stand-alone system can allow an operator to address the market for fixed Internet services. In regions that lack reasonably priced access to high speed Internet access, 1xEV could satisfy this demand. It could also open up new opportunities in the high-speed mobile market sooner than competing technologies.

A carrier could also consider deploying 1xMAP if there are delays with W-CDMA equipment. Both 1xEV and 1xMAP can be implemented in new 2GHz spectrum, or in the 1800MHz band in a 1.25 MHz channel if an operator has excess capacity on their existing 2G network.

Figure 3.1 shows the throughput for 1xEV and displays how 1xEV, as a data only technology for mobile or fixed segments, promotes efficient transport for high-speed services.

Figure 3.1 **Peak Rate and Efficiencies**

Technology	Spectral Width	Peak Rates	Bits/Hertz
1xEV	1.25MHz	2,458kbit/s	1.966bits/sec/Hz
WCDMA	3.84 MHz	2,000kbit/s	0.521bit/sec/ Hz
cdma2000 1x	1.25MHz	614kbit/s	0.491bit/sec/Hz

Another factor to consider is that 1xEV and 1x are in the marketplace today. 1xEV is in market trials and 1x is already commercial. Both technologies will work in conjunction with GSM networks.

1xEV uses a standard IP backbone, which can run in parallel with a GSM voice system or alongside a GPRS system, sharing many of the same IP network elements.

Migrating to 1x MAP leverages the investment in the 1xEV network and provides another path to offering 3G services. In addition terminal devices are available for 1x and being built to support 1xEV. Moore's law will allow the eventual integration of GSM, 1x, 1xEV and W-CDMA in a single handset.

3.2 Exploiting latent fixed Internet demand

The fixed network

Adding 1xEV in parallel to a GSM network enables operators to address demand in the data market. Because 1xEV can offer peak rates of 2.4Mbit/s per sector and 1.4Mbit/s average stationary throughput and 880kbit/s average mobile throughput, it could well prove to be an alternative technology for fixed network access technologies, particularly in countries where consumers are unwilling to tolerate high prices and slow connection times. In countries where the PSTN is below 64kbit/s, implementing 1xEV will improve the user experience in accessing the Internet.

Having these high data rates available today enables residential users to access a personal email account, watch film clips and access their favourite sites faster than over their current PSTNs. For the home worker, they would be able to use the system to access the corporate intranet and retrieve files faster than using ISDN. The user experience would barely differ from sitting in the office.

Potential revenues for 1xEV in the German market

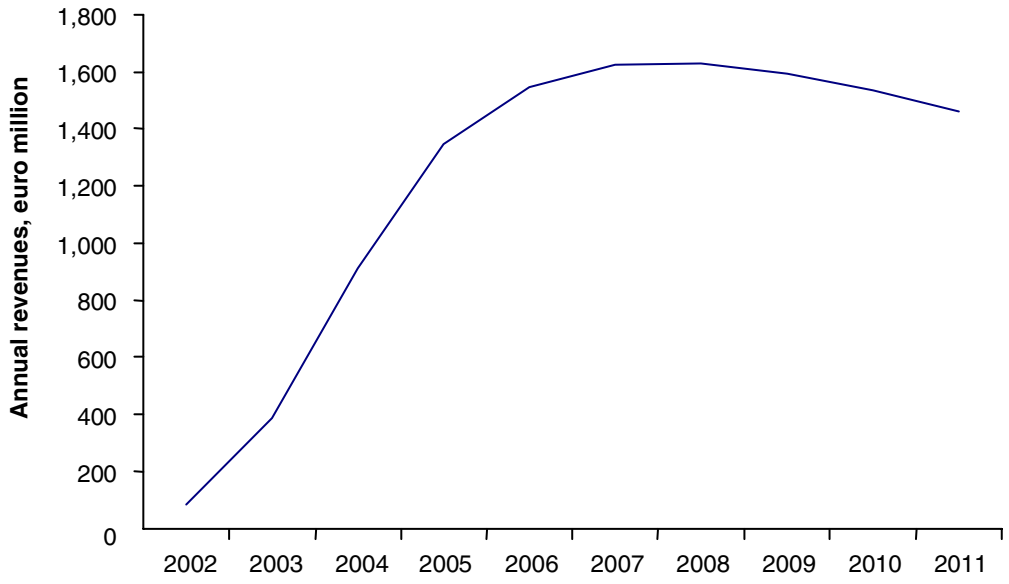
In our deployment scenario in Section 5, 1xEV is rolled out in Germany. We could expect the technology to compete with and be an alternative to fixed broadband services in the market.

Figure 3.2 shows Germany's fixed broadband data revenues that are addressable using a 1xEV network. This considers the substitution of the following data access technologies: DSL, fibre to the premises, fixed broadband wireless access (LMDS, MMDS) and cable modems. It includes all current and potential broadband Internet users, that is:

- business: intranet usage, Internet access
- consumer: broadband multimedia usage, Internet access.

In addition, a proportion of consumer Internet and business data users with narrowband connections will be prime targets for 1xEV adoption, as they may be frustrated by the installation delay or high connection charges associated with alternative broadband access technologies.

Figure 3.2 **Addressable market for fixed Internet 1xEV revenues in Germany, euro millions**



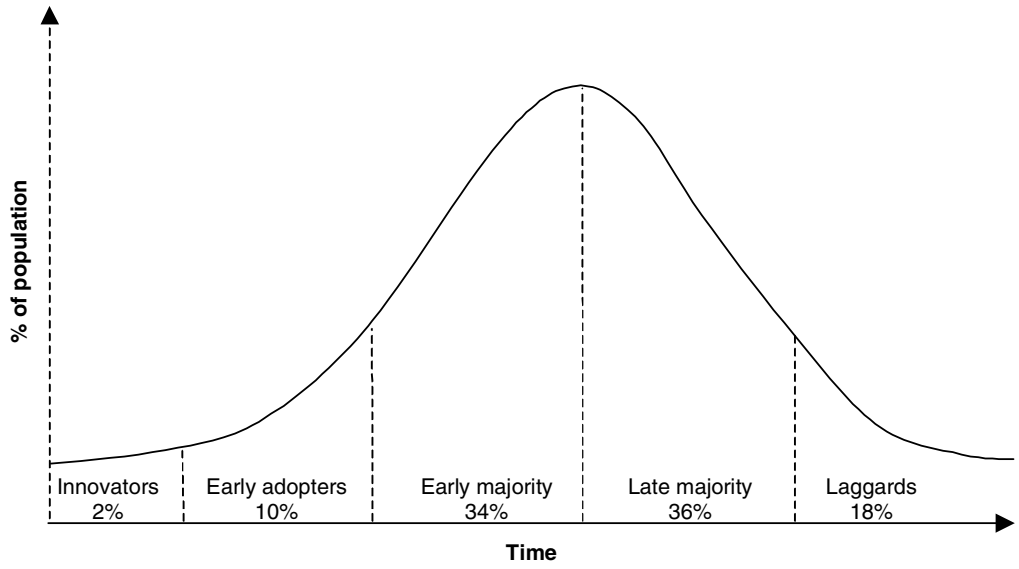
We assume that by 2005 the proportion of broadband users, who would use 1xEV as an alternative access technology, could grow to approximately 50%. We have applied a market adoption curve for the market segmentation. See Figure 3.3. If 1xEV were deployed in 2002, we would expect the potential adoption of innovators (2%), early adopters (10%) in 2003 and the early majority (34%) in 2004. For narrowband users, we have assumed that up to 25 % of business users, and up to 20% of consumer Internet users, could adopt 1xEV by 2005.

Overall penetration of this addressable market could reach up to 50% by 2005. We further assume that 1xEV is priced at similar levels to current DSL technologies. The resulting revenues available are then shown in Figure 3.2. In year one, 2002, the addressable market for an operator would be euro86 million; this could reach as much as euro1.6 billion by 2007. This assumes that the monthly average revenue per user declines from euro48 to euro30 between 2002 and 2011.

New technologies are initially hindered by lack of user familiarity with the technology, and a general 'wait and see' approach occurs. We assume that overall business uptake will be lower than consumer uptake. 1xEV will be more attractive to consumers, who will be more concerned with price and time to market of the service. However, 1xEV could prove attractive to business users, who are also home workers.

It is the appeal of this latter scenario, which applies equally well for the road warrior scenario that forms the basis of a 1xEV market trial.

Figure 3.3 **Market adoption by segmentation**



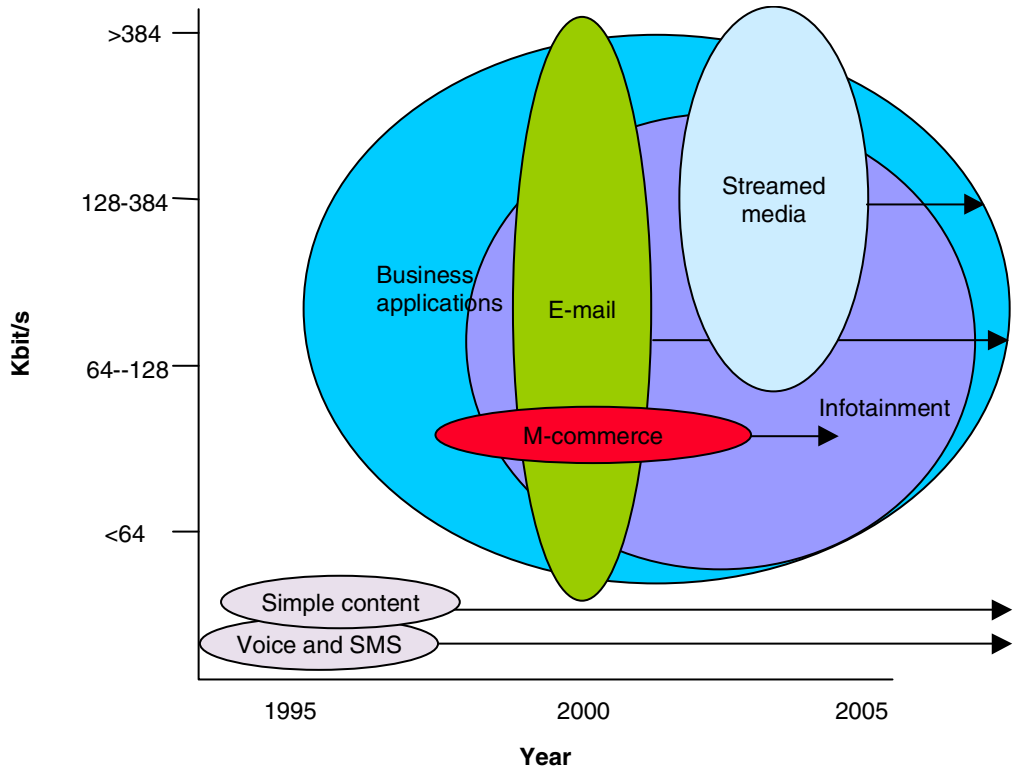
3.3 Accelerate the datawave: 1xEV for the mobile market

High speed mobile applications can become a reality sooner rather than later

The fixed market is not the only segment that can be addressed with high-speed wireless. Figure 3.4 shows a selection of the types of services that become available as networks are upgraded to enable faster data rates. Many of these applications are deemed 3G due to either their rich content or their bandwidth hungry nature. Most are expected in the market post 2002. However the 1xEV solution demonstrates how many of these applications can be supported today.

In the market trial a van is driven around town and along a motorway, between three cdmaOne base stations; 1xEV channel cards demonstrate soft-handoff. Under varying load conditions, they demonstrate web surfing, e-mail and file downloads at peak rates of 2.4Mbit/s per sector, an average mobile throughput of 880kbit/s.

Figure 3.4 **Uptake of applications is dependent on data rates**



Source: Ovum Ltd.

There is a cluster of services emerging: e-mail, banking and business applications. Many are web browsing services and optimum performance will need at least 64kbit/s. But higher data rates are required if accessing an intranet and downloading documents, spreadsheets or graphic-rich PowerPoint presentations are to become an attractive proposition to the user.

Streamed media, audio and video are bandwidth hungry. Added to this, the associated propositions, such as listening to MP3 files from a central server or downloading music videos, are seen as mass market, with particular appeal to the youth sector.

Accelerating the demand for mobile data

To date, mobile data adoption has been constrained by lack of suitable supporting technology. 1xEV technology could accelerate this adoption by increasing available transmission speeds.

Operators in turn will be able to support a wider variety of data services, and the increased capacity could accommodate more users. Faster connection times and data transfer would improve the user experience and consequently lead to more frequent initiation of requests,

greater time online and the transfer of larger amounts of data. The market is ready for mobile data. Replicating or exceeding the fixed experience and speeds will accelerate the demand for mobile data.

In 2001 we expect the penetration for mobile data will be 5% of the population and eventually reach 90% of the population by 2011. Penetration of devices could easily surpass 100% as machine-to-machine interfaces are developed and as mobile communication is designed into automobiles, refrigerators and other household appliances and devices. This assumes that an operator deploys low speed data rates now but plans to upgrade to high-speed data rates in the near future. This assumes the existence of the accompanying support from distribution channels, a trained sales force and widespread availability of suitable portable mobile data devices.

3.4 A safety net if W-CDMA equipment is late

As with any new technology, there are inevitably rumours that the standards or equipment and handsets will not be ready as scheduled. Thoughts turn to return on investment and safety nets or exit strategies, should the rumours become reality.

There is evidence to suggest that reality is closing in. Telefonica of Spain initially intended to launch a W-CDMA-based UMTS system in 2001. However in February 2001, it noted that "…mobile handsets of sufficient quality are unlikely to be widely available before 2003". Portuguese Operator Telecel also believes that "handsets will simply not be available until the middle of 2002."

As these stories begin to appear, operators need to make sure that they are aware of alternative deployment strategies for 3G services.

cdma2000 carriers have already deployed commercial 3G networks with cdma2000 1x equipment in Korea. Further launches are scheduled this year.

MC-MAP, or IS-833, is a standard that combines this cdma2000 1x radio access network with the GSM-MAP core network to maintain global roaming and GSM services. MC-MAP is also an IMT-2000 approved 3G standard.

If W-CDMA is late and a carrier has deployed 1xEV, then adding 1xMAP is a straightforward upgrade. An operator adds a 1xMAP channel card and a base station controller to the network. The operator would leverage all of the 1xEV base stations and PDSNs that had already been deployed.

The 1xEV to 1xMAP migration path provides a carrier with the opportunity to:

- penetrate the fixed Internet market and begin generating revenues with 1xEV in 2002
- migrate to 3G voice and data in 2003 with 1xMAP if delays occur in W-CDMA equipment availability.

Naturally, there are concerns that need to be recognised for these implementation paths. Whilst 1xEV provides access to the fixed market, installing it does represent another round of radio network infrastructure investment for an operator. Also pure mobile operators will need to review coverage of suburban areas. They may be less certain of where demand will occur

for fixed data services than competitors with fixed networks. Existing suburban mobile network coverage may be too thin to cope with high levels of demand.

Full adoption of 1xEV, and indeed all 3G technologies, will depend on the wide availability of multimode terminals and assurance of supply. Terminal development is prioritised by prospective volumes and/or availability of chips. 1xEV is expected to be available at the end of 2001. Multimode terminals with 1xEV, 1x, GSM and W-CDMA will be available in 2004.

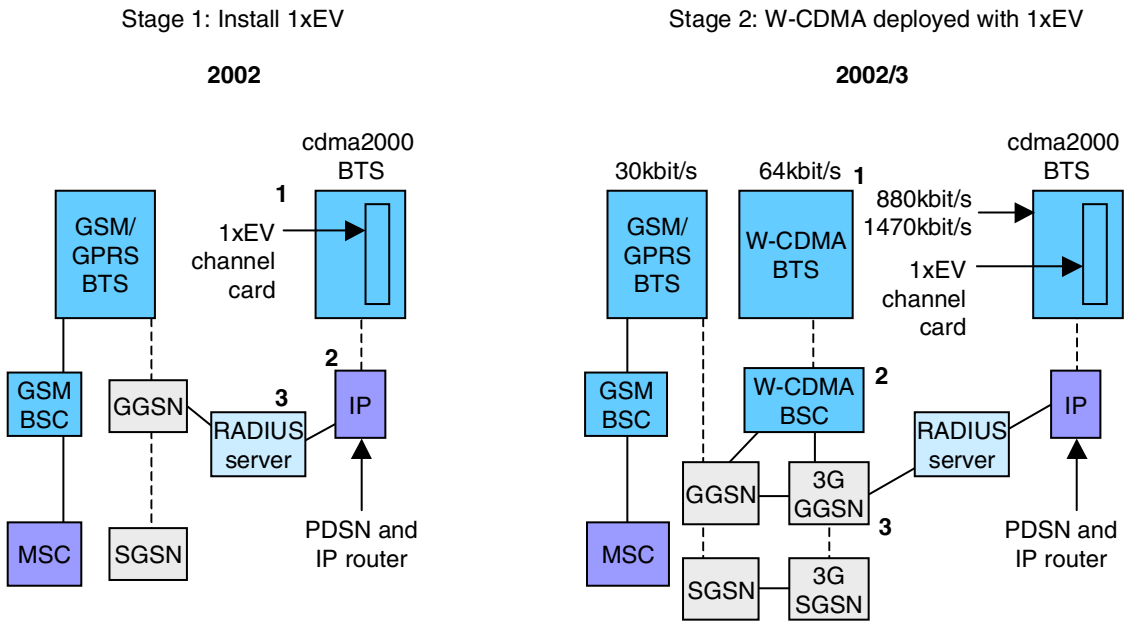
Another issue is managing spectrum allocation if an operator decides to migrate through 1xEV on to W-CDMA. This would be suitable for deployment if they have excess capacity in the 1800MHz band or 2x15MHz of new spectrum because they will only need to take a 1.25MHz carrier (out of 5MHz) to implement 1xEV. However, if they have 900MHz or 2x10MHz, then they would need to consider whether they want to wait for W-CDMA or go ahead and implement 1xEV and 1xMAP in 1.25MHz carriers.

4. Technology deployments of 1xEV and 1xMAP

4.1 1xEV with W-CDMA deployment

A GSM operator can deploy 1xEV alongside its current network. To add 1xEV an operator needs to install a cdma2000 base station (BTS) with a 1xEV channel card, a PDSN (packet data serving node) and IP router. A common RADIUS server can serve the GPRS network and the 1xEV network. WCDMA can be deployed in parallel or at a later date.

Figure 4.1 **Two stage technical implementation for 1xEV to W-CDMA Migration**



1. Install cdma2000 BTS. Install 1xEV channel card
2. Install PDSN
3. Connect PDSN to RADIUS server.
   RADIUS server is used for GPRS and 1xEV

1. Install W-CDMA BTS. Install 1xEV channel card
2. Install W-CDMA BSC (RNC)
3. Install 3G GGSN/SGSN. RADIUS server is used for GPRS and 1xEV

Figure 4.2 **Market development scenario for UMTS spectrum**

Deployment schedules	**Now**	**Now**	**2001-2002**	**2002**
Standard	**GSM**	**GPRS**	**1xEV**	**W-CDMA (UMTS)**
Speeds **- Standard written/submitted**	9.6kbit/s	171.2kbit/s	2,458kbit/s	2,000kbit/s
…at launch		20-30kbit/s throughput	- 2,458kbit/s peak rates - 880kbit/s high mobility (average)(3) - 1,470kbit/s low mobility(average) (3)	64kbit/s
…2 years after launch		50-64Kbit/s throughput		144kbit/s high mobility 384kbit/s low mobility
Applications (avail at launch year) (1)	Voice SMS	DATA ONLY Email & messaging Business applications Infotainment M-commerce	DATA ONLY Email Business applications Infotainment M-commerce Streamed media	Voice Email Business applications Infotainment M-commerce Streamed media
Market segment	Consumer SoHo SME (2) Corporate	Corporate SME	Consumer Corporate SME SoHo	Consumer Corporate SME SoHo
Terminals	GSM and DCS 1800 handsets Smart Phones PCMCIA cards	PCMCIA cards available now Handsets Mobile data devices (2002)	1xEV PCMCIA Cards Mobile data devices (2002)	Dual-mode GSM/ UMTS handsets Multi-mode handsets Mobile data devices
Infrastructure requirements	GSM BTS and BSC	Install GPRS backbone network: SGSN and GGSN Upgrade software in GSM BTS and BSC	Install cdma2000 1xEV BTS (Include 1xEV channel cards) Install PDSN with IP router- Tie PDSN to RADIUS server	Install W-CDMA BTS and BSC Upgrade MSC Install 3G GGSN and 3G SGSN

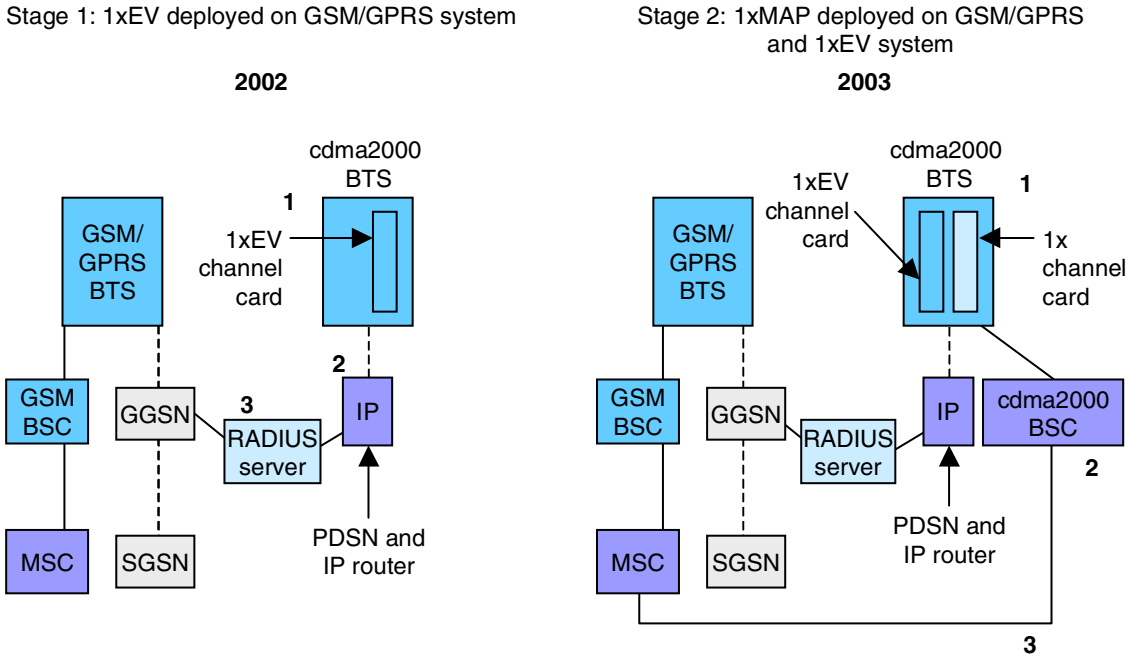
(1) Business applications includes: email, intranet and database access, file transfer
Infotainment includes financial, weather, sports, news, catalogues, directories and later interactive games and broadcast entertainment
M-commerce includes electronic ticketing, coupons & vouchers, banking and online auctions
(2) SME = small and medium-sized enterprise
(3) Fully loaded
Source: 3GPP, Ovum Ltd.

4.2 1xEV with 1xMAP deployment

A GSM operator can deploy 1xEV alongside its current network. To add 1xEV an operator needs to install a cdma2000 base station (BTS) with a 1xEV channel card, a PDSN (packet data serving node) and IP router. A common RADIUS server can serve the GPRS network and the 1xEV network.

If W-CDMA is delayed the operator can add a 1xMAP channel card to the cdma2000 base station and add a BSC which the operator can connect to its GSM-MAP switch.

Figure 4.3 **Two stage technical implementation for 1xEV to 1xMAP Migration**



1. Install cdma2000 BTS
2. Install PDSN
3. Connect PDSN to RADIUS server.
   RADIUS server is used for GPRS and 1xEV

1. Install 1x channel card
2. Install cdma2000 BSC
3. Connect BSC to MSC via A/Iu interface

Figure 4.4 **Market development scenario for UMTS spectrum**

Deployment schedules	**Now**	**2001-2002**	**2003**
Standard	**GSM/GPRS***	**1xEV**	**1xMAP**
Speeds **-Standard written/ submitted** **…at launch** **…2 years after launch**	9.6kbit/s (GSM) and 171.2kbit/s (GPRS) 20-30Kbit/s throughput (GPRS) 50-64Kbit/s throughput (GPRS)	2,458kbit/s - 2,458kbit/s peak rates – 880kbit/s high mobility (average) (3) - 1,470kbit/s low mobility (average) (3)	614kbit/s -1x launched at 144kbit/s in Korea -1xMAP can be launched at 307kbit/s (2002)
Applications (avail at launch year) (1)	Voice SMS GPRS Email & messaging Business applications Infotainment M-commerce	DATA ONLY Email Business applications Infotainment M-commerce Streamed media	Voice Email Business applications Infotainment M-commerce Streamed media
Market segment	For GSM: - Consumer - SoHo - SME - Corporate For GPRS: Corporate SME	Consumer Corporate SME SoHo	Consumer Corporate SME SoHo
Terminals	GSM and DCS 1800 handsets Smart Phones PCMCIA cards	1xEV PCMCIA Cards Mobile Data Devices	1xEV PCMCIA Cards Smart Phones Tri-mode GSM + 1x + 1xEV handsets Multi-mode GSM-1x-1xEV-WCDMA handsets by 2004
Infrastructure requirements	GSM BTS and concentrators	Install cdma2000 BTS Include 1xEV channel cards Install PDSN with IP router-Tie PDSN to RADIUS server	Install 1xMAP channel card in cdma2000 BTS Install cdma2000 BSC Connect BTS to GSM MAP switch via BSC and A/IU interface

**GPRS is not necessary in this migration but it can work in parallel*
(1) Business applications includes: email, intranet and database access, file transfer
Infotainment includes financial, weather, sports, news, catalogues, directories and later interactive games and broadcast entertainment
M-commerce includes electronic ticketing, coupons & vouchers, banking and online auctions
(2) SME = small and medium-sized enterprise
(3) Fully loaded

Source: 3GPP2, Ovum Ltd.

4.3 Availability of handsets

Of all the factors effecting adoption of new technologies, the availability of affordable, user friendly terminals is paramount. The concern of all operators is whether they will have handsets and devices when they launch their service.

cdma2000 1x phones are already available in Korea and 1xEV is expected to launch later in 2001 with data devices including PCMCIA cards. These devices will perform data-centric tasks. For the data world, the most appropriate devices are:

- PCMCIA cards
- Phone form terminals
- PDAs and Palm-like terminals.

The PCMCIA card will allow an operator to address the latent fixed Internet market with high speed Internet access. Single mode phones and data devices such as the Palm is next step, then attempts are made to combined the two. Samsung for example has already developed a cdmaOne phone that downloads MP3 files. Handspring is already marketing a GSM module that will allow a user to carry on a conversation through the PDA. The data and voice worlds are converging.

The 1xEV and 1xMAP migrations described above (see Figure 4.4) require multi-mode terminals.

- In 2002, 1xEV PCMCIA cards and data only PDAs will be available
- In 2003 multi-mode voice and data terminals will be available.
- In 2004 the integration of W-CDMA is likely to occur whereby global data and voice roaming will become a reality.

5. The economics of deployment of the 1xEV and 1xMAP 3G business case in the German Market

5.1 Key points

We have developed a 1xEV and 1xMAP business case to investigate the economics for deployment for a theoretical GSM incumbent in Germany. We have examined the incremental revenue, with the associated requirements for additional capital and operational expenditure. Figure 5.1 summarises the key financial outputs.

By 2011 the German operator has been able to sell fixed access services to 4 million of its 23 million installed base of subscribers. An operator can leverage its existing mobile subscriber base by bundling fixed services with approximately 20% of the 3G users with an incremental capital cost of euro122. This fixed segment will generate an additional incremental ARPU of euro30 (total ARPU of euro78)

The operating expenses on these fixed subscribers is primarily backhaul and maintenance. The EBITDA could be increased over 500 basis points by adding the fixed market segment.

- Mobile ARPU rises 15% from euro42 in 2002 to euro48 in 2011
- Fixed subscribers are a new segment
- The NPV is euro2.7bn over the 10 year period, assuming a terminal value multiplier of 12 on the final year's EBITDA
- The business case will be EBITDA positive by 2007.

These figures result from the scenario of:

- Established GSM network with 37% market share
- Roll-out and initial adoption of the 1xEV system in Year 1
- Roll-out and adoption of the 1xMAP system in Year 2
- The number of cell sites for national coverage is 20,000
  This number is derived from Ovum's discussion with industry sources.
- 3G traffic for mobile users rises to 130Mbytes / user / month by 2011.

Figure 5.1 **Financial summary for 1xEV and 1xMAP serving mobile and fixed users, 2011 Totals**

	Mobile	Mobile and fixed substitution	Difference
Subscribers (000s)			
GSM/GPRS	2,574	2,574	0
3G	20,648	20,648 (4,000 fixed)	0
Total	23,222	23,222	0
3G Revenues (euro millions)	11,799	13,260	1,461
Monthly ARPU (euro)			
Mobile subscriber	48	48	0
Fixed subscriber	0	30	30
EBITDA Margins %	47	53	6
Capital Expenditure per sub (euro)			
3G	384	506	122
Operating Expenditure (euro millions)			
Total		6,285	
Cell Counts			
GPRS	12,000	12,000	0
3G	20,000	20,000	0
Total	20,000	20,000	0

5.2 Market assessment

We have based our market implications on a theoretical incumbent operating in the German market. We have chosen the German market as it represents:

- a medium level of mobile penetration (60%), but growing fast
- widespread 64kbit/s fixed network, but relatively low Internet penetration on the fixed network
- Europe's most competitive mobile market with six operators.

  It is questionable whether the sixth, or indeed the fifth operator, will achieve a breakeven within a sensible period. However there is a stronger risk of a price war that can decrease the returns to established players. Consolidation will be likely as weaker competitors are forced out of the market or merge with larger players

Geographically and demographically, Germany incorporates:

- a population of 80 million, the largest in western Europe
- large conurbations such as the Ruhr
- multiple business centres, such as Berlin, Frankfurt, Hamburg, Munich and Stuttgart, dotted across the country as a result of Germany's federal structure
- difficult terrain such as the Bavarian Alps and Black Forest
- largest national landmass and population in western Europe
- a relatively high GDP per capita.

In order to achieve coverage targets, an operator will require a greater number of base station sites per capita than in other large west European countries. Penetration of population reaches the ceiling of 90% in 2009.

5.3 Revenue assumptions

The business model that Ovum has developed for an incumbent in the German market concludes that there is no one single killer application that will drive mass adoption of 3G services.

The applications from which revenues are generated are shown in Figure 5.2.

The largest new revenue generators are likely to be:

- Content-based services offering revenues of euro2.4bn by 2011
- E-mail accounting for almost euro1bn by 2011.

Figure 5.2 **Components of incremental revenue generation, euro millions**

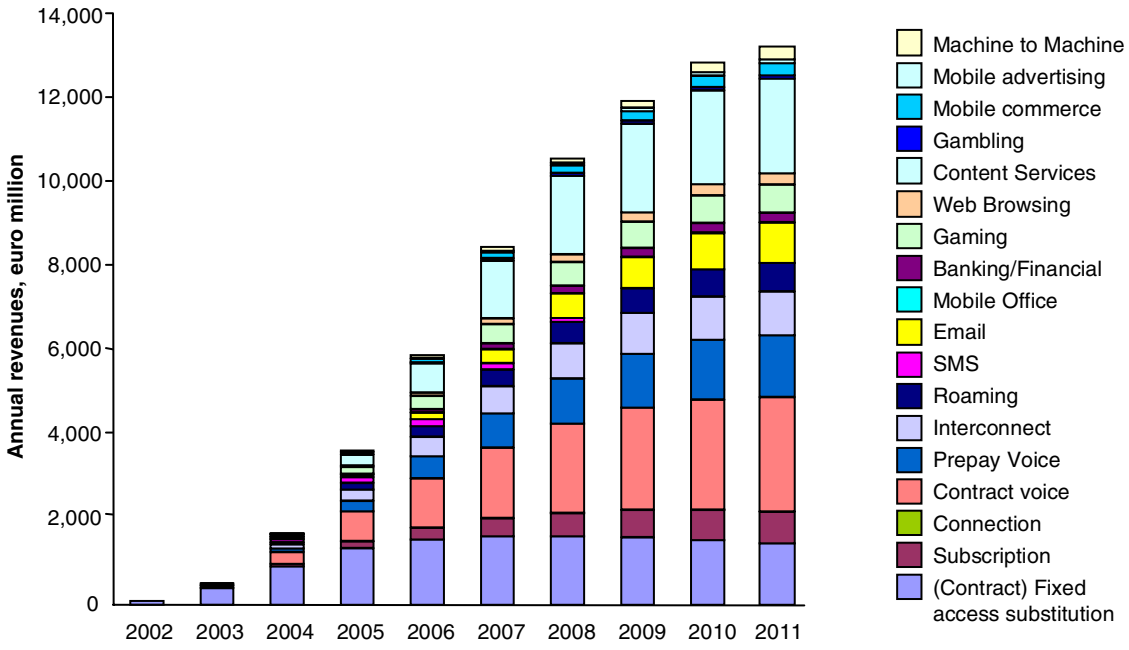
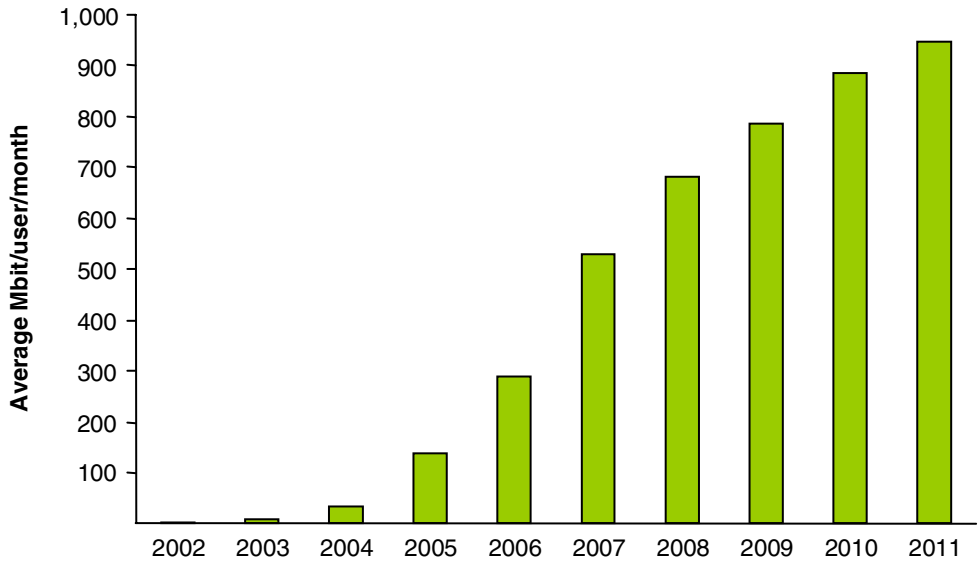
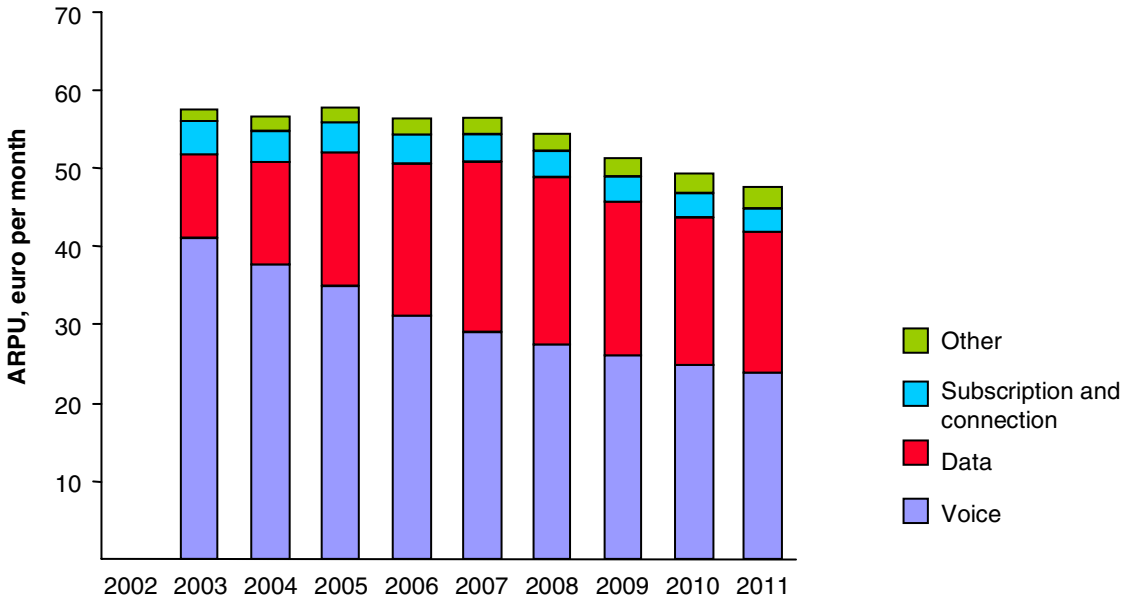


Figure 5.3 **Megabits per user per month, for mobile services**



Between 2002 and 2011, the average data download grows by almost 100% per annum. We expect that gaming, web browsing, and content services will generate the majority of this data traffic by 2011.

Figure 5.4 **3G mobile ARPU voice versus data, euro per month**



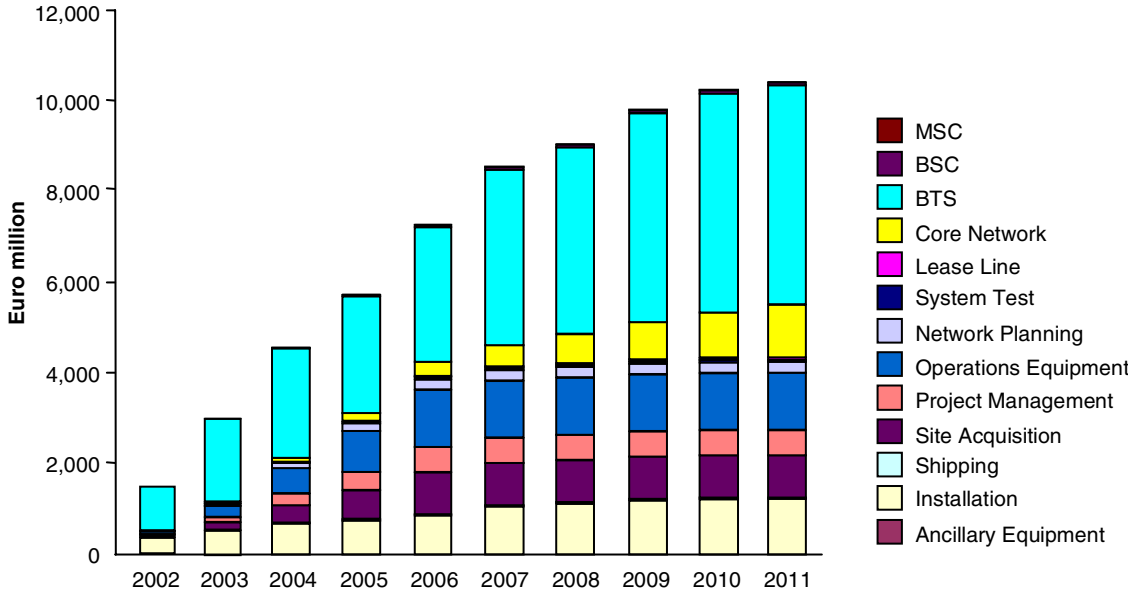
Voice services are, and will continue to be, an important driver of revenues. In 2003, with an average ARPU of euro58 for an incumbent operator, voice will still account for 71% of this total. Voice will continue to dominate user revenues. By 2011, voice will account for 50% of revenues, data for 38%.

5.4 Capital expenditure and assumptions

We estimate that an incumbent operator will spend a total of euro10bnon a 1xEV network over a ten year period in order to achieve mature coverage and capacity.

The average capex per subscriber will be euro424. The typical breakdown by network element is demonstrated on Figure 5.5

Figure 5.5 **Cumulative CAPEX by network element, euro millions**



The business plan is highly sensitive to the speed of roll-out that an operator chooses to adopt. This is based on commercial and technical decisions. We have assumed:

- Initial roll-out of the 1xEV system in Year 1 and adoption in Year 1
- Roll-out of the 1xMAP system in Year 2 and adoption in Year 2
- The number of cell sites for national coverage rises from 12,000 to 20,000 for full implementation of both technologies
- Continued investment in radio network for capacity from years 2-10.

Our scenario assumes that by 2011, there are a total of 20,000 cell sites, with a one for one site reuse for 1xEV and 1xMAP.

Ovum determined the costs for 1xEV and 1xMAP network elements through research with industry sources. This covers all the elements referred to in Figure 4.1 and Figure 4.3.

We assumed that there are 3 sectors per cdma2000 BTS; we have also assumed that the cell radius for 1xEV is the same for 1x.

Network roll-out was planned to maximise revenues for a GSM incumbent with UMTS spectrum and to meet licensing requirements.

5.5 Operational expenditure and assumptions

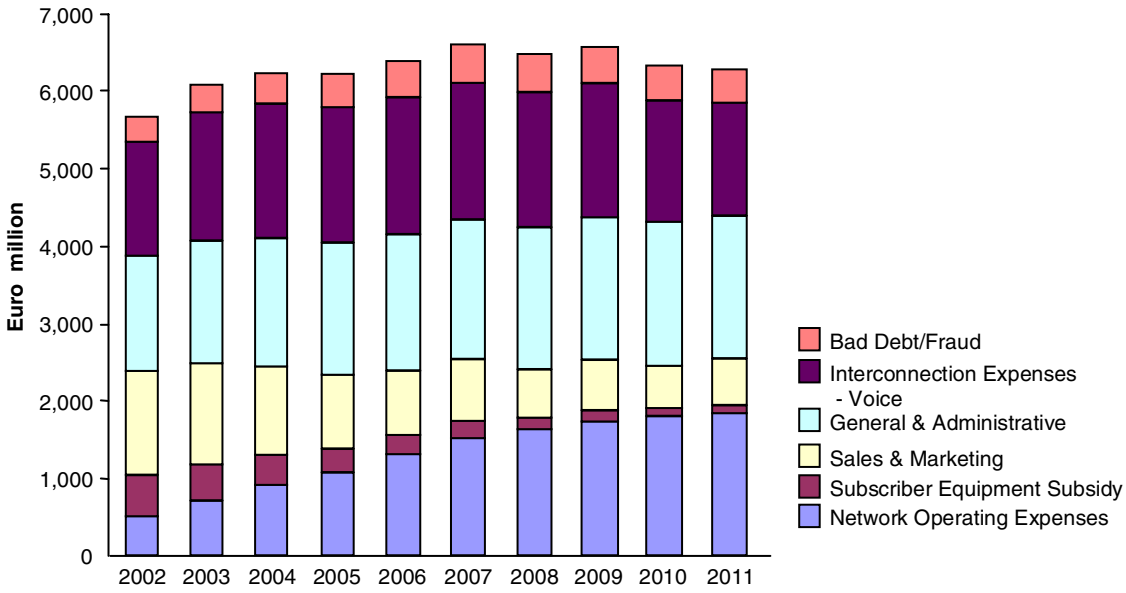
The table below shows the main opex categories.

The main factors influencing opex in this model are:

- Network opex, which includes cost of utilities, site rental and back-haul.
- Cost of marketing and advertising.

  This cost should not be underestimated. The current spend on advertising alone, for a mobile operator in a four player European market, is approximately euro60 million per annum. In a more competitive environment, where new services are launching, we would expect this to increase even further. Also subscriber acquisition costs (SAC) for persuading users to upgrade to 3G services will be similar for existing and new network operators
- General and administrative costs, including the cost of staff.
- Interconnection payments to other operators.

Figure 5.6 **OPEX over plan period, euro millions**



5.6 Financing

Vendor financing will exist, but will be an expensive option. With network roll-outs happening simultaneously in many European countries, vendors will not be willing to provide a high degree of financing to operators and to absorb the inherent risks.

The bond ratings of operators have become worse, as a result of 3G auctioning across Europe. This has had the effect of increasing borrowing costs and will have a potential negative impact on their ability to achieve a rapid roll-out at high expense. We assume a weighted average cost of capital (WACC) of 13% in the business plan.

This situation is changing rapidly. Many banks will be unwilling to increase their exposure to 3G ventures, so the primary source of new financing may move to high yield bonds at 15-20% interest.

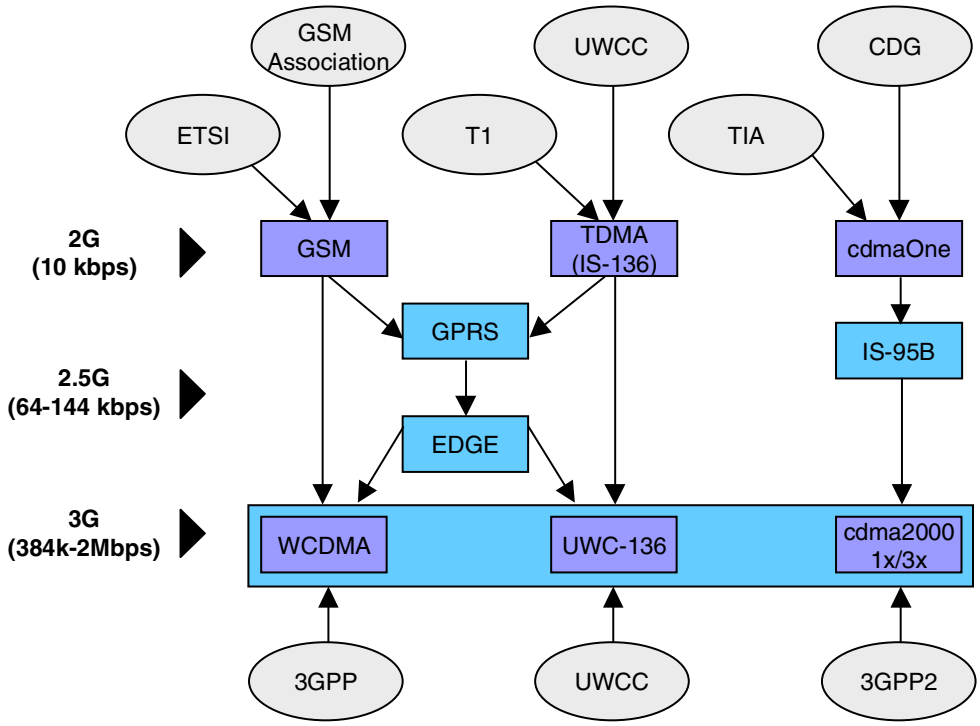
We have not explored the financing aspects here and we have made no assumptions about interest payments.

6 Standards

6.1 IMT-2000 family of standards

The ITU has defined Third Generation Standards to include CDMA-based and TDMA-based air-interfaces. Figure 6.1 shows the IMT-2000 defined air interface standards with the corresponding partnerships, consortia, and standards development organisations. The 3G-CDMA modes, W-CDMA and cdma2000 operate on GSM-MAP core networks and evolved ANSI-41 networks.

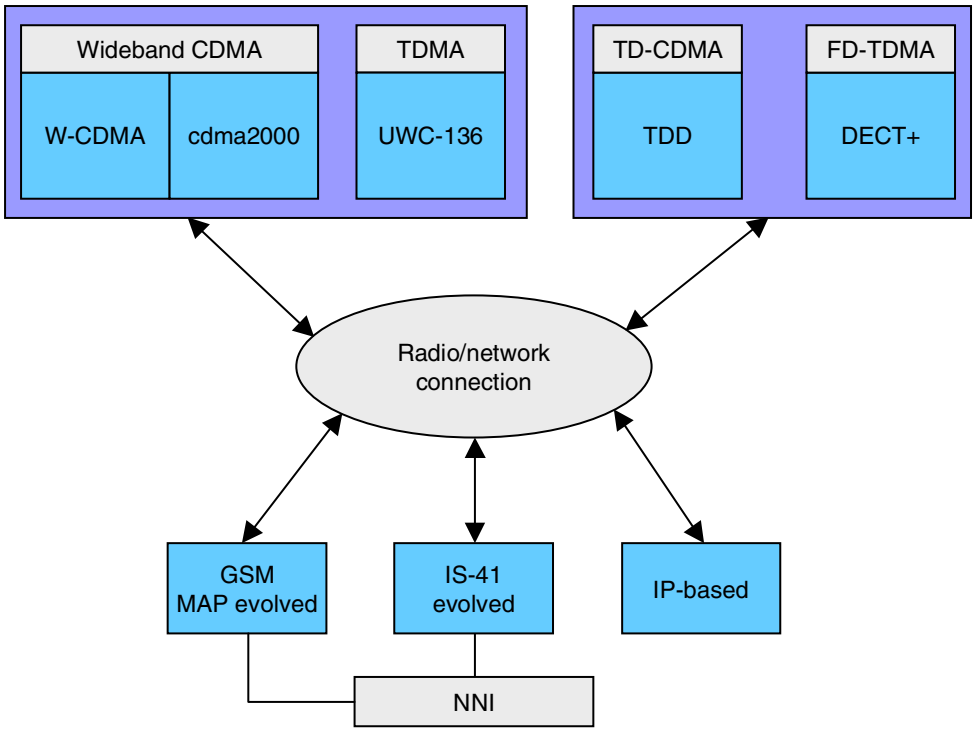
Figure 6.1 **ITU IMT-2000 Family of Standards**



Source: ITU

Figure 6.2 shows that it is possible to combine any of the air-interfaces shown in Figure 6.1 with GSM-MAP core networks or with evolved ANSI-41networks. The IMT modular harmonisation specification commissions the inter-working of all radio interfaces with the GSM-MAP core network including inter-network roaming. Using a cdma2000 air interface with GSM-MAP core network has been standardised as IS-833. This cross-mode standard is being developed by 3GPP2 with support from 3GPP and it is referred to as 1xMAP.

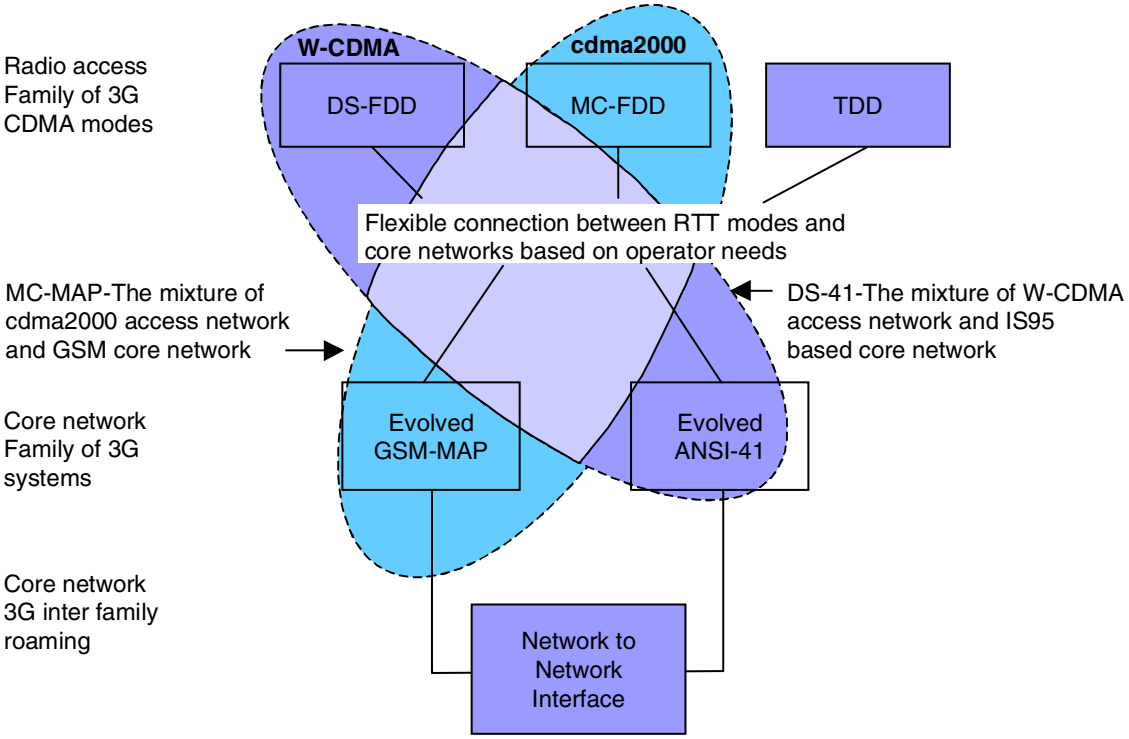
Figure 6.2 Modular IMT-2000 Harmonisation



Source: ITU

In 1999 a group of operators formed the Operators' Harmonisation Group (OHG) to help harmonise the CDMA-based modes. The OHG worked within the ITU to define cross modes to allow cdma2000 and W-CDMA to work with GSM-MAP core networks and ANSI-41 networks, respectively. The cross-modes have been accepted by the ITU and standardised as MC-MAP and DS-41 as shown in Figure 6.3.

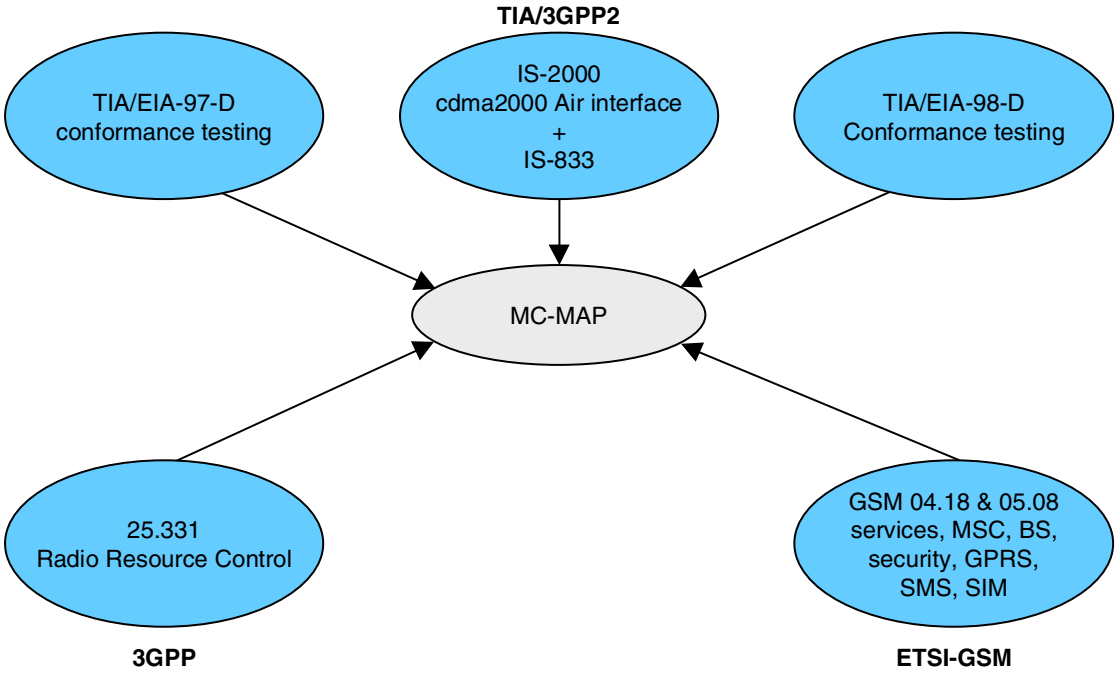
Figure 6.3 **OHG agreement for 3G for Cross Modes**



Source: ITU

3GPP2 has developed and published MC-MAP (3GPP2 C.S0008, also known as TIA/IS-833) and the DS-41 (3GPP2 C.S0007, also known as TIA/IS-834) specifications. The MC-MAP specifications are shown in Figure 6.4.

Figure 6.4 **MC-MAP Standards**

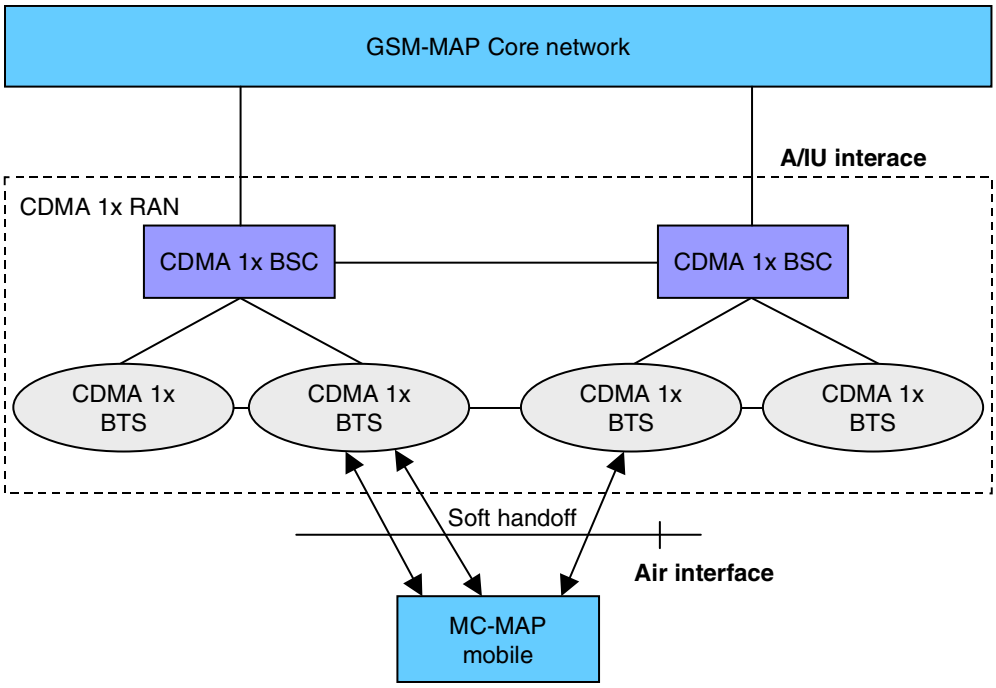


Source: 3GPP2

The standardisation of the air interface used in a 1xMAP system has been completed. Many standards bodies contributed to the 1xMAP standard (previously known as 1xMC-MAP) including TIA, 3GPP2, 3GPP and ETSI. The 1x air interface standard is suited for implementation on an ANSI-41 core network as well as on a GSM-MAP core network.

The A/Iu interface standard has been adapted to support 1xMAP. Soft handoff is supported by the standard interfaces already used between CDMA BSCs. Further work needs to be done to define the interworking with Serving GPRS Support Nodes (SGSN). Figure 6.5 illustrates the 1xMAP radio access network (RAN).

Figure 6.5 **1xMAP RAN architecture**



Source: 3GPP2

6.2 Definition of key second generation voice and data standards

GSM

Global Standard for Mobile communications is a circuit-switched mobile standard optimised for voice communications. Based on a TDMA-based air interface, it has a GSM-MAP switching architecture. GSM supports circuit switched data at 9.6kbit/s. GSM systems have been commercially launched in 160 countries.

GPRS

General Packet Radio System is a packet-mode network upgrade for GSM. GPRS will allow GSM phones to transmit packet based data at speeds up to 171.2kbit/s. Initial systems will be launched at speeds of 20 – 30kbit/s.

cdmaOne

EIA/TIA-95A

IS-95A is the low data rate mode of cdmaOne. Based on spread spectrum code division multiple access techniques, the system is designed for low speed circuit-switched and packet-mode data and voice communications. In addition, IS-95A also provides data links with speeds of up to 14.4kbit/s.

EIA/TIA-95B

IS-95B is the medium data rate mode of cdmaOne. The system supports packet-mode data services and by aggregating the existing channels it can provide data speeds of up to 114kbit/s. In April 1999, IDO and DDI began to deploy IS-95B in Japan. SK Telecom in Korea launched IS-95B services in August 1999. In both countries, data rates of 64kbit/s can already be supported.

Annex A: Glossary of terms

3GPP	Third Generation Partnership Project 3GPP is a co-operative effort from members of ARIB/TTC (Japan), ETSI (Europe), T1 (US), CWTS (China) and the TTA (Korea) standardisation bodies, to produce specifications for a 3G mobile system based on the evolved GSM core networks and the radio access technologies that the organisation partners support.
3GPP2	Third Generation Partnership Project 2 3GPP2 was formed in January 1999 and comprises five standards development organisations: ARIB and TTC (Japan), TTA (Korea), TIA (US) and CWTS (China). The group's objective is to co-operate in preparing globally applicable technical specifications based on the ANSI-41 core networks that form the basis of CDMA and TDMA technology.
A/Iu	Open Interface defined between the BSC and MSC of WCDMA networks
BSC	Base station controller is a high-capacity switch that provides functions such as hand-over, cell configuration data, and control of radio frequency (RF) power levels in base transceiver stations. It provides all the control functions and physical links between the MSC and BTS. A number of BSCs are served by an MSC.
BTS	Base transceiver station. It handles the radio interface to the mobile station. The BTS is the radio equipment (transceivers and antennas) needed to service each cell in the network. A group of BTSs are controlled by a BSC.
CDMA	Code Division Multiple Access
cdma2000	Third generation ITU digital mode supporting data rates up to 2.4Mbit/s. cdma2000 1x, cdma2000 1xEV and 1xMAP are part of the cdma2000 family
DC	Direct Carrier
DS	Direct Spread
GGSN	Gateway GPRS Service Nodes. These are routers that link the Internet to the IP backbone
GPRS	General Packet Radio Service
GRAN	Generic Radio Access Network
GSM	Global System for Mobile Communications, a standard for digital cellular systems. Based on a TDMA air interface and GSM-MAP core network
Hand over	The action which a mobile unit takes when a caller moves from one cell to another during a call. It involves changing the communications channel, and sometimes changing the frequency in use and switching to a different database. Also called hand off.
HLR	Home Location Register is the database used for storage and management of subscriptions. It stores permanent data about subscribers, such as their service profile, location information, and activity status.
IMT-2000	International Mobile Telecommunications 2000

IS-136	A digital cellular standard which is an upgraded version of IS-54 to operate in both the 800 and 1900MHz bands. IS-136 is often referred to as simply TDMA.
IS-41	A standard signalling protocol for wireless networks. IS-41 enables customer information to be sent to networks which use different technologies
IS-54	A digital cellular standard, which operates in the 800MHz and 1900MHz, band and uses TDMA multiplexing. IS-54 is often referred to as TDMA or D-AMPS
IS-95	A digital cellular standard, which deploys CDMA multiplexing. In the US, IS-95 is often referred to as CDMA
IS-833	MC-MAP, the combination of a GMS-MAP core network and cdma2000 radio access network. Implementation with 1x is called 1xMAP
IS-856	A digital cellular standard which operates in IMT-2000 frequencies and is known as 1x Evolution (1xEV), which is the data only mode for cdma2000
MAP	Mobile Application Part – core GSM switching network and signalling protocol
MAPI	Mobile Application Program Interfaces
MASE	Mobile Application Support Environment
MSC	Mobile Switching Centre performs the telephony switching functions of the system. It controls calls to and from other telephone and data systems. It also performs such functions as network interfacing and common channel signalling
Multi-band terminal	Terminal equipment with the capability of accessing services using different frequency bands
MC	Multi-carrier, also known as cdma2000
MC-MAP	Multi-carrier over GSM Mobile Application Part (MAP)
Multi-mode terminal	Terminal equipment with the capability of accessing services using different radio interfaces and/or techniques
NNI	Network to Network Interface. A protocol converter that allows GSM-MAP and ANSI-41 protocols to be translated
Node B	The base station in a 3G network architecture. Referred to in this paper as BTS
PDSN	Packet Data Serving Node
RADIUS server	Undertakes billing information and authentication in the network
RAN	Radio access network
RNC	Radio Network Controller. Referred to as BSC in this report. Responsible for the handover decisions that require signalling to the user equipment
Roaming	Taking a mobile or cordless terminal from one network to another and using it there.
SGSN	Serving GPRS Support Node
TDMA	Time Division Multiplex Access
UMTS	Universal Mobile Telephone System, European version of third generation standard

UTRAN	UMTS Terrestrial Radio Access Network
VLR	Visitor Location Register contains temporary information about subscribers that is needed by the MSC in order to provide a visiting subscriber with service.
W-CDMA	Wideband CDMA. Third generation ITU digital mode supporting data rates up to 2.4Mbit/s

Annex B: Announcements for 1x and 1xEV

ALLTel	29 Jan 2000 (Infrastructure agreement)
Bell Mobility	27 Sept 2000 (Live over-the-air trial)
Clearnet	31 May 2000 (Infrastructure deployment announcement)
KDDI Corporation	17 October 2000 (Infrastructure agreement), 15 May 2000 (Announced plans to deploy technology)
KT Freetel	21 Sept 2000 (Infrastructure agreement)
SK Telecom	1 October 2000 (Commercial launch announcement), June 2000 (Infrastructure agreement)
Sprint PCS	9 January 2001 (Infrastructure agreement), 23 October 2000 (Field trial), 13 July 2000 Live over-the-air trial), 28 April (Lab demonstration), 29 March 2000 (First voice call demonstration)
Telstra	17 July 2000 (Trial/demonstration, voice and data), 13 June 2000 (Voice call/trial)
Telus	30 May 2000 (Announced plans to deploy/trial technology)
Verizon Wireless	2 November 2000 (Live over-the-air trial), 17 November 1998 (Infrastructure agreement)
1xEV	
Sprint PCS	22 June 2000 (Announced 1xEV trial plans)
Verizon Wireless (Bell Atlantic Mobile, PrimeCo and Vodafone AirTouch)	21 November 2000 (Announced 1xEV trial plans)
Hitachi	24 May 2000 QUALCOMM, IDO, & Hitachi Cooperate on Japan's First High Data Rate Technology Trial; Trail Set the Stage for Future Commercial Deployment

Source: CDMA Development Group (CDG, 30 January 2001). http://www.cdg.org