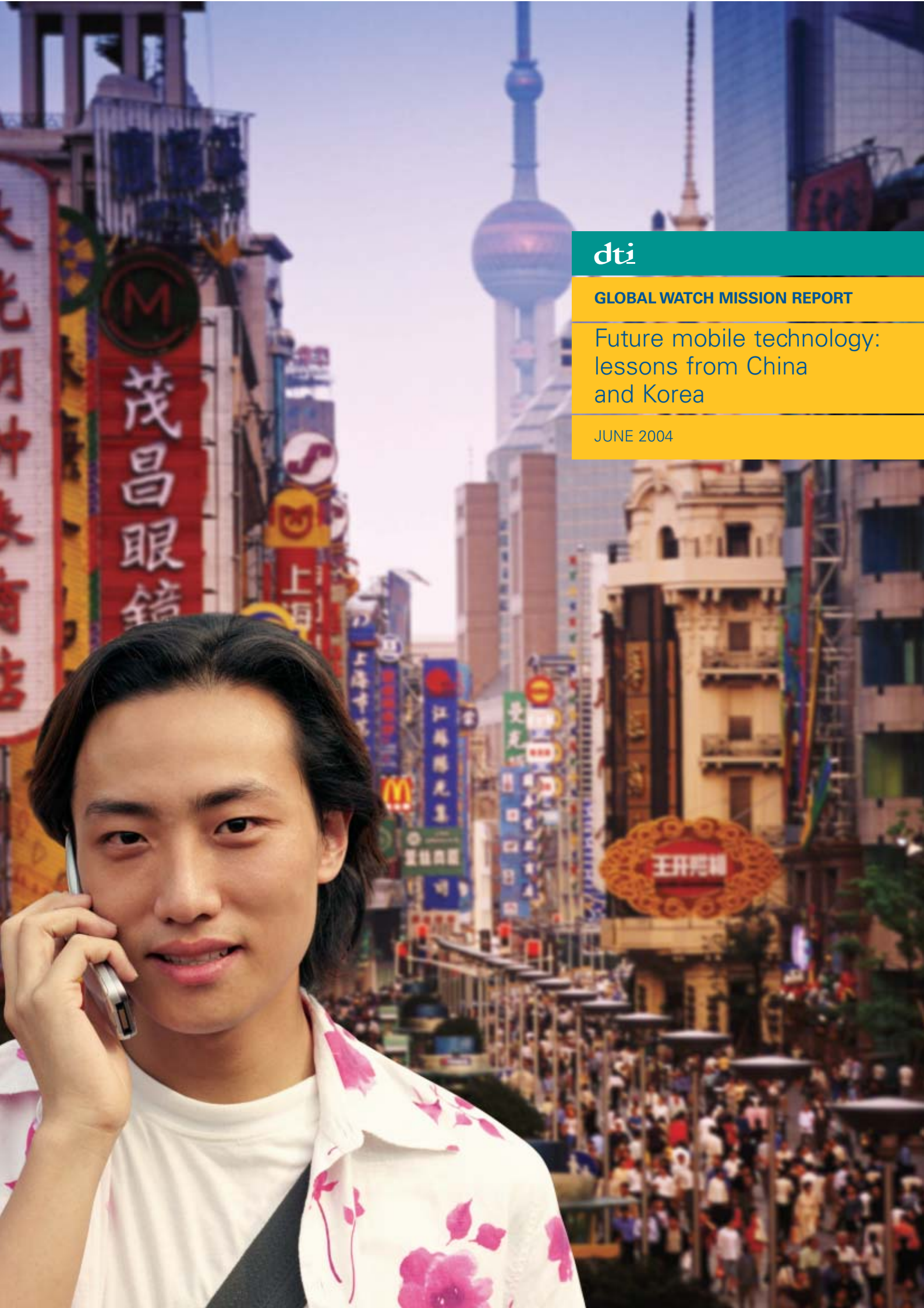

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GLOBAL WATCH MISSION REPORT

Future mobile technology: lessons from China and Korea

JUNE 2004

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Future mobile technology: lessons from China and Korea

REPORT OF A DTI GLOBAL WATCH MISSION
JUNE 2004

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ACKNOWLEDGMENTS

The mission team wish to express their gratitude to:

- The DTI Global Watch Service for their financial support of several of the mission participants and for their help in the organisational arrangements.
- The staff of the British Embassies in Seoul and Beijing, and the Consulates in Shanghai and Shenzhen, for their excellent on-the-ground support in organising activities during the mission fortnight and their prior help in facilitating meetings with appropriate senior executives in the key organisations in their respective countries.
- The host organisations in Korea and China for their hospitality and openness in discussion. Their participation in symposium, seminars and receptions was also valuable in providing opportunities for informal as well as formal exchanges of views and was appreciated.
- UK Trade & Investment (Asia Pacific) for their financial support of the Symposium in Seoul and the Seminar in Shenzhen.
- Their own companies and organisations, for allowing them time to devote to this activity.

FOREWORD

Keith Baughan OBE
Chairman, Mobile VCE

The last two decades have seen dramatic changes in both mobile communications technology and the resulting telephone 'experience' for the customer. UK industry has been at the forefront of this revolution and, in terms of leading-edge research and subsequent deployment of cellular mobile systems, has made an outstanding contribution to first-generation analogue, second-generation digital (GSM) and its derivatives (GSM1800, EDGE, GPRS…). More recently, the UK has worked to drive forward the research and understanding of third-generation (3G) technologies and is in the vanguard of European 3G deployment.

The industry is already looking beyond 3G, to the future evolution of mobile systems. Whereas Europe was the epicentre of GSM development, 3G has seen the emergence of very significant activity in the Far East (China, Japan, Korea). With this in mind, Mobile VCE organised and led a technology mission on behalf of the industry, sponsored by DTI's Global Watch Service, tasked with examining the current position on future mobile technologies, *'Beyond 3G'*. This report has been prepared as one of the outcomes.

The Global Watch Mission was to the leading telecommunications country in the world (South Korea) and to the country with the largest population (China), which has a scale of mobile network unimaginable in the UK or Europe. The team explored all areas of future mobile communications, including government strategies, research priorities, today's and future services and applications, and gained a deep level of understanding of the philosophy and approach that is driving advances in these two countries.

This report clearly draws out issues that we in the UK need to consider in addressing the future requirements for mobile technology research, development and operation. In addition, it raises probing questions as to how Europe, and the UK in particular, should respond to the emergence of Asia as a major new force in mobile communications.

EXECUTIVE SUMMARY

The DTI Global Watch Mission to Korea and China in June 2004, led by Mobile VCE, sought to explore and better understand the context, drivers and perspectives that are shaping thinking in these two important countries in respect of the future evolution of mobile communications beyond 3G (third generation).

The mission team, comprising operators, manufacturers, a regulator and an academic, met with corresponding counterparts in both countries – a total of 24 different organisations, as well as having other opportunities for informal discussions. In summary, their key findings were as follows:

General findings

- *Economic development* – China and Korea both see telecoms as a central plank, arguably the central plank, of ICT (information and communication technology) strategy, vital to national economic development. The role of the mobile communications industry is seen as paramount within this.

- *Commitment* – China and (especially) Korea have committed considerable intellectual and financial capital to developing detailed national technology policies and strategies to strengthen future global competitiveness.

- *Research technologies* – The technologies being researched are similar in both countries – MIMO (multiple input, multiple output), smart antennas, space-time coding, OFDM (orthogonal frequency-division multiplexing), SDR (software defined radio), context-aware services, interworking between different networks (eg mobile, broadcast), IPv6 (Internet Protocol, version 6)-enabled networks, and ubiquitous communications. These technologies do not differ significantly from those addressed in the UK – within Mobile VCE's own programmes, for example, and within those of its industry members. A difference, however, is the scale of funding[1] and research exploitation.

- *Research exploitation* – In both countries, basic research is quickly translated into experimental test-beds, facilitated by the scale of funding from government and from industry ('encouraged' by government). Being able to take the research much closer to implementation provides a strategic advantage.

- *'4G'* – The evidence seen in Korea and China was that the European view of evolution – the integration of new wireless access technology onto existing and evolving mobile infrastructures – is increasingly being adopted, although the 'generational' nomenclature of '4G' (fourth generation) still remains predominant in Korea, and 'B3G' (beyond 3G) predominant in China[2].

- *Spectrum and standards* – Both China and Korea are very active in the ITU-R (International Telecommunication Union – Radiocommunication Sector) standardisation activity. The research

1 A corresponding mobile communications technology mission to Japan in 2002 came to similar conclusions – that the UK was level in addressing the key research issues but that the level of funding was far higher in Japan, with more experimental, as well as theoretical, research.

2 Research organisations in China often used the term 4G, less so industry or government.

programmes noted herein support their national inputs to the ITU process and are geared to provide their national administrations with the hard quantitative data required for the international negotiations on spectrum requirements for 4G at the 2007 World Radio Conference.

Korea

- *Motivation* – Past success in government-sponsored mobile industry initiatives motivates Korea to aggressively drive research and innovation, to maintain its perceived global lead in mobile technology and services.

- *Economic growth engine* – The Korean government sees ICT as a key engine for economic growth, and to this end, MIC (Ministry of Information and Communication) has established an integrated strategy, IT 839, of which mobile is a central part.

- *Industry ecosystem* – The relationships, human mobility and cooperation facilitated by Korea's mobile communications industry ecosystem are key factors in translating the IT 839 strategy into reality. Government and industry plan to invest £100 million and £50 million respectively in next generation mobile in the period 2003-2007.

- *Nation as a test-bed* – Korea's advanced infrastructure allows the country to serve almost as a large-scale test-bed for new technologies and services.

- *Converged services* – Korean operators are deploying leading-edge converged services – eg NESPOT, OnePhone, DMB (digital multimedia broadcasting) – creating challenging new markets for its industry. These services, and future ones, are clearly identified elements in the IT 839 strategy.

- *Wireless broadband (WiBro)* – A technology emerging from ETRI's (Electronics and Telecommunications Research Institute's) original FWA HPi (fixed wireless access – high-speed portable internet) research (cf IEEE 802.16d), which will be licensed imminently to provide wireless extension of broadband with limited mobility.

- *High-speed mobile multimedia (HMm)* – Complementing its WiBro research, ETRI's HMm project is aimed at high-speed wide area multimedia service delivery. Contributing technologies are as those researched elsewhere in the world, including UK/Europe.

- *ETRI's 4G vision* – This combines WiBro, HMm and today's 3G and WLAN (wireless local area network) technologies, with a view to system demonstration in 2007.

- *Industry's 4G vision* – Industry has mixed views of what and when '4G' will/should be, wishing to respond to the call to technological leadership, whilst also recognising the need to secure returns on 3G investments. Korean industry will in any case be well positioned to use '4G' research for 3G enhancement.

China

- *Motivation* – China's huge market for wireless communications motivates China to seek increased independence, in terms of technology and IPR (intellectual property rights). The social and economic impact of telecom provision is an important factor in the management of mobile rollout across this vast and diverse nation.

- *Market maturity* – The mobile market in China is both very much larger yet much less mature than in Korea, or in Europe. 2G networks continue to grow rapidly, whilst 3G technology and licence decisions are still awaited.

- *To 3G or not to 3G?* – China is evaluating 3G technologies prior to licence awards (2005?). Some (few) in China believe that if IPR royalty costs cannot be contained, China should consider skipping 3G deployment. The mission team consider this unlikely. Deployment of all three technologies, in 2005/2006, would appear to be the most likely outcome, in time for the 2008 Beijing Olympics.

- *Industry ecosystem* – Whilst there remains a strong 'feel' of central planning and control, China is a country in transition. Companies are responding to markets and opportunities. Government facilitation of technology innovation and development remains an important enabler for the industry.

- *4G vision: whose?* – With 3G not yet deployed, few in industry or government appeared keen to promote 4G; in fact, for some major organisations, it was not yet really on the radar.

- *4G research* – Despite this, the government, through CATR and the FuTURE 863 programme, supports the ITU-R activity with ongoing research (as does Korea). The technologies being researched focused primarily on air interface development and were similar to those observed in Korea.

Outlook and recommendations

- *Future outlook* – The mission saw specific examples of world-class researchers returning to China and Korea from the West to lead new R&D (research and development) facilities[3]. Many global mobile companies[4] are increasing R&D investments in Asia, whilst downsizing such activities in the UK. Strategic action is urgently needed at a national level if the UK is to retain its role as a global knowledge-based economy in mobile communications over the next decade.

- *Research base* – The UK's research base is fundamentally strong, in terms of science, ideas and concepts, but coordination and mechanisms for pull-through are weak, compared to Korea and China, and are not strategically driven. Development of integrated policy across key agencies, with full involvement of industry, offers the potential for securing improved outcomes from the same inputs in a way that would strengthen the UK's position in what is today a globally competitive market. Such coordination is arguably needed as an enabler of a significant international peering activity.

- *International peering* – The potential exists for the UK to initiate R&D peering between the UK and China and/or Korea in respect of B3G. This would require a mechanism/organisation of appropriate scale, which could perhaps emerge from increased national coordination. Such a strategic initiative would allow the UK to play a significant role in shaping future evolution and increase the likelihood of a strong telecommunications industry in ten years time.

3 Such individuals were met in LG, Samsung, Philips, France Telecom.

4 Notably Alcatel, Lucent, Nokia, Nortel, Siemens, *inter alia*.

INTRODUCTION

Background

Mobile cellular communications has developed over the past two decades into a consumer mass market used by almost 25% of the world's population. The trigger for growth was the introduction of the GSM (Global System for Mobile Communications) digital system in the early 1990s in Europe, followed by the American IS-95 (Interim Standard 95); today, these second-generation (2G) systems have 1.3 billion and 0.2 billion users respectively. Recent growth in Asia, notably China and India, has reflected their large populations and historically low telecommunications penetration; as costs have fallen, so cellular has provided a rapid and effective means of meeting this real need.

Today, more than 1 in 6 cellular users lives in China; user numbers there (2G, GSM + IS-95) are approaching 300 million, exceeding wireline users; and new subscribers are being added at ~8 million per month. Such statistics illustrate why Asian countries have recognised the importance to their economies of nurturing and developing their mobile communications industry.

Japan was the first such Asian country to prioritise development of its mobile industry. In the early 1990s, Japan realised it would need to manufacture GSM phones if it was to address the burgeoning world market for cellular. This they did well, but at the cost of paying royalties on the GSM IPR. This motivated early engagement with Europe to develop the WCDMA (wideband code-division multiple access) third-generation (3G) technology. For 3G, Japan has deployed both WCDMA and CDMA2000 networks, evolutions from GSM and IS-95 respectively.

Korea chose not to compete with Japan or Europe in GSM but instead adopted a high-risk strategy of partnering US company Qualcomm and their at-that-time-unproven CDMA approach, a strategy that paid high returns. Like Japan, Korea has deployed both CDMA2000 and WCDMA networks, although with the latter yet to see commercial success. Korea sees itself at the leading edge of service innovation. For Korea, mobile communications exports are seen as a key growth engine of their economy – for this reason it is aggressively pushing to maintain a leadership position through technology research and innovation.

China has deployed GSM and IS-95 2G networks. It has yet to license 3G; it is presently evaluating WCDMA, CDMA2000 and its own home-grown TD-SCDMA (time-division synchronous code-division multiple access) technology. The latter offers greater independence and reduced IPR royalties, but is presently less mature. The Western cellular suppliers, recognising China's huge market, are investing heavily in JVs (joint ventures) and local research facilities, to secure their place in the country. This offers China, ever astute and entrepreneurial, an opportunity to catch up technologically and to strengthen its position.

For such reasons, China and Korea are actively engaged in research, to influence future standards. In 2007, the ITU's World Radio Conference will meet to discuss, *inter alia*, spectrum for future systems, so-called '4G' or 'beyond 3G' (B3G). This Global Watch Mission to Korea and China sought to meet with the key players and influencers in these countries, to understand more fully the local context and perspectives of future mobile evolution, with a view to drawing

lessons for research and industry development in the UK and Europe.

Aims and objectives

Mobile VCE, the Virtual Centre of Excellence in Mobile & Personal Communications, aims to harness the UK's academic excellence in mobile communications for the benefit of industry. As the organisation has matured, and as the industry has globalised, so today Mobile VCE has developed an international reputation for its research quality and innovation, which is used by its industrial members to 'seed & feed' in-house research. With industry members across the spectrum of the mobile industry – infrastructure and handset manufacturers, fixed and mobile operators – and with its international linkages and focus on future mobile technology, Mobile VCE was ideally placed to organise this mission to Korea and China.

Two key aims and objectives of the mission were identified in conjunction with the industrial team members:

- To explore commonalities and differences of thinking between UK and Chinese/Korean industry at the present time, in respect of future visions of mobile communications

- To consider and debate technology and R&D priorities, with a view to identifying opportunities for deepening collaboration and cooperation

Over two weeks, the mission team visited 24 organisations in the two countries – including government, telecom operators, manufacturers, SMEs (small or medium enterprises), research establishments and universities – in addition to informal discussions with others at industry seminars, receptions, dinners, etc.

Mission overview

The DTI Global Watch Mission to Korea and China took place during 14-25 June 2004. Walter Tuttlebee, Executive Director of Mobile VCE, coordinated the mission. He was accompanied by representatives of BT, Fujitsu, Lucent, Ofcom, Orange, Roke Manor Research (a Siemens company) and the University of Surrey. Representatives of the DTI Global Watch Service and UK Trade & Investment (UKTI) also participated (see Appendix A for full details of the mission team).

The mission itinerary was developed by Mobile VCE in conjunction with the British Embassies in Seoul and Beijing, with support from the Consulates in Shanghai and Shenzhen, and is shown in Exhibit 0.1 (see Appendices B and C for detailed information on the organisations visited).

The all-day symposium in Seoul on 15 June proved a valuable opportunity to introduce the mission to Korean industry and to gather common views. The possibility of a follow-up event in the UK in 2005 is under consideration.

In both Korea and China, various Embassy receptions, dinners and other events provided additional opportunity for informal discussion both with companies visited and with others who were not explicitly included on the itinerary.

The mission team gained a good insight into the context and factors that are shaping thinking about future mobile evolution in both Korea and China. The findings are set out in the next two chapters.

Korea	
Monday 14 June	Korea Telecom (KT) SK Telecom Yonsei University
Tuesday 15 June	Korea-UK Symposium on 'Future Mobile Evolution' Organised with support from MIC and from the NGMC Forum (See Appendix D) with ~350 Korean attendees Dinner with Minister Chin (MIC)
Wednesday 16 June	LG Electronics KTF ReakoSys (SME)
Thursday 17 June	Electronics and Telecommunications Research Institute (ETRI) Samsung Seminar 'Mobile Content'
Friday 18 June	Ministry of Information and Communication (MIC)
China	
Monday 21 June (Beijing)	Ministry of Information Industry (MII) China Mobile China Academy of Telecommunication Research (CATR) Beijing University of Posts and Telecommunications (BUPT)
Tuesday 22 June (Beijing)	China Telecom China Unicom DaTang Mobile Tsinghua (Qinghua) University
Wednesday 23 June (Shanghai)	Huawei ZTE Shanghai Wireless Communications Research Centre
Thursday 24 June (Shanghai)	Acell (SME) Bwave (SME) Alcatel Research Centre
Friday 25 June (Shenzhen)	Konka UK Trade & Investment (UKTI) Seminar

Exhibit 0.1 *Mission itinerary*

1 KOREA

1.0 Contents

1.1 South Korea: national context

1.1.1 People and geography

At 48 million, the population of the Republic of Korea (aka South Korea) is comparable numerically with the UK. Its area of ~100,000 km^2 is less than half that of the UK (~240,000 km^2). With 80% of the land area mountainous, population is concentrated in the cities, with close to 12 million people, 25% of the population, living in the capital, Seoul.

In excess of 60% of the country's population resides in high rise apartment blocks[1] in the cities. The population is very IT-literate and keen to try out new technology, a situation that has arisen as a direct result of an active government policy of extensive public provision of IT training during the economic downturn of the late 1990s.

Exhibit 1.1 *Map of South Korea*

1.1.2 National development

Since the early 1960s, following the ravages of the Korean war, South Korea has achieved an incredible record of growth and integration into the high-tech modern world economy. Four decades ago, GDP (gross domestic product) per capita was comparable with levels in the poorer countries of Africa and Asia. Today, its GDP per capita is 18 times North Korea's and equal to the lesser economies of the European Union (EU). South Korea is today the 11th largest economy in the world, with strong ambition to move higher.

This success through the late 1980s was achieved by a system of close government/business ties, including directed credit, import restrictions, sponsorship of specific industries, and a strong labour effort. The Chaebol system (inter-related industrial conglomerates) facilitated an interdependent and mutually beneficial industry structure. In this period, the government promoted the import of raw materials and technology at the expense of consumer goods, and encouraged savings and investment over consumption.

In 2003, 19% of total exports went to China, Korea's biggest export partner after the USA[2]. Korean labour costs are higher than those in China, and competition is intense. The traditional heavy industries such as shipbuilding are now in strong decline, and the focus has moved on to a knowledge economy, with ICT playing a major role.

1 This statistic has substantially assisted the country's exceptionally successful wireline broadband rollout.

2 In 2004, exports to China are now overtaking those to the USA for the first time.

1.1.3 Economy and ICT

Korea presently sees itself as in an economic downturn, with overall growth (at 5%) being low in comparison to its recent past, although with continuing strong export growth (42%). Some 30% of Korea's exports are ICT-based, and the bulk of export growth is IT related, with this sector showing 90% growth year-on-year in telecoms, electronics and mobile phones. Such a situation, combined with its growth ambitions, positions Korea as a major competitor to Europe's Lisbon objectives of leading the world of knowledge-based economy.

The Chaebols, and smaller Korean companies, recognise that they have to compete against the USA and Europe for high-technology development rather than against China for low-cost manufacture. Investment in R&D, which for years had been focused on the 'D', has in recent years been changing, with considerably more 'R' taking place, particularly within the IT-related Chaebols such as LG and Samsung, both of whom are now amongst the world industry leaders in several of their fields of activity, notably including mobile communications.

1.1.4 Role of government – MIC

In the IT arena, the Ministry of Information and Communication (MIC) is the government body responsible for industry development, market regulation, and spectrum management. MIC has implemented a policy of deregulation and competition in both wireline and wireless telecoms, with multiple operators now in these markets. Unlike the UK, it has yet to separate the functions of industry promotion and regulation; it is, however, exploring how to move in this direction.

MIC has played an important role in helping to establish Korea as a world leader in wired broadband and CDMA mobile communications over the past decade. In IT, the nation is clearly characterised by a strong commitment to pioneering and implementing innovation, a process fostered by very close links between government, government-funded research centres and industry. Mobility of people, and strong personal networks, exist between government, industry, universities and the national research organisation ETRI.

As part of its national IT strategy, Minister Daeje Chin initiated a proposal to work with China and Japan to promote North East Asia as an IT hub[3]. This was formalised at the Second Korea-China-Japan IT Minister's Meeting held on Jeju Island, Korea, in September 2003, when the ministers signed an agreement to collaborate on R&D in seven key IT fields, viz:

- Next-generation mobile communication
- Internet
- Open-source software
- Digital TV
- Broadcasting
- Telecommunication network security
- Information protection

1.1.5 Wired and wireless telecommunications

The government push for wired broadband deployment in the 1990s has resulted in a very advanced communications infrastructure. Korea Telecom (KT) has a massive IP-based convergence backbone called KORNET. This backbone supports the widespread use of broadband access via VDSL – an installed average 4.3 Mb/s (downstream) broadband is deployed to nearly 10 million households, with over 28 million users. FTTH will start to

3 Press release from Korea's MIC, 8 September 2003, 'Korea, China and Japan Agree to Boost Regional IT Cooperation', www.korea.net/News/News/NewsView.asp?serial_no=5821

be deployed shortly, offering 100 Mb/s residential services. To appreciate this, consider that in the UK, wired 'broadband' refers to a service that is typically 512 kb/s and enjoyed by a very small proportion of the population by comparison with Korea.

Government policy in mobile communications in the 1990s was unique, with Korea positioning itself, through its national telecommunications research institute, ETRI, as an ally of the US company Qualcomm to develop and deploy CDMA wireless technology at a time when this technology was still viewed as high-risk and unproven.

As the technology matured and became more widely adopted, Korean companies found themselves with a major slice of this new market, as well as a valuable technology capability as CDMA emerged as the basis for the major 3G standards. MIC estimate that their investment in CDMA of 100 billion won reaped a return of 54 trillion won over the period 1996-2002.

As described later in this chapter, in the advanced market of Korea, mobile network operators are keen to introduce new services, which are seen (as in Europe) as being key to future revenue growth. In Korea, however, this involves not only deployment of new services on existing infrastructure, but also the introduction of new wireless networks and products, such as digital multimedia broadcasting (DMB), a public WiFi service (NESPOT), short-range m-payment systems, and a 'OnePhone' combined fixed-mobile, single-number service (analogous to the BT project Bluephone) – all of these services are either already launched commercially or will be by end 2004.

	2003	2004 (est)	2007 (est)
Production	209 trillion won	240 trillion won	380 trillion won
Employment	1.23 million	1.28 million	1.5 million
Exports	$57.6 billion	$70 billion	$110 billion

Exhibit 1.2 *Korean economic projections for 2003-2007*

4 See Appendix E for further details of IT 839.

5 Concurrence is, however, not universal; the role of WCDMA is one area where different views exist, for example.

1.1.6 Strategy for industry growth – IT 839

Not content with the current incredible levels of technology penetration nationwide, the Korean government has set as its goal transforming Korea from what it sees as being a country possessing an 'advanced IT infrastructure' to becoming an 'IT powerhouse'. Under a national banner of 'Broadband IT Korea', the government in September 2003 outlined the next phase of its technology plan, the IT 839 Strategy[4] – '8 services, 3 infrastructures, 9 new growth engines'. The plan promotes a specific and comprehensive view of the IT industrial value chain and the respective roles of government and companies, a detailed approach to industrial strategy that both academia and industry (both manufacturing and operator) generally[5] concur with and, more importantly, coordinate to execute. The plan details specific outcomes expected from each area of activity in terms of production, employment and exports – see Exhibit 1.2 – as well as detailing specific financial investments by government and industry. Many of the technology evolutions identified in IT 839 build upon already-deployed 3G and broadband (xDSL) technologies, and whilst not unfamiliar in the UK or Europe, in some areas represent a significant leap from today's service deployment; in other areas, such as digital terrestrial television, Korea lags the UK.

Differing views were expressed to the mission team as to the degree to which IT 839 truly represents a government strategy or a re-badging of industry's own goals.

In reality, this does not matter – the significance of the strategy is the attempt and apparent success in articulating an integration of technology, industry and government policy to the degree that specific and shared objectives can be defined and targeted, together with detailed investment plans.

The IT 839 strategy, and the mobile communications element thereof, received further impetus subsequent to the mission[6] when Minister Chin, in a conference with President Roh, announced plans for 'u-Korea', or 'ubiquitous Korea' – which means a nation connected by telecom networks that will provide uninterrupted, high-speed access to the internet, fixed lines and mobile networks anytime, anywhere – by 2007.

6 'U-Korea project a driving force of national economy', 1 September 2004, www.korea.net/News/News/NewsView.asp?serial_no=20040831023

1.2 Wireless technologies

In this section we begin by examining the status of the mobile technologies that are already deployed in Korea (CDMA2000, WCDMA), followed by several more recent wireless technologies and services which are presently either being introduced or developed. We then discuss the Korean activities and perspectives of the evolution of future wireless technologies towards '4G'.

1.2.1 CDMA2000 1x EVDO and EVDV

Korea today has 35 million cell phone subscribers. The market is shared between three operators – KTF, LG Telecom and SK Telecom, with market shares of 32, 14 and 54% respectively (end 2003). Korea was one of the first CDMA2000 adopters and has maintained its leading position in that it has also adopted and deployed early the EVDO enhancements to CDMA2000. EVDO is a technology much like HSDPA is to WCDMA, in that it is considered to be a '3.5G' technology that is directed to improving the delivery of datacentric applications. Korea's cellular operators already have a good percentage of their users using this technology. EVDO is seen as a key enabler for data application growth.

The Korean broadband cellular service has grown strongly with a dramatic move of subscribers away from 2G, facilitated by the backward compatible evolutionary route of CDMA IS-95 to CDMA2000. Initial commercial launch of a CDMA2000 1x RTT service in 2000 was followed by launch of the 3G EVDO data service in 2002. Already, 17 million subscribers (across all operators) use EVDO high data-rate services[7], and some 26 million (75% of the subscriber base) use 3G and 1x RTT.

EVDO traffic presently accounts for 23% of all wireless packet data, and for around 20% of operator revenue, and is continuing to grow. Along with the increase in wireless data usage, there have also been other beneficial side effects, most notably that data application usage has pulled through additional voice usage.

Further to early EVDO adoption, it appears likely that EVDV will also be adopted early, possibly by the end of 2004. Whereas EVDO requires a separate 1.25 MHz carrier for data services, EVDV can be used to mix both voice and data services.

All three operators offer a wide range of advanced data services under their own brands – eg NATE and JUNE (SKT), and FIMM (KTF). They also offer m-Commerce services and the ability to pay for shopping transactions via the phone, m-payment – eg MONETA – with different systems presently used by different operators.

1.2.2 WCDMA

CDMA2000 is not the only 3G technology present in Korea. In deciding to award 3G licences in 2000, the government recognised the importance of WCDMA as an export market for its industry and, to ensure that this was given adequate priority, insisted on the deployment of WCDMA networks also in Korea. Part of MIC's IT 839 strategy is thus the deployment of nationwide WCDMA networks across Korea's cities by 2006.

Both SK Telecom and KTF hold WCDMA licences and began network rollout in 2003; both have deployed a very substantial number of base stations and repeaters in the Seoul metropolitan area. By May 2004, subscriber numbers were minimal: ~1,300 subscribers, split between the two operators; however, the network infrastructure would

7 The CDMA2000 service presently offers 1.2 Mb/s downlink and 300 kb/s uplink.

appear to be fully capable of supporting commercial usage.

The Korean mobile network operators already have nationwide CDMA2000 networks deployed that are successfully generating revenue and are operating in a saturated market (in terms of subscriber penetration). In such a situation, there appears little in the way of short-term incentives for operators to invest in a new nationwide infrastructure nor for subscribers to switch to the new networks. Operators were therefore understandably reticent to be drawn on detailed WCDMA rollout plans, although some indicative views were forthcoming from various quarters. For example, a final CDMA2000 evolution could be the incorporation of EVDO rev A, thereafter with a move to WCDMA HSDPA. Another broader interpretation suggested the use of the WCDMA bands as expansion bands for CDMA2000 services; however, such an interpretation appears to conflict with the present view of the regulator (MIC) that the operators are under a clear obligation to deploy WCDMA.

MIC is pursuing a carrot-and-stick approach that will enable the removal of obstacles to the successful widespread adoption of WCDMA. For example, MIC is supporting a measurement and network development programme to ensure that there is comparable service quality between CDMA2000 and WCDMA, it is encouraging manufacturers to improve the price of terminals by developing single-chip solutions for the two technologies, and it is also permitting WCDMA handset subsidies. Whilst reviewing its policy to identify ways to encourage investment in infrastructure (a carrot), MIC is at the same time pushing operators to abide by the agreed coverage conditions specified in the WCMDA licence awards (a stick).

1.2.3 OnePhone – wireless and wired service convergence

For wireline network operators, the success of mobile telephony in Korea has posed similar questions to those faced by such operators in the UK and Europe. In Korea, a perception that consumers, particularly young consumers, prefer to have their own personalised phone has influenced KT to introduce a dual-mode wireline/wireless product incorporating Bluetooth technology, branded as the OnePhone[8]. The OnePhone uses Bluetooth in-home for short-range access to the wireline network and CDMA for public mobile access, providing single-number access regardless of environment. Due for launch just after the mission team visited Korea in June, the period July-September was seen as a crucial rollout period.

1.2.4 DMB – digital multimedia broadcasting

DMB, due for commercial launch in September 2004 by SK Telecom, uses a derivative of European DAB technology operating at 2.6 GHz to provide wide area broadcast of video to cellular (dual-mode CDMA/DMB) handsets. The system utilises satellite distribution, with terrestrial repeater equipment to provide in-city coverage. Attractive handset terminals have been developed by Samsung and LG for this service. See Appendix H for more information.

1.2.5 NESPOT

In Korea, wired broadband is a ‘done deal’. With the highest penetration and usage in the world, the success of Korea – specifically KT – in this regard is well known. For KT, however, this has required the development of a service evolution strategy that looks towards an era

8 In the UK, BT launched a similar service in 1999, based on DECT/GSM which was subsequently withdrawn; Telekom in Germany had a similar experience, closing its service in 2002. BT continues, however, to explore a new similar project, termed BluePhone.

characterised by declining fixed-line voice revenues, fixed broadband saturation and an increasing consumer demand for individuality and mobility. Within such a strategy, NESPOT appears as the first step.

NESPOT is the brand name of KT's WiFi service (IEEE 802.11), which provides KT's customers with unified wireless broadband access in the home, office and in public hotspots, using common AAA (authentication, authorisation and accounting). KT's public WiFi hotspots account for over 50% of the world's deployments – 12,000 by March 2004, with a planned 23,000 by end 2004.

NESPOT subscribers numbered 387,000 in May 2004. Subscriber growth has been stimulated by the launch, around May 2004, of the NESPOT Swingphone[9], a combined WiFi/CDMA (and MP3 and GPS) pocket PC device. NESPOT has to date primarily attracted the technology 'early adopter' market segment, with mention made of applications such as messaging, network gaming and blogging. It is probably too early to tell whether NESPOT can of itself become a truly financially viable service. It is, however, providing KT with valuable experience of extending its broadband service wirelessly, and also preparing the market, in anticipation of the advent of the wider area WiBro technology. See Appendix F for more detail on NESPOT.

1.2.6 WiBro – portable internet

Licences for a new air interface technology, called WiBro, in the 2.3 GHz band, are scheduled to be issued in February 2005. WiBro – or '2.3 GHz portable internet' as it is also termed – is intended to extend the reach of traditional broadband services to consumers on the move, offering '**Wi**reless **Bro**adband' at 1 Mb/s and $50/month.

WiBro has been developed by ETRI, in conjunction with industry, and is being standardised by the Korean standards body the Telecommunications Technology Association (TTA)[10]. It is one of the eight services identified in the government's IT 839 strategy, with a goal of service launch in 2006. It is widely envisaged as supporting portable data (such as internet, e-mail, near DVD quality VoD streaming), rather than voice, services.

Technical specifications

A summary of WiBro's proposed technical specification is given in Exhibit 1.3; see Appendix G for more details of WiBro.

Parameter	Specification
Frequency band	2.300 GHz ~ 2.400 GHz
Channel bandwidth	10 MHz
Multiple access	OFDMA-TDD
Modulation	QPSK, (8PSK), 16QAM, 64QAM
Channel coding	CTC (Convolutional Turbo Code)
Frame length	5 ms
Maximum data rate	30 Mb/s (without SA/MIMO) 50 Mb/s (with SA/MIMO)
AP synch	GPS
Cell coverage	Urban ~1 km Suburban ~5 km

Exhibit 1.3 *WiBro specification*

WiBro is an OFDMA-TDD technology. The aim of this technology is to provide user mobility in the range 0 to 60 km/h in a 10-MHz carrier in the 2.3 GHz band. Currently, the technology uses a 5 to 3 downlink to uplink ratio, with the current focus on data services (no voice). The targeted capacity per WiBro access point is 125 attached users with 30 simultaneous active data users. The key service advances over NESPOT are cell coverage area and operational speed.

9 The Swingphone uses KT's network for WiFi access and KTF's mobile network for CDMA access.

10 TTA: see www.tta.or.kr for information on TTA and Korean standards (WiBro, DMB, etc).

Standardisation

Technical work on the WiBro standardisation within TTA in Korea is being led by ETRI, in collaboration with Samsung. The WiBro specification is based upon the WiMAX IEEE 802.16e standard with enhancements (ie multiple antennas). Approval of the first TTA specification was scheduled by July 2004, based on WiBro recommendation version 3.0. A year later, TTA will release its second version of the wireless broadband specification.

In terms of international standardisation, Korea would presumably hope to converge to 802.16e as an international version of WiBro, although to achieve this, some degree of harmonisation will need to occur; this could be part of the second phase in the development of WiBro. Discussions suggested that a firm strategy for this is still to be developed.

Application

This technology is of particular interest to the fixed-line operators who see it as a wider area wireless extension of their broadband xDSL infrastructure, extending the wireless broadband access well beyond the limitations of IEEE 802.11b NESPOT. Perhaps more significantly, the technology is capable of modest vehicular speeds (up to 60 km/h – perhaps greater in the future evolutions?) In the metropolitan environments of Korea, WiBro could therefore represent an opportunity for the fixed-line operators to enter the mobile market via the backdoor, with an ability to deliver services similar to those supported by current and planned 3G enhancements, such as EVDO rev A and HSDPA. Whether regulation will permit this, however, remains to be seen.

Licensing

MIC has not yet specified detailed eligibility criteria, nor potential service limitations, for WiBro licences. At the present time, both fixed and mobile operators have interest in such licences; however, the eventual bidders may well depend on the constraints that MIC may introduce for strategic policy reasons.

The commercial introduction of WiBro in the Korean market raises an early prospect for fixed-mobile convergence. In fact, because of Korea's aggressive stance on technology adoption through, for example, the development of cellular DMB convergence and the promotion of RFID and sensor networks, along with the prospect of some fixed-line operators offering digital services over WiBro, the notional idea of access convergence begins to take on a whole new significance, one which has a greater impact on the terminal and core networks, as they both try to cope with the mobility and accessibly that such a convergence would have to offer.

Positioning and evolution

WiBro represents an important commercial evolution of wireless technology in Korea. It is seen as supporting higher data rates than 3G, but lower mobility (see Exhibit 1.4). As well as a commercial service in its own right, targeted for 2006, WiBro is also seen by some as a base from which future cellular 4G systems could evolve[11].

The future evolutionary aim of WiBro is the prospect of 20 Mb/s in 10 MHz bandwidth (an efficiency of 2 b/s/Hz), with an ultimate aim of attaining 50 Mb/s with MIMO (an efficiency of 5 b/s/Hz).

11 In many ways, this is similar to the way in which China holds TD-SCDMA as the possible progenitor of a future Chinese 4G cellular interface – see Chapter 2.

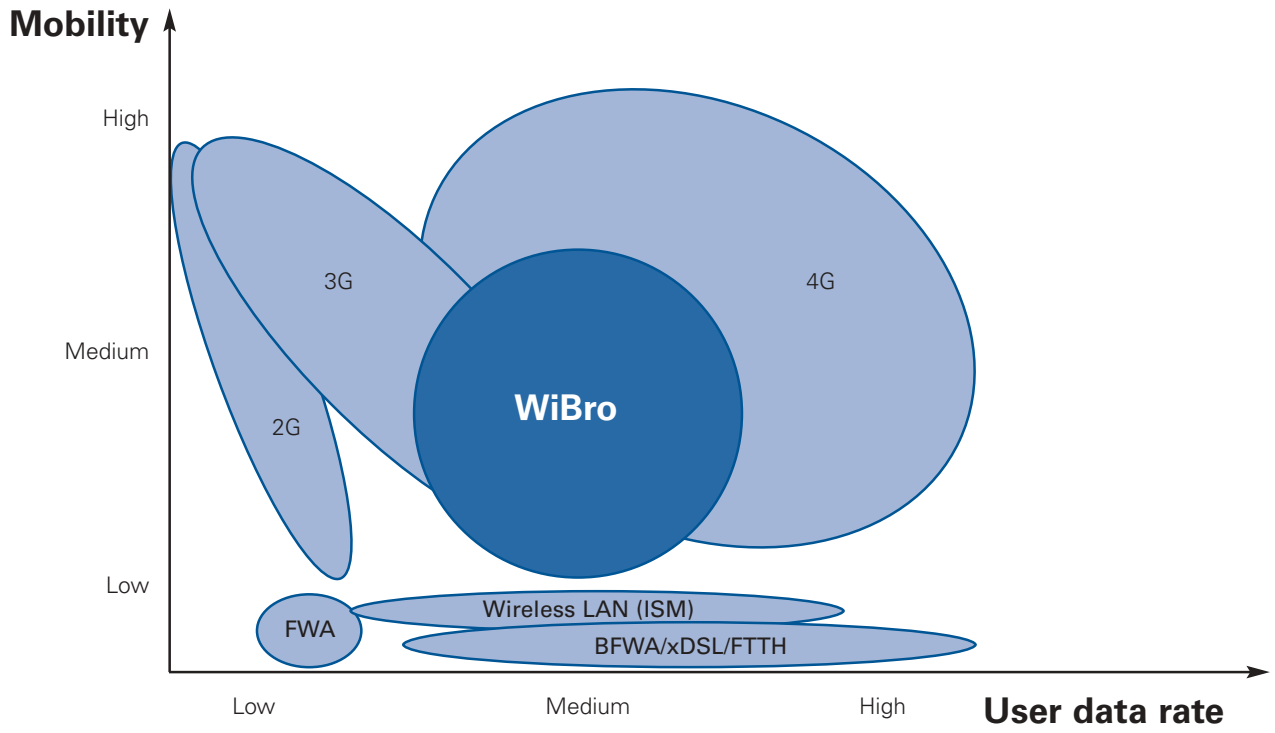

Exhibit 1.4 *Positioning of WiBro*

1.2.7 Future wireless evolution

Evolutionary framework

Next-Generation Mobile Communications is explicitly identified as one of the nine new growth engines within Korea's IT 839 strategy. The government announced an investment of ~£100 million for Next Generation Mobile Communications research[12] over the period 2003-2007, much of which is being undertaken by ETRI. Within the IT 839 framework, the development of a Portable Internet Prototype (WiBro) has been a specific goal for the 2004 plan; a demonstrator, showing the delivery of streaming video, which is being developed at ETRI, was shown to the mission team. Development of a '4G Mobile Communications Prototype' is identified as a later goal (2007) of the IT 839 strategy, although ETRI has intermediate demonstrator objectives (see below).

MIC clearly sees wireless ADSL (asymmetric didital subscriber line) as an essential evolution of wired broadband, and that WiBro has emerged in Korea as an important first stepping stone in terms of new technology evolution. The main reason, in Korea at least, for the current focus on further evolution is to provide the solution and opportunities that 3G originally promised.

Promise of 3G and 'systems beyond...'

3G's original promise was 2 Mb/s capacity; in early days this was interpreted as 2 Mb/s for the user. In Korea at least, 2 Mb/s to the end user is seen as a logical and necessary step, given that he already has access to a 4 Mb/s wired broadband service. To achieve this, it is seen that such evolution has to be able to connect anything, at anytime, to anywhere. This then requires a broad structure of delivery technologies:

- Mb/s fixed (ADSL)
- kb/s mobile (cellular)
- Mb/s everywhere (4G/B3G)

12 IT Korea Journal, January 2004, p 26-39, summarises the investment in all nine new growth engines detailed in the IT 839 strategy, of which Next Generation Mobile Communications is one.

Along with this requirement, other commonly held requirements include:

- High mobility (300 km/h)
- High local area transmission rates (1 Gb/s)
- High spectral efficiency (10 b/s/Hz)

In these respects, and in terms of timescales, Korea's views are aligned with the ITU-R 'Systems beyond…' vision. Reflecting this, Korean institutes and industry are pushing technologies that give a clear distinction between mobile (bit rates up to 100 Mb/s, such as WiBro) and nomadic (bit rates up to 1 Gb/s, such as variations on ultra-wideband – UWB).

Within this framework, much of the current wireless technology research in Korea, as elsewhere in the world, is focused on the physical layer, with smart antennas, MIMO, interference cancellation, software defined radio (SDR) and new coding schemes apparent as being dominant topics.

It is thought that advances in the air interface will be coupled to changes in the supporting access architecture. In this sense, there has to be an incremental approach to deploying infrastructure which needs to be 'router' like. In the beginning, these deployments will be more like hot spots, evolving into cellular deployments. The anticipated arrival of such new high-bit-rate 4G air interface and access architectures is thought to commence with standardisation beginning in 2007, and deployment occurring between 2010 and 2015. Differing views of timescales were expressed to the mission team whilst in Korea; the 2010 date comes from the August 2004 Samsung press conference (see below), probably reflecting the ITU-R position.

From an industrial perspective, the operators and manufacturers appear to be investing heavily in the new technologies, often in collaboration, or at least coordination, with the national research institute, ETRI, and in line with the national strategic plan. At a press conference at Samsung's '4G Forum', held on Jeju Island in August 2004, subsequent to the mission, Lee Ki-tae, President of Samsung, stated: *'We will increase our R&D spending to about 9% of our overall telecom revenues, and a third of them will be channelled into 4G technologies before its full-fledged takeoff'.*

4G wireless technologies and demonstrators

In terms of national R&D facilities for future wireless technology, ETRI is the primary facility. Established in 1976, ETRI is Korea's largest government-funded research facility in ICT, focusing on semiconductors, mobile communications, networks and security[13]. Its remit is to extend technology development, based on high risk, high return research. It has already seen significant success in this goal, including technology development for 2G CDMA, commercialised in Korea in 1996, and for 3G – CDMA2000 (1997-99) and WCDMA (1999-2001). By working closely with Korean industry, these technology developments are translated into commercial exploitation.

An example of building on past achievements is ongoing work on the practical application of smart (adaptive array) antennas to 3G (WCDMA) base stations. ETRI's Smart Antenna Testbed is a lab demonstrator based on the June 2001 (Rel 3) specification, and is aimed at a 3-sector, 8-antennas/sector system designed to give 4x capacity increase over a 2-antenna diversity system. Real-time beam steering (up- and down-link), tracking a mobile handset as it was moved around the room whilst a mission team member used it to make a call, was demonstrated at the ETRI facility. As well as application as a 3G enhancement technology, smart antennas are seen as an integral element of 4G.

13 It is interesting to note that, with the exception of semiconductors, these are the same areas of focus that have emerged within the UK's Mobile VCE research programme.

Similarly, a demonstration SDR base station, supporting software implementations of both CDMA2000 and WCDMA up- and down-links, was also shown to the team. Using today's commercial technology (TI DSP and Xilinx FPGA), such implementations provide valuable pre-commercialisation experience.

The government-funded ETRI programme aimed at 4G was initially focused on two elements, a low-tier technology – HPi (high-speed portable internet), which has evolved into WiBro – and a high-tier technology – HMm (high-speed mobile multimedia). The goal of the HMm technology is a wide area delivery capability for 15-100 Mb/s to high-speed terminals.

Whereas perhaps initially the vision of 4G was seen as simply the combination of HPi and HMm, today ETRI are working towards a '4G R&D Testbed' which brings together four elements:

- IMT-2000 (WCDMA and CDMA2000 1x EVDO/EVDV)
- Low-tier wireless LAN
- Low-tier WiBro
- High-tier HMm

It is envisaged that all four elements will be supported on a common IP-based core network. In this respect, it is clear that, like Japan, Korea has embraced the European emphasis on 'evolution, not revolution' and the need to fully exploit the market potential and infrastructure investment in 3G technologies.

ETRI is targeting testbed implementations of HMm in 2005 and 2007. They envisage that the use of physical layer technologies such as OFDM and MIMO, being widely researched worldwide, in conjunction with adaptive modulation schemes (including QPSK, 16QAM and 64QAM) and LDPC channel coding, will permit peak data rates of 60 Mb/s and 100 Mb/s respectively for their demonstrators in these timescales. Simulation test environments are already being implemented, with an evolutionary path to full demonstration.

From the air interface perspective, 4G interfaces based on hybrid combinations of current approaches are also being investigated. Initial studies have been performed in this area by Korean universities, and a hybrid system of MC-CDMA is currently the preferred choice in one of these activities[14]. This idea, combined with others such as multidimensional scheduling to achieve diversity (a form of cross layer optimisation), are also being considered in which the scheduling degrees of freedom are extended across user, antenna and carriers. From a structural standpoint, all of these access technologies are being targeted at some form of software-defined radio (SDR) or system-on-a-chip, principally for access point (base station) technology.

However, in stark contrast to this direction, some see the optimisation of the current networks as one that would yield more fruit rather than purely focusing on the search for a new physical layer. At one level, this mirrors the European perspective of networks-of-networks, with 'vertical' handovers between different types of wireless access networks. When considered at the network infrastructure level, however, rather than air interface, such an approach does arguably reflect a different philosophical perspective, in that network operators in Korea focus strongly on branding their service (eg NATE, JUNE, FIMM), which may then, in principle, be delivered independently of the underlying network. Such a service delivery and development perspective in fact accords with the evolutionary concept of a Next-Generation Network (NGN) based upon 3GPP architectures extended to support wireline requirements.

14 Research on MC-CDMA formed part of Mobile VCE's Core 2 programme for its industrial members, which included Korean companies Samsung and SK Telecom.

1.2.8 Future infrastructure evolution

The Korean government view of future infrastructure evolution is typified by the three infrastructure elements identified in its IT 839 strategy, viz:

- Broadband Convergence Network (BcN)
- Next-Generation Internet Protocol (IPv6)
- Ubiquitous Sensor Network (USN)

Before we consider these, we briefly review the present infrastructure situation.

Wireline and wireless infrastructure

Korea Telecom (KT) used to be the national PTT, with moves to duopoly and further competition in 1996/97, but today remains by far the biggest wireline operator. Following a deep downturn in the Korean economy during the late 1980s, the Korean government invested heavily in IT education of the general public, and put in place a programme to accelerate broadband uptake across the country. KT have now supplied broadband, at an average installed data rate of 4.3 Mb/s (downstream), throughout the country, with some 71% of households connected. Current new subscriber minimum data rates are 20 Mb/s, with typical users taking the 50 Mb/s offering. The government are very keen to see Korea as leading the world in broadband use, particularly in the use of converged broadcast/data networks. Indeed, broadband provision has recently been reclassified by the government from a value-added service to a basic service.

Despite their tremendous success, KT's markets are saturated, the traditional wireline business is not projecting growth, and capital expenditure costs are rising for broadband offerings due to pressure from customers for very fast internet access services. KT see voice traffic falling, and need to address this.

Mobile operators are taking ever-increasing proportions of the voice business. It is felt that one of the reasons for people using mobiles rather than fixed phones is the fact that users want to have their own personalised terminal. They don't want to have to use a shared family phone. This becomes ever more important as people start to use data services. It is felt that future success therefore depends (at least partly) on offering personalised mobile phones that can use the wired network – this explains KT's partnering with KTF to introduce the OnePhone product described earlier (analogous to the BT project Bluephone and a comparable offering from France Telecom). KT's investment in, and ongoing expansion of, the NESPOT service, and its hopes to secure a WiBro licence and launch commercial service, are further manifestations of this thinking – the need to find new revenue streams by providing wireless access to its existing wired infrastructure.

From a wireline infrastructure perspective, the key operator is being driven by the need for increased revenue, rather than a desire to invest heavily in network development. One possibility to address this dichotomy is for the government is tie conditions relating to infrastructure investment to licensing for the new WiBro service. Such options for influence are present in countries such as Korea and China, where the separation of the functions of industry promotion, regulation and spectrum management has not progressed as far as in the UK.

From the wireless infrastructure perspective, a factor perceived as holding back 3G data services has been the lack of a common platform across the three mobile networks available in Korea. In order to address this, Korea has recently standardised, and is now adopting WIPI – Wireless Internet Platform for Interoperability – a single mobile virtual machine middleware platform implementing Java, C and C++. The use of WIPI will enable

third-party services to be delivered to subscribers independent of the mobile network to which the user is subscribed, thereby widening markets for wireless internet services and reducing development costs for content providers. The introduction of WIPI demonstrates a recognition amongst Korean operators of the added-value offered by third-party content providers in stimulating consumer demand and service usage.

The mobile network operators are working hard on developing their mobile core infrastructures in order to handle multiple future access networks, including WiBro from 2006 onwards. Two mobile operators already have both CDMA2000 and WCDMA networks; however, neither was keen to explain in detail their plans for evolution or convergence of functionality across the two.

Nonetheless, it was clear that the perspective of mobile operators is one of desiring to deliver unified services across multiple access mechanisms; a logical requirement of this is infrastructure convergence.

Infrastructure convergence

A key factor in the evolution of the Korean core network is seen as being the convergence of broadcast, telecoms and the internet in an advanced all-IP infrastructure. This is reflected in the government's IT 839 programme by the identification of the Broadband Convergence Network (BcN) as one of the three infrastructures. Legislation is already proceeding to permit broadcast and telecom convergence, and KT are planning to offer IP-TV over their broadband IP network. It is envisaged that the BcN will allow the delivery of QoS-enabled multimedia services anywhere, anytime, by any means (including wireless). End-user data rates of 50-100 Mb/s are envisaged, along with IPv6 support.

In many ways, Korea's BcN is seen as a specific implementation of what is generally today termed a Next-Generation Network (NGN), with specific additional requirements identified to support integrated home networking, broadcasting, etc. It is seen as the central enabler of 'Broadband IT Korea' – Korea's drive to move from what it sees as its role today of 'Country with advanced IT infrastructure' to 'IT powerhouse'.

Discussions regarding IPv6 indicated a clear separation in opinion between the government and the telecom operators. The government is pushing IPv6 as part of its Korean IT 839 programme. The mobile and wireline operators are cognisant of the amount of work and investment that will be required within their networks to accommodate the transition. The general opinion of the mobile network operators seems to be that the government's IPv6 drive is something that they have to address, but that the target of 2007 should be interpreted as a soft target not a hard one.

A pragmatic four-phase transition approach from IPv4 to IPv6 was presented by Samsung at the Future Mobile Evolution Symposium, comprising the steps:

- IPv4 plus IPv6 trial networks (proof of concept)
- IPv6 islands in an ocean of IPv4
- IPv4 islands in an ocean of IPv6
- All IP with IPv6

Temporary technologies for the transition stages are seen as dual stacks, v6 through v4 tunnelling and v4/v6 translators.

Relatively little was heard by the team about the Ubiquitous Sensor Network (USN) – although this was probably because this was not a main focus of the mission, rather than because little is happening. The mission was given a tour of MIC's technology showcase – the 'Ubiquitous Dream House' exhibition – a facility configured as a home, showing potential applications and future benefits of

an integrated ubiquitous wireless environment, based around a range of prototype domestic products supplied by Korea's IT manufacturing industry. This facility is open to the public, and promoted by MIC along with its 'Broadband IT Korea' strapline by TV advertisements (even at 0300 h!). In a culture that likes to try new technologies as soon as they become available, this is an interesting strategy to encourage a future domestic market.

A comment expressed by one company visited, suggested that the advent of large-scale sensor networks, and the need to be able to directly bill against the identified end device (and perhaps accessed via the personal mobile device), would help drive the take-up of IPv6 from addressing and usage perspectives.

1.3 Handset technology

1.3.1 Major handset manufacturers

Samsung and LG Electronics are Korea's largest handset manufacturers, both within the top 5 in the global industry in terms of market share. According to Strategy Analytics, Samsung enjoyed a market share of 10.8% in 2003, and ranked 3rd, after Nokia and Motorola. LG's market share was 5.3%, equal 5th ranking with Sony-Ericsson, after Siemens in 4th place.

The progress made by the Korean handset industry in recent years is illustrated further by the fact that both Samsung and LG are suppliers of 3G WCDMA handsets to UK operators. Both companies have a competitive product line in this technology, as well as in their country's other technology of choice, CDMA2000.

1.3.2 Other handset manufacturers

As well as its two well-known manufacturers, Korea also has a significant number of smaller handset manufacturers, less well known outside of Korea. Pantech Curitel is the third largest handset player in the local market; other manufacturers include KTF Technologies, Maxon, Sewon, SK Teletech & Telson.

Korea has an interesting perspective on terminal technology, which if viewed from its Chaebol tradition is not entirely surprising. All the mobile operators have related handset manufacturers within the same Chaebol family, as shown in Exhibit 1.5.

Operator	Handset manufacturer
LG Telecom	LG Electronics
KTF	KTF Technologies
SK Telecom	SK Teletech

Exhibit 1.5 *Korean mobile operators and related handset manufacturers*

Regulation in Korea presently limits the ability of some of the more closely-related handset manufacturers in terms of mass retail in Korea. However, they are allowed (not unsurprisingly) to export their wares, which potentially may be re-branded and imported at a later date.

An important role of companies such as SK Teletech is as a stimulus to accelerate the development of advanced handset capabilities. Their parent operators use their 'home grown' handsets as an inducement to the larger (established) handset manufacturers to advance the state of their own terminal capabilities faster than might otherwise happen[15].

1.3.3 Handset technology evolution

From a handset manufacturer perspective, the key driver for future handset technology evolution is primarily the need to deliver enhanced and evolving services – see Exhibit 1.6. As one might expect in a country that has evolved 3G rather well, the Korean manufacturers view handsets as much more than a voice device.

Applications as a driver

In this respect, they see the handset as an extension of the user's personality, where peer-to-peer (P2P) symmetric communication will play an important role, and where multimedia instant messaging (MMIM), blogging, video on demand (VoD) and digital multimedia broadcasting (DMB) are services

15 This has (limited) similarities to the approach of Vodafone in the UK in commissioning customised handsets for its Vodafone Live! service from the Japanese manufacturer Sharp.

Drivers	Key issues
Standards/networks	2G – GSM, GPRS, EDGE 3G – CDMA 1x EVDO, EVDV 3G – WCDMA Short range – WLAN, Bluetooth
Infrastructure solutions	Network servers Content/applications Software platforms (Java, MP4, etc)
Technology/ components	Enhanced displays Camera Multimedia processors

Exhibit 1.6 *Drivers of handset evolution: future handsets will support multiple standards, interact with new infrastructure capabilities and embody advanced components*

Exhibit 1.7 *Samsung DMB CDMA2000 EVDO phone*

that will become increasingly commonly accessed from the handset. Along with these ideas is the increased need for security on the handset, not only from an ownership perspective, but also from a transaction authorisation perspective. To this end, handsets in the future will require biometric processing capabilities to enable these kinds of applications and transactions; such technology requirements are very much on the handset evolution roadmap.

WIPI – Wireless Internet Platform for Interoperability

As explained earlier, the three mobile operators – KTF, LGT and SKT – have recently introduced WIPI – Wireless Internet Platform for Interoperability. By the end of 2004, it is intended that every handset brought to market will support WIPI. WIPI-enabled handsets will support applications written in Java, C and C++, and will be backwards compatible to existing mobile handset applications.

Multimode, multifunction terminals

A clear trend toward increasing terminal complexity and capability was evident in the various demonstrations seen by the mission team of multimode, multifunction handsets. Examples of this type of product evolution include the recent CDMA/NESPOT Swingphone PDA device, the CDMA/ Bluetooth OnePhone, and the addition of DMB into CDMA2000 EVDO terminals (see Exhibit 1.7).

Fixed-line operators, who are best positioned to take advantage of the WiBro licences that will be issued early in 2005, see a need for trimode terminals (CDMA, WiFi and WiBro) to bridge the gap between wireless ADSL and cellular. This demand will place a number of major technological challenges on the handset, not least of which are larger screens, hybrid network roaming, increased memory requirements, and (naturally) improved battery capacity. The fact that the Korean handset industry is being pushed to address such challenges earlier than elsewhere, due to the early rollout of these new services, will mean that they are likely to lead in developing solutions, further enhancing their global competitiveness.

In contrast to the fixed operator view, there are other views held in Korea that see the need for separate terminals rather than a single ubiquitous terminal. The development of multimode handsets certainly could help to accelerate service convergence, causing market erosion for some operators to the benefit of others. In all probability, whilst some segments of the market may demand a single multifunction terminal, other segments may prefer multiple devices.

1.4 Business models, content, applications

1.4.1 Wireless business model

Generic business model

In respect of the actors involved, the wireless business model can be generically represented as in Exhibit 1.8. Each interface supports some form of financial transaction. The service provider and network operator are shown as separate entities because, in some countries, the infrastructure may be owned and managed by a third party, whilst the branding and customer relations and ownership is carried out by the service provider[16].

Within this model it can be seen that the operator/service provider can choose to be purely a 'bit pipe', and offer a transparent route to unbranded content. With this approach, providers secure their revenue from airtime and from a relatively small revenue-sharing on the content; in this approach, the operator gives no undertaking to the customer to support the service, providing only a connection path.

Alternatively the operator/service provider can offer own-branded or co-branded content, generally through his portal. The operator pays either development or licensing costs for such content, or forms a strategic alliance with the portal provider. In this approach, the operator plays a much greater part in content creation, in content marketing and in providing support through customer services and links into the billing system. In this case, the operator's proportion of the revenue share is significantly greater, in order to recoup his costs.

The ratio of branded to unbranded services depends upon a number of factors, such as the maturity of the market, and the resources available in-house for the generation and subsequent maintenance and support of the content and platforms. The cost to the subscriber of content, and the ease by which content can be billed, are also important

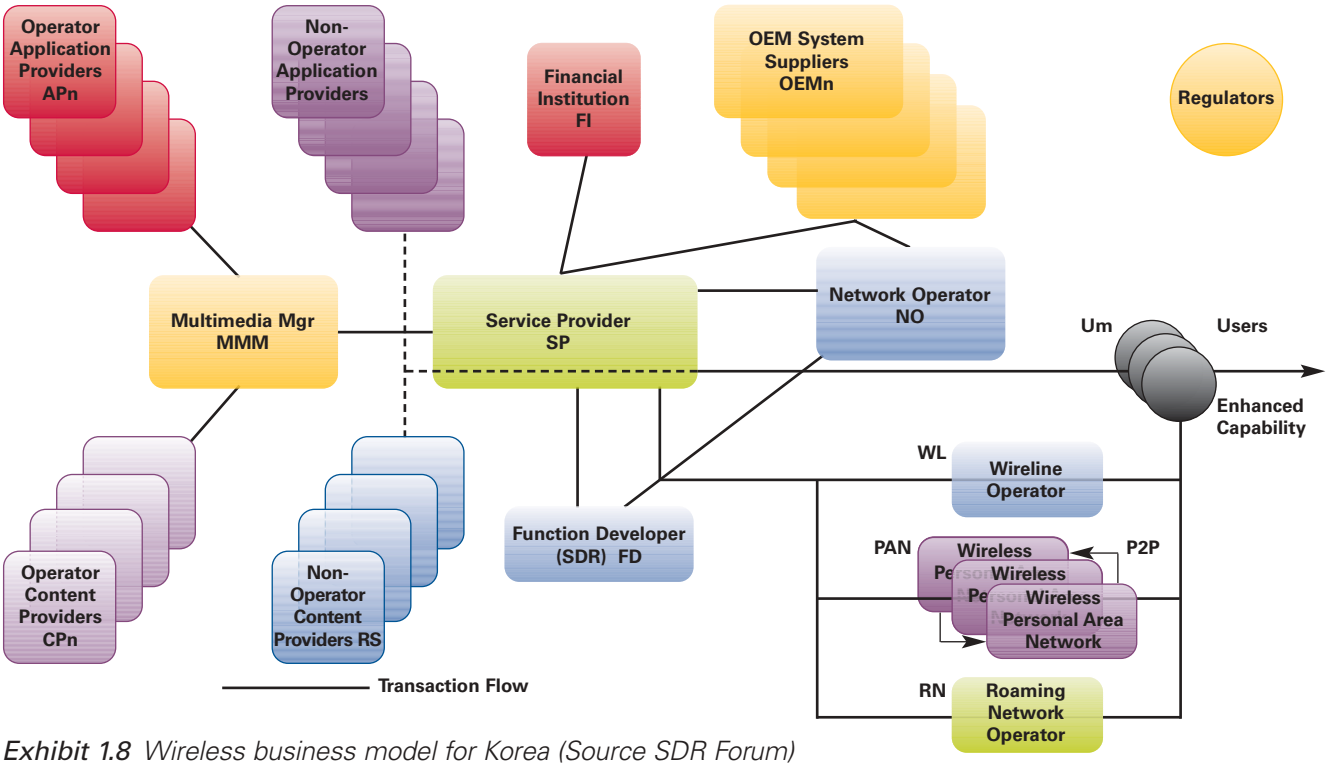

Exhibit 1.8 *Wireless business model for Korea (Source SDR Forum)*

16 This is also the case for the mobile virtual network operator (MVNO) scenario.

factors. The strength of the operator's brand is also a significant issue, as it is important for an operator with a strong brand that there is no erosion of brand values by presentation of faulty or unsuitable content. The relative positioning of the operator within the market is also a factor.

1.4.2 Stimulating growth in a mature market

Need to drive ARPU

The Korean wireless market is mature, with the three mobile network operators each having good brand projection; for each to grow, their aim must be to increase average revenue per user (ARPU) through stimulating increased data usage[17]. This situation is similar to the UK where, although subscriber numbers are important to compare the relative success of marketing campaigns and public awareness, the key driver is increase of ARPU.

Korea has a high mobile penetration rate of around 75%, with three advanced operators, led by SK Telecom with 18.4 million users (52.7% of the subscriber base) followed by KTF and LG Telecom. To increase ARPU, operators compete with each other in the provision of innovative content, applications and services.

Consumer focus

In Korea, the focus of the mobile operators appeared to be primarily on development of the consumer market, unlike the UK where, certainly from a 3G perspective, the focus is much more upon the business market. This is demonstrated by the launch of 3G datacards by both Vodafone and Orange, with the 'Mobile Office' theme to the business market in advance of their main consumer launch. In contrast, 3, as the latest entrant into the UK market and lacking a 2G network, has targeted the consumer market from the outset to drive subscriber numbers and gain market share.

1.4.3 Search for content and applications

As described previously, all three Korean operators launched with CDMA IS-95 A/B for 2G and have migrated the majority of their users to CDMA2000 1x (2.5G), and then to 1x EVDO. WCDMA has also been launched, although with uptake slow, with only some 1,300 subscribers by May 2004 (6 months after launch)[18]. There is a drive by all the operators for a suite of 3G-branded mobile applications which will demonstrate obviously improved performance of 3G over 2.5G. To do this, the operators have developed a portal through which applications and content can be offered by both the operator and, equally as important, from strategic partners providing both innovative content, applications and service offerings which may or may not be branded, depending upon the perceived value and revenue share agreements; such portals are being heavily marketed in Korea (cf Vodafone Live! and Orange World in the UK) to stimulate the market.

Portals – NATE

The biggest operator – SK Telecom – has a particularly interesting strategy of launching a series of branded service portal offerings. Even the first of these included both video- and audio-on-demand on their 2G portal called nTOP in 2001. This was then followed by enhanced service offerings on a 2.5G/2.75G portal called NATE, offering a single entry point to the internet from multiple devices including in-car and home appliances – Any Time, Any Place, Any Device & Fully Personalised – the development of

17 However, it should be noted that voice services continue to be the cornerstone of the businesses and will remain so for the foreseeable future.

18 This is somewhat understandable, as there is no noticeable difference to many users in the performance of WCDMA, with a cost premium over CDMA2000 1x EVDO.

this continues. To date, the NATE service portfolio includes approximately 34,000 content offerings from 900 content providers being offered to NATE users through nine channels. For all this variety of content, however, ring tones generate some 24% of the NATE platform revenue.

JUNE – driving 3G ARPU

However, in parallel with this, they have engaged in a bold strategy to stimulate interest in 3G by launching JUNE – a premium-brand service designed to be a growth engine for 3G multimedia. Entertainment and communication are JUNE's main services, with an emphasis on movies, music, 3D games and broadcasting services, as well as expanding the already widespread information services (for example, through offering location-based services such as access to traffic cameras along the route). There was also recognition of the need to target the older segment.

Generating airtime/packet transfer revenue through P2P content transfer through the network is also a major component of SKT's 3G deployment strategy. To stimulate such traffic, it is aiming to develop communities to enhance content sharing opportunities.

With the introduction of JUNE, SKT wireless data ARPU doubled in 15 months. JUNE users average 2.7 times higher ARPU than pure voice applications. Data represents some 22% of their total revenue.

MMS and VoD

Given the fairly slow take-up of MMS in the UK and Europe, it was surprising that KTF indicated that they regarded MMS, together with VoD, as their killer applications, and saw their killer content as the delivery of TV to the mobile. It should be noted that the slow take-up of MMS in Europe has been mostly due to problems of phone interoperability; possibly the development and adoption of WIPI may circumvent such problems in Korea.

KTF also promote their portal, but their approach has been to form strategic alliances with existing major portal providers rather than develop their own platform. They also reported that the number of data transactions has increased threefold since the introduction of EVDO.

Games and adult content

Korea is one of the leading countries for games development, and games is a major revenue generator. KTF reported that they had some 700-1,000 games in their portfolio at any one time, both download and online, although for online games latency is an issue. Satellite broadcast, DMB, is being viewed as a possible alternative to CDMA2000 1x to address the latency issue and to address multiplayer mobile gaming.

Adult entertainment, particularly with the improved video streaming capability now being offered, is a growth area for all the operators.

M-commerce and m-banking

One significant area which all the operators address is m-commerce and m-banking. The CDMA phone does not in general have a SIM but does have the capability to carry a SIM-sized smart chip for use as a mobile credit card and which can also be used for access to bank information at an ATM via infrared. The mobile wallet concept means that membership cards can also be downloaded, stored and erased in the handset, so m-commerce effectively replaces the wallet with the handset.

Convergence of mobile and broadcast services

To further enhance the 3G offering, whilst there is not yet a true convergence in respect of services handing over between cellular and broadcasting technologies, cellular operators are using a DMB satellite with a footprint covering both Japan and Korea. A range of dual-mode handsets have been delivered into the Korean market by the main local players, Samsung and LG, allowing the reception of live TV broadcasts on the handset itself. Whilst some such services have previously been available via the cellular network, it is anticipated that DMB will provide a lower cost delivery mechanism, enabling lower prices and more rapid market growth. Looking to the future, the development of interactivity, modifying content through the cellular network, is envisaged.

1.4.4 Summary

The Korean wireless market is mature, therefore the business model is similar to that of the mobile operators in the UK, and Western Europe in general, with a focus on increasing ARPU through offering a rich variety of contents and applications to the customer. There is an extensive content and application generation industry which is also exporting to Europe. This industry was already growing rapidly by virtue of the fact that Korea has one of the highest penetration levels of wired broadband in the world. The introduction of 3G mobile technologies has provided a good opportunity for further rapid growth in the Korean wireless industry, while the high level of competition has meant that there is great choice for the customer.

1.5 Regulatory and spectrum policies

1.5.1 Ministry of Information and Communication (MIC)

The role of MIC is threefold:

- Industry promotion
- Market regulation
- Spectrum management

– this is the kind of model common in Europe in the 1980s, pre-deregulation. MIC's responsibilities embrace both telecommunications and broadcasting, the convergence of which it sees as key to future industry and export growth under the banner of 'Broadband IT Korea'. To facilitate service convergence, MIC has established a committee to consider converging policy and regulation of radio, telecommunications and broadcasting. The current regulatory structure (see Exhibit 1.9) emphasises the need to provide a new legal framework and restructuring with the Broadcasting Commission.

The existing approach and structure has meant that, at least to date, there has been a close and effective interrelationship between policy in the three areas of industry policy, regulation and spectrum – 'joined-up' thinking. MIC's latest views in respect of industry promotion are summarised in its IT 839 strategy (see Appendix E). In this section, we primarily consider its other two policy areas, regulation and spectrum management.

MIC is also seeking to strike a better balance between promoting industry and regulation, and recognises the limitations of and potential conflicts inherent in the present structures. MIC officials took the opportunity to meet with members of the mission team to learn lessons from the UK, exploring the evolution of the UK approach, how it has worked out in practice, and the background to the recent formation of Ofcom as a unified regulator for communications and broadcasting.

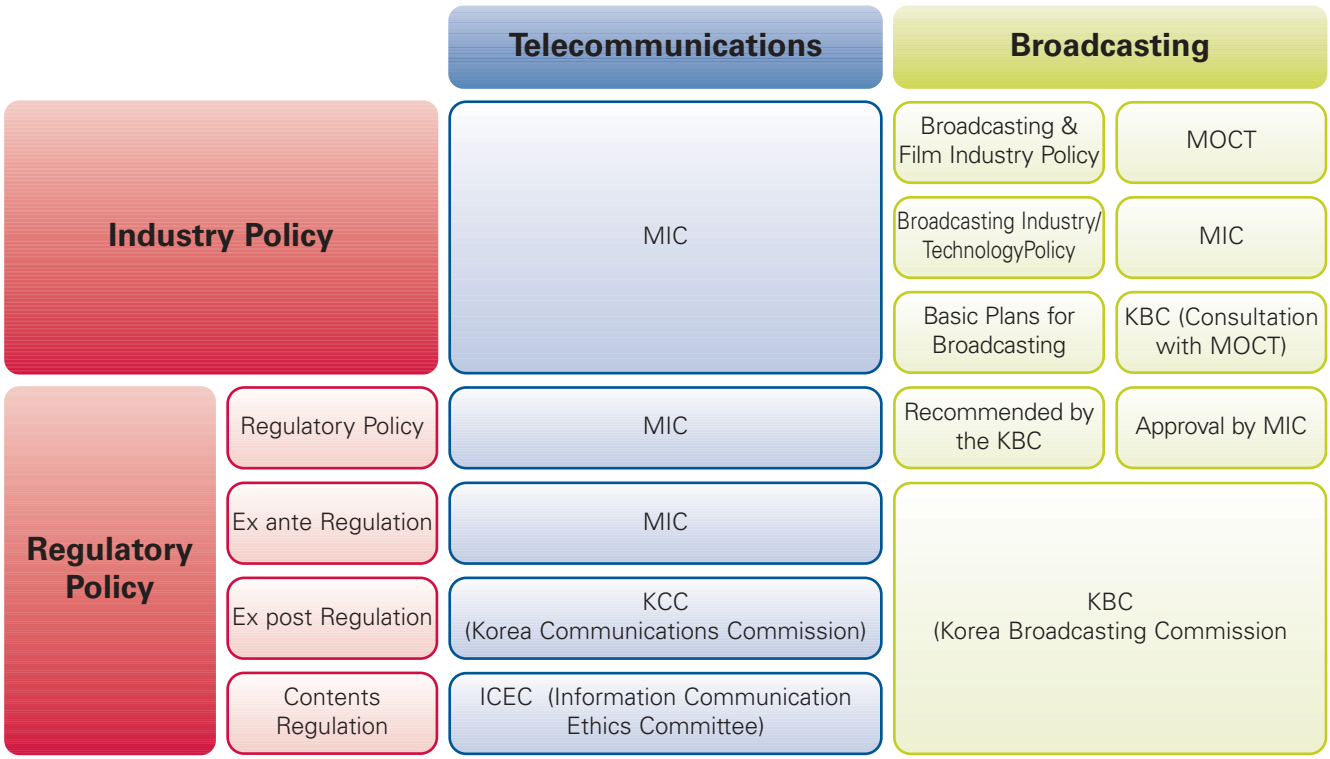

Exhibit 1.9 *Korean regulatory framework*

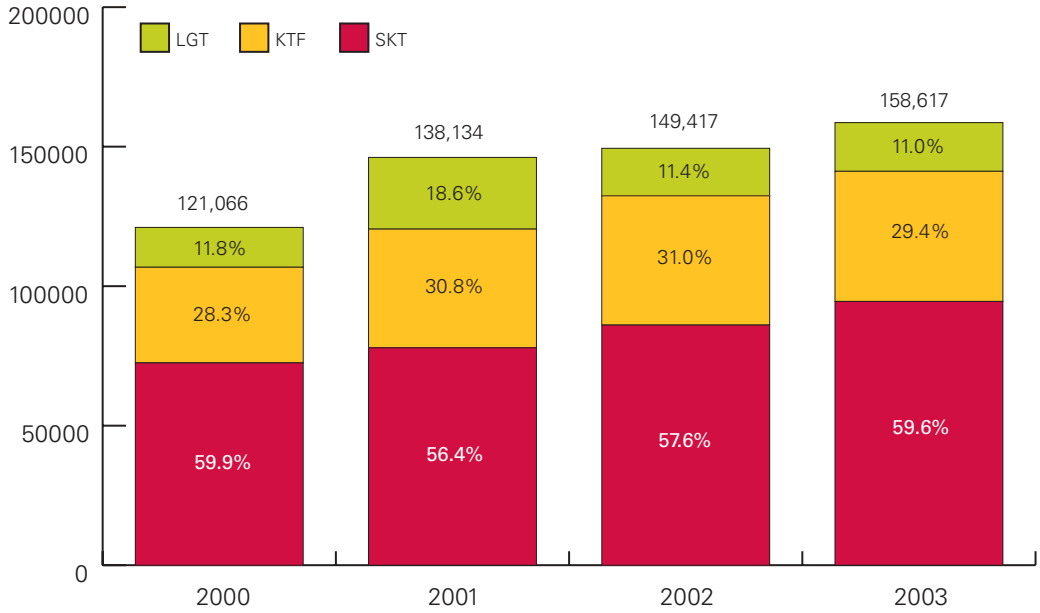

Exhibit 1.10 *Korean mobile market conditions (in 100 million won, 2003)*

1.5.2 Regulation

The key driver for telecoms regulatory policy is to increase market competition, to address concerns regarding KT's 96% dominance in fixed local telephony and 50% dominance in broadband, and SKT's 50% dominance in mobile.

To attract new revenues as Korea has reached market saturation in broadband and mobile communications, innovative and competitively-priced services are being introduced by MIC and industry, such as the world's first commercial mobile broadcast TV service – DMB, Digital Multimedia Broadcasting. Today, voice still accounts for up to 70% of mobile usage, and internet attracts 70% of fixed broadband revenue, with P2P becoming an increasing issue for MIC.

Mobile communications

In the past four years, SKT has maintained 50% market share of the mobile space, being first to market with 3G video services over their rivals KTF (part of the KT group of companies) and LGT (subsidiary of LG group) who compete for the remaining market share (number 2 and 3 mobile players, respectively). SKT hold the 800 MHz frequency spectrum, whereas KTF and LGT operate in the 1,800 MHz PCS band. To address SKT's market dominance, MIC has introduced two key policies. The first of these relates to mobile number portability, and the second to spectrum charging.

Number portability is being introduced in a phased manner, such that the operators have been permitted to have numbers ported onto their networks sooner if they have lesser market share. This means that, as the dominant player, SKT has been prevented from providing number portability onto its network until its competitors have number portability already established. Since this was introduced in January 2004, SKT's market share has dropped slightly – a few percentage points. Mobile number portability is also claimed to have helped accelerate the growth of 3G subscribers.

The second policy which MIC has adopted is to discriminate spectrum usage fees in favour of SKT's competitors (in a ratio of 1:0.7).

MIC is also reviewing the MVNO (mobile virtual network operator) position as an option to enhance competition to SKT.

Broadband fixed networks

The Korean government has overseen the successful rollout of broadband, and are keen that Korea should maintain its world lead in broadband use, particularly in the convergence of broadcast/data networks. The government programme to accelerate broadband has achieved over 70% population penetration. Current new subscriber minimum data rates are 20 Mb/s, with typical residential consumers taking the 50 Mb/s VDSL offering. Further improvements in service capability are anticipated, with deployment of 100+ Mb/s fibre to the home (FTTH) imminent.

The fixed broadband market is showing signs of effective competition, but there are concerns of KT's dominance in the future. KT dominates local telephony (96%) due to control of the local loop; for this reason, KT are being required to provide local loop unbundling (LLU). Cable TV operators are just starting to compete with an internet service offering. To encourage fair competition, MIC is reclassifying the broadband internet access service from a value-added service to a basic service for market-dominant players, such as KT.

Convergence of telecoms and broadcasting

Digital terrestrial TV has a clear role on the roadmap for IT 839. The goal for 2004 was to resolve the selection of technical standard; this has now been done by MIC – Korea will adopt the American, not European, standard. The government is also creating the legal and regulatory framework to permit broadcast and telecom convergence – see Exhibit 1.12. For example, KT will offer IP-TV over the broadband IP network (ADSL based).

1.5.3 Spectrum management

Organisation

MIC's spectrum management organisation is shown in Exhibit 1.13.

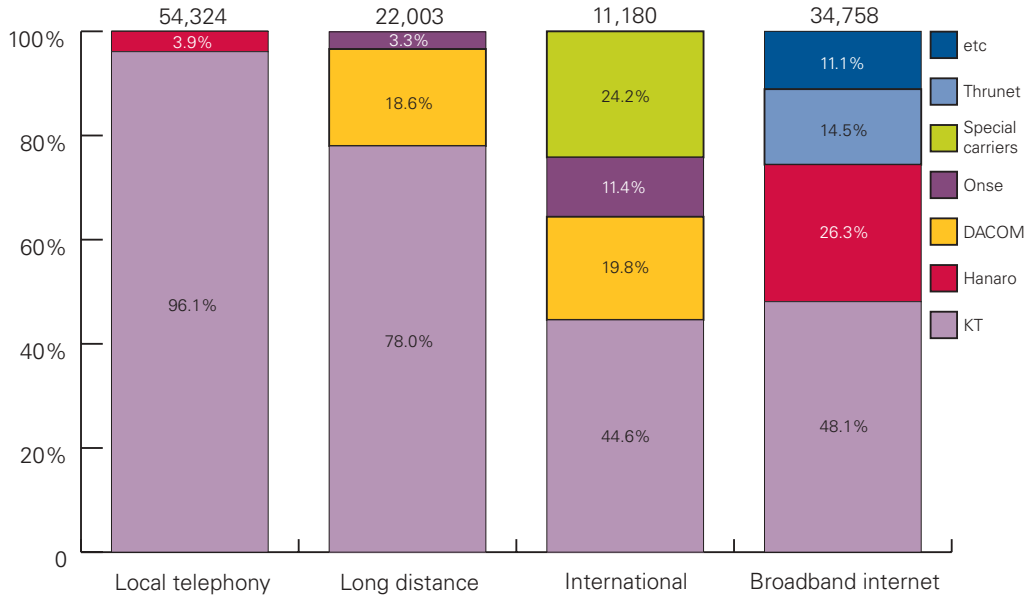

Exhibit 1.11 *Korean fixed market conditions (in 100 million won, 2003)*

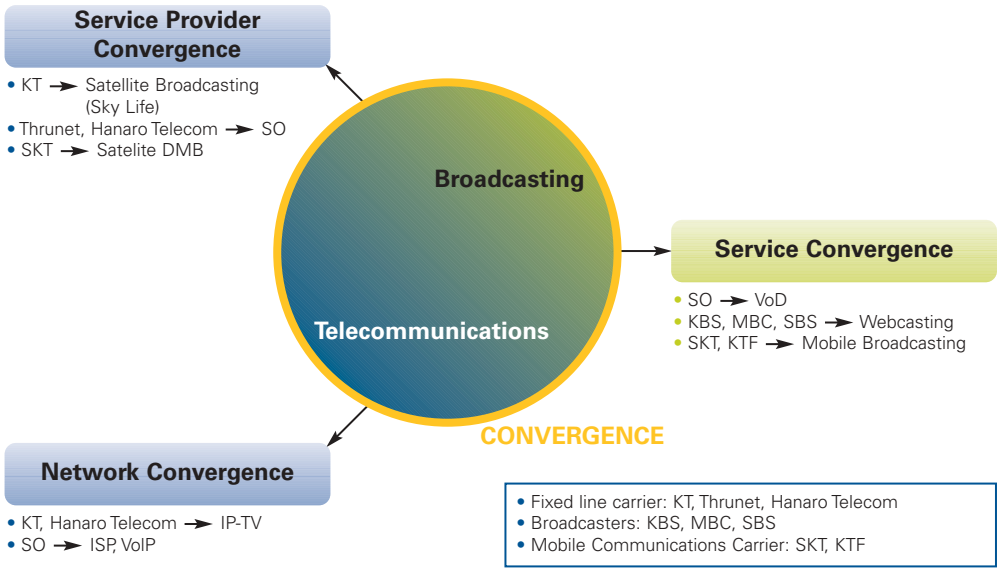

Exhibit 1.12 *Broadcast/telecoms convergence: business landscape*

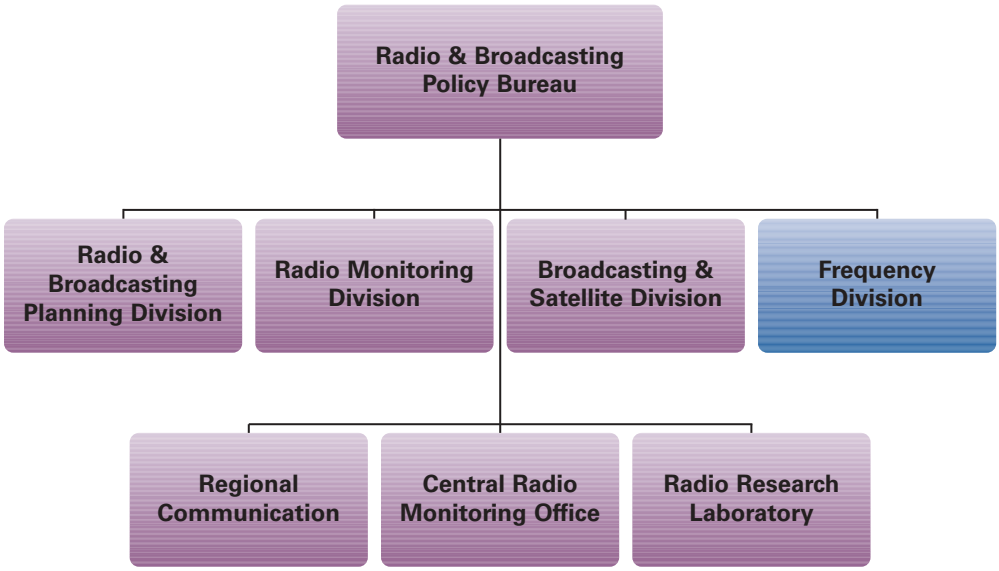

Exhibit 1.13 *MIC spectrum management organisation*

Service	Frequency (MHz)			Operators	Subscribers (m)
	Mobile Tx	Base-station Tx	Bandwidth		
Cellular	824-849	896-894	2 x 25	1	17.85
PCS	1750-1780	1840-1870	2 x 30	2	15.31
IMT2000	1920-1980	2110-2170	2 x 60	3	
Trunked radio	371.5-381.5 806-821	389.5-399.5 851-866	2 x 10 2 x 15	6 (5 ROs)	192
Wireless data	898-900	938-940	2 x 2	3	84
Paging		161.2-168.975 322-328.6	7.775 6.6	4 (3 ROs)	17
Broadband WLL	24250-24750	25500-26700	500/1200	3	

Exhibit 1.14 *Spectrum for telecoms services*

Current major spectrum allocations for telecom services in Korea are shown in Exhibit 1.14.

Converging broadcast/telecoms to deliver cheaper mobile TV

To generate revenue from a wider choice of attractive competitively priced multimedia services, MIC has made spectrum available for the trialling of converged mobile/broadcast services (DMB) by SKT to offer cheaper mobile TV to consumers at 450 kb/s. To watch a 90-minute film via VoD over 3G at normal rates would be prohibitively expensive ($900!). The mobile and fixed line operators are awaiting DMB licence approval by MIC, whilst competitors KT and KTF are lobbying against SKT due to the potential for market dominance.

Personalised wireless broadband

As a further approach to offering cost-effective personalised mobile multimedia (VoD), KT have been allowed the use of spectrum for its commercial wireless LAN service, NESPOT, again discussed earlier. This is regarded by some as a stepping stone for mobility services.

Spectrum at 2.3 GHz has recently been designated by MIC for use for the WiBro service, and licensing is anticipated late 2004/early 2005. WiBro is positioned as an intermediate air interface technology between cellular and broadband xDSL wireless systems[19]. Naturally, fixed line operators see this as a favourable approach to convergence, while mobile operators see WiBro as an unnecessary technology that could potentially hinder incremental enhancements to current air interfaces (a cheaper alternative for them). KT would like to offer CDMA/WiBro terminals, whilst mobile operators believe such terminals could potentially undermine their 3G offerings (for which they paid $1 billion licence fees). MIC are currently assessing options for their licensing strategy in an attempt to identify an approach that will ensure commercial success (in the interests of industry promotion) whilst taking into account concerns over the market dominance of KT and SKT (in the interests of regulation).

Ubiquitous home – RFID and WLAN

Korea plans to provide the next generation 'digital lifestyle' to 0.5 million homes by 2005, combining home networks and devices allowing remote control of ubiquitous home services using the mobile phone – for example, programming the video recorder or setting the washing to start. In preparation for the ubiquitous society, MIC is planning new spectrum allocations, to be available by end 2004, for:

19 In effect, a form of cellular xDSL.

- RFID (band 908.5-914 MHz)
- WLAN (5 GHz), effectively promoting IEEE 802.11a

Such action is indicative of the Korean government coordination of industrial and spectrum management policies.

Ultra-wideband (UWB)

Spectrum requirements for UWB are under consideration, with a study on emission limits started in 2003. No speculations on the likely outcome were indicated.

Spectrum and standards for 4G

In order not to be left behind, as in the early days of the 3G system definition and standardisation, and also to build upon its leading edge in broadband technology and deployment, MIC has been keen to ensure that Korea plays a very active part in ITU-R's 'Beyond 3G' standardisation activity. This activity has a dual focus of spectrum requirements and eventual standardisation.

MIC financially sponsors research programmes (mainly at ETRI) that form the basis of Korea's inputs to the ITU process. The outcomes from this research will also provide quantitative evidence to MIC, to support Korea's submissions to the ITU WRC 2007 conference discussions on spectrum requirements for 4G. MIC supports a wide ranging research activity at ETRI aimed at evolving the 4G converged technologies. For realising 4G mobile communications, ETRI is focusing on the development of core technologies, the acquisition of international standardisation IPR, and joint R&D with industry, as discussed earlier in Section 1.2.

ETRI also provide leadership for the Next-Generation Mobile Communication (NGMC) Forum, the creation of which was encouraged by MIC. The NGMC Forum provides a coordinating mechanism across industry and government and has the following objectives:

- Coordination and exchange of information with foreign 'B3G/4G' research activities (eg WWRF, mITF, FuTURE, Mobile VCE)
- Collection of NGMC member companies' opinions through holding industry seminars, workshops, etc
- Interfacing between MIC's 'Next Generation Frequency Research' spectrum team and NGMC member companies

Key interrelationships are shown in Exhibit 1.15.

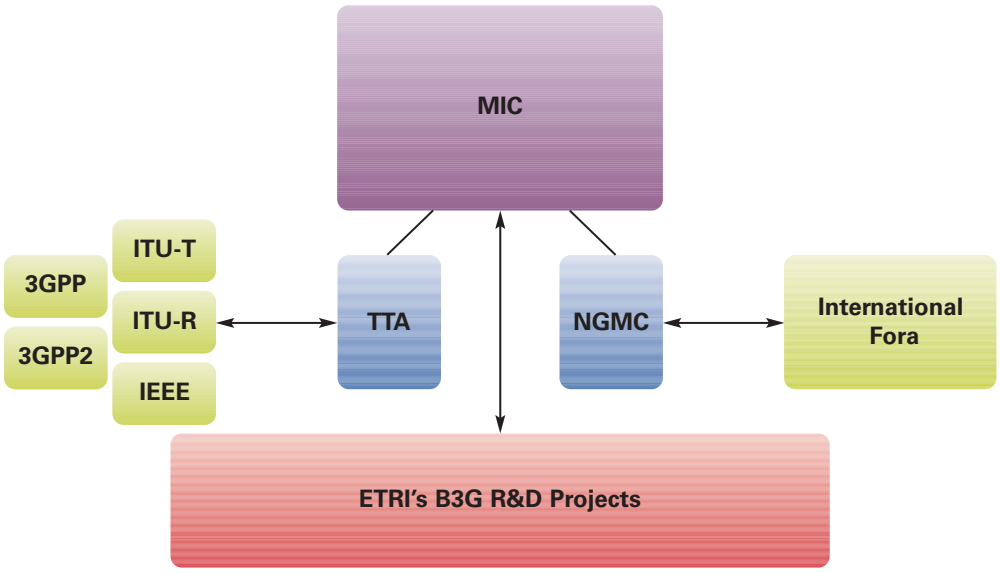

Exhibit 1.15 *Interrelationships between MIC, the NGMC Forum and other bodies*

The Spectrum Working Party within the NGMC Forum has built extensive experience in calculating spectrum requirements for wireless communication services supporting MIC's own spectrum management staff. Its past contributions include a method for calculation of frequency for WLAN in Korea (ITU-R M.1651, WLAN Method for Frequency Calculation) and a method for calculation of frequency for WiBro (based on ITU-R M.1390 and M.1651).

The NGMC Forum's Spectrum Working Party is charged with defining the spectrum allocation for beyond 3G, and the calculation of spectrum requirements for beyond 3G services. It intends to develop these spectrum requirements by 2005. This activity will feed into the ITU-R Working Party 8F work and into national preparations for WRC 2007 – see Exhibit 1.16.

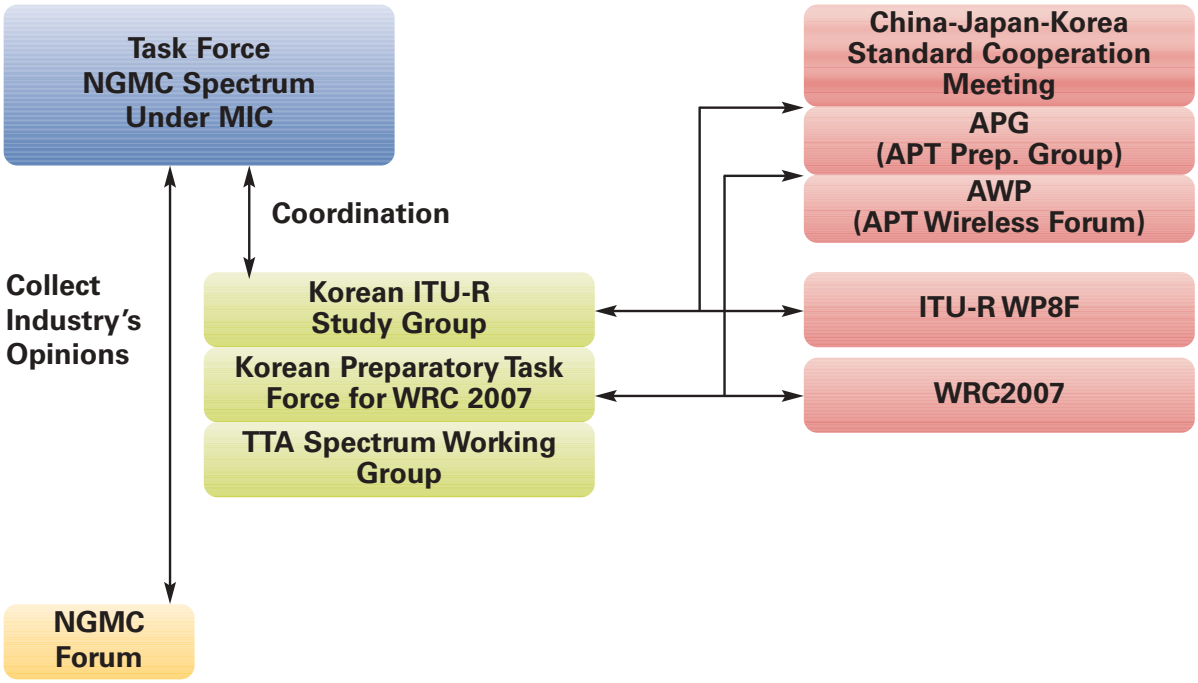

Exhibit 1.16 *Korean bodies involved in spectrum planning and preparations for WRC 2007*

1.6 Industry ecosystem in Korea

1.6.1 National industrial priorities

Korea acknowledges the central importance of telecommunications to its domestic IT agenda and its aspirations for export growth in future global trade. It has evolved effective and close methods of working, encompassing regulation, telecom operators, indigenous equipment manufacturers, the state research organisation and academic institutions which supports these aspirations in a very tangible and successful manner.

Korea has seen demonstrable success, evidenced by the current leadership position enjoyed by the country in both mobile and fixed line services and by its massive export revenues. It is clear that the system is capable of addressing both internal IT and export growth, to the degree that Korea markets itself as a showcase for services and products.

This is not to say that government, operators, vendors etc are in total agreement on all issues – far from it. However, despite their (at times profound) differences, an overriding commitment exists to effectively plan and work together towards a common national good that pays dividends for both industry and government.

The in-country market for telecommunications is based upon a population of 48 million people, many of whom seem willing and able to take up new IT services, both from a fixed and wireless perspective. The market for both fixed and mobile operators seems buoyant, although saturation of existing services in key markets is evident. The response to this is to actively seek new services to drive future growth.

During its week in Korea, it quickly became apparent to the mission team that this response was coordinated industry-wide, and created in anticipation of such developments rather than with hindsight. What was in operation was an effective industry ecosystem, which plays a key role in addressing the next evolutionary step in both Korean and global markets.

The fact that it has been possible for MIC to create a detailed strategic initiative such as IT 839, with explicit public/private financial commitment over the next five years, is a remarkable achievement. The mutually constructive interplay between the Korean telecommunications industry and the government ensures not only an effective provision of advanced communications services to the country but also serves as a sales reference model stimulating exports and national economic growth. The elements, linkages and interactions within this network are described below.

1.6.2 Key elements

Governmental factors

- *Policy integration* – MIC has prime responsibility for the telecommunications environment in terms of industrial policy, regulation, spectrum allocation and future evolution and has worked to develop an integrated set of policies across these areas.

- *Experienced leadership* – The Minister responsible for MIC, Dr Chin Daeje, is understood to have previously held a senior executive position in one of the in-country equipment vendors, hence has a thorough understanding of the industry; the previous Minister is now President of the NGMC Forum.

- *Openness to new ideas* – The mission team saw clear evidence that MIC was proactive both within Korea and actively looking for fresh ideas on a global basis; they were keen to understand the UK and

European perspective on issues. As a measure of this, they expressed interest in the team's views on the exploitation of WiBro and regulation for future telecommunications services.

- *Motivation* – MIC clearly seeks to drive and lead in the telecommunications market. Measures of this are the 'Ubiquitous Dream House' exhibition facility, hosted in central Seoul with strong support from a number of equipment vendors, and promotional videos available on MIC's website.

- *Funding* – MIC funding for 4G research in 2004 is £8.5 million[20]. Of this, 15.5 billion won (£7.4 million) is directed to ETRI, and 2.4 billion won (£1.14 million) to three universities: Seoul National University, Information and Communication University, and Hanyang University.

State research bodies

- *ETRI* – The Electronics and Telecommunications Research Institute (ETRI) is a state research organisation which has a prime focus upon telecommunications futures. Founded in 1976, it currently employs 2,300 people, with mobile communications being a major element of its activity.

- *ETRI linkages* – ETRI takes its directional lead from MIC, but also works on a contractual basis with equipment vendors and links into the academic structure in Korea. The outputs from ETRI are via a number of streams including IPR licensing and spin-out companies. ETRI claim to have spun out ~200 companies to date, but with little recent activity (only 1 start-up in the last year), said to be due to the state of the worldwide ventures market.

Telecommunications operators

- *Mobile operators* – The mission team met with SKT (the market leader) and KTF. Their views on future evolution of the industry demonstrated a strong linkage into the ecosystem, but clearly with a view on growing their domestic revenues.

- *Fixed operators* – KT recognised the need to work with all parties in the ecosystem, but expressed a strong commercially-driven need to develop their products and services independent of the needs of other factors in the system. Typical of this was the drive to push forward with the high-speed internet service (WiBro) evolution, an activity which will bring conflict with mobile operators' own aspirations for future growth.

Prime equipment vendors

- *Wide perspectives* – The mission team saw clear examples of the key indigenious equipment/solutions vendors working proactively with all elements in the ecosystem. Examples of this were: Samsung who are taking the lead role in equipment development for the Korean WiBro activity; LGE who showed the drive towards new mobile terminals and network architecture thinking around the fixed/mobile convergence space; as well as some SMEs who recognised both the in-country and global context of their activities.

Academia

- *Wide linkage* – The team had limited opportunity to visit universities in Korea, but what was seen demonstrated creative thinking based upon the premise of national and international growth. Linkage into the national ecosystem and into a

20 This figure, provided by MIC, is less than the ~£12.5 million cited for 2004 in the IT Korea Journal. It does not include other lines of government funding for mobile communications listed therein.

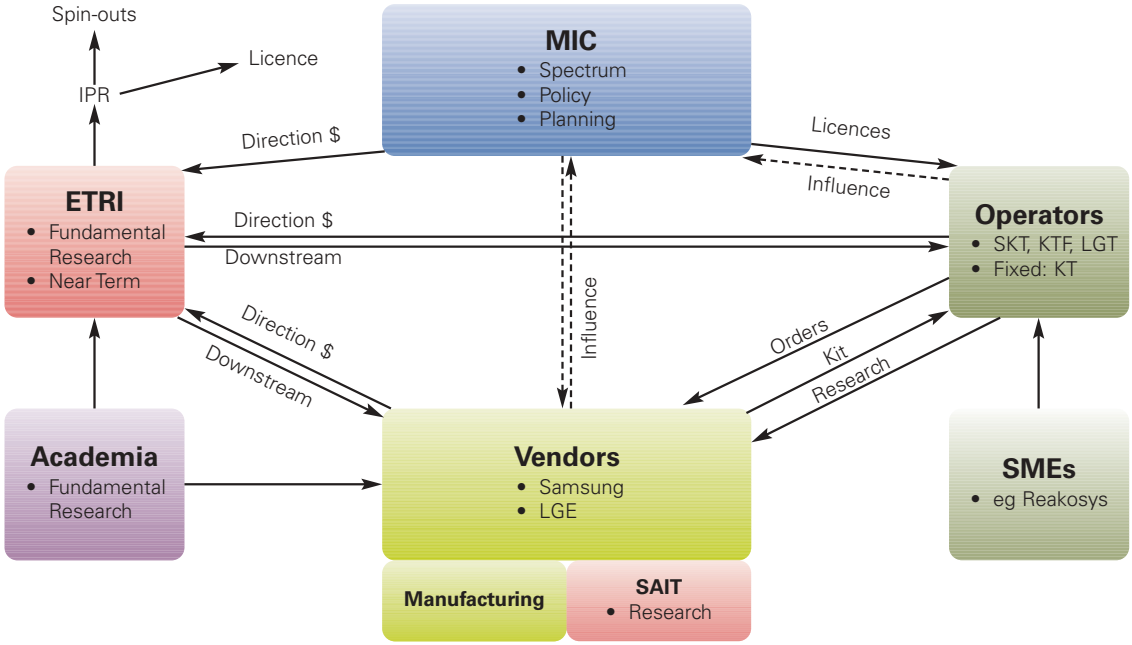

Exhibit 1.17 *Korean telecoms ecosystem*

global network of knowledge and ongoing research was evident. The team met academics who had returned from working in the USA and Japan, bringing insights from these environments into the Korean industrial system.

1.6.3 Interactions

Exhibit 1.17 depicts a simplified approximation to the Korean industry ecosystem as assessed by the mission team. Whilst not all of the linkages are formal, many are, and all elements seem to interact to drive the telecommunications evolution in Korea; during the visits to the representative organisations it was possible to see the linkages and interactions. In respect of future mobile evolution, a strong sense of common agreement was in place – albeit with varied views, even within a single company, on how short-term market initiatives (such as NESPOT and WiBro) might pan out.

A good balance between a state-controlled and -defined evolution strategy and the views of the other participating elements (operators, vendors, etc) seemed to exist. The recognition and relevance to both national and global markets suggested to the mission team that the system appeared to be sustainable in the longer term.

Korean telecommunications ecosystem	
Objectives	• Global/National economic growth • Drive Korean telecoms services • Korea as a global sales reference model
Outputs	• Single future vision • Funding for R&D • Early technology lead • National market creation • Market capture
Competitive market	• Operators: – Service differentiation • Manufacturers: – Product/price/timetable

Exhibit 1.18 *Korean telecoms ecosystem – main objectives, outputs and market issues*

2 CHINA

2.0 Contents

2.1 China: national context

2.1.1 People and geography

The People's Republic of China is the most populous country on earth, with a population of ~1.3 billion and an area of 9,600,000 km^2. The difference of scale between China and Korea or the UK is one key factor in shaping the Chinese perspective on future evolution of the mobile communications industry and the associated technology and standards.

Exhibit 2.1 *Map of China*

The distribution of wealth and power in China is far from even, with major west-east differences. Even in the well-developed regions visited by the mission team – Beijing, Shanghai and Shenzhen – the differences were very evident.

Beijing has historically been, and remains, the centre of political power and influence. Policy is set in Beijing and it is home to the headquarters of the telecommunications operators and government ministries and agencies. Beijing, as a city even, seems to reflect something of a sense of restraint and conservatism.

By contrast, Shanghai is a city with a dynamic atmosphere of growth, in every way reflecting its entrepreneurial past and embracing of the market economy.

In the south of the country, just across the Shenzhen River from the Hong Kong border, lies the city of Shenzhen and its Special Economic Zone, an industrial region with a population of 'new immigrants' and an average age under 30. A major manufacturing region, Shenzhen again is quite different from the other two cities.

2.1.2 National development

The development of the Chinese economy has been much in the news during 2004, as the media has recognised and publicised its rapid economic growth of the past few years; the sources of this growth can be traced to major changes in the country over the past two decades.

The Chinese leadership began to move the economy from a sluggish, centrally planned, structure towards a more market-oriented approach as far back as 1978. Whereas the system operates within a political framework of formal central control, the economic influence of non-state organisations and individual citizens has been steadily increasing since that time. The authorities have: switched to a system of household and village responsibility in agriculture in place of the old collectivisation; increased the authority of local officials and plant managers in industry; permitted a wide variety of small-scale enterprise in services and light manufacturing; and increasingly opened the economy to growing foreign trade and investment.

The result has been a quadrupling of GDP since 1978. In 2002, with 1.3 billion people but a GDP of just $4,600 per capita, China stood as the second largest economy in the world after the USA (measured on a purchasing power parity basis). Agriculture and industry have posted major gains, especially in coastal areas near Hong Kong and opposite Taiwan, regions where foreign investment has helped spur output of both domestic and export goods.

On the darker side, China's evolving hybrid system has at times experienced the worst results of both socialism (bureaucracy and lassitude) and capitalism (windfall gains and growing income disparities). Beijing has thus periodically backtracked, retightening central controls at intervals. The government has struggled to collect revenues due from provinces, businesses and individuals; to reduce corruption and other economic crimes; and to keep afloat the large state-owned enterprises, many of which had been shielded from competition by subsidies and had been losing the ability to pay full wages and pensions.

Between 80-120 million surplus rural workers are estimated to be adrift between the villages and the cities, many subsisting through part-time low-paying jobs. Popular resistance, changes in central policy, and loss of authority by rural cadres have weakened China's population control programme, which is seen as essential to maintaining long-term growth in living standards.

Another long-term threat to growth is the deterioration in the environment, notably air pollution, soil erosion and the steady fall of the water table, especially in the north. China continues to lose arable land because of erosion and economic development. Beijing will intensify efforts to stimulate growth through spending on infrastructure – such as water control and power grids – and poverty relief, as well as through rural tax reform aimed at eliminating arbitrary local levies on farmers.

Access to the World Trade Organisation (WTO) strengthens China's ability to maintain sturdy growth rates, and at the same time puts additional pressure on the hybrid system of strong political controls and growing market influences. Beijing has claimed 8% annual growth in recent years, although many observers believe the rate, while strong, is more like 5%. Concerns over the risk of the economy overheating, and China's impact on raw material prices on the world market, however, have caused the leadership to take steps to restrict growth in recent months.

2.1.3 Economy and IT

In 2003, China's electronic information products industry realised a sales income of $223 billion, up 34% from the previous year, becoming China's number one industry and ranking third in the world in terms of industrial scale.

In telecommunications, China's (ongoing) transition from a centrally-planned socialist state towards a market-based economy has manifested itself in the introduction of competition in telecommunications service provision and manufacture. Recent economic growth, perhaps unsurprisingly, has coincided with a rapid and major growth in telecommunications provision. ITU estimates of teledensity in China in 1990 were 1%; by early 2004 this figure was close to 40%, as the total number of exchange lines was close to 600 million. The advent and rollout of mobile cellular systems played an important role in this, with the number of mobile lines in China today exceeding that of fixed lines.

Alongside the growth of mobile communications, China has also recognised the importance of broadband access and has

taken steps to accelerate its deployment and take-up. Broadband subscribers in China have now overtaken South Korea in terms of absolute numbers, and China is now second to the USA in numbers of internet users (growth of 300% per year). Household penetration in China is of course low, estimated by IDC as below 3% in 2003.

As part of its national strategy to develop its IT and IT industry, China has formally linked with Korea and Japan to promote North East Asia as an IT hub[1]. At the Second Korea-China-Japan IT Minister's Meeting in September 2003, the ministers signed an agreement to collaborate on R&D in seven key IT fields, viz:

- Next-generation mobile communication
- Internet
- Open-source software
- Digital TV
- Broadcasting
- Telecommunication network security
- Information protection

The growth of the Chinese telecoms market, both fixed and mobile, has facilitated rapid growth opportunities for indigenous manufacturers such as Huawei[2] and ZTE[3], whilst the opening up of China to the international stage has facilitated opportunities for export and international expansion.

2.1.4 Wired and wireless telecommunications

Telecommunications provision in China was for many decades a centrally planned monopoly, administered by regional/provincial networks; it was only within the last few years that competition was introduced. Today, in the wired arena, China Netcom and China Telecom are the two major providers; China Unicom also has a wireline network, as well as being one of the two mobile operators, alongside China Mobile. Two other notable, smaller, operators are China Railcom and China Satcom. The introduction of competition and other factors that have stimulated market growth over the past few years have created enormous opportunities and logistical challenges for these companies. With the growth of broadband and the advent of VoIP such challenges look set to continue.

On the wireless front, whilst mobile communications has played an important role in the country's recent economic development, this has been built upon 2G, primarily GSM, networks. In marked contrast to Korea, China has yet to award licences for or to deploy commercial 3G networks. This reflects the fact that China constitutes a much larger, more economically diverse, and less affluent, country; as such, the mobile market is less developed.

China Mobile and China Unicom have deployed both of the major 2G technologies, GSM and CDMA IS-95. In both cases, the number of subscribers involved is staggering. China Mobile, which operates a GSM network, has subscriber figures of 188 million (end July 2004); China Unicom, which operates both GSM and CDMA networks, has subscriber figures of 83 million and 25 million respectively. The competitive situation in mobile may, however, change with the advent of 3G, in that it is widely anticipated that today's fixed telecom operators may also receive 3G licences. Fixed line operators China Telecom and China Netcom are keen to offer mobile access, and this has led them already to deploy the Personal Access System (PAS), a wireless access system based on the Japanese Personal Handyphone System (PHS) technology, offering short-range limited

1 Press release from Korea's MIC, 8 September 2003, 'Korea, China and Japan Agree to Boost Regional IT Cooperation', www.korea.net/News/News/NewsView.asp?serial_no=5821

2 Huawei's international turnover grew from US$50 million in 1999 to US$1 billion in 2003.

3 ZTE's total turnover grew from US$0.5 billion in 1998 to US$3 billion in 2003.

mobility. Compared with cellular, PAS offers lesser performance, but lower usage costs, with the result that some cellular users also have PAS handsets.

Currently, China's 2G mobile subscribers, at ~300 million, exceed the number of fixed line subscribers. According to several forecasts cited during the mission team's time in China, mobile subscriber numbers will peak in about five years time at (conservatively) 500 million; this leaves substantial opportunity for market growth over the next few years.

The belief in China is that perhaps as many as ~850 million people may fall into the category of not being able to afford, or benefit from, a mobile phone. Saturation market size could, however, exceed 500 million as the size of this non-addressable segment will be crucially dependent on the country's economic development, the way that future wealth is shared, and pricing (of both handsets and service).

Three factors are readily apparent as being primary influences on China's approach to developing its mobile communications market and industry:

- *Population* – With such a large population (1.3 billion people), the need to socially plan the benefits of technology (in general) affects the way technologies are being developed and deployed.

- *Culture* – The manner in which wireless technology is being managed still gives the impression of being centrally planned and run.

- *Technology* – China is desperately trying to level the global playing field as far as technology is concerned, and to achieve this they are promoting indigenous technologies internationally in order to gain IPR parity with the international community. An example of this, in terms of 3G, is TD-SCDMA; this same issue is motivating its approach to B3G/4G.

With such factors, and such ongoing 2G market growth, the timing of 3G licensing in China could be significant. There appeared to be a great deal of conservative thought, particularly amongst operators, on the deployment of advanced technology, which contrasts with the government desire to develop the country's technology and IPR. China is in a somewhat dichotomous position, where its government wishes to position it strongly for 4G, which it sees as an important future global market, whilst not yet having decided its timing and approach to deploying 3G.

2.1.5 Context of 3G licensing and deployment

China has recently joined the WTO and is reforming its industries to compete internationally. At present, however, its policies and regulatory methods are still transitioning out of an era that was steeped in central planning and controlled policy execution. There thus remain careful controls in place affecting how technologies can be adopted and deployed in China. Essentially, the Ministry of Information Industry (MII) and its technical assessment arm, CATR (China Academy of Telecommunication Research), must first evaluate the suitability of a technology for deployment[4]. For 3G, this manifests as a two-phase test and assessment process, described later, of the three candidates – WCDMA, CDMA2000 and China's own standard TD-SCDMA technology.

In determining its approach to 3G licensing, the government has stated that its decisions

4 In a sense, if we were to make a comparison from a UK perspective, once type approval for vendor equipment has been obtained, the responsibility for interoperability testing would be the operator's. However, because of China's legacy of central planning, the acceptance of a technology, and therefore its interoperability, is still the responsibility of the Ministry (MII).

will take into account both the outcome of CATR's assessment of the maturity and performance of the technologies, and also its own assessment of market factors.

Technology maturity and interoperability

For a country the size of China, a nationwide deployment of any technology requires a huge investment to correct or rectify problems; post-deployment, such expense can be potentially prohibitive. Therefore, a very cautious approach is being taken that involves protracted testing of vendor equipment.

The reason given for this approach is largely historical. When 2G technologies were deployed, the prior assessment of technologies was not rigorous; because of the perceived lack of forethought, the interoperation between networks was not as good as it could have been. An example of this, cited to the mission team, was the lack of SMS interoperability within China – it took the intervention of MII to resolve this problem. It is to avoid such problems for 3G that a rigorous testing approach is being taken to ensure technology maturity and stable interoperation of equipment from various vendors prior to licensing.

Role of 3G IPR

A further factor influencing the careful approach to 3G licensing is that, with the potentially large size of its 3G market, China needs to negotiate favourable terms for 3G IPR. Some have interpreted the slow pace of 3G licensing as a method of securing improved IPR terms, since no one makes any money on IPR until the equipment is purchased and deployed. Stalling deployment means that IPR revenue streams are delayed; this then may motivate IPR holders to offer more favourable IPR terms rather than hold out and face further delay. The development and testing of the home-grown TD-SCDMA standard has been interpreted by some as evidence of this approach and as a means of justifying the slow pace of decision-making.

Several organisations visited, independently commented on the 'vast size of the country', and it is clear that a major legacy of central planning relating to this is a cultural conservatism, which is reflected in the decision making on 3G. Whilst IPR is undoubtedly a factor, it is not the sole factor.

Discussions with the Chinese operators and manufacturers generated the view of a divided camp on 3G, if the IPR issues cannot be resolved. In one camp there is a strong pro-3G lobby, who wish to see speedy deployment of 3G; while in the opposing camp is an anti-3G lobby who think that 3G should not be deployed and could be bypassed, with some kind of 4G technology deployed at a later date, when China is in a more favourable position, possibly seeing TD-SCDMA evolve in such a direction.

2.1.6 3G technology evaluation trials

Phase I trials

The technical testing for 3G has been divided into two phases. In Phase I (completed September 2003), indoor testing was carried out on vendor equipment for specification and interoperability compliance. The mission team were shown the 3G installations at CATR used for this purpose. This testing was undertaken at the vendors' expense.

Phase II trial organisation and participation

The Phase II field trials (the current phase) began in October 2003 and are being undertaken in three cities – Beijing, Shanghai and Guangzhou; all three technologies are deployed in Beijing and Shanghai, whilst only CDMA2000 and WCDMA are deployed in Guangzhou. For the Phase II trials, the costs of testing are being shared between the vendors and operators.

All the field tests are in the 2 GHz band. For the WCDMA trials, there are currently a maximum of 1,000 handsets per field trial, with a vendor typically supplying a core network, two RNCs, and between four and ten NodeBs; handset providers involved in the field trials are typically providing about 100 handsets each. All the principal Western vendors are participating in the trials; the numbers of equipment vendors for the three technologies are shown in Exhibit 2.2.

	Number of infrastructure suppliers	Number of handset suppliers
WCDMA	12	11
CDMA2000	9	5
TD-SCDMA	4	1[5]

Exhibit 2.2 *China's 3G Phase II technology suppliers*

Phase II objectives and reporting

The Phase II trials include the testing of services and applications (including MMS, Java, WAP, streaming, etc) and the interoperation of these services, as well as network performance tests. The field trials will also refine the final choice of standard, whether it should be R99 or R4. In the current set of testing, R4 infrastructure is being used, but with R99 interface. This is causing some problems, since it is impossible to use R4 for all experiments, and is currently being discussed with the manufacturers. The trials will also, as a by-product, provide operators with experience of live 3G network management.

The trial networks are being tested by both government and operators for performance. However, a general criticism of the field tests is that the numbers of subscriber terminals being used for the field trials will not stress the network, and not really prove network reliability. Indeed, it was suggested by some sectors that a more appropriate number for testing the network would be 10 or 20 million users!

The evaluation testing being undertaken in China is probably the most intensive interoperability testing of 3G in existence, and has naturally attracted much operator attention from abroad. In terms of results, the manufacturers receive relevant results of the tests involving their own equipment. However, the participating operators get to see all of the results. If one takes into account the fear expressed by MII on interoperability issues, then one can see the results as guidance being given to operators on which combination (and ultimately vendor selection) is preferred. All field testing is scheduled to be completed by the end of September 2004, after which a report will be generated and sent to the government and industry.

5 Development of dual mode GSM/TD-SCDMA chipsets has begun in China, and a recent MII press statement (13 July 2004) indicated an expectation that handsets will be available in June 2005 from indigenous handset manufacturers Lenovo, Bird, Hisense and Amoi.

2.2 Wireless technologies

2.2.1 Wireless technology groupings

China's wireless technology may be classified essentially into three groups:

- 'Immediate' deployed technologies, namely GSM, CDMA (IS-95) and PAS
- 'Impending' technology needs which will arrive once the technical assessment of 3G technologies has been completed, and MII grants 3G operating licences; the technologies here are WCDMA, CDMA2000 and TD-SCDMA
- 'Future' evolution; technologies being researched under China's FuTURE[6] 863 research programme (see later, and Appendix I) and elsewhere fall into this category, and are focused towards B3G/4G

The remainder of this section describes the status of China in terms of these three categories of wireless technology.

2.2.2 2G wireless technology

Cellular – GSM and CDMA

The 2G mobile market in China is shared between China Mobile (67%) and China Unicom (33%).

China Mobile's network is based on GSM/GPRS, with data revenues (primarily SMS) having grown from 2.2% in 2001 to almost 10% in 1H2003; 1.1 billion SMS messages were sent in 2003. With a basis of GSM, the logical evolution path for China Mobile would be to WCDMA.

As well as fully-overlaid GSM and CDMA IS-95 networks, China Unicom also operates wired PSTN and broadband networks, including a VoIP network covering 400 cities (the largest in the world). At present, these networks are operated as separate entities. Core network integration is envisaged at some stage in the future, initially between the GSM and CDMA networks, and later extending this to the fixed network (as the network evolves to an NGN). Having a CDMA network, China Unicom in principle could evolve readily to CDMA2000, as operators have done in Korea; however, this network at present only carries about 20% of its subscribers, so such evolution would not be completely straightforward. It could also evolve its (larger) GSM network to WCDMA.

PAS – Personal Access System

As indicated previously, China has contradictory needs. On the one hand, it sees itself as needing to advance technologically and compete on parity with the rest of the technically enabled world; this aim is clearly evident in the way China has promoted and developed TD-SCDMA. On the other hand, China has a massive population of which the majority still live in rural areas. The need to promote technology to accelerate social and economic development in such areas leads to a need for low-cost wireless access – which may include existing, non-leading edge, wireless technologies that can provide voice services to this part of its population.

One such technology is PAS, which is based on the Japanese PHS technology. This is a wireless local loop standard that can provide voice access very cheaply. It has limited mobility and, crucially, also has limited roaming capabilities within deployment areas. Currently, there are around 44 million PAS subscribers, with a growth rate of ~3 million new subscribers per month. Two (fixed line) operators have deployed this technology to date – China Telecom and China Netcom. Both operators offer subsidised handsets and flat fees for PAS services.

6 FuTURE = Future Technologies for Ubiquitous Radio Environment, a 10-year research, technology development and standardisation initiative.

Historically, PAS has not been a favoured technology, and deployment has been restricted to rural areas; PAS services have previously been prevented from being deployed in the major metropolitan areas of Beijing, Shanghai, Guangzhou and Tianjin. However, this regulation has been relaxed, and recently China Telecom and China Netcom have deployed trial networks in Beijing and Tianjin, with new services also being deployed in Guangzhou and Shanghai. Indications from MII suggest that PAS could benefit in the near future should the delays in 3G licensing continue.

Some users of mobile cellular also have subscribed to PAS, to benefit from improved control of usage costs, indicating a potential need for dual-mode PAS/GSM handsets. UTStarcom launched such a PAS/GSM dual-mode handset in March 2004, with Chinese domestic manufacturers announcing similar products shortly after. Domestic vendors such as Jinpeng and Teltron already have similar products trialling, while others such as ZTE and Huawai have announced plans for such products. This trend was also seen among the companies that we visited, where dual-mode PAS/GSM phones were being developed with a targeted unsubsidised retail price of ~$50. Some Chinese operators are willing to subsidise the price of this type of handset in order to fulfil the social and technological needs.

The cost effectiveness of PAS is very attractive for voice services, where the call charges are around half of that for wide area cellular calls. Another recent advance that allows it to compete favourably in China is that PAS handsets can now have interchangeable dial numbers. Previously, PAS handsets had the number burned into the handset; this new development means that the old handset number can be retained when a new handset is purchased. This gives PAS the same flexibility that GSM and CDMA phones possess, by swapping SIM and UIM cards respectively. This point is important, since in China there is no number portability between operators; allowing subscribers to keep the same number when replacing a PAS handset gives the subscriber a valuable reason not to shift to GSM or CDMA.

However, all is not perfect in the PAS world. None of the current PAS operators have GSM licences; therefore, the present utility of the dual mode domestically is questionable from a regulatory perspective; however, this could change.

2.2.3 3G wireless technology

An important contrast with Europe and Korea is the motivation for and approach to 3G in China. In contrast to other countries, China has taken a very steady and methodical approach to the introduction of 3G technology and networks. As explained earlier, this in part has stemmed from how China deployed 2G and the problems that were subsequently encountered. Ironically, these problems were not inherent in the wireless technology per se, but rather the configuration of the systems, which made it difficult to deliver applications in a pan-operator manner[7].

The three wireless technologies being considered for 3G are WCDMA, CDMA2000 and TD-SCDMA; having said this, opinions differ in China as to what actually constitutes 'true 3G'. For example, some see CDMA2000 1x EVDO and EDGE (both classified as 3G) as 2.75G technologies, whereas in Korea, EVDO was at least considered to be a 3.5G technology. The impression gained was that WCDMA is seen as a true 3G technology, and enhancements to that, such as HSDPA and EUDCH, are considered as 3.5G technologies. In part, such views are probably a result of the lengthy testing undertaken of 3G vendor equipment.

7 This is in fact not dissimilar to Korea's 3G experiences which have led to the specification and adoption of WIPI to enable pan-operator delivery of common services.

China still has unused 2G spectrum available in the PCS 1,800 MHz and IS-95 bands to cope with the enormous ongoing subscriber growth; thus, unlike Europe, lack of 2G capacity is not a motivation to move to 3G. From a government perspective, China is in no rush to deploy 3G, a view not entirely shared by industry (both operator and vendor).

In China today, the major application envisaged for 3G systems still seems to be voice – in contrast to Europe, Korea and Japan where there is a prevalent educational emphasis on leading the consumer to use more datacentric wireless internet applications. Possibly such an emphasis will emerge, post-3G-licensing – perhaps with an emphasis on 'exciting applications' to demonstrate to coincide with the Beijing Olympics in 2008.

Current position of TD-SCDMA

China's conception, development and promotion of the TD-SCDMA technology and standard has been a major investment and achievement, both technically and politically. TD-SCDMA began as part of China's 863 programme (see Appendix I) in the mid-1990s, and the first outdoor mobile call on the system was publicly demonstrated in February 2002. Some five years ago, China had just two external technology partners; this had increased to 20 by 2002, and today many more. The TD-SCDMA Forum[8] was founded in October 2002 with eight members, as the first step to creating the required industry value chain. By mid-2004, the forum membership had reached 420 – 15 director members, 15 senior members and 390 common members drawn from 30 countries and regions; how many of these companies have joined simply to access the China market, however, is unknown.

Datang Mobile was established as a new company in February 2002 to lead the commercialisation of TD-SCDMA; collocated with CATR, Datang Mobile continues to have close state linkages. China has successfully developed significant international partnerships, as well as spreading adoption of the technology within China's own industry. Examples cited to the team were Datang's collaboration with Nortel (seen first hand at the Datang test-bed facility, where the Datang RAN is complemented by Nortel CN equipment), Huawei's JV with Siemens, and various JVs for chipset development for terminals in Beijing (Philips, Samsung) and in Shanghai (Nokia, Texas Instruments). In August 2004, MII announced the award of $85 million to companies commercialising TD-SCDMA, including Datang, Huawei and ZTE[9]. The goal for full commercialisation of TD-SCDMA products is stated as mid-2005.

While TD-SCDMA technology is less mature than the other two 3G technologies, by perhaps two years, it would seem inevitable that TD-SCDMA will be deployed in China, although not as the only technology. China is promoting the technology abroad, increasingly as a potential complement to WCDMA. In June 2004, the GSM Association (GSMA) and TD-SCDMA Forum signed a formal agreement in which the GSMA committed to assist the international promotion of TD-SCDMA[10]. Further attempts to ally with Europe and WCDMA have recently been reported by the Chinese press[11].

Network convergence

Currently, there are two mobile operators; with the issuing of 3G licences there could be several more operators offering mobile service. Most of the envisaged new mobile operators have some kind of fixed-line

8 See www.tdscdma-forum.org (press releases listed in footnotes 5, 9 and 10 may be found there).

9 'MII allocating US$84.58 million to TD-SCDMA developers', press release, 26 August 2004.

10 'GSMA and TD-SCDMA Forum cooperate on 3G Development', press release, 17 June 2004.

11 'China to Blend Two 3G Standards', SinoCast China IT Watch via Factiva, 1 September 2004.

operation. This raises the natural question of convergence between wireline and wireless networks. Opinion on this appeared divided; some operators cannot see any benefit in doing this (one presumes because they have more immediate needs to address), while others have already thought through how such convergence might happen. The most natural path in convergence from a Chinese perspective is to converge the wireline and wireless networks around an all-IP network.

2.2.4 Future wireless evolution

Different perspectives on B3G/4G

In contrast to current technologies, the Chinese attitude to wireless technologies after 3G is very different. The main point that one notices is that future technology evolutions are seen by some as an unnecessary distraction from the current and imminent problem of moving beyond 2G to 3G; for operators who have yet to deploy 3G, and manufacturers waiting to supply them, this is an understandable pragmatic approach. Future technology evolution was often referred to in China, notably by government and operators, as B3G, rather than 4G, for such reasons.

At the same time, the investigation of new wireless technologies under the government's FuTURE programme is seen as a key part of the national 863 programme (see Appendix I) aimed at allowing China to develop its own technology and IPR and to operate on a par with the rest of the developed world in these respects. However, many in China do recognise that even with its investment into next-generation IPR, its technology adoption policies are likely to result in it being a follower rather than a leading developer of 4G[12].

In terms of timescales for the adoption of 4G technologies, some organisations visited cited this arriving perhaps as far away as 20 years from now. This figure was arrived at by recalling that 3G was first mentioned in the mid 1980s and is only now arriving in China, 20 years later. By contrast, research institutes have a much more aggressive perspective, more consistent with the more optimistic interpretation of the ITU schedule. As with the rest of the world, the definition of 4G in China is diverse, but almost all that the team met anticipated new air interface technology. For guidance in this area, and for possible timelines, most organisations met deferred to the definitions being proffered by the ITU 2010 vision.

Shanghai is positioning itself as a centre for 4G research, reflecting both the formation, in July 2003, of the Shanghai Wireless Communications Research Centre, and the cultural dynamism and entrepreneurial approach of this megacity; most major players, both national and international, have research based in Shanghai. Shanghai is acting as host for the 14th ITU-R WP8F meeting in October 2004; alongside this will be held a 'Global Mobile Congress' on 3G and B3G technology endorsed by, and with speakers from, MII, and the launch event of a new '4G Mobile Forum'[13]. These events appear to be a coordinated attempt to strengthen China's position in future mobile standardisation, given its difficult position in having yet to deploy 3G.

Beyond 3G – a role for TD-SCDMA?

The role that TD-SCDMA will play in future evolution will be dependent upon the Chinese government's decisions in respect of 3G licensing; however, it is unlikely that TD-SCDMA will not play a major part in 3G in China. From a wireless technology

12 Whilst this is a pragmatic view, it would be disputed by the more forward-looking research institutes, and indeed, as a policy statement, by the government. Indeed, if 4G timescales were to be accelerated, it is unlikely that China would not respond.

13 www.delson.org/4gmobile/main.htm

perspective, most manufacturers that the team met considered that some of the characteristics of TD-SCDMA, most notably its TDD, smart antenna, distributed management and QoS characteristics, will be important contributions to 4G. Some of these concepts are widely researched in Korea, Europe and Japan as '4G' technology.

Some in China, for this reason, seek to position TD-SCDMA as a '3G+' technology that could form a base for 4G; whilst this perspective is understandable, an alternative view would be that the maturity and implementation of these concepts in TD-SCDMA lags current research on these technologies. The TDD thread of Chinese 4G air interface research appears to be aimed to build on TD-SCDMA.

One university visited outlined plans for an enhanced TDD system capable, for large range multicells, of:

- 30-50 Mb/s
- spectral efficiency 1.5-2.5 b/p/s/Hz
- target Eb/No <0 dB for normal voice

In hotspot areas, the enhanced system would be capable of:

- 40-100 Mb/s peak rate
- spectral efficiency 2-10 b/p/s/Hz
- coverage 15 km
- normal voice capabilities

In more detail, the system was seen as comprising a hybrid of multiple access technologies that employ space-time diversity (MIMO) on both terminal and base stations. The system should be capable of high order modulation (64QAM) and high vehicular speeds. Ideas being investigated in order to achieve the desired cellular bandwidths are cell coordination techniques that lead to a kind of distributed cellular MIMO. Interestingly enough, at each stage of the system descriptions that the team saw, the main application was still voice.

The target date for demonstration of such a system was cited as 2Q2005, with the results of the demonstrator feeding into the 4G standardisation process around 2008.

Beyond 3G – the FuTURE programme

The highest profile B3G research activity in China is the FuTURE programme, sponsored by the Ministry of Science and Technology (MOST) through the 863 programme. FuTURE is a phased 10-year programme

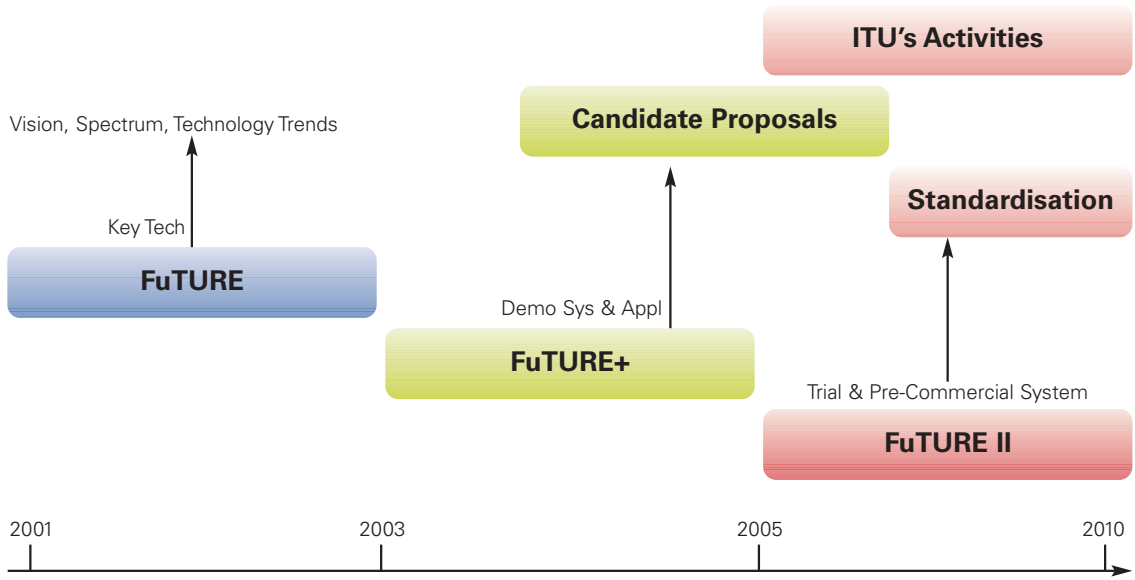

Exhibit 2.3 *China's FuTURE programme phases*

originally approved by MOST in November 2001. The phased nature of the programme is shown in Exhibit 2.3; detail on its organisation and administration is given in Appendix I.

The first phase of FuTURE, 2001-2005, was accorded a budget of RMB 100 million (~€10 million). The main action guidelines were collected from the first round call for participation in December 2001, and were approved by MOST and sent to MII for discussion in June 2002. The second round call for participation was published in July 2002.

The second phase of FuTURE has an overall budget of RMB 1.5 billion (~€150 million) over five years. In terms of wireless technologies, most of the projects are described at a high level, with detail being added in the coming year (2005). The programme has three stages:

- Stage 1 (2005) is to examine critical technologies (OFDM, MIMO, SDR, smart antenna, etc); in terms of wireless access, much like the rest of Asia, it is a new access type, but its use involves service architectures, etc which are not a 'generation thing' per se
- Stage 2 involves cooperation with other 4G fora such as WWRF and relevant fora in Japan, etc; their aim in this phase is to reach a research consensus and then plan the eventual standardisation
- Stage 3 involves producing regional criteria for B3G to ITU to achieve international standardisation

B3G technologies in FuTURE

Within the scope of the FuTURE activity, Exhibit 2.4 lists some of the identified requirements and possible solutions, based on progress to date.

The current project topics under investigation within the FuTURE programme are summarised below (the number in the bracket indicates the number of similar ongoing grants with different approaches):

Requirements	Possible solutions
Sufficient personalised IP addresses	Explore IPv6
Dominant services: packet data	Efficient air-interface, best suited for bursty data
Large dynamic range of data rates from 10 kb/s to 100 Mb/s	Flexible mechanism for radio resource management
High spectrum efficiency	MIMO
Low power transmission and high EMC performance	New cell structures

Exhibit 2.4 *FuTURE programme high-level requirements and possible solutions*

- B3G Radio Access Techniques (6)
- Wireless LAN and AdHoc (2)
- Multiple Antenna Environment (MIMO) and RF (2)
- 3G-based AdHoc (2)
- IPv6 Mobile Core Network (2) joint with other programme
- Generic Techniques for Mobile Communications (16)
- System Structure, Requirements and High Layer Applications (1)

The research on air-interface and wireless transmission approaches is summarised in Exhibit 2.5. As already noted, the specific technologies identified are similar to those found in Korea and researched within Mobile VCE.

The universities and research institutes participating in FuTURE are divided into two groups based on their approach to B3G air interface research, broadly FDD and TDD:

- FDD (Frequency Division Duplex) Group
  - Southeast University
  - Tsinghua University
  - University of Science and Technology of China

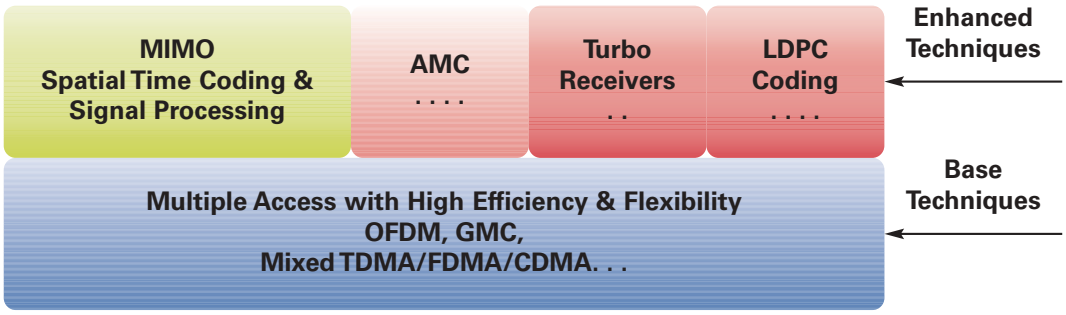

Exhibit 2.5 *Air interface research activities within the FuTURE programme*

- TDD (Time Division Duplex) Group
  - Beijing University of Posts and Telecommunications
  - Huazhong University of Science and Technology
  - University of Electronic Science and Technology of China
  - Shanghai Jiao Tong University

Collaboration opportunities

In the FuTURE+ phase, all the TDD and FDD solutions are to be demonstrated under a set of defined requirements and conditions for fair evaluations, and also in order to focus resources in appropriate directions in future phases. The Shanghai Wireless Communications Research Centre plans to facilitate such hardware/software facilities for lab-tests.

Participations of foreign R&D centres are welcomed in the programme, through joint application with a Chinese partner. The IPR generated would be shared on a fair basis, and additional funding can be provided by the Chinese government for each international cooperation. Funding from foreign governments or research institutions is also encouraged. For such collaborations, an international coordination group would be set up to steer the FuTURE project, once the joint applications are successful.

External influences

As well as its own internal wireless technology initiatives, and in common with other countries, China is also taking into account wider technology developments, such as WiMAX, which could form potential candidate 4G technologies[14]. Also evident was a pragmatic view on how evolution could take place: a progression and subsumption of technologies such as 802.11, 802.16, 802.20 (plus any other air interface that may evolve) into a single common system. However, the main difference here, and this is where it plays to the direction given by the FuTURE programme, is a belief that OFDMA by itself will be insufficient, and that multicarrier OFDM and other derivatives[15] will emerge as the dominant 4G technology.

14 The opinion generally held in China is that WiMAX is a good technology but it is impossible to replace 3G, and that it would, if deployed, account for a small market share of 3G. Hence it is viewed as a 4G technology.

15 For example, CDMA-OFDM combinations similar in nature to the approaches seen in Korea.

2.3 Handset technology

2.3.1 Handset manufacture in China

China has historically been a source of OEM for foreign manufacturers. This has been true of mobile handsets in recent years, as for other products. As the mobile market in China grew, so increasingly local manufacturers and entrepreneurs recognised the opportunity to supply the market under their own local brands. In some cases, this was done in collaboration with major suppliers (eg Ningbo Bird and Siemens) where clear benefits could be seen for both companies. Elsewhere, the know-how for these terminals was sourced from abroad. Indeed, UK technology suppliers such as TTPcom and UbiNetics have benefited from this opportunity at the expense of the global handset suppliers. However, today the situation would appear to be changing fundamentally.

2.3.2 2G handsets

The capability and approach of local Chinese industry to address the current (rapidly growing) 2G handset market is illustrated by Konka, a brand unknown in the UK, except perhaps as a supplier of power drills to certain DIY outlets.

By contrast, in China, Konka is recognised as one of the top 10 brands (across all industries), with major activities in TVs and set-top boxes (18% market share and #1 in the TV market) and in mobile handsets (#3 of the Chinese brands and #5 of all brands). Konka has seen rapid sales growth of what are, by UK standards, attractive and lightweight handset products.

Exhibit 2.6 *Example 2G handset (Konka)*

To compete, Chinese manufacturers have to provide competitive features, functionality and price points, whereas for the internal market there is a need to produce cheap handsets. This was exemplified by one company visited who cited a target retail price of RMB 400-600 ($50), in order to grow the lower end of the local Chinese market. At present, the majority of handsets are sold in relatively affluent metropolitan areas which exhibit the same commercial pressures that we see here in Europe, with handsets replaced every eighteen months to two years; for this market segment, terminal manufacturers are working closely with operator specifications aimed at the higher end of the market.

2.3.3 3G handsets

Whilst there are many companies supplying 2G handsets in China, there are few who have as yet developed a strong capability in 3G. In part, this reflects the continuing uncertainty regarding the Chinese government's decisions regarding choice of technology. Companies focused purely on the local Chinese market have been reluctant to invest significantly in specific 3G handset development until the way ahead is clear.

Chinese companies who have already reached the stage of addressing export markets have, however, taken the step to 3G handsets, recognising the potential size and importance of the global 3G market,

irrespective of the timescales and technology for China's own local evolution.

Huawei's 3G R&D, for example, began in 1998, and has included work on CDMA2000, WCDMA and TD-SCDMA; however, Huawei is a latecomer to handset manufacture. Handset developments include a CDMA2000 1x handset and also a dual-mode GSM/WCDMA handset, the D208, which was tested on Huawei's own pre-commercial WCDMA network in late 2003. Commercial supply of these products is stated as being scheduled for the second half of 2004.

Development of TD-SCDMA handsets is clearly lagging that of the infrastructure, with only a single sourced handset from Datang being available for the present field trials. This is not surprising given the fact that TD-SCDMA development began later than WCDMA and CDMA2000, and that typically handset availability lags infrastructure, as was seen with the introduction of GSM in the 1990s, and more recently with WCDMA.

2.3.4 Encouragement of technology innovation

Building upon initial international collaborations, some manufacturers such as Ningbo Bird and Huawei have in recent years established their own R&D capabilities. Others are looking to the plethora of start-ups and design houses that have emerged to perform R&D for the indigenous manufacturing base. One source gave a conservative estimate of there being around 50 such design houses in China that currently address the terminal industry. From this statement, one can see that in China the focus understandably remains, for the majority of companies, much more on development rather than research; this is particularly so for those without any significant export activity. Many perspectives of '4G' expressed to the mission team whilst in China, compared to those in Korea, reinforced such a less-developed view.

Local start-ups and design houses are addressing everything from terminal design to dual and triple mode chipsets. For example, in order to attain a competitive technical edge, one SME was being sponsored by MOST in the design of chipsets capable of TD-SCDMA, WCDMA, CDMA and GPRS. In some cases, the Chinese Academy of Sciences[16] (CAS) is partnering with certain SMEs and start-ups in order to produce dual mode WCDMA and GPRS dual chips. It is anticipated that this form of government support for technology development will continue, with MOST and CAS assisting technology start-ups to produce the research and innovation necessary in order to close the handset technology gap.

Another example seen was the development of chips for digital terrestrial broadcasting, by a company also working on 3G chips, a combination that could yield technology for convergence terminals that support both cellular and DMB standards, eg for the Korean DMB/cellular handset market. Some of the research results emerging from China's universities, as part of the FuTURE 863 project, are likely to feed through to exploitation in similar fashion, for example in the field of MIMO for handsets.

Clearly, this approach is designed at ensuring that China develops from being just a manufacturer for other people's IPR (although this is profitable, and China is more than willing to do this) to also place itself competitively abroad, where innovative feature sets at low prices are essential.

16 In terms of 4G research, CAS and MOST are two key players responsible for the creation of the Shanghai Wireless Communications Research Centre in July 2003.

2.4 Business models, content, applications

2.4.1 Overview

As is clear from previous sections, the Chinese wireless market is still in the rapid growth stage. What is most striking is the sheer scale of the operation required to:

- Deploy and maintain networks that cover such a vast country of wildly different terrain to support such a huge population
- Provide the customer services effort required in provisioning several million new subscribers per month

Analysts anticipate a new order by China's telecom regulator in the latter part of this year which will clamp down on aggressive discounting; this is expected to slow growth and may also slow churn rates as well – some users have been rapidly moving between networks to gain better deals. However, this does not detract from the high level of management skills and organisation required to successfully operate at such scale; this is discussed in more detail below.

2.4.2 Wireless business model in China

A representation of the wireless business model for the Chinese market is shown in Exhibit 2.7. As previously, each interface supports some form of financial transaction, and again, the service provider and network operator are shown as separate entities to reflect the differing roles, albeit they may reside within the same organisation. The model shown is less complex than that for Korea, reflecting the differing states of the two markets.

However, as described below, in China the major operators in reality comprise a series of subsidiary companies within autonomous provinces, so Exhibit 2.8 may reflect more closely the full reality of the situation.

2.4.3 Market differences

A key difference between the UK wireless market and that in China is the fact that in China no direct handset subsidy normally exists.

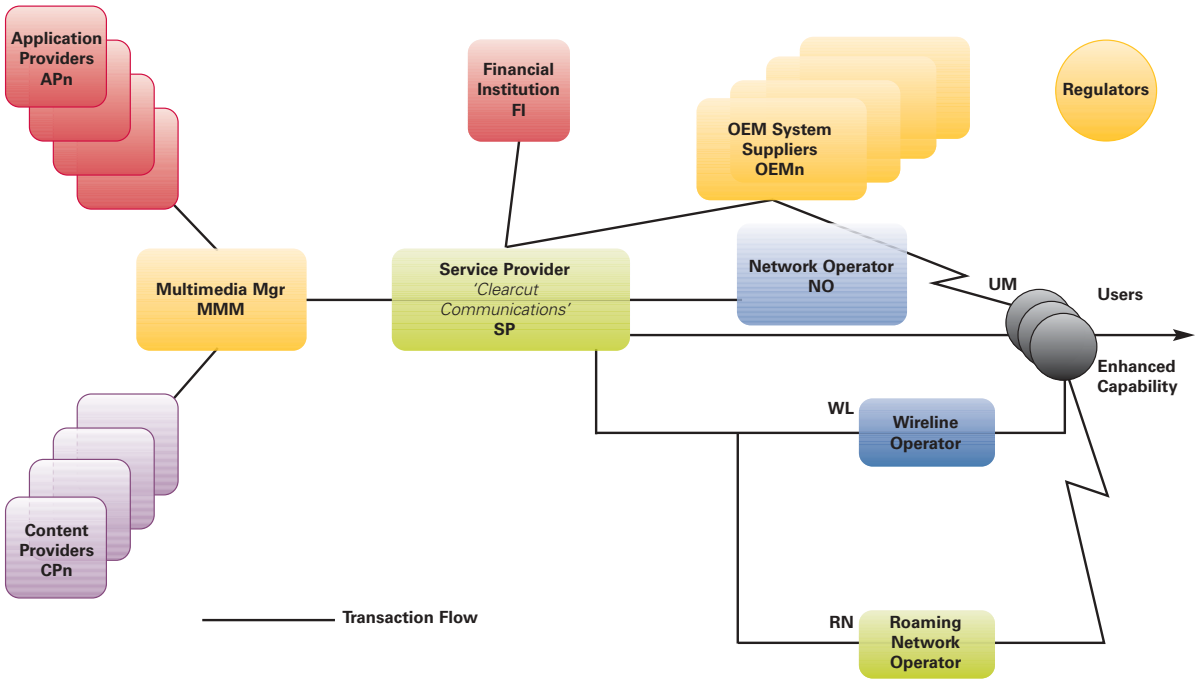

Exhibit 2.7 *Chinese mobile operator business model*

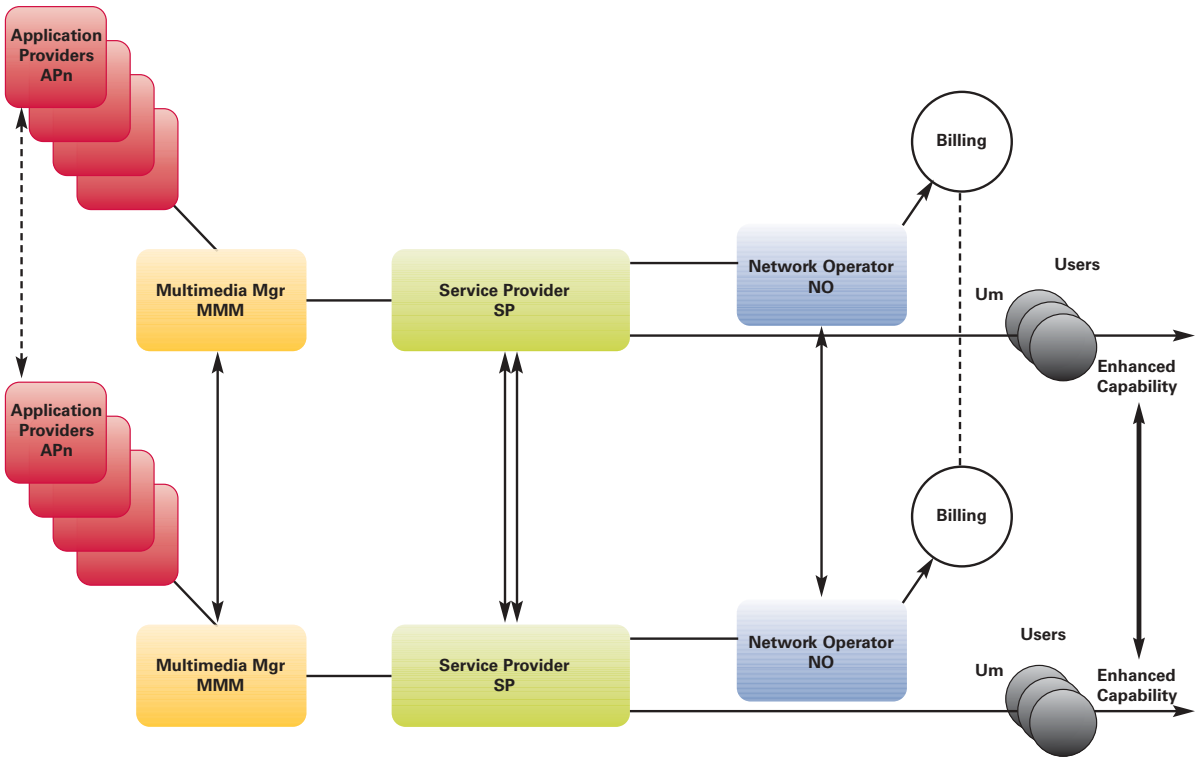

Exhibit 2.8 *China mobile network business interconnection diagram*

A potential subscriber purchases the handset of his choice, without a SIM, at full price from one of the multitude of white goods retail outlets or phone specialists, in a similar manner to the UK. He then goes to the operator of his choice and makes a contract to obtain the SIM. Handset prices in China are similar to those in the shops in the UK; however, this represents a significant purchase when one compares the price to average salaries. Despite the high relative cost, the mobile phone is certainly a 'must have' for the youth market segment.

In terms of the billing model, the Chinese market is more like the markets in the US or Singapore, where the subscriber has to pay not only for making but also receiving a call – 'Called Party Pays'. Although the population of China is some 1.3 billion people, many anticipate that the total number of subscribers will plateau at around 500-600 million as a result of the level of poverty in the outlying regions, precluding people from making the initial investment to purchase the phone and, more importantly, being able to afford the running costs.

It would be interesting to predict how large the potential market might be if the billing model changed to the normal European approach of 'Calling Party Pays'.

It is unlikely that the handset subsidy model as used in the UK during the growth period would be adopted, at least in the short term, since the initial costs borne by the operator (typically recouped over a two-year period) would be prohibitive. However, with the high rate of subscriber growth being achieved at the moment it does not seem to be an issue. Such an approach might be envisaged as the market moves toward saturation, perhaps with government encouragement, motivated by a desire for social inclusion and development.

2.4.4 Network operators

As described previously, there are two main cellular mobile operating companies in China today – China Mobile Communications Corp (China Mobile) and China United Telecommunications Corp (China Unicom). In addition, there are two large fixed network

operators (China Netcom, China Telecom) and two smaller players (China Railcom, China Satcom); it is widely anticipated that five, or even all six, operators may be awarded 3G licences.

CMCC – China Mobile

China Mobile Communications Corp (CMCC, or China Mobile) was officially established in April 2000, and is directly under central government control. It is a key state-owned enterprise (SOE), based on the mobile business that was spun out from the former China Telecom as a result of the reform and restructuring of China's communications industry.

China Mobile has a registered capital of RMB 51.8 billion yuan, assets of over RMB 320 billion yuan, and 120,800 employees. It has wholly-owned subsidiaries in ten provinces (autonomous regions) in China, and fully holds the equity of China Mobile (HK) Group Ltd. China Mobile (HK) Ltd (branded China Mobile), which is the actual network operator, of which China Mobile (HK) Group Ltd is the major shareholder (another notable shareholder being Vodafone), has wholly-owned subsidiaries in 21 provinces (autonomous regions and municipalities directly under the central government) in China, and went public on the Hong Kong and New York stock exchanges.

China Mobile is the world's largest mobile operator by subscriber numbers, reported to have nearly 159 million subscribers at the end of June 2004, after signing up 17 million new customers in the first six months of the year. These figures are based on just the 21 provinces; China Mobile's shareholders have recently approved acquisition of the remaining ten provincial networks from its parent, extending its coverage to all 31 provinces. Including the ten provinces, the company is expected to have a total of 203 million subscribers by the end of the year.

China Mobile operates not only basic mobile voice services but also value-added data services such as IP telephony. It also operates internet services and the international gateways.

CUTC – China Unicom

China United Telecommunications Corp (CUTC, branded China Unicom) was established in July 1994. The birth of China Unicom brought competition into China's telecom market and has been instrumental to the reform and development of the country's telecom industry.

China Unicom has more than 300 subsidiaries across China. It is also the only Chinese telecom operator simultaneously listed on the New York, Hong Kong and Shanghai stock exchanges. China Unicom's successful IPO in Hong Kong and New York in June 2000 raised a total of US$5.65 billion for the company, ranking one of the top 10 IPOs around the world. In October 2002, the company was listed at the Shanghai Stock Exchange as the largest domestic listed company in terms of market capitalisation.

China Unicom has expanded its telecom services offering from GSM mobile phone and wireless paging at the very beginning to both GSM and CDMA mobile phone, long-distance call, local call, data communication (including internet service and IP telephony), value-added telecom service, wireless paging and a variety of related services. They have the largest VoIP network in the world, allowing connection all over the world using a prepaid card with a different access number for each country to allow billing by distance.

China Unicom has some 78 million GSM subscribers, and reached almost 24 million CDMA subscribers at the end of June. China Unicom is the world's third largest wireless communications operator, and second largest CDMA operator.

Competition

Despite being still a predominantly 2G growth market, there exist very high levels of competition in China, and one must not be fooled into thinking that China Mobile and China Unicom are the only wireless players. As described earlier, both China Telecom (one of the biggest fixed-line operators worldwide) and China Netcom have deployed PAS systems as wireless extensions to their fixed-line offerings in major cities at low cost to the subscriber, meaning that it is not uncommon for people to have both a GSM/CDMA phone and a PAS phone which, from a cost perspective, would be their first choice for receiving calls (because of the 'Called Party Pays' billing model). There are also a number of smaller operators offering wireless services, although not on the same scale.

Outward looking

Despite the huge domestic market, it is worth noting that all the wireless companies are internationally focused and, in many cases, working with European partners. For example, China Netcom and Equant China, part of the France Telecom group of companies, have a joint venture to provide international connectivity for the European interests of China Mobile. Similarly, Vodafone have a strategic share ownership of ~3.3% of China Mobile as mentioned earlier.

2.4.5 Services, applications and content

With the high level of competition, there is a drive to differentiate between offerings, and therefore multimedia services are beginning to be deployed into the market. These are nowhere near the levels seen in Korea, as voice is still the dominant application, reflecting the 2G wireless infrastructure. Recently, the number of fixed broadband users in China has for the first time exceeded that in Korea; thus one can envisage that there will be a growth of content providers to meet the expectation of the wireline broadband user. In due course, as 3G networks are deployed, so many of these broadband wireline users may be early adopters of 3G; similarly, the broadband content providers may be expected to begin to service this new market, in the same way as has happened already in Korea. In the meantime, of course, Korean content providers are in a strong position to migrate content for the Chinese market.

The reason for focusing particularly upon China Mobile and China Unicom is that they are structured unusually, and therefore, by necessity, for practical reasons, have a differing approach to the provision of mobile services, applications and content.

China Mobile

China Mobile seeks to deploy unified services across currently 21 subsidiary networks, potentially 31 in the near future; therefore brand marketing is a key factor.

China Mobile has sought to improve the value of the corporate brand by focusing on ensuring a good customer service system and providing innovative services with rich content. In addition, based on market segmentation, China Mobile has also established a number of nationwide household brand names like 'GoTone', 'Shenzhouxing' and 'M-Zone'. 'GoTone' has gained a massive take-up among high-value customers for superior value of service, while innovative brands like 'M-Zone' are welcome in the 'Fun-Love-Youth' group as it is known! This segmentation approach is similar to the approach adopted by SK Telecom in Korea.

Also similar to Korea is the content delivery business model already described in detail. China Mobile has established close partnerships with equipment providers, content providers, system integrators and terminal providers and also with enterprises

in other sectors such as aviation, insurance and banking. The 'Monternet' business model, as it is called, has brought together more than 500 content providers to deliver a diversified range of services to the mobile user over the network.

Whilst the number of content providers is considerably less than, say, that of NTT DoCoMo's i-Mode service in Japan, or the operator portals in Korea, it should be noted that as yet these services are being deployed only on 2G networks, as 3G is still only at a trial stage. The speed and quality of interconnection has been optimised through interconnect agreements signed with other operators, allowing direct network interconnection. The potential for service development when 3G is deployed is clear.

China Unicom

China Unicom chose to deploy a CDMA network as well as a GSM network as a service differentiator, allowing a potential evolution to CDMA-1x.

So far, its GSM network not only offers voice service, but also a variety of value-added services, including Prepay, Mobile VoIP, Voice SMS, Super SMS, Unicom Secretary, Mobile Pager, Mobile Stock Trading, Mobile Banking, etc. Similarly, it also has a wireless internet service brand, 'Uni-Info', providing a wide range of wireless VAS such as hot news, weather forecasts, stock info, foreign exchange rates, railway schedules and flight schedules. Multiple access modes are available under 'Uni-Info', allowing access to both branded services and other non-branded internet content. The '10158 Voice SMS' service gives users an alternative of creating by voice and hearing short messages. The sending of e-mails via the mobile phone without accessing the internet is also a popular service, and is achieved by linking mobile phone numbers to e-mail boxes. A videoconferencing capability is currently offered by China Unicom on their fixed network; however, they are currently doing mobile trials.

GSM-1x 'Worldwind' – The most notable service from China Unicom, which can be regarded as a significant step forward, is its 'Worldwind' dual-mode GSM and CDMA mobile phone service. This was officially launched in Beijing on 5 August 2004 but had been discussed, albeit very briefly, during the mission (at which time it was pre-launch and therefore commercially sensitive).

In the UK, the dual-mode GSM/WCDMA phone is the cornerstone of the 3G UMTS offering, in order to ensure basic nationwide coverage when outside 3G coverage areas; however, worldwide 3G roaming is not likely to appear on the roadmap of product offerings for some time.

By contrast, CDMA IS-95 2G networks[17] are already widespread in some parts of the world, notably Korea and the USA. The 'Worldwind' dual-mode mobile phone service, initiated and developed by China Unicom, offers both an innovative way of offering a '2.5/2.75G' service to its GSM subscribers without additional infrastructure costs, by allowing GSM users to access the high-speed value-added data services of 'U-Max' based on CDMA 1x while retaining their existing mobile numbers, and also enhanced roaming capability on a global basis on current GSM as well as CDMA networks.

Whilst for GSM/WCDMA handsets the USIM provides authentication on both networks, the dual-mode 'Worldwind' phone is equipped with dual sockets and initially two cards, one for each network, which will be inserted at the same time; users access both the CDMA and GSM services by switching between the two networks. The first set of dual-mode handsets offered in the market, all high-end products, includes the Motorola A860,

17 Globally, IS-95 subscribers currently number 212 million, whilst GSM subscribers number 1,300 million.

Samsung SC-W109 and LG W800. However, what was discussed, in both China and Korea, was that the industry is looking to evolve towards a single number supported on both networks, akin to the USIM approach, leaving a slot free for m-banking and m-commerce applications.

Convergence – Unlike Korea, broadcast services are not a feature of the current wireless offerings in China. For China Unicom, the scope of convergence was restricted to consideration of the convergence of fixed and mobile networks, for which they have developed a strategy. The first step is seen as the coordination of the GSM and CDMA core networks, followed by the development of a converged core network for both fixed and mobile services, based on IP. It is then viewed that the network would migrate to IPv6 for future networks. China Unicom is presently trialling IPv6 in the core network as part of a government-sponsored trial.

2.4.6 Towards 3G and beyond

All six telecom operators[18] are taking part in 3G trials of the three candidate technologies – CDMA2000, TD-SCDMA and WCDMA – and, whilst it appeared that the operators in principle wished to deploy 3G services, there were considerable concerns expressed over the huge cost of the infrastructure and potential IPR licensing costs. From a government perspective TD-SCDMA would be the preferred technology as the IPR is owned in the majority by DaTang and Siemens[19]. Potentially, the government may license all three technologies. It was evident that, at least in June 2004, no firm decisions had yet been made.

2.4.7 Summary

Although the Chinese wireless market is still very much in the growth phase, from both subscriber numbers and technology perspectives, it is evident that differentiation between value-added services is becoming increasingly important, even though voice is still the main revenue generator. With broadband users in China now exceeding those in Korea, one can envisage significant content and application development over the next couple of years. Such a trend is already evident in some of the research institutions.

Within the FuTURE 863 programme, significant investment has been made in researching new air interfaces for B3G; this has included development of experimental hardware by these institutions and partner companies. Hardware development and manufacturing has always been regarded as the cornerstone of the Chinese economy, and, whilst this remains the case, both research institutions and major companies are now beginning to add content, applications and software generation to their portfolio of activities.

The Korean telecoms industry invests heavily in China, and one can already see the gradual shift of power from European infrastructure manufacturers to both China and Korea. Once decisions are made concerning the issue of 3G licences, and strategic partnerships are established with Korean and/or European/ American players to fund the rollout, the Chinese wireless market will grow from strength to strength.

18 China Mobile, China Unicom, China Netcom, China Telecom, China Railcom and China Satcom.

Siemens is also partnering Huawei in the CPRI initiative.

2.5 Regulation and spectrum management

2.5.1 Government structures

Like Korea, China's regulatory structures resemble those of Europe in the 1980s, with close integration of the roles of industry development, market regulation and spectrum management. In China, however, where many companies are still in the category of being state-owned enterprises, it would seem that policy is more clearly set by government and followed by industry than in Korea, where a more robust dialogue appeared to exist. Having said this, the team were pleasantly surprised at the willingness of individuals to express views at variance from the official line.

The three key government organisations involved with the telecommunications industry are:

- MII – Ministry of Information Industry
- MOST – Ministry of Science and Technology
- NDRC – National Development and Reform Commission

The latter is a top-level state policy body, whereas MII and MOST are the relevant bodies charged with overseeing industry and academic activities respectively.

Government priorities include:

- Provision of communications services
- Growth of its indigenous industry to reduce reliance on imports
- Development of China's own technology capability and IPR

With China now part of the WTO, the Chinese practice is to follow international market opportunities, service offerings and payment models. MII expressed an interest to learn lessons from the UK practices on separation of industry promotion and policy research with regulation.

2.5.2 Regulation

MII works closely with MOST to provide the regulatory framework and strategic direction to Chinese industry; eg, the President of MOST was appointed by MII. Duties and responsibilities include communication, operation, production of electronic products, development of software, and spectrum management.

The China Academy of Telecommunication Research (CATR) supports the industry policy and regulation activities of MII. CATR analyses telecommunications and information technological trends alongside marketing and economic status, and support MII in:

- Laws and regulation
- National communications network technological policies, technical standards and specifications (the 3G technology trials are an example of this)
- Telecom equipment testing and certification
- Enterprise quality system certification consulting service
- Enterprise strategic management consultation
- Consultation on enterprise network planning and technical specifications

MOST is responsible, amongst other activities, with administering the 863 programme aimed at development of China's technology capability, and under which the TD-SCDMA research was initiated. MOST is also the government sponsor for the FuTURE research programme, part of 863.

2.5.3 Spectrum management

Spectrum in China is considered a national asset owned by the government. Unlike most of the world, where operators have to

purchase spectrum rights and then pay an annual usage fee, in China the regulator, MII, grants the licence for free to the operator, whilst designating the type of technology associated with the licence. Spectrum cannot be purchased but, as elsewhere, the operator pays an annual usage fee. This is the approach that will be followed for 3G licensing.

Whilst spectrum is regulated by MII, the State Administration of Broadcast, Films and TV is responsible for interpreting and regulating content and transmission, a separation of roles unlike the UK.

Like Korea, China is very active in ITU-R's Beyond 3G standardisation activity, though on the face of it for very different reasons. In the case of China, it appears to be aimed at reducing future foreign IPR dependence, and in the case of Korea to maintain its technological momentum and market lead. The FuTURE research programme forms an important source of technical information for the inputs to the ITU process, and provides evidence to support WRC 2007 conference discussions on spectrum requirements for 4G.

The time the mission team spent with MII in China mainly focused on 3G evaluation and licensing activities, and did not cover other aspects of regulation.

2.6 Industry ecosystem in China

2.6.1 National industrial priorities

Telecommunications is a major growth industry within China, and this is clearly recognised outside of its own borders. Within China, its industry is growing rapidly to meet demand, but imports have also risen to address this demand.

Reflecting this, the priorities of the Chinese government faced with this situation were assessed as being:

1 Provision of communications services to the Chinese public, to facilitate social and economic growth
2 Growth of its indigenous industry, to reduce its reliance on imports
3 Development of its own technology, to reduce IPR costs to its industry and to create export opportunities

With such a different social, market and political situation compared to Korea, the mission team discovered a quite different industry ecosystem. As previously, we describe below the elements of this ecosystem and their interactions.

2.6.2 Key elements

Government factors

- *Ministry of Information Industry* – MII works to provide strategic direction to Chinese industry with responsibility for industry policy, regulation and spectrum management. In this task it liaises closely with the Ministry of Science and Technology (MOST).

- *Ministry of Science and Technology* – MOST is the central government agency under the State Council, responsible for China's science and technology activities. As such, it oversees the 863 programme and specifically sponsors research for next-generation mobile technology, primarily via the FuTURE research programme.

- *National Development and Reform Commission* – NDRC is a department of the State Council. It is a macro-economic regulatory department, with a mandate to develop national economic strategies, long-term economic plans and annual plans, and to report on the national economy and social development to the National People's Congress. It thus determines the framework within which MII and MOST operate.

State research bodies

- *CATR and CATT* – The China Academy of Telecommunication Research (CATR) and the China Academy of Telecommunications Technology (CATT) are state-owned research organisations which support the industry policy and regulation activities of MII in respect of telecommunications. CATT primarily undertakes 'hard' research related to product, whereas CATR focuses on analysis and advice. CATT is the parent company of the Datang telecom group.

Telecommunications operators

- *Mobile operators* – The mission team met with both China Mobile and China Unicom, both of whom closely follow the lead set by MII. Their views on the future evolution of the industry demonstrated close alignment and linkage with MII.

- *Fixed operators* – China Telecom recognised the need to work with all parties in the industry, but still expressed a strong commercially biased need to develop their own products and services. It was noted that it was 'good that government sought operator views on the market and its development'.

Prime equipment vendors

- *Manufacturers* – The mission team saw indications of a massive indigenious equipment/solutions vendors market, with a significant number of newer (start-up) operations in place, some of whom were keen to attack the world market. Examples of key indigenous vendors visited were ZTE and Huawei, who took the opportunity of the global telecom downturn to expand their activity in the export market, and Konka, the #5 handset supplier in China in 2003. Indigenous industry has seen very rapid recent growth.

Academia

- *Universities* – The team visited two universities, and in both cases were exposed to creative thinking based upon the premise of national telecommunications growth. The main universities are working closely, linked through the FuTURE programme, and demonstrated linkage into the global academic research network. Academics from the leading universities involved in the FuTURE programme were present at a couple of meetings hosted by the operators and manufacturers. The extent of industry-funded long-term research at universities seemed limited, however[20]. Some universities are also working with/for foreign manufacturers.

2.6.3 Interactions

The system diagram in Exhibit 2.9 seeks to depict the Chinese ecosystem as perceived by the mission team. Whilst not all of the linkages are formal, many are; others are implied.

The balance between the influence of state bodies and that of the other participating elements (operators, vendors etc) was significantly different to that in Korea. The priority focus of the industry remains at present national 3G implementation as the key area; equipment vendors were keen to explore other (global) opportunities whilst at the same time being keen to support what was seen as a clearly government-driven strategy within China.

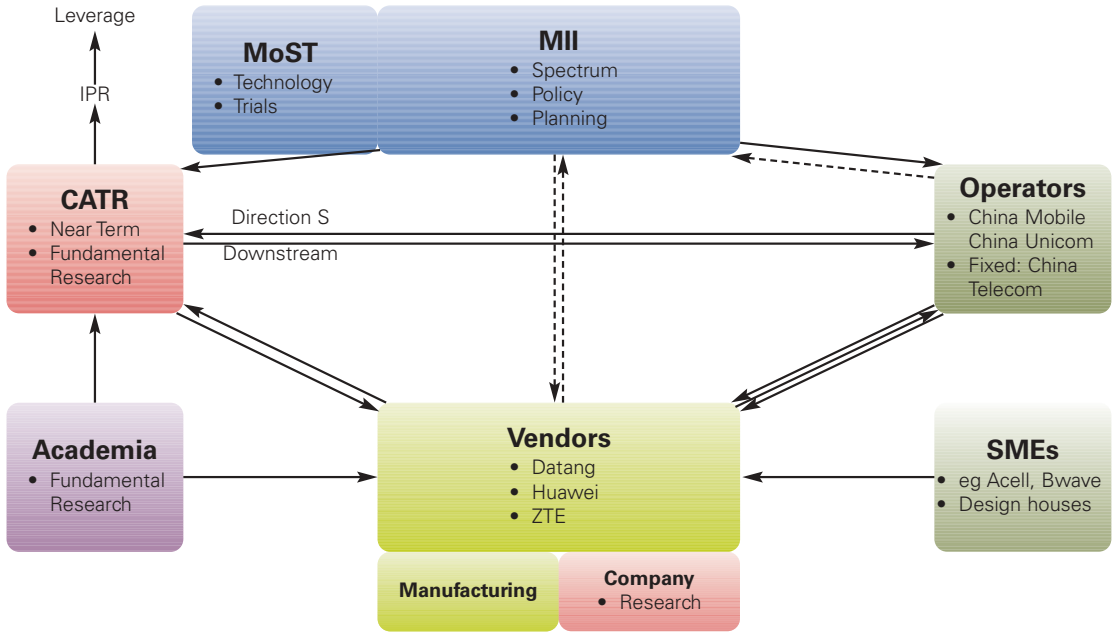

Exhibit 2.9 *Chinese telecoms ecosystem*

20 Limited informal discussions suggested industry-university relationship was generally on a short-term basis; eg, one university cited software tool development for a network operator to address current problems. In the UK, both short- and long-term collaboration occurs, eg via Mobile VCE.

Chinese telecommunications 3G ecosystem	
Objectives	• Drive Chinese telecoms services • Reduce dependence on imports and foreign IPR • Later: national economic growth
Outputs	• Single future vision • Funding for R&D • In country telecoms management
Competitive market	• Operators: – Service differentiation? • Manufacturers: – Product/price/timescale – Global markets

Exhibit 2.10 *Chinese telecoms ecosystem – main objectives, outputs and market issues*

OBSERVATIONS AND RECOMMENDATIONS

Korea and China are both very different – culturally, economically, socially – from the UK. Solutions appropriate for these countries are not appropriate for each other, nor indeed for the UK; each country and region needs to find appropriate policies and industry initiatives suited to its own environment.

Having said this, however, the mobile telecommunications industry is today a global phenomenon, with local developments and policies having impact across the globe; a prime example of this, seen by the team first hand, was the return of Chinese nationals – who had spent many years in the West – to lead new R&D laboratories being opened in China as a result of major foreign investment by the mobile industry.

There are lessons that we can learn from the policies of Korea and China, and it is appropriate to seek to identify appropriate responses from a UK and European perspective – responses appropriate to our own environment.

Korea

- *Government and industry commitment* – Korea acknowledges the major economic importance of mobile communications, and has developed detailed national technology policies and strategies, including commitment of corresponding resources, to strengthen its national position. This is manifested in, or some might argue the result of, the existence of strong and effective relationships amongst all parts of the industry environment (ecosystem) – government and private. This does not mean universal agreement – robust differences exist, in the midst of profound cooperation.

- *Research pull-through* – This cohesive national approach, and an appropriate scale of funding from both government and industry, allows enabling theoretical research to be quickly translated into national experimental test-beds. By virtue of this approach, Korea has pulled ahead of the UK – for example in wired broadband, DMB and WiBro. Being able to bring research much closer to implementation is providing a strategic economic advantage to its industry and economy.

- *Collaboration opportunities* – ETRI is the major player in next-generation mobile research in Korea, not only undertaking a significant volume of government- and industry-funded R&D, but also playing a leadership role in the NGMC Forum and oiling the relationships between industry and MIC. ETRI has many foreign collaborations, and is open to new ones. In addition, the universities identified as active in the field also welcome overseas collaborations; these include Hanyang University, Information and Communication University, KAIST, Seoul National University and Yonsei.

China

- *Unique market drivers* – China continues to be a rapidly growing mobile market; its challenges (social, regulatory and technological) are markedly different from those of Korea. China, due to its vast size and huge population, is more concerned with a truly interoperable service that delivers low-cost voice to a large rural population. To achieve this aim, China is prepared to move more cautiously than other adopters of 3G in granting 3G

licences. Award of 3G licences is not expected until 2005, with deployment perhaps 2006/07.

- *IPR, technology development and baseline research* – Wishing to reduce its historic dependence on foreign IPR, China wishes to minimise the royalty penalties of 3G. To do this, it is willing delay 3G rollout. It has invested significantly in research, through its 863 programme, to develop and promote indigenous technologies, such as its TD-SCDMA standard. China has a maturing research infrastructure clearly targeted to reduce external IPR dependence. The implication of this, especially given the size of China's domestic market, is that over the long term, China intends to become fully self-sufficient in mobile technology.

- *Future technologies* – Looking to 4G, it has again begun investing, via a select group of Chinese universities, in its FuTURE project, part of the 863 programme. To date, the technologies being researched, as with Korea, are similar to those presently being researched in the UK and Europe.

- *Collaboration opportunities* – Various opportunities exist for research collaboration with these Chinese universities and with other organisations, such as the Shanghai Wireless Communications Research Centre. The outcome of recent moves to court European support for its TD-SCDMA technology, if successful, could influence the path of future mobile evolution and open up new collaboration opportunities.

Implications for the UK

Where is the UK relative to Korea and China?

- Korea sees itself today as *the* world leader in broadband and wireless telecommunications. In terms of the capability of the commercial systems deployed, and in terms of market penetration, it is hard to argue with this assessment[1]. In terms of ideas, research and base technology, however, the conclusion of the mission team was that the UK remains on a par, if not a little ahead, of Korea.

- China, by contrast, is lagging Korea and the UK in terms of systems deployment and market maturity. In China, similar technologies are being researched to Korea, but with a lower level of investment at present; based on past track record, such investment may be expected to escalate, once 3G is licensed.

- The mechanisms to pull research through to market in both Korea and China are different, but both give their industry significant advantage, by enabling research to rapidly transition to the demonstration phase.

Implications for UK plc

- How UK (and European) industry chooses to compete in the future will require careful thought. Today, almost every country has aspirations to be the leading knowledge-based economy.

- Korea not only has such aspirations, but is doing the groundwork, investing for its future today and positioning itself as an IT hub for Asia.

1 Although Japan is similarly positioned.

- China has recognised its need for IPR independence in the knowledge-based economy and is determined to secure this.

- Three common factors were clearly visible in Korea and China, viz:

  – *Industry/government collaboration*
  – *Critical mass of research activity*
  – *Rapid research pull-through*

  The effect of these factors is clear – very substantial foreign direct R&D investment is moving from Europe to Asia. Researchers from Korea and China are already occupying key roles in the definition of future mobile systems and technology, as can be easily seen from the evolution of the ITU-R 8F international standards activity over the past few years.

- It is time for UK industry and government to find new ways to work together not only to stimulate technology innovation, which it does well, but to increase critical mass and accelerate industrialisation and market pull-through.

- Coordination of industry regulation and government policy are also factors to be considered. We cannot, and should not, revert to mechanisms of the 1980s, of a single government body responsible for industry promotion, market regulation and spectrum policy – indeed, both Korea and China are looking to the UK to learn how to move on from this model. However, in a globally competitive marketplace, the negative economic implications of disjoint policy in these three areas must be recognised and addressed.

- It is clear that models and structures appropriate for Korea and China are not appropriate for the UK. However, the UK's creativity is such that we must be able to identify approaches to achieve these goals and thereby derive substantial national benefits. The mission team and Mobile VCE wish to work closely with DTI, and to involve wider industry participation, to explore ways in which this can be done.

Possible practical steps

Examples of areas where such dialogue could result in specific proposals include:

- *Policy coordination* – The separation of responsibilities for industry promotion, market regulation and spectrum planning, such as we have evolved in the UK, need not and should not imply disjoint policy, given agreed objectives between industry and government. Clear coordination of policy across agencies, understood by industry, could enable longer-term planning and coordination by industry and an increased willingness to commit to shared risk/return initiatives.

- *Research pull-through* – The UK's research base is strong in terms of ideas, theoretical research and innovative fundamental concepts. However, compared with Korea and China, low-risk mechanisms for the creation of demonstrators, experimental hardware and application pilots to achieve research pull-through are lacking. A wider pooling of risk and funding could facilitate this, as well as encourage greater inter-industry collaboration.

- *Research coordination* – Improved leveraging of the UK's existing R&D base is possible. Mobile telecoms research is funded and managed through many mechanisms in the UK – individual companies, Mobile VCE, EPSRC, MoD, Ofcom et al. Improved coordination, aligned with clear policy, could secure higher impact results from the same inputs.

- *International peering* – The UK's reputation and R&D capability in mobile

communications remain strong, as do government-to-government relationships between the UK and both China and Korea. A window of opportunity exists, prior to WRC 2007, for the UK to build on these factors to initiate an R&D peering activity between the UK and China and/or Korea in respect of B3G technology and standardisation. Given the centrally coordinated B3G/4G activity in these countries, such peering would require a mechanism/organisation of appropriate scale. Such an initiative would allow the UK to play a significant role in shaping the future evolution of the industry and would provide a strengthened rationale for inward investors and UK-based companies to maintain and grow their UK R&D presence over the coming years.

Appendix A

MISSION TEAM

(Mission Leader)

Dr Walter Tuttlebee
Executive Director

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As Chief Executive of the Virtual Centre of Excellence in Mobile & Personal Communications – Mobile VCE – Walter Tuttlebee heads up a unique not-for-profit company established eight years ago by the mobile telecoms industry, academia and UK government to undertake long-term, industry-steered, collaborative research.

Mobile VCE today has 20 industrial members[1], operators and manufacturers, including several Asian companies. Its research results 'seed & feed' its industrial members' internal R&D programmes as well as influencing WWRF, SDR Forum, DVB and IETF. Its research addresses core technology evolution to support the growth of the mobile communications industry.

In the 1980s and '90s, Dr Tuttlebee led industry R&D teams in 2nd and 3rd generation mobile communications, conceiving and playing a key role in key European 3G research programmes which contributed to the 3G standards; he is also acknowledged as a pioneer of software radio in Europe. Prior to joining Mobile VCE, he had operated in a business development role in personal communications, digital broadcasting and satellite communications.

In his current role, as well as managing Mobile VCE's activities, he works closely with the Board of Mobile VCE and with senior executives across the mobile and related industries to develop future policy and facilitate mutually beneficial collaboration.

1 Members of Mobile VCE presently include BAE Systems, BBC, BT, Fujitsu, Inmarsat, LG Electronics, Lucent, Matsushita, NEC, Nokia, Nortel, Ofcom, Orange, Philips, Samsung, Siemens, SK Telecom, Thales, Toshiba, Vodafone.

(Korea visit only)

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Mike Hook (BSc, MSc) joined Roke Manor Research in 1985, focusing on the application of knowledge-based systems technology in telecommunications. Mike has over 18 years experience in developing sophisticated system simulations and highly usable applications and services in fixed and mobile telecommunications. He is responsible for Roke Manor Research's interaction with mobile network operators worldwide. His present involvements include IMS (IP Multimedia Subsystem) and trials of IMS-based solutions.

Roke Manor Research is Siemens' R&D centre in the UK. A centre for communications R&D, covering fixed and mobile networks, it is at the forefront of 3G network and device development, including participation in 3GPP and IETF standardisation. It undertakes work for a wide range of customers, including Siemens.

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Stephen Hope started his career in the satellite industry in 1975, moving into terrestrial mobile communications in 1980 through military and then cellular communications, managing manufacturing test of early 1G handsets. Having been involved with system aspects of 2, 2.5 and 3G cellular, interspersed with public safety and transport PMR system design, Stephen is now involved with Beyond 3G (B3G) activities. Stephen joined Orange in 1993 and led Orange participation in various UK and European research programmes. Based in Orange Research and Innovation, Stephen is responsible for International Relations with both academic and industrial research entities. Stephen is on the Board of Directors of the SDR Forum and Mobile VCE.

Orange UK is the leading operator in the UK in terms of active subscribers, despite being the last of the four network operators to have entered that market. At end 2003, Orange UK had a market share of 27% with nearly 14 million active customers. Orange is part of the France Telecom Group, with operations in 19 countries. At end 2003, Orange served markets with approximately 550 million people, had 49 million customers in its controlled operations, and a turnover for the year of ~€18 billion.

Dr Adel Rouz
Director Mobile Communications Research

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Adel Rouz holds MSc and PhD in Computer Science achieved in 1991-2. He joined Fujitsu Ltd in 1991 and Fujitsu Europe R&D Centre (UK) in 1996. Since October 2001, he has been Director of the Mobile Communications Research Division at Fujitsu Laboratories of Europe Ltd (FLE), where his responsibilities include: 3G and B3G research activities in Europe; open mobile architecture; IP-based mobile networks; radio network planning, mobile applications and terminal development.

FLE's R&D activities are focused on mobile communications, including 3G and systems beyond, grid computing, optical processing and nanotechnology. FLE collaborates with a number of UK and European universities, funding several joint research projects. In addition, FLE, with many other companies, is investing in Mobile VCE, which is undertaking pre-competitive R&D of future mobile systems and networks, as well as actively participating in a number of research projects under the EC's 5th and 6th Framework Programmes.

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Louis ('Sam') Samuel (PhD, MEng) leads Bell Labs Research at Lucent Technologies in the UK. After service in the Royal Navy (1981-91) as a technical specialist, Sam studied at Queen Mary and Westfield College, University of London, receiving an MEng in Communication Engineering in 1995 and a PhD in Teletraffic Modelling in 1999.

Since November 1998 he has been with Bell Labs Research, where he undertook the development of advanced protocols and network architectures for wireless communications, prior to assuming his present wider responsibilities.

His research interests include non-linear dynamics, complexity theory, agent-based systems, software architectures and infrastructures, software protocols, 4G systems, mobility and resource management.

Lucent Technologies designs and delivers the systems, services and software that drive next-generation communications networks. Backed by Bell Labs R&D, Lucent uses its strengths in mobility, optical, software, data and voice networking technologies, as well as services, to create new revenue-generating opportunities for its customers, while enabling them to quickly deploy and better manage their networks. Lucent's customer base includes communications service providers, governments and enterprises worldwide.

Professor Rahim Tafazolli
Head of Mobile Communications Research Group

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Rahim Tafazolli leads the Mobile Communications Research Group at CCSR, held the role of Academic Coordinator of the Core 2 Networks & Services research within Mobile VCE, and sits on the Vision Group within WWRF. He is Founder and Past Chairman of the IEE 3G Mobile Communications Technology Conference.

CCSR is the largest academic mobile communications research group in the UK, comprising 12 academics, 30 research assistants and 60 PhD students. The group plays a leading role in both Mobile VCE and European research activities. Its research work spans both mobile and satellite communications. CCSR is a member of both the Nokia and Ericsson global university alliances.

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As Head of Partner and Supplier Relations within BT Research & Venturing, Malcolm Payne has a particular focus on identifying and establishing research partnership opportunities. He has extensive experience within the telecommunications industry, having worked with leading organisations, spanning start-ups to established industry players. He is heavily involved in both broadband and mobility research programmes within BT. Malcolm holds a BA (Hons) Technology, an MBA, is a member of the BCS and author of a book on Software Rich Systems.

BT Group is one of Europe's leading providers of telecommunications services. Its principal activities include local, national and international telecommunications services, higher-value broadband and internet products and services, and IT solutions. In the UK, BT serves over 20 million business and residential customers with more than 29 million exchange lines, as well as providing network services to other licensed operators. BT Exact is BT's research, technology and IT operations business, helping BT's customers gain maximum advantage from communications technology, by combining an in-depth knowledge of networks and networked applications.

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Michele Wakefield is a Senior Manager with Ofcom and has over 15 years experience of managing successful international telecommunications, broadcasting and internet projects in regulatory and commercial sectors. Prior to the formation of Ofcom, at ITC, Michele was responsible for working with industry to facilitate digital services to meet consumer needs and inform policy on the impact of mobile communications technology developments, particularly where mobile DTT services may find important commercial advantages over 3G networks for the delivery of popular on-demand content to handheld devices.

Previously, Michele worked for six years in BT, leading the e-commerce division's strategy and planning, alongside project managing e-business solutions to meet the needs of commercial banks and retailers.

(Korea visit only)

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The International Technology Promoters (ITP) network, funded through the DTI Global Watch Service and managed by Pera Innovation Ltd, is designed to facilitate international technology partnerships.

The ITPs provide direct assistance to UK companies to raise awareness of, and provide access to, technology-based opportunities with the world's leading investors in R&D. These include sourcing overseas technologies, licensing arrangements, or collaboration in product or process development.

ITPs understand the social and business cultures of their 'target' country and so can help UK companies avoid many of the usual pitfalls and problems associated with international business ventures. There are currently 16 ITPs covering Japan, North America, Europe, South Korea, China, Russia, Taiwan and Singapore.

Hong Hai Seeto has 20 years of international experience in technology transfer and product and process development with industry, particularly within SMEs. Together with the British Embassy in Seoul, he has developed comprehensive access points to all the leading R&D laboratories of the Korean global corporations and government institutes, and the growing numbers of dynamic high-tech venture companies. He achieved his degree and postgraduate qualifications in Edinburgh and London.

Appendix B

ORGANISATIONS VISITED IN KOREA

GOVERNMENT

Ministry of Information and Communication
www.mic.go.kr

The Ministry of Information and Communication (MIC) is the government department responsible for the industry promotion, market regulation, and spectrum management. It sees its primary role as ensuring that IT serves as a key engine for national economic growth. It has a history of success in this respect with mobile communications (CDMA) and broadband – Korea is global leader in both of these and IT accounts for 30% of Korea's exports.

The ministry is strongly driven by its present Minister, Dr Chin Daeje, who has a strong technology background. Minister Chin joined the UK team for dinner on the evening of the Symposium, providing opportunity for informal discussion. Two separate meetings were held with his staff responsible, respectively, for spectrum management and for industry regulation.

TELECOM OPERATORS

Korea Telecom (KT)
www.kt.co.kr

KT is the dominant fixed-line operator in Korea, with market shares of 88% wireline, 49% broadband. Its highly successful broadband rollout was in fact at the time a survival strategy, in the face of declining revenues and the growth of mobile telephony. KT owns 44% of the mobile operator KTF; the lack of majority ownership limits its influence over its mobile offspring.

KTF
www.ktf.com

KTF is the second largest mobile network operator in Korea, with 32% market share. It was created in 1997 and grew by merger with KTM.com in 2001. It began by deploying a CDMA IS-95 infrastructure which it evolved to CDMA2000 1x and to EVDO. KTF secured a WCDMA licence and has established an infrastructure in the Seoul area.

SK Telecom (SKT)
www.sktelecom.com

SKT is one of Korea's Chaebols (industry conglomerates) with very wide ranging activities, encompassing electrical, electronic, petrochemical, financial services, etc. It is the dominant mobile operator in Korea, with 54% market share. Its 2G deployment, like all operators in Korea, was based on CDMA IS-95. SKT evolved this infrastructure to CDMA2000 1x EV to launch 2.5G services in October 2000, and introduced EVDO in February 2002. ARPU is continuing to increase – it is introducing many innovative services in order to drive ARPU growth. Like KTF, SKT secured a WCDMA licence and has established an infrastructure in the Seoul area.

MANUFACTURERS

LG Electronics (LGE – Anyang R&D Centre)
www.lge.co.kr

LG is one of Korea's Chaebols (industry conglomerates) with very wide ranging activities, encompassing electrical, electronic, petrochemical, financial services, etc. The LG

Chaebol own LG Telecom, the third mobile operator (whom the team did not visit), and LG Electronics (LGE). LGE is an infrastructure and handset supplier, having risen rapidly in recent years to joint 5th (2003) in the global rankings for handset market share.

Samsung (SAIT – R&D Centre)
www.sait.samsung.co.kr

Samsung is one of Korea's Chaebols (industry conglomerates) with very wide ranging activities, encompassing electrical, electronic, petrochemical, financial services, etc. Samsung's annual R&D budget is $5 billion, of which $230 million is spent by its central research labs, Samsung Advanced Institute of Technology (SAIT), and the remainder by the business units, much of whose R&D is collocated with SAIT. Like LG, Samsung also is a supplier of both infrastructure and handsets, as well as of semiconductors. Samsung ranked 3rd globally for handset market share in 2003.

RESEARCH INSTITUTES AND UNIVERSITIES

Electronics and Telecommunications Research Institute (ETRI)
www.etri.re.kr

ETRI, established in 1976, is Korea's largest government-funded ICT research facility, encompassing semiconductors, mobile communications, networks and security. It focuses on research, with development undertaken by industry; it specifically addresses high risk, high return research. It has a basic research laboratory and 10 divisions, one of which is the Mobile Telecom Research Division. This has 200 staff, structured into 4 groups, 20 teams, with a vision to be the global leader of next-generation mobile telecom technology. In addition, whilst not entitled 'mobile comms', many of the other research groups are involved in closely related activities – eg network infrastructure, security, broadcasting, etc. ETRI provides the secretariat for the NGMC Forum. It produces extensive patents and publications, and undertakes technology transfer to companies, primarily through patent licensing.

Yonsei University
nasla.yonsei.ac.kr

Yonsei University, based in Seoul, has both Electrical and Computer Science departments. They have established a 'Centre for IT at Yonsei' (CITY), one of five such specialised research groups, sponsored by MIC, KOSEF (Korea Science and Engineering Foundation), etc. CITY has two 'task groups', TG1 addressing Next Generation Digital Mobile System, and TG2 addressing Next Generation Digital Media System.

SMEs

Reakosys
www.reakosys.com

Reakosys is a fast growing start-up company, working with operators, broadcasters and handset manufacturers to provide multimedia content and application software. Founded in 2000 with 10 staff, they now have 90 employees.

Appendix C

ORGANISATIONS VISITED IN CHINA

GOVERNMENT

Ministry of Information Industry, Beijing
www.mii.gov.cn

The Ministry of Information Industry (MII) was established in 1998, through the merger of the Ministry of Postal Affairs and the Ministry for Electronic Industries. MII has 300 staff, structured in 13 departments, of which Science and Technology is one, holding responsibility for communications operations, development of products, and administration of radio.

TELECOM OPERATORS

China Mobile (R&D Centre), Beijing
www.chinamobile.com

China Mobile is the dominant mobile operator, with 67% market share (December 2002) and 110,000 staff. It was demerged from China Telecom in April 2000, and today has similar revenues to its parent. In 1H2003, data revenues (SMS & GPRS) accounted for ~10% of turnover.

China Telecom, Beijing
www.chinatelecom.com.cn

China Telecom is the main fixed-network provider in China. It provides local loop access also to China Unicom. China Telecom has deployed PAS (quasi mobile wireless services) in some areas and hopes to secure a 3G mobile licence.

China Unicom, Beijing
www.chinaunicom.com.cn

China Unicom is the second mobile operator, with both GSM and CDMA networks, covering the same geographical regions, with 83 million GSM subscribers and 25 million CDMA subscribers. Unicom also provides fixed network services.

MANUFACTURERS

Alcatel Shanghai Bell Co Ltd (ASBC), Research Centre, Shanghai
www.alcatel-sbell.com.cn

ASBC is one of six Alcatel research labs around the world. Until relatively recently, 2002, it was a JV with the Chinese government, MII. It employs 45 researchers, out of a total of 600 researchers worldwide, with a strong mobile communications activity.

Datang Mobile, Beijing
www.datangmobile.cn

Collocated on the same premises as CATR and CATT, Datang has obvious tight connections with government and other state-run telecom organisations. The team visited their TD-SCDMA test-bed facility, a joint facility established with Nortel who provide CN (core network) infrastructure to which their RAN (radio access network) is connected.

Huawei, Research Institute, Shanghai
www.huawei.com

Huawei is one of the three major Chinese telecoms manufacturers (alongside ZTE and Datang), with a turnover in 2003 of

~$3.8 billion. Huawei manufacture both infrastructure and handsets, with mobile product lines including GSM, CDMA and PCS, PHS, BWA, access networks and core network switching. In 2000, the company took advantage of the downturn, as competitors in Europe and North America cut back, to launch a major export push, opening offices around the world. Started with four people in 1988, Huawei remains 100% employee-owned.

Konka Research Institute, Shenzhen
www.konka.com

Konka is an SOE (state-owned enterprise) focused in multimedia (TVs and STBs, #1 with 18% market share) and mobile communications (handsets). It is one of the top 10 brands, across all industries, and #13 of the top electronics enterprises in China, with RMB12.8 billion turnover in 2003. In mobile handsets it is the #3 of the Chinese brands, and #5 overall, selling 1.8 million handsets in 2002, increasing to 5 million in 2003.

ZTE, R&D Centre, Shanghai
www.zte.com.cn

ZTE is one the three major Chinese telecoms manufacturers (alongside Huawei and Datang), with a turnover in 2003 of ~$3.5 billion. ZTE manufacture both infrastructure and handsets, with mobile product lines including GSM, CDMA and PCS, PHS, BWA, access networks and core network switching,

RESEARCH INSTITUTES AND UNIVERSITIES

Beijing University of Posts and Telecommunications (BUPT)
www.bupt.edu.cn

BUPT, one of China's leading universities, is one of seven university participants in the country's 4G FuTURE research programme. Prof Zhang Ping, who leads the group, is active in international 4G activities.

China Academy of Telecommunications Research (CATR), Beijing
www.catr.com.cn

CATR is an independent organisation, of 900 staff, whose director is appointed by MII, and which provides technology advice to MII. Evolved from the Chinese Academy of Posts and Telecoms in 1956, CATR in its present form was established in 2000. CATR addresses network planning, technology strategy, standards and testing; it undertakes 'soft' research, rather than 'hard' research on products – this is done by CATT (which undertakes R&D for Datang). CATR comprises several institutes: RITT (transmission technology), IIR (information research), IPR (planning research), and TMC (testing). CATR's VP, Ms Cao Shumin, is active within ITU-R WP8F, leading the Chinese standardisation contribution, as well as overseeing CATR's 3G technology trials.

Shanghai Research Centre for Wireless Communications
www.shrcwc.org

SHRCWC was established July 2003, a JV between SIMIT (Shanghai Institute of Microsystem and Information Technology) and CAS (Chinese Academy of Sciences). It is supported/ funded by around five different sources, including a joint agreement between national and local government. Government funding is fixed, irrespective of industry income.

Tsinghua (Qinghua) University, Beijing
www.tsinghua.edu.cn

Tsinghua University is ranked as one of the top universities in China. It is one of seven university participants in the country's 4G FuTURE research programme. Prof Zhou, who leads the group, is active in international 4G activities.

SMEs

Shanghai Acell Communication Technology Co Ltd (Acell)
www.acell.com.cn

Acell is a handset design company, which develops handset designs for Kejian and is seeking to diversify its customer base. It currently supplies GSM solutions, and is developing WCDMA solutions.

Shanghai Bwave Technology Co Ltd (Bwave)
www.bwavetech.com

Bwave is a 3G chipset IP supplier, comprising a team of ex-DoCoMo 3G researchers.

Both Bwave and Acell were founded in the last couple of years, each with ~50 staff.

Appendix D

FIRST JOINT KOREA-UK SYMPOSIUM 'FUTURE MOBILE TECHNOLOGY – EVOLUTION FORUM'

A one-day symposium, with speakers from the UK and Korea, was organised by Mobile VCE, with the help of the British Embassy, and with the support of the Korean Ministry of Information and Communication (MIC) and the Next-Generation Mobile Communication (NGMC) Forum, to facilitate an exchange of perspectives on the future evolution of mobile communications and associated technology over the next 5-10 year timescale.

Staff from the Korean mobile industry had the opportunity to learn about current UK and European thinking, and the mission team had the opportunity to meet with a wider cross section of the Korean industry. The event was opened by Warwick Morris, the British Ambassador to Korea, and by Dr Sang-Chul Lee, Chairman of the NGMC Forum and previously Minister of Information and Communication.

Over 350 people attended the event, which was followed by a networking reception attended by the current Korean Minister of Information and Communication, Dr Daeje Chin, who subsequently joined the mission team and Korean speakers for a private dinner.

Exhibit D.1 *Mission team and other participants outside the Joint Korea-UK Symposium, with Dr Chin in the middle*

First Joint Korea-UK Symposium: 'Future Mobile Technology – Evolution Forum'

Korean Chair: Prof Jaiyong Lee, Yonsei University
UK Chair: Prof Rahim Tafazolli, University of Surrey

Tuesday 15 June 2004, Seoul

Time	Proceedings
09:25-09:30	Chairmen's call to open the Symposium
09:30-09:40	Opening Speech by Warwick Morris, British Ambassador to Korea
09:40-09:50	Keynote Speech by Dr Sang-Chul Lee, President of NGMC Forum
	Subject 1: The Korean and UK/European Mobile Industry, Today and Tomorrow
09:50-10:10	Korea: Dr Ki-Chul Han, VP, ETRI
10:10-10:30	UK: Dr Walter Tuttlebee, Executive Director of Mobile VCE
10:30-10:50	Q&A
10:50-11:10	Coffee break
	Subject 2: New and Emerging Wireless Technologies Beyond 3G
11:10-11:30	Korea: Dr Byung K Yi, Senior EVP of LG Electronics
11:30-11:50	UK: Dr Louis Samuel, Head of Bell Lab Research, Lucent UK
11:50-12:10	Q&A
	Subject 3: Network Technologies in an All-IP World
12.10-12:30	Korea: Dr Kwansoo Lee, Senior EVP of Samsung Electronics
12:30-12:50	UK: Mike Hook, Roke Manor Research
12:50-13:10	Q&A
13:10-13:15	Chairmen's call to close morning session
13:15-14:05	Lunch
14:05-14:10	Chairmen's call to open afternoon session
	Subject 4: Security – Requirements and Approaches to Securing Future Mobile Services
14:10-14:30	Korea: Dr Kyo-Il Chung, ETRI
14:30-14:50	UK: Malcolm Payne, Head of Partnerships, BT
14:50-15:10	Q&A
	Subject 5: Content, Services and Applications – New Business Models and Revenue Streams
15:10-15:30	Korea: Dr Wonhee Sull, VP of SK Telecom
15:30-15:50	UK: Stephen Hope, Technology & International Relations of Orange
15:50-16:10	Q&A
16:10-16:30	Coffee Break
	Subject 6: Spectrum Beyond 3G – Regulatory Change and Challenges
16:30-16:50	Korea: Dr Byoung-Moon Chin, VP, TTA
16:50-17:10	UK: Michele Wakefield, Ofcom
17:10-17:30	Q&A
17:30-17:45	Overall Q&A
17:45-17:50	Chairmen's call to close the Symposium
17:50-19:00	Networking Reception, with Guest of Honour, Dr Daeje Chin, Minister of Information and Communication

Exhibit D.2 *Programme for First Joint Korea-UK Symposium*

Appendix E

IT 839 PROGRAMME (KOREA)

The Ministry of Information and Communication (MIC), as a government department in Korea, is responsible for the promotion of the IT industry, for its regulation and for spectrum management. It is working with industry to implement its IT 839 strategy, aimed at increasing the Korean per-capita GDP to US$20,000. The strategy defines eight services, three infrastructures and nine new economic growth engines, with specific short-term plans and longer term goals required to achieve this end, as detailed below.

Eight services

1 WiBro service
2 DMB service
3 Home network service
4 Telematics service
5 RFID-based service
6 WCDMA service
7 Terrestrial digital TV
8 Internet telephony – VoIP – seen as the killer application for the BcN (see below)

Three infrastructures

1 BcN – Broadband Convergence Network – the convergence of broadcast, telecoms and the internet (QoS and IPv6 for 50 Mb/s to 100 Mb/s end-user data rates)
2 USN – Ubiquitous Sensor Network – large-scale deployment of RFID tag readers
3 Next-generation Internet Protocol – IPv6

Nine new growth engines

1 Next-generation mobile communications (4G)
2 Digital TV – terrestrial DMB receiver and transmitter, converged broadcast/data
3 Home network – converged wired/wireless home unit – wireless firewire, powerline comms within the house for ubiquitous connectivity of devices within the home
4 IT system-on-chip (SoC) – Korea aims to broaden chip fabrication from the current focus on the memory market to development of non-memory chipsets, eg multimedia mobile phone chipsets
5 Next-generation PC – wearable computers, eg wristwatch PC
6 Embedded software – target to be 2nd largest producer of embedded software
7 Digital contents – target to generate 3D games engines, etc
8 Telematics – in-vehicle mobile office
9 Intelligent service robot

A copy of MIC's booklet describing the IT 839 programme in greater detail, including specific short- and long-terms targets, and anticipated production, employment and export contributions to the Korean economy, can be downloaded from *www.mic.go.kr/eng/res/res_pub_it839.jsp*

Financial investment

The specific breakdown of financial investment in 'next-generation mobile communications', item 1 of the nine growth engines, planned by Korean government and industry, is detailed in Figure E.1. In approximate terms, the combined investment is of the order of £160 million over a five-year period, split 1.6:1 government:industry (total government investment 2003-2007, £100 million; total private investment 2003-2007, £57 million).

Category		2003	2004	2005	2006	2007	Total	Note
4G mobile communications system development	Gov't	224	250	250	250	250	1224	
	Private	–	–	–	140	140	280	
High speed mobile internet system development	Gov' t	–	–	–	–	–	–	
	Private	120	120	120	–	–	360	
Intelligent integration handset development	Gov't	–	20	40	40	40	140	New
	Private	–	–	60	60	60	180	
Multimedia handset core components development	Gov't	–	5	40	40	40	125	New
	Private	–	–	–	60	60	120	
Low power for handset RF/HW/SW module development	Gov't	–	65	70	70	70	275	New
	Private	–	–	–	100	100	200	
HR development		50	60	60	60	–	230	
Mobile data market test market		20	20	–	–	–	40	
Gov't contribution		294	420	460	460	400	2034	
Private investment		120	120	180	360	360	1140	
Total		414	540	640	820	760	3174	

Exhibit E.1 *IT 839 next-generation mobile communication sectors and investment plan by year (MIC) (Note: units are multiples of 100 million won (~£50,000))*

A financial breakdown for, and more detailed explanation of, all nine growth engines is available in the IT Korea Journal, January 2004, Special Report on the 'Top 9 Growth Engines of Korea IT'. This may be downloaded from MIC's website, via the following URL: *www.mic.go.kr/eng/res/res_journal_2004_jan.jsp*

Appendix F

NESPOT: STATUS, SPECTRUM, LICENSING

Exhibit F.1 *NESPOT Swing terminal*

In Korea, an innovative WiFi (802.11b) based service has been deployed by Korea Telecom, branded NESPOT. In parallel to their innovative OnePhone service, Korea Telecom are strongly backing nomadic and relatively slow moving wireless broadband access using very widespread deployment of WiFi. KT are also strongly backing WiBro, a Korean form of WiMAX with mobility similar to that provided for by IEEE 802.16e.

The KT NESPOT service currently (May 2004) has 390,000 subscribers and 12,000 public WiFi sites. The new dual-mode CDMA/WiFi PDA NESPOT Swing handset (see Exhibit F.1) is helping to drive demand. Whilst not yet profitable, KT are planning on extending deployment to 23,000 WiFi sites by the end of 2004. KT regard NESPOT (and also the CDMA/Bluetooth residential OnePhone) as preparing the public for WiBro.

KT would like to offer CDMA/WiBro terminals, but it is understood that the major mobile operators are not keen on the government permitting that, believing that such terminals would undermine their 3G offerings (and the US$1 billion each paid for their WCDMA licences).

Appendix G

WIBRO (WIRELESS BROADBAND)

Origins, drivers and functionality of WiBro

Another example of Korean innovation, research and development is the drive for an early WiMAX-like technology termed wireless broadband. Wireless broadband, or WiBro, originated in ETRI when they were looking for a low-cost delivery mechanism for broadband wireless local loop. WiBro was based on IEEE 802.16a/d originally. However, given the very high fixed-access penetration, it didn't make commercial sense for the fixed-access scenario. ETRI then looked at incorporating limited mobility support – this led to high-performance internet (HPi). In addition to government funding, ETRI has been sponsored by Hanaro Telecom, KT, KTF, SKT and Samsung. The programme began in January 2003 and is due to complete in December 2005. The government were understood not to be keen on the HPi name – hence WiBro. WiBro is thus essentially WiMAX-d with some -e-like functionality offering support for device mobility at speeds of up to 60 km/h.

A key driver for WiBro deployment is cost per bit. Existing 3G technologies (CDMA2000 1x EVDO and WCDMA) are seen as relatively expensive for delivering substantial streaming video content such as 90-minute movies. The focus in developing WiBro is thus centred on reducing deployment infrastructure costs to deliver cheaper volume mobile data access. ETRI are expecting an average 1 Mb/s throughput per subscriber (typically in the range 512 kb/s to 3 Mb/s, with a target of 2 Mb/s).

WiBro will operate in the 2.3 GHz band. The regulator (MIC) has allocated spectrum, and is currently deciding who will receive licences – award is expected towards end 2004/early 2005. The expectation is that two or three licences will be awarded. Wireline operators such as Korea Telecom are very keen to deploy WiBro, and are considering aggressive deployment schedules.

WiBro terminals

Initial WiBro terminals will probably be single air interface radio (ie WiBro only) instant messaging/games/video-console type devices. It is unlikely that they will be converged terminals, at least initially. If there is no CDMA phone in the WiBro device, then battery life is less of an issue – the device can be turned off altogether rather than having to maintain a standby state with CDMA listening out for incoming calls.

Consoles will support near-DVD quality VoD streaming. The Koreans expect teenagers to use the service for viewing pop videos and the like, and for adults to use the service for a wide range of movies. KT are very keen on using H.264 (as are SKT) with media transcoding servers in the network if necessary to deliver best possible content at 1 Mb/s or so. The WiBro consoles are also expected to support massively multiplayer games too – online games are hugely popular in Korea. A demonstration of MP4 video streaming over early prototype WiBro equipment was shown to the mission team at ETRI.

In due course, WiBro chipsets will be incorporated in small form-factor devices such as compact flash cards and SD cards, as well as PCMCIA-format Cardbus32 cards. ETRI see the chipsets eventually being incorporated within a wide range of cameras, MP3 players and other products.

Samsung and ETRI expect to see WiBro deployed both indoors and outdoors. WiBro is a nomadic (rather than a mobile) service, and supports limited mobility – at speeds of up to 60 km/h – but with good range, up to 60 km being possible, although urban cells will typically be of 1 km radius.

There is discussion within the industry as to whether the initial WiBro handsets will support both WiBro and WiFi. Some players favour transitioning many indoor WiFi access points to WiBro access points and using WiBro both indoors and out. Others favour dual-mode (WiBro and WiFi) devices which use WiBro outdoors and WiFi indoors.

WiBro infrastructure

The expectation (given usage predictions) is for three types of base station equipment:

- 1 km radius cells, deployed with large base stations using adaptive beam-forming antenna technology; cell planning required for such deployments
- Cheaper 100 m microcells would be deployed in public areas
- Very cheap picocells would be deployed within the home or office

The government would like to see IPv6 supported to WiBro consoles (IPv6 is part of the Korean government's IT 839 strategy). However, the operators believe that to meet the aggressive planned timescales, devices that use IPv4 would be more easily accommodated within the telecommunication operator networks.

WiBro technical information

Frequency allocation	2.3 GHz ~ 2.4 GHz
Channel bandwidth	10 MHz
Wireless access	OFDMA-TDD
Modulation	QPSK, (8PSK), 16QAM, 64QAM
Channel coding	CTC (Convolutional Turbo Code)
Frame length	5 ms
Max transmission speed	30 Mb/s (without SA/MIMO) 50 Mb/s (with SA/MIMO)
AP synchronisation	GPS
Cell reach	Urban ~1 km Suburban ~5 km

Exhibit G.1 *WiBro technical information*

WiBro schedule

2003 Development of HPi prototype system, HPi spec 1.0

2004 TTA Standards v1.0, HPi Spec v2.1 and v3.0 (Q4 HPi based on TTAv1.0, enhanced with MIMO, Q4 licences awarded)

2005 TTA Standards v2.0, HPi Spec v3.5, Q4 WiBro commercial field trial

2006 Commercial WiBro service launched

Differing views of WiBro

Whilst Samsung are very supportive of WiBro, LGE are more cautious.

One view in LGE was sceptical regarding WiBro – observing that WiBro will offer 1 Mb/s, but that EVDO is offering that now, and is already in the pockets of 17 million consumers. A mobile network operator view is that although EVDO offers good data rates, the price that has to be charged to consumers is too high for volume multimedia; in this respect WiBro offers a cheaper route.

A second view in LGE was that WiBro will turn out to be a disruptive technology and will tremendously change the public's attitude to mobile data. However, LGE's take on the existing KT WiFi NESPOT service was that no one wants to pay commercially viable rates for it – everyone feels that WiFi should be free. On that basis, people might also expect WiBro to be cheap or free, which would undermine its business case. Such a view implied that the real money in WiMAX generally was to be made by Intel for the chipsets and by LGE for the notebook PCs!

Appendix H

DIGITAL MULTIMEDIA BROADCASTING

Summary

Digital multimedia broadcasting (DMB) is a new business concept in broadcasting to mobile communities. The service is digital broadcasting to mobile and personal users, using the 2.6 GHz radio frequency band. It consists of a large number of various multimedia broadcasting programmes, such as high-quality digital audio programmes, video programmes, and also data transmission to be received by vehicular and small portable receivers in mobile environments.

The service is to be launched by SK telecom, the dominant terrestrial mobile cellular operator in Korea, in September 2004.

System architecture

The system configuration consists of a broadcast centre, a broadcasting satellite (MBSAT) with its control ground stations, terrestrial gap-fillers and various types of receivers. The 14 GHz band uplink transmitted from the broadcasting centre consists of two signals, one is a CDM (code-division multiplex) signal and the other is a TDM (time-division multiplex) signal.

The CDM signal is converted into an S-band downlink signal by a satellite transponder, and is transmitted for direct reception by mobile terminals in open areas. The TDM uplink is converted into a 12 GHz downlink signal by a satellite transponder, and is transmitted for reception by gap-filler equipment. The gap-fillers are used to mitigate the heavy blockage and shadowing caused by buildings, trees, etc in built-up areas. The gap-fillers receive the TDM signal from the satellite, convert it to a CDM signal which has the same content as the CDM satellite signal, and transmit it to provide coverage where the satellite signal is blocked. The direct broadcasting from satellite combined with signals from the gap-fillers provides contiguous service coverage.

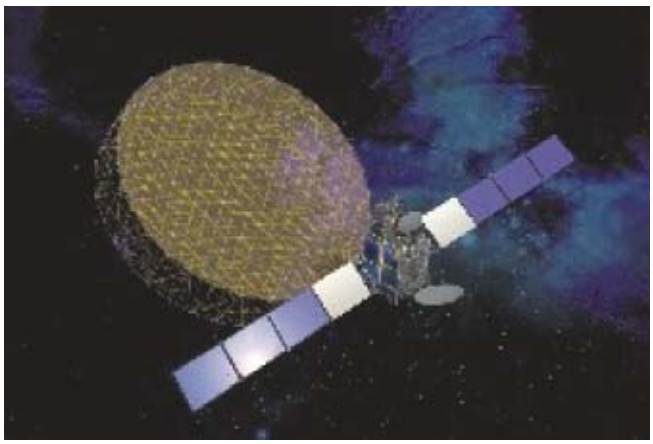
The MBSAT satellite is financed by Japan Toshiba and MBCO (Mobile Broadcasting Corporation, *www.mbco.co.jp*) and is located at East Longitude 144°.

System characteristics

The following two tables give information on internationally agreed air-interface specifications, together with details of additional features adopted in the Korean implementation of DMB.

ITU-R Recommendation BO.1130-4 System E	
Modulation	DS-CDM/QPSK
Chip rate	16.384 MHz
Number of channels	30 or more
Data rate	256 kb/s/ch
Spread code	64-Walsh
Error correction	Convolutional & Reed-Solomon
Video/audio codec	MP4/MP2-AAC+
Receiver	RAKE receiver (6 fingers/port)
Antenna	Circular or omnidirectional antenna

Korea DMB characteristics	
Frequency	2630-2655 MHz
High power satellite	EIRP 67 dBW
Mobile reception techniques	CDM, bit interleaving, RAKE receiver
Gap filler system in shadow areas	



Satellite characteristics

The basic satellite details are summarised in the following table:

Orbit slot	144 E
Launch weight	~4 tons
Payload power	7.5 kW
Design life	>12 years
S-band transponder	EIRP 67 dBW, antenna reflector 12 m
Ku-band transponder	EIRP 54 dBW, antenna reflector 2.4 m

Terminal concepts

A photograph of the Samsung DMB/CDMA dual-mode phone handset is shown earlier in the body of the report (Exhibit 1.7, page 26).

Terrestrial gap filler

The function of the gap-filler repeater is to receive the TDM downlink signal from the satellite, convert it into S-band CDM signal and to transmit a CDM signal to mitigate the blind spots. The gap-filler repeater consists of a Ku-band receiving antenna with LNA, a TDM-to-CDM converter, and transmission amplifier(s) and antenna(s).

MBCO is developing various types of gap-filler repeaters which enable selection of the most suitable type of gap-filler to match the conditions at each site. Each gap-filler repeater is managed by a monitoring centre via a terrestrial communication link.

Key players

The key players in DMB in Korea include:

- SK Telecom – the local network operator and service provider in Korea
- Japan Toshiba and MBCO – financing the satellite
- LG Electronics and Samsung – terminal manufacturers

Functionality, pricing and distribution

The following table summarises information of the consumer offering:

Channels	11 video, 25 audio, 3 data		
Pricing	Subscription fee		Only for new customers: $16~17
	Basic	Video Audio	Monthly fee: $10~12.5
	Premium		Additional fee by monthly base: $4.2/month
Distribution channels	Minimise the initial cost of resources via consignment contract Gradual enlargement from aftermarket to beforemarket in vehicles		

Market size

The forecast growth of Korean DMB usage is summarised in the table below. Penetration is defined as expected number of subscribers/ total population of Korea (estimated as 48.8 million in 2004, 51 million in 2010).

Year	2004	2005	2006	2007	2008	2009	2010
Expected subscribers	0.5 million	1 million	2.2 million	4 million	6 million	7.2 million	8 million
Penetration	1%	2%	4.5%	8%	12%	14.3%	15.8%

Appendix I

863 PROGRAMME AND FUTURE (CHINA)

Summary

In March 1986, Deng Xiaoping (then Chinese Head of State) stated that China needed to develop itself in many technology areas, and thereby the programme 863 was initiated as a major national initiative to bring China into high technologies on a par with advanced countries. China's TD-SCDMA 3G development began as part of the 863 programme, and is seen as one of its successes.

FuTURE is a 10-year research programme funded and coordinated by MOST within the scope of the 863 programme. This is the only major Chinese research programme in the field of mobile/wireless communications, and mainly supports the universities' activities.

Origins of FuTURE – the HTRDP

The High-Technology R&D Programme (HTRDP) is one of several programmes under the 863 programme, and focuses on telecommunications. It was founded in 1992, is sponsored by MOST, and managed by an expert committee. The research areas are:

- Networks and switching, multimedia applications
- Optical communication systems
- Wireless and mobile communications

HTRDP's mission is to promote the competition capability of China's telecommunication industry via technology innovations and system-level demonstrations, as well as by acquiring the core technology know-how and IPR via independent R&D, and to train high-level talents for the industry.

Current research topics in HTRDP are:

- Tb/s networking and applications:
  - *Router and switching*
  - *Optical Transmission*
  - *Demo and application system*
- IPv6 demonstration system
- 10 Gbit fixed-access systems
- Intelligent optical networking
- High altitude communication platform (HAPS)
- Beyond 3G and universal radio environment (FuTURE project)
  - *Beyond 3G cellular*
  - *Wireless regional area networks (WxAN)*

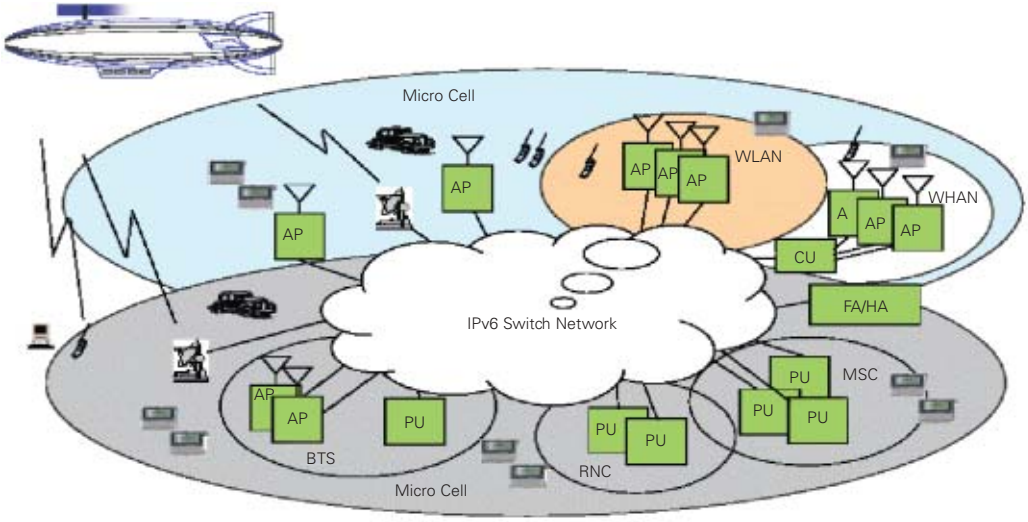
FuTURE project

FuTURE was launched as part of a 10-year programme in 2001 to support research in the domain of wireless communications. The FuTURE programme mission is to establish a universal radio experiment environment that can meet the future application demands and development trends for years 2005-2010, and bring up China's wireless R&D in line with the advanced countries.

FuTURE aims to integrate different radio access technologies via an IPv6 core network into a layered communication system comprising:

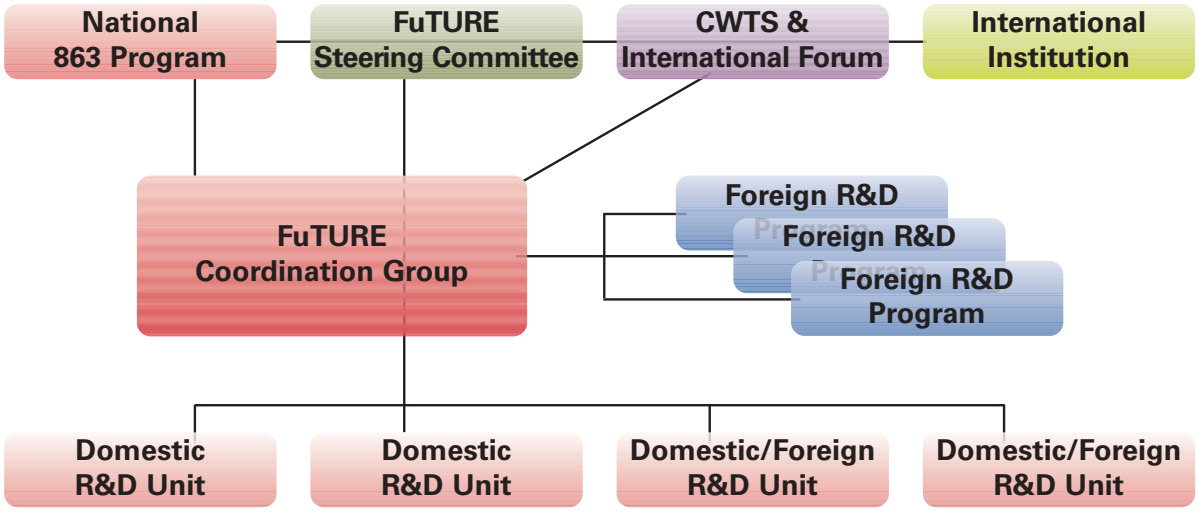
- Broadcast layer: HAPS – high altitude (10-30 km) space communications
- Cellular layer: B3G/4G mobile
- Areas layer: WxAN (including WLAN/WPAN/WHAN...)

This layered approach is depicted in the following picture:



FuTURE organisation

The organisational structure and administration of the FuTURE programme is illustrated below. As with next-generation mobile research in Korea, China is very conscious of the need to maintain international awareness and collaborations. These are both regional (Korea, Japan) and wider, notably Europe.



Appendix J

LIST OF EXHIBITS

Appendix K

GLOSSARY

1G	first generation
1H2003	first half of 2003
1x	one channel
2G	second generation
2.5G	second-and-a-half generation
2.75G	second-and-three-quarters generation
2Q2005	second quarter of 2005
3D	three dimensional
3G	third generation
3GPP	3rd Generation Partnership Project
3.5G	third-and-a-half generation
4G	fourth generation
8PSK	8-phase shift keying
AAA	authentication, authorisation and accounting
ADSL	asymmetric DSL
aka	also known as
ARPU	average revenue per user
ASBC	Alcatel Shanghai Bell Co Ltd (China)
ATM	automated teller machine
b	bit
B3G	beyond 3G
BcN	Broadband Convergence Network
BCS	British Computer Society
BUPT	Beijing University of Posts and Telecommunications (China)
BWA	broadband wireless access
B-WLL	broadband WLL
CAS	Chinese Academy of Sciences
CATR	China Academy of Telecommunication Research
CATT	China Academy of Telecommunications Technology
CCSR	Centre for Communication Systems Research (University of Surrey, UK)
CDM	code-division multiplex
CDMA	code-division multiple access
CMCC	China Mobile Communications Corp (aka China Mobile)
CN	core network(ing)
CPRI	Common Public Radio Interface
CUTC	China United Telecommunications Corp (aka China Unicom)
DAB	digital audio broadcasting
dB	decibel
dBW	decibels referenced to one watt
DECT	digital enhanced cordless telecommunications
DIY	do-it-yourself
DL	downlink

DMB	digital multimedia broadcasting
DSL	digital subscriber line
DSP	digital signal processing
DTI	Department of Trade and Industry (UK)
DTT	digital terrestrial television
DVB	digital video broadcasting
DVD	digital versatile disc
EC	European Commission
EDGE	enhanced data for global evolution
EMC	electromagnetic compatibility
ETRI	Electronics and Telecommunications Research Institute (Korea)
EU	European Union
EUDCH	enhanced uplink data channel
EVDO	evolution version data only
EVDV	evolution version data and voice
FDD	frequency-division duplex
FLE	Fujitsu Laboratories of Europe Ltd (UK)
FPGA	field programmable gate array
FTTH	fibre to the home
FuTURE	Future Technologies for Ubiquitous Radio Environment (initiative) (China)
FWA	fixed wireless access
Gb	gigabit
GDP	gross domestic product
GHz	gigahertz
GPRS	General Packet Radio Service
GPS	Global Positioning System
GSM	Global System for Mobile Communications
GSMA	GSM Association
h	hour
HFC	hybrid fibre coaxial
HMm	high-speed mobile multimedia
HPi	high-speed portable internet/high-performance internet
HSDPA	high-speed downlink packet access
HTRDP	High-Technology R&D Programme (China)
Hz	hertz
ICEC	Information Communication Ethics Committee (Korea)
ICT	information and communication technology
IEE	Institution of Electrical Engineers (UK)
IEEE	Institute of Electrical and Electronics Engineers
IETF	Internet Engineering Task Force
IMT2000	International Mobile Telecommunications (at) 2000 (MHz)
IP	Internet Protocol

IPO	initial public offering
IPR	intellectual property right(s)
IPv4	Internet Protocol, version 4
IPv6	Internet Protocol, version 6
IS-95	Interim Standard 95
IT	information technology
ITU	International Telecommunication Union
ITU-R	ITU – Radiocommunication Sector
ITU-T	ITU – Telecommunication Standardisation Sector
JV	joint venture
KAIST	Korea Advanced Institute of Science and Technology
kb	kilobit
KCC	Korea Communications Commission
km	kilometre
KOSEF	Korea Science and Engineering Foundation
KT	Korea Telecom
LAN	local area network
LDPC	low-density parity check
LGE	LG Electronics (Korea)
LLU	local loop unbundling
LNA	low-noise amplifier
Mb	megabit
MBCO	Mobile Broadcasting Corp (Japan)
MC-CDMA	multicarrier CDMA
MHz	megahertz
MIC	Ministry of Information and Communication (Korea)
MII	Ministry of Information Industry (China)
MIMO	multiple input, multiple output
mITF	mobile IT Forum (Japan)
MMIM	multimedia instant messaging
MMS	multimedia messaging service
MOCT	Ministry of Construction and Transportation (Korea)
MOST	Ministry of Science and Technology (China)
MP3	MPEG audio layer 3
MP4	MPEG audio layer 4
MPEG	Motion Picture Experts Group
ms	millisecond
MVNO	mobile virtual network operator
NDRC	National Development and Reform Commission (China)
NGMC	Next-Generation Mobile Communication (Forum) (Korea)
NGN	next-generation network
OEM	original equipment manufacture(r)
OFDM	orthogonal frequency-division multiplexing
OFDMA	orthogonal frequency-division multiple access
P2P	peer-to-peer
PAS	Personal Access System (China)
PC	personal computer
PCMCIA	Personal Computer Memory Card International Association

PCS	personal communication services
PDA	personal digital assistant
PHS	Personal Handyphone System (Japan)
PMR	private mobile radio
PSK	phase-shift keying
PSTN	public switched telephone network
PTT	post, telegraph and telephone
QAM	quadrature amplitude modulation
QoS	quality of service
QPSK	quadrature phase-shift keying
R&D	research and development
RAN	radio access network
RFID	radio frequency identification
RMB	renminbi/yuan (Chinese currency): £1 ≈ RMB14.5
RTT	radio transmission technology
s	second
SA	service area
SAIT	Samsung Advanced Institute of Technology (Korea)
SD	secure digital
SDR	software-defined radio
SHRCWC	Shanghai Research Centre for Wireless Communications (China)
SIM	subscriber identity module
SIMIT	Shanghai Institute of Microsystem and Information Technology (China)
SKT	SK Telecom (Korea)
SME	small or medium enterprise
SMS	short message service
SoC	system-on-chip
SOE	state-owned enterprise
STB	set-top box
S/W	software
TDD	time-division duplex
TDM	time-division multiplex
TD-SCDMA	time-division synchronous CDMA
TTA	Telecommunications Technology Association (Korea)
TV	television
UIM	user identity module
UK	United Kingdom
UKTI	UK Trade & Investment
UL	uplink
UMTS	Universal Mobile Telecommunications System
US(A)	United States (of America)
USIM	Universal Subscriber Identity Module
USN	Ubiquitous Sensor Network
UWB	ultra-wideband
VAS	value-added service
VCE	Virtual Centre of Excellence
VDSL	very high data rate DSL
VoD	video-on-demand

VoIP	Voice over Internet Protocol
VP	Vice President
WAP	Wireless Application Protocol
WCDMA	wideband CDMA
WiBro	wireless broadband
WiFi	wireless fidelity
WiMAX	Worldwide Interoperability for Microwave Access
WIPI	Wireless Internet Platform for Interoperability
WLAN	wireless local area network
WLL	wireless local loop
won	Korean currency: £1 ≈ 2,000 won
WP8F	Working Party 8F (ITU-R)
WPAN	wireless personal area network
WRC	World Radiocommunication Conference (ITU)
WTO	World Trade Organisation
WWRF	Wireless World Research Forum
xDSL	a generic term for the suite of DSL services, where the 'x' can be replaced with any of a number of letters *(see, eg, ADSL, VDSL)*

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Printed in the UK on recycled paper with 75% de-inked post-consumer waste content

First published in October 2004 by Pera Innovation Limited on behalf of the Department of Trade and Industry

URN 04/1434