MIGRATION TO IMT-2000 SYSTEMS

Handbook

Supplement 1 (revision 1)

Deployment of IMT-2000 Systems

English Edition 2011

Radiocommunication Bureau

This edition includes the modifications introduced by the corrigendum dated 28 April 2006.

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FOREWORD

This revised Supplement 1 expands on the first edition of the ITU Handbook – Deployment of IMT-2000 Systems and represents much of the work that has occurred since the release of the Handbook to address among other topics, the subject of evolution and migration from the current mobile systems towards IMT-2000. ITU-R has developed this work in response to on-going liaisons and interaction with the ITU-D and ITU-T Sectors and sees this material as the natural extension of the information presented in the Handbook.

We acknowledge the significant contributions and extensive deliberation that have made this Supplement a well rounded and balanced treatment of the options and alternatives on how deployment of IMT-2000 might be achieved in an orderly manner from any number of pre-IMT-2000 situations.

Mr. Maurice Ghazal, ITU-T Q.5/SSG Rapporteur, who crafted and steered the first edition of the Handbook, in his foreword of that text urged that work proceed expeditiously to address the topics that are found in this Supplement. We are happy to report that his appeal has been heard, and we gratefully acknowledge his diligence, foresight and his continued efforts to bring IMT-2000 to practical status in the many countries around the world.

We believe that this revised Supplement 1 to the Handbook on Deployment of IMT-2000 Systems, together with other ITU publications, will serve as a practical tool to assist countries in their endeavours to further develop their mobile communication networks and enhance the quality of services offered.

TABLE OF CONTENTS

Page

Page

Page

CHAPTER 1

INTRODUCTION

The Handbook on Deployment of IMT-2000 Systems[1] addresses a variety of issues related to the deployment of IMT-2000 systems, to inform and guide key decision-makers on critical aspects concerning third-generation mobile communication systems, and to facilitate decisions on the selection of options and strategies for the introduction of their International Mobile Telecommunications-2000 (IMT-2000) networks.

This revised Supplement 1 to the Handbook offers additional information and guidance on the radio aspects of IMT-2000 systems based on further studies and the experience gained since the Handbook was first published. In particular, it deals with evolution and migration aspects. In reading this Supplement the reader should be familiar with the material already presented in the ITU Handbook and related ITU-R publications[2].

IMT-2000 systems provide access to a wide range of telecommunication services, supported by the fixed telecommunication networks (e.g. public switched telephone network (PSTN)/integrated services digital network (ISDN)/Internet protocol (IP)), and to other services which are specific to mobile users.

To meet the ever increasing demands for wireless communication, and the expected higher data rates needed to meet user demands, IMT-2000 is being continually enhanced and systems beyond IMT-2000 are envisaged. The framework and overall objectives of the future development of IMT-2000 and systems beyond IMT-2000 are described in Recommendation ITU-R M.1645.

Resolution 228 (Rev.WRC-03)* noted that appropriate naming is to be developed for the future development of IMT-2000 and systems beyond IMT-2000. Thus the term "systems beyond IMT-2000" was used as a temporary name. Therefore, Resolution ITU-R 56-Naming for International Mobile Telecommunications, was adopted that clarifies the relationship between the terms "IMT-2000" and "the future development of IMT-2000" and gives the new name to those systems, system components, and related aspects that include new radio interface(s) that support the new capabilities of systems beyond IMT-2000. Resolution ITU-R 56 determined that IMT-2000 also encompasses its enhancements and future developments and that the term "IMT-Advanced" will be applied to those systems, system components, and related aspects that include new radio interface(s) that support the new capabilities of systems beyond IMT-2000. The root name International Mobile Telecommunications (IMT) encompasses both IMT-2000 and IMT-Advanced collectively.

While the scope of this Supplement is only the migration to IMT-2000 systems, it is noted that the IMT-Advanced process is well underway as described in the ITU web page for the IMT-Advanced submission and evaluation process[3]. All IMT-2000 technologies described in this Handbook are well poised to evolve/migrate to IMT-Advanced in due time; thus enabling a continuous enhancement of mobile networks. The key features of IMT-2000 and IMT-Advanced systems are summarized in § 1.4 of this revised Supplement 1.

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* *Note by the Secretariat:* This Resolution was suppressed by WRC-07.

[1] The ITU Handbook [2003] Deployment of IMT-2000 Systems can be obtained as follows:
Hardcopy: http://www.itu.int/publications/docs/tsb/imt2000.html
Softcopy: http://www.itu.int/itudoc/gs/imt2000/84207.html

[2] ITU-R Handbook – Principles and approaches of evolution towards IMT-2000/FPLMTS (Volume 2 of the Handbook on Land Mobile, including Wireless Access).
Available at: http://www.itu.int/itudoc/gs/subscirc/itu-r/229-7.html

[3] http://www.itu.int/ITU-R/index.asp?category=study-groups&rlink=rsg5-imt-advanced&lang=en

1.1 Background

During the last few years, large pre-IMT-2000 mobile communication networks have been built up in many parts of the world (analogue since the 1980s and digital since the 1990s). In some developed countries the penetration of mobile users has surpassed 100%, and in many countries there are more mobile subscribers than fixed-line telephone subscribers. The networks built up so far are mostly designed to provide coverage over the territory of a country, so these are large networks. The flexibility in using these networks and the high degree of mobility is a feature of pre-IMT-2000 systems. Mobility between networks is today an important aspect. Transparent roaming and handover between networks, including international cross-border roaming is a normal operation today.

As described in the Handbook, many countries have licensed terrestrial IMT-2000 networks based on the international framework of ITU Recommendations, and commercial deployment of IMT-2000 systems began in 2000.

Whereas it is desirable for pre-IMT-2000 systems to be able to evolve to IMT-2000, the decision whether or not to evolve must be made by those responsible for each particular system/service. However, the ITU can assist those parties making such decisions by providing background information, such as that contained in the handbooks, and in Recommendation ITU-R M.1308 – Evolution of land mobile systems towards IMT-2000. In developing the ITU-R Recommendations for IMT-2000, particularly the terrestrial radio interfaces in Recommendation ITU-R M.1457, the ITU-R considered provisions that facilitate the evolution of pre-IMT-2000 systems towards IMT-2000 without compromising the capabilities, objective, and performance of IMT-2000.

1.2 About Recommendation ITU-R M.1457

International Mobile Telecommunications-2000 (IMT-2000), third generation mobile systems, provide access to a wide range of telecommunications services, supported by the fixed telecommunications networks (e.g. PSTN/ISDN/IP), and to other services which are specific to mobile users.

Recommendation ITU-R M.1457 has been developed jointly by the ITU and the radio interface technology proponent organizations, global partnership projects and standards development organizations. Updates, enhancements, and additions to the radio interfaces incorporated in this Recommendation have undergone a defined process of development and review to ensure consistency with the original goals and objectives established for IMT-2000 while acknowledging the obligation to accommodate the changing requirements of the global marketplace.

This Recommendation identifies the detailed specifications for the IMT-2000 radio interfaces. It has been developed based on consideration of the results of a defined evaluation process employed by the ITU-R on IMT-2000 radio proposals that have been submitted in response to a set of defined requirements. Further consideration was given to consensus building, recognizing the need to minimize the number of different radio interfaces and maximize their commonality keeping in mind the end-user needs, while incorporating the best possible performance capabilities in the various IMT-2000 radio operating environments.

By updating the existing technologies, harmonizing existing interfaces, and entertaining new mechanisms, IMT-2000 remains at the forefront of mobile radio technology.

1.3 From existing mobile networks to IMT-2000

The number of mobile users worldwide augmented four times between 2003 and 2010. The number of mobile subscriber reached 5.3 billion by the end of 2010. More than 90% of the world's population now has access to a mobile network, making mobile telephony truly ubiquitous. Growth is strong in developing countries, from 53% of total mobile subscriptions at the end of 2005 to 73% at the end of 2010 mainly driven by the Asia-Pacific region. India and China alone added over 300 million mobile subscriptions in 2010. In Africa, the penetration rate is forecast to reach 41% at the end of 2010[4].

[4] ITU Database and Recommendation ITU-R M.1645 – Framework and overall objectives of the future development of IMT-2000 and systems beyond IMT-2000 and ITU News No. 10 (December 2010).

The transition from pre-IMT-2000 to IMT-2000 systems will happen over a period of time that will allow operators to capitalize on investments made in pre-IMT-2000 infrastructure. There are potentially many different techniques for wireless operators to evolve or migrate from existing systems using IMT-2000 technologies. Administrations and operators need to consider what solutions are available at the time the transition is considered and conduct the business case with extensive financial and technical analyses before making decisions on the best approach.

Most mobile network operators have already identified clear evolution paths to IMT-2000 third generation networks. By and large, operators of GSM, the America’s TDMA and Japan’s Personal Digital Cellular (PDC) networks have identified evolution paths to IMT-2000 CDMA Direct Spread (WCDMA) and IMT-2000 TDMA Single-Carrier solutions and cdmaOne (IS-95) operators have identified evolution paths to IMT-2000 CDMA Multi-Carrier (CDMA2000)[5] solutions, while some operators are transitioning to the new IMT-2000 standard, OFDMA TDD WMAN. However, operators are also evaluating all the options available for them to migrate to IMT-2000.

As a matter of course, the possible transition paths reflect local situations and conditioning – including the (competitive) service provision environment, the service penetration policy, and the strategic and financial aspects. Before and during the transition process, it is required that operation and economic implications of the network deployment be assessed. It is then realized that there is no single solution that is right for every operator. Moreover, the network deployment needs to be fine-tuned, considering the uncertainty margins by which the range of parameters associated with the evolution or migration decisions are affected.

In terms of transition from existing mobile systems, this Supplement does not make any comparison between performance of different technologies and promotion of specific technologies. This Supplement provides facts about the various mobile systems and technologies that might help to decide on the right transition path.

1.4 IMT-2000 and IMT-Advanced systems

IMT-2000, third generation mobile systems started service around the year 2000, and provide access by means of one or more radio links to a wide range of telecommunications services supported by the fixed telecommunication networks (e.g. PSTN/ISDN/IP) and to other services specific to mobile users. Since then, IMT-2000 has been continually enhanced.

International Mobile Telecommunications-Advanced (IMT-Advanced) systems are mobile systems that include the new capabilities of IMT that go beyond those of IMT-2000. Such systems provide access to a wide range of telecommunication services including advanced mobile services, supported by mobile and fixed networks, which are increasingly packet-based.

Key features of IMT-2000 and IMT-Advanced are contained in Recommendations ITU-R M.1645, ITU-R M.1822 and IMT-Adv/2 Rev.1.

Key features of IMT-2000 are:

– high degree of commonality of design worldwide;
– compatibility of services within IMT-2000 and with the fixed networks;
– high quality;
– small terminal for worldwide use;
– worldwide roaming capability;
– capability for multimedia applications, and a wide range of services and terminals.

The key features of IMT-Advanced are:

– a high degree of commonality of functionality worldwide while retaining the flexibility to support a wide range of services and applications in a cost efficient manner;
– compatibility of services within IMT and with fixed networks;

[5] CDMA is a registered trademark of the Telecommunications Industry Association (TIA).

- capability of interworking with other radio access systems;
- high quality mobile services;
- user equipment suitable for worldwide use;
- user-friendly applications, services and equipment;
- worldwide roaming capability;
- enhanced peak data rates to support advanced services and applications (100 Mbit/s for high and 1 Gbit/s for low mobility were established as targets for research).

1.5 Driving forces for IMT-2000

The key driving forces for IMT-2000 are covered in detail in Recommendation ITU-R M.1645. Some of the key features and objectives of IMT-2000 as compared to pre-IMT-2000 are covered specifically in Recommendation ITU-R M.1308 and the ITU-R Handbook [1997] on Principles and Approaches of Evolution to IMT-2000/FPLMTS.

The driving forces that are particularly important in developing countries include:

- market projections for mobile data;
- inter-working of OFDMA, CDMA, TDMA and GSM networks;
- evolution of content based services;
- growth of packet networks;
- high speed data capability in wireless communications would provide wireless access technology with competitive advantage vis-à-vis the wireline access technology;
- marketing advantage.

In developing countries, the task of bridging the digital divide arrived at a juncture where most of the countries were still grappling with the problem of providing voice access. Large-scale computerization and growth of e-services have necessitated the availability of higher bandwidth on the local access network. In these countries, most of the access lines are likely to be implemented using wireless technology and, therefore, the options such as xDSL or CATV or ISDN are not a mass scale consideration. Therefore, IMT-2000 has a unique advantage in these markets.

In many developed countries the local copper plant has been unbundled to promote competition in broadband. As it is not possible to carry out such unbundling in the wireless network, interworking of different wireless technologies would be an alternative to provide competing broadband services.

1.6 Demand for non-voice, high bit-rate services

Of the top 20 mobile second generation operators who lead the world in terms of data revenues expressed as a percentage of their total average revenue per user (ARPU), 19 of them are running GSM networks[6]. A key contributor to this success is the demand for non-voice services as evidenced by the explosive popularity of SMS, or text messaging, with over 1 billion short messages being sent daily. In the United Kingdom alone, more than 70% of mobile phone users now use their handsets for text messaging – a figure that is even higher in countries such as Germany and Ireland – and 16.8 billion chargeable person-to-person text messages were sent across the United Kingdom's four GSM networks in 2002[7].

Other services, meanwhile, are steadily generating an increase in non-voice revenues for operators. Building on the enormous success of SMS, mobile multimedia messaging service (MMS) has so far attracted well over 1 million subscribers in Europe alone, allowing them to create, send, store and share their own pictorial content.

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[6] Global Mobile Suppliers Association.

[7] Mobile Data Association.

Already offered by more than 115 operators[8] – chiefly in Europe and Asia – MMS provides the market with an early glimpse of the service opportunities offered by higher speed data services. Rapid progress is also being made to open up MMS interoperability – an indicator of the importance that operators are placing on the success of this market. This demand for non-voice services underscores the need for the high-speed packet data services only IMT-2000 systems can support.

1.7 Flexibility: Multi-environment capabilities

New services and applications created by IMT-2000 will also exhibit distinct regional trends in terms of user take-up. An example of this is Asia Pacific, where the UMTS Forum an industry association predicts that annual revenues for all IMT-2000 technologies will reach USD 118 billion by 2010, with "customized infotainment" – personalized access to news, sports results, gaming and other forms of information and entertainment – representing 36% of all Asian IMT-2000 revenues, ahead of simple voice (28%), mobile access to the Internet and corporate networks (14%) and MMS (13%). In addition, at the 3G World Congress in Hong Kong June 2002, data was presented that showed that 3G operators were experiencing a 16% increase growth in ARPU (USD 35.4 to USD 41.8) between 2000 and 2002. Of this increase, 67% was directly attributed to users adopting and using packet data services[9].

Furthermore, IMT-2000 has an important role to play in bridging the "digital divide" between regions and cultures.

Of this enormous market opportunity, it is anticipated that the largest revenue generators will be voice; personalized access to information and entertainment services ("infotainment"); mobile access to the Internet and corporate networks; and MMS. Other contributors to operators' revenues will include Location Based Services and "Rich Voice" – an extension of normal voice communications that overlays the simultaneous transmission of photos, graphics, video, maps, documents and other forms of data.

For further information on Services please refer to Chapter 2 and Annex C of the ITU Handbook [2005] on Deployment of IMT-2000 Systems.

1.8 Information on IMT-2000 Satellite Technologies

The satellite and terrestrial components of IMT-2000 generally complement each other by providing service coverage to areas which either alone may not serve for economic reasons. Each component has particular advantages and constraints. The satellite component can provide coverage to areas which may not be within the economic range of the terrestrial component, such as rural and remote regions.

There are currently six satellite systems defined as part of the IMT-2000 family through their radio interfaces (see Recommendation ITU-R M.1850. Each can be expected to operate independently of one another. All aim to provide coverage for regional, multiregional or global service areas and hence there may be several satellite systems, capable of providing service in any country.

1.9 Standards development organizations dealing with IMT-2000

IMT-2000 is a system with global development activity and the IMT-2000 radio interface specifications in the ITU Recommendations have been developed by the ITU in collaboration with the radio interface technology proponent organizations, global partnership projects and standards development organizations (SDOs). The ITU has provided the global and overall framework and requirements jointly with these organizations. Each of the radio interfaces defined by an external organization is shown in Table 1.1.

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8 Global Mobile, EMC, GSMA, (http://www.gsmworld.com).

9 3G World Congress in Hong Kong June 2002 – "Mobile Services in Korea, 1X and Beyond", Wong Tong, President Samsung R&D Institute.

TABLE 1.1

IMT-2000 Terrestrial Radio Interfaces: External Organizations

Full Name	External Organizations
IMT-2000 CDMA Direct Spread	3GPP
IMT-2000 CDMA Multi-Carrier	3GPP2
IMT-2000 CDMA TDD (time-code)	3GPP
IMT-2000 TDMA Single-Carrier	ATIS WTSC and TIA
IMT-2000 FDMA/TDMA (frequency-time)	ETSI
IMT-2000 OFDMA TDD WMAN	IEEE

1.10 Organization of this revised Supplement 1

Chapter 2 addresses consideration of evolution and migration to IMT-2000 including the needs of operators, regulators and consumers, particularly in developing countries, and evolution/migration strategies including user density and universal service considerations. It also provides guidance on the use of the frequency spectrum, including a description of the various methods to licence the frequency spectrum. Finally, it covers briefly the important issue of lawful interception and common access to emergency services.

Chapter 3 covers the evolution/migration paths including consideration of factors such as the availability and use of spectrum for both pre-IMT-2000 and IMT-2000 systems, availability of equipment and service applications for the various technologies and their performance in the desired operating environment. The systems based on the IMT-2000 terrestrial radio interfaces are covered in detail; however, this Supplement does not make any comparison between the performances of different technologies or promote specific technologies.

Chapter 4 addresses the economics of evolution/migration to IMT-2000. The Chapter starts by providing a general overview of market analysis and trends in various parts of the world. The factors that have an influence on the costs and benefits of evolution/migration are discussed briefly in general and then in more detail for the specific IMT-2000 technologies. This Chapter concludes by leading the reader though a detailed business plan exercise for a hypothetical wireless operator.

Chapter 5 provides concluding remarks on the revised Supplement 1.

Annexes are included to provide additional information on various aspects of the Supplement. Annex A provides definitions for the terms used in the Supplement, the common names of the IMT-2000 air interfaces, and a glossary of terms and abbreviations. Annex B provides information on operator evolution/migration paths. Annex C provides information on operator experiences in transitioning to IMT-2000 systems.

CHAPTER 2

DEVELOPMENT OF POLICIES FOR THE EVOLUTION/MIGRATION OF EXISTING NETWORKS TO IMT-2000

The variety of situations in developing countries relating to the technology and the development of existing mobile networks implies the need for diverse and different transition policies toward networks based on enhanced systems. This Supplement is therefore intended to address only those cases where the transition to IMT-2000 networks is expected to affect medium term plans.

The identification of a transition policy is based on the analysis of key aspects, that impact demand, investments and revenues. As already stated, although these aspects are common to all countries, their implications for developing countries deserve special treatment.

2.1 Special needs of operators, regulators and users in developing countries

The number of mobile subscribers in developing countries is low compared to developed countries, but the number of subscribers is increasing significantly, calling party pays has helped some developing countries to rapidly increase faster their mobile penetration. In fact, in many countries mobile penetration exceeds fixed-line penetration, therefore developing countries have a great potential when the penetration rates are concerned. However, due to economic conditions, users in developing countries may be able to allocate very little of their income to telecommunications. With additional services like videoconferencing and high speed mobile Internet, some usage fees of the IMT-2000 services are expected to be higher than those of current mobile services. Moreover, IMT-2000 infrastructure costs can cause increase in the usage fee. As a result, some of the pre-IMT-2000 subscribers in the developing countries may wish to continue to use the current systems. Therefore, determination of suitable methods of transition is an important issue for protecting the rights of present subscribers preferring not to migrate.

Costs will be another key consideration for operators, as their investments in current pre-IMT-2000 mobile systems are great and returns may have not yet covered those costs. Operators must consider these costs in planning to deploy IMT-2000 systems, and actual deployment may be delayed. In order to capitalize on current mobile systems, IMT-2000 networks and terminals should be as compatible as possible with the current pre-IMT-2000 systems, and reuse of the existing pre-IMT-2000 infrastructure in the deployment of IMT-2000 systems, and infrastructure sharing, can reduce costs. Furthermore, there should be enough reasonably priced dual mode terminals that users in developing countries can afford them. This will help IMT-2000 to penetrate quickly.

Some typical needs of operators and consumers in developing countries are:

– Low licensing fees to reduce the entry cost for service providers.

– Ability to offer tariffs that are affordable to the end-users.

– Affordable pricing of mobile services, minimal initial investment and total network cost.

– Sufficient charging (billing) flexibility to adapt to different charging schemes and be capable of being configured for special conditions where mobility between cells, or even within a cell, is not required.

– Roll out obligations that are in keeping with the business case of the operator and the consumer’s interest.

– Solutions that enable coverage of rural areas (with varied terrain characteristics) with large cells.

– Ability to share infrastructure to facilitate speedy and cost-effective deployment.

– Promotion of local development of applications and terminals.

– Hardware and software supporting open standards.

– Terminals that support local requirements, e.g. language and character sets.

In addition to these general needs it is also important to recognize that the needs of developing countries should not be just related to topographic and technical issues, but they should also be expressed in terms of commonly defined societal conditions.

2.1.1 Special needs of operators

Minimization of infrastructure costs is a concern for operators in developed as well as developing countries. However, due to lower penetration rates and ARPUs in developing countries this constraint is heavier in these countries. Thus, from the standpoint of the operators there is a need for a regulatory environment that minimizes implementation and roll-out costs (such as sustainable coverage obligations, low licence fees, choice between alternative technologies allowing a cost efficient network deployment, possibility to use lower frequency bands, infrastructure sharing). Furthermore, since in most developing countries mobile networks provide more extensive coverage than fixed networks, administrations in these countries may wish to support the usage of such networks for fixed/data applications.

TABLE 2.1

Special needs of operators

Item	Operator needs and rationale
Costs	Costs should be minimized as much as possible because the vast majority of the population has little discretionary budget for telecommunications/entertainment. Recovery of evolution/migration capital expenditure (CAPEX) and operating (OPEX) costs
Fixed wireless access	Some operators may provide fixed wireless access for IMT-2000 services in urban areas
Coverage and deployment obligations	Target coverage/service penetration and roll-out schedule set by regulators in some cases. The goal for coverage for IMT-2000 systems, which will be realized over time, should be consistent with existing pre-IMT-2000 systems. Roll-out obligations must be set keeping in view the business case of the operator and the user's interest
Transition time	Time frame for transition from existing "mobile"/"fixed" towards IMT-2000. Operators should have maximum flexibility in determining and finalizing the transition
Mass application	Applications such as tele-education, telemedicine, e-government may require IMT-2000 technologies
Government support	Role of government subsidy for infrastructure and/or advanced applications (not for infrastructure but for affordability of services by all including universal service obligations)
Value depreciation	Possible obsolescence of new infrastructure investments while waiting for IMT-2000 demand
IMT-2000 bands	Access to appropriate frequency bands and adequate spectrum is required. Use of frequencies below 1 GHz and allocation of future frequency bands as per WRC/WARC decisions may be advantageous in providing cost-efficient coverage. Use of harmonized IMT-2000 bands decreases equipment costs and facilitates worldwide roaming

TABLE 2.1 (*end*)

Item	Operator needs and rationale
Technical and administrative conditions	Conditions for use of spectrum (licensing/roaming/coverage/other operator obligations)
Infrastructure sharing	Sharing of (radio/network) resources for rapid rollout and coverage (VNO – virtual network operator) can be encouraged to facilitate speedy deployment of new technologies and lower the costs to operators
Satellite component	Usage of satellite component of IMT-2000
Market analysis and business cases	How to develop market analysis/business case? (population literacy, disposable income, ...)
Services and applications	– Low entry fees would reduce the entry cost of service provider – Use of IMT-2000 for access to education in remote villages, rural economic development, access to Internet at affordable price
Availability of equipment from multiple vendors	– Existence of multiple vendors increases competition with positive price effects for operators – Dependency of operators on vendors is reduced – Multivendor systems require standardization by a broad community and leads to open standards

2.1.2 Special needs of regulators

Regulators in developing countries may wish in particular to set up a regulatory/legal frame work that minimizes network deployment costs while facilitating the provision of an extensive network coverage and of specific "socially efficient" services and applications (e.g. e-health, e-education). Education policies that improve literacy rates will increase the population's ability to utilize Information Technology (IT) services.

TABLE 2.2

Special needs of regulators

Item	Operator needs and rationale
Licence handling and allocation	Capitalize on experience of developed countries on: – licence awarding method – licence conditions – licence fees – number of licences
Databases	Capitalize on experience of developed countries on: – request for proposal (RFP) issued for awarding IMT-2000 licences – Rationale behind the preferred licence awarding methods – Information on the method of determination of lowest bid rates – Standard concession agreements – including provisions related to QoS numbering, interconnection, roaming, coverage, infrastructure sharing etc. – that were signed with the IMT-2000 operators – A list of rights and obligations of the IMT-2000 operators, including the rationale behind each

2.1.3 Special needs of users

Due to lower income levels, the user's ability to pay for telecommunications services is lower in developing countries than in developed ones, calling party pays was introduced in some developing countries in order to facilitate access by low-income subscribers. IMT-2000 services and applications can be adapted to meet the needs of specific regions in local languages. Affordability of services and terminals are of key interest to users.

TABLE 2.3

Special needs of users

Item	Operator needs and rationale
Costs	User affordability for services and terminals. – Tariffs should be affordable to the end-users
Terminals	Ease of use and convenience of terminals. – The terminals should support local requirement in terms of language and must take into consideration the literacy level across the country
Easy roaming	– Users want to use their usual terminals when travelling. – Roaming is facilitated by low prices and by the availability of compatible technologies/terminals in foreign countries
Services and applications	– Use of IMT-2000 for education in remote villages, rural economic development, access to Internet at affordable price. Training of users on wireless data applications

2.2 Strategies for smooth transition

2.2.1 Regulatory flexibility to allow transition

The adoption of flexible policies for the national allocation of the radio spectrum and for the choice of technologies provides market incentives for the development and deployment of advanced wireless services throughout the world. Regulators may wish to allow operators to transition their pre-IMT-2000 systems to IMT-2000 using their existing licensed spectrum, so that operators would not need to deploy these systems in new spectrum bands. This spectrum flexibility benefits operators by allowing them to spend capital resources on improving their system and can keep costs low. This can also be achieved by minimizing licensing costs for new spectrum. In developing spectrum policy, regulators should be aware that services enabled by the more advanced technologies will be bandwidth intensive so operators will require more contiguous spectrum to deploy these new technologies mainly in the most populated cities to avoid a decrease in the quality of service.

The ITU recommends that IMT-2000 systems be deployed in any of the bands identified by the ITU for IMT-2000 in the Radio Regulations (RR). Recommendation ITU-R M.1036 states that administrations may deploy IMT-2000 systems in bands other than those identified in the RR, but these bands may lack economies of scale.

Some countries have licensed IMT-2000 systems in bands not currently being used for pre-IMT-2000 systems, but identified in the RR for IMT-2000. Moreover, in some countries (for example, the United States of America), system upgrades to IMT-2000 are taking place in the cellular bands (800 MHz and 900 MHz) and in the personal communications services (PCS) bands (1 800 MHz and 1 900 MHz). There are various possibilities to facilitate in-band transition. The regulators should evaluate these options carefully and select the one which best meets their needs.

One possibility to facilitate in-band migration consists of the following:

First, there are no regulatory limitations on which technologies can be used in the existing mobile bands. Regulations and/or licence conditions specifying the use of a particular technology or standard in the bands would have to be eliminated.

Second, service definitions may also have to be modified to accommodate the new flexibility. This can be achieved in the regulations or licence authorizing mobile services (e.g. cellular, PCS or IMT-2000), by keeping the definition broad and non-specific. For example, the use of a broad definition has allowed existing pre-IMT-2000 operators in various countries to pursue in-band transition to IMT-2000 using whatever technology they choose. In this case the operator makes the choice of technologies that best meets its business objectives. In addition, the operator is given the flexibility to introduce a new technology at any point in the licence duration.

An alternative possibility to facilitate in-band migration is for the regulator to enhance the existing licences and identify some preferred technologies in order to meet the demands of end users and operators. For example, these preferred technologies might be the IMT-2000 family. Spectrum management by the regulator may be simplified in this case because the properties (e.g. spectral emissions, transmit power, channel spacing etc.) of the technologies being deployed are known when issuing/enhancing the licences. Given a choice from among the preferred technologies, the operators can still select the most appropriate technology from the set of technologies as well as the timing of the introduction of the new technology.

Harmful interference between licences using pre-IMT-2000 and IMT-2000 systems may be addressed by specific technical rules that seek to avoid harmful interference between operators on adjacent channels in the same area. These technical rules include out-of-band emission limits, power flux-density or field strength limits at the edge of the service areas or borders, guardbands, and coordination requirements.

2.3 Accommodating special needs for transitioning to IMT-2000

2.3.1 Solutions for low density areas

In rural, sparsely populated and/or low-traffic density areas, the coverage advantages of lower frequency ranges will be an important consideration for the deployment of wireless systems, including IMT-2000. Lower frequency radio waves propagate, or travel, farther than higher frequency waves. This variation in propagation as a function of frequency results in greater coverage per cell site in a cellular system operating in a lower frequency range as compared to one operating in higher frequency bands. Greater coverage per cell site results in the need for fewer cells to provide service for a geographic area. Additionally, there exists an inverse relationship between maximum achievable average data rate and maximum cell range.

Worldwide, operators are using first and second generation mobile spectrum for IMT-2000. For example, it is worth noting that operators in Brazil, Canada, Ecuador, India, Japan, Korea, Mexico, New Zealand, Venezuela and the United States of America, among others, are currently utilizing the 800 and/or 1 900 MHz bands to offer IMT-2000 services by transitioning existing first and second generation systems to IMT-2000. Similarly, operators in Romania, Belarus, Poland, Russia, Uzbekistan and Sweden have upgraded first generation systems in the 450 MHz band to IMT-2000[10]. It could be more costly to deploy IMT-2000 systems in non-harmonized frequency bands than in those that are harmonized and utilized by the majority of operators due to a lack of economies of scale.

Similarly, let us now consider the case of two technologies such as GSM/EDGE radio access network (GERAN) and UMTS terrestrial radio access network (UTRAN). In terms of technology, both GERAN and UTRAN can be used to realize large cell radii as required in sparsely populated areas. But due to the different frequency ranges where GERAN and UTRAN are envisaged to operate today, GERAN is more suitable for large cells. One reason for that is that GERAN is operated in 900 MHz, 800 MHz and is specified for operation in 450 MHz. UTRAN can be used as a complement to GERAN to enhance the traffic capacity and to offer significantly higher data rates.

2.3.2 Solutions for high density areas

Many developing countries have densely populated cities, which are growing so quickly that fixed lines cannot be installed fast enough to meet demand. In such situations, wireless systems, such as IMT-2000, may be a cost-effective and flexible solution.

A wireless system is likely to be less expensive and faster to deploy than a wireline network. In addition, wireless systems can be configured to handle both fixed and mobile traffic, which provides flexibility for operators to meet the demand for both types of services, which may vary over time. Wireless systems, such as IMT-2000, can also provide both basic voice, as well as low-to-high-speed data services. The capability to handle both basic and advanced services is another advantage for operators that want to expand their networks as demand for these services increases.

[10] The 450 MHz IMT-2000 system in Romania, Belarus, Russia and Uzbekistan are commercial, whereas the system in Sweden is still in a trial stage.

Finally, it is important to note that operators of wireless systems in lower frequency ranges, such as those below 1 GHz, can provide services in both rural and dense urban areas using the same network in terms of technology and frequency range. As explained above, operators in large countries with both rural/sparsely populated areas as well as densely populated areas (such as Brazil, Canada, and the United States of America) are able to meet demand for both voice and data services using IMT-2000 networks in bands below 1 GHz. In high density areas, due to the significantly high traffic load, it may be necessary to deploy additional spectrum – preferably in the harmonized frequency bands.

IMT-2000 can be used to realize small cell radii as required in densely populated areas, because there exists an inverse relationship between maximum achievable average data rate and maximum cell range.

In general, IMT-2000 systems can be engineered to balance between traffic capacity and higher data rates.

2.3.3 Universal service/access to basic and advanced services

In several developing countries around the world, the number of wireless users has overtaken the number of wireline subscribers. Increased competition is bringing down the price of wireless phone service, while simultaneously spurring higher levels of service quality. By encouraging investment in wireless systems, whether through allocation and assignment of suitable spectrum, or through the implementation of regulatory policies that provide incentives and flexibility to operators to meet user demands, administrations can leverage wireless technologies, such as IMT-2000, to address the lack of access to basic voice services.

In addition to improving access to basic voice services, developing countries are also looking to expand the definition of universal service/access to include data services, such as Internet access. Wireless systems, such as IMT-2000 have been designed to handle both basic voice as well as low-to-high-speed data services. IMT-2000 technologies with their higher data rates can bring advanced services to a wider range of users, while meeting important social needs such as providing high speed connectivity to clinics, schools, libraries, governments, telecenters and other priority users.

In addition to Internet access, many other applications essential for developing countries, such as e-health/telemedicine, can be provided over wireless systems, including IMT-2000. Other applications include using IMT-2000 networks to monitor remote outpatients with specific health conditions.

2.3.4 Extension of IMT-2000 services to other accesses, including access via fixed networks

Wireless technologies, including IMT-2000, can be used for either mobile or fixed applications. Often regulators decide to allocate spectrum for fixed wireless access (FWA) systems to help increase teledensity, create competition and build out the local loop. Operators of FWA systems are able to charge different tariffs for fixed and mobile services, even though each service may be provided using the same equipment.

Also, due to the high-speed data capabilities of IMT-2000 technologies, users may decide to utilize such technology for Internet access. In addition to accessing the Internet directly with wireless handsets or personal digital assistants, IMT-2000 handsets can be used as a modem connected to a laptop or desktop computer via Bluetooth or cables. Also available are IMT-2000-capable PCMCIA cards, which are wireless modem cards that plug into laptop or traditional desktop computers.

Requirements for the use of fixed networks in the role of fixed access networks are addressed in ITU-T Recommendation Q.1761[11].

2.4 IMT-2000 service offerings

Typical mobile and IMT-2000 service offerings include but are not limited to:

– Voice
– Slow-scan video

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[11] ITU-T Recommendation Q.1761 – Principles and requirements for convergence of fixed and existing IMT-2000 systems (01/2004).

- Streamed video
- Interactive multimedia
- File and image transfer
- Web browsing (Internet and intranet access)
- e-mail
- Information services
  - Health
  - Education
  - Entertainment
  - Finance
  - Travel
  - Local Government
- Telemetry
- SMS (person to person)
- SMS (Applications)
- MMS
- Games
- Mobile Money
- Location Based Services
- ITS-enabled services
- Mobile multimedia-broadcasting/multicasting
- Emergency calling, public alerting, priority service and lawful intercept.

2.5 Spectrum requirements (including the possibility of using existing bands)

2.5.1 Current spectrum identified for IMT-2000

To date, the following frequency bands have been identified in the Radio Regulations (RR) for IMT and/or IMT-2000 by WARC-92, WRC-2000 and WRC-07: 450-470 MHz, 698-960 MHz, 1 710-2 025 MHz, 2 110-2 200 MHz, 2 300-2 400 MHz, 2 500-2 690 MHz, 3 400-3 600 MHz. This identification does not preclude the use of these bands by any application of the services to which they are allocated and does not establish priority in the Radio Regulations. Different regulatory provisions apply to each band. The regional deviations for each band are described in the footnotes applying in each band, as shown in the table below[12]:

Band (MHz)	**Footnotes identifying the band for IMT**
450-470	5.286AA
698-960	5.313A; 5.317A
1 710-2 025	5.384A, 5.388, 5.388A, 5.388B
2 110-2 200	5.388
2 300-2 400	5.384A
2 500-2 690	5.384A
3 400-3 600	5.430A, 5.432A, 5.432B, 5.433A

[12] Some administrations may deploy IMT-2000 systems in bands other than those identified here.

Also, some administrations may deploy IMT-2000 systems in bands other than those identified in the RR.

In ITU-R the work on the frequency arrangements for bands identified for IMT is designed to unite ITU Member states in support of common band plans for mobile services. The goal is to avoid market fragmentation and achieve the greatest possible agreement on harmonized frequency arrangements. The motivation for this harmonization is to produce lower network costs, simplified roaming and inexpensive devices.

ITU-R is currently updating Recommendation ITU-R M.1036-3, which is expected to result in a draft revision in 2012[13]. This revision will include the frequency arrangements that are recommended for implementation in the bands that were identified for IMT at WRC-07 and are in the Radio Regulations (RR). The order of the frequency arrangements within each annex does not imply any priority. Administrations can implement any of the recommended frequency arrangements to suit their national conditions. Administrations can implement all or part of each frequency arrangement.

Administrations should take into account the fact that some of the frequency arrangements in the same band have an overlap of base station transmitter and mobile station transmitter bands. Interference problems may result when a frequency arrangement overlaps with the frequency arrangement in neighbouring countries.

In order to determine the principles and practical use of the spectrum for IMT-2000 systems it is considered:

a) that the RR identify the bands 450-470 MHz, 698-960 MHz[13], 1 710-2 025 MHz, 2 110-2 200 MHz, 2 300-2 400 MHz, 2 500-2 690 MHz and 3 400-3 600 MHz as intended for use on a worldwide basis by administrations wishing to implement IMT-2000, as indicated in RR No. 5.388, No. 5.384A, No. 5.317A (WRC-2000), Resolution 212 (Rev.WRC-97), Resolution 223 (WRC-2000), Resolution 224 (WRC-2000) and Resolution 225 (WRC-2000); by taking these footnotes and resolutions into account, flexibility should be afforded to administrations to decide on using these bands at the national level according to each administration's evolution/migration plan;

b) that in some countries, other services are in operation in the bands identified for IMT-2000 as indicated in Resolution 225 (WRC-2000), RR No. 5.389A, No. 5.389C, No. 5.389D[*], No. 5.389E and Recommendations ITU-R M.1073-1 and ITU-R M.1033-1;

c) that a minimized number of globally harmonized frequency arrangements in the bands identified for IMT-2000 by one or more conferences will:

- facilitate worldwide compatibility;
- facilitate international roaming;
- reduce the overall cost of IMT-2000 networks and terminals by providing economies of scale;

d) that when frequency arrangements cannot be harmonized globally, a common base and/or mobile transmit band would facilitate terminal equipment for global roaming. A common base transmit band, in particular, provides the possibility to broadcast to roaming users all information necessary to establish a call;

e) that when developing frequency arrangements possible technological constraints (e.g. cost efficiency, size and complexity of terminals, high speed/low power digital signal processing and the need for compact batteries) should be taken into account;

f) that some administrations may consider the use of the lower UHF land mobile bands, e.g. below 470 MHz, for the deployment of IMT-2000 systems in cases where it is desirable to evolve an existing first or second generation system to IMT-2000 and/or to take advantage of coverage benefits for rural, sparsely-populated or low-traffic density areas;

g) that some administrations are planning to use parts of the bands 698-960 MHz or 2 300-2 400 MHz for IMT-2000.

[*] *Note by the Secretariat*: RR No. 5.389D was suppressed by WRC-07.

[13] For the latest version in force see, http://www.itu.int/rec/R-REC-M.1036

2.5.2 Use of first and second-generation mobile spectrum for IMT-2000

Recognizing the advantages of evolving/migrating existing systems to IMT-2000, WARC-92 and WRC-2000 identified the frequency ranges, including the 800 MHz, 900 MHz, 1 800 MHz and 1 900 MHz bands, in which most commercial first and second-generation wireless systems operate and encouraged administrations to facilitate evolution/migration from one generation to another in those bands.

Operators in Brazil, Canada, Chile, Japan, Korea, New Zealand, Romania and the United States of America, among others, are using first and second-generation mobile spectrum for IMT-2000. Operators of analogue systems in the 800 MHz and 450 MHz bands can upgrade their networks to IMT-2000 with commercial equipment that is available today. Similarly, second-generation operators of TDMA, cdmaOne[14] and GSM are able to purchase commercially available IMT-2000 equipment to upgrade their systems. Given the significant initial capital expenditures necessary to deploy entirely new IMT-2000 systems, operators are finding that upgrading networks in existing spectrum is a more economically viable option.

2.5.3 Specific concerns of developing countries

– Selection of spectrum band: WARC-92 identified the 1 885-2 025 MHz and WRC-2000 identified the 802-960 MHz, 1 710-1 885 MHz, and 2 500-2 690 MHz frequency bands for IMT-2000 systems. WRC-2007 identified 450-470 MHz, 698-960 MHz, 1 710-2 025 MHz, 2 110-2 200 MHz, 2 300-2 400 MHz, 2 500-2 690 MHz and 3 400-3 600 MHz frequency bands for IMT systems. These frequency bands were accepted internationally. Additional frequency bands may also have to be considered for the future development of IMT-2000 systems. Choosing one of these bands will help developing countries derive the benefits of interoperability and economies of scale.
– Re-allocation of pre-IMT-2000 spectrum: The re-allocation of pre-IMT-2000 spectrum was also looked upon as a solution by many countries, to increase the spectrum available for IMT-2000. One of the problems faced was the use of sandwiched channels within pre-IMT-2000 spectrum by other services.

2.6 Interoperability with existing networks and among IMT-2000 technologies

Inter-working between IMT-2000 systems and with legacy fixed and mobile systems is an important issue since, for the user, access to his/her services and applications globally (e.g. virtual home environment) is important.

Inter-working (including with legacy systems) is important to provide coverage and global circulation of terminals. In this respect, it is important to note that specific multimode terminals will be available as commercial networks become a reality. Subscriber identification module (SIM) cards are another solution that can help overcome some of the interoperability issues between networks, but nevertheless require the use of multiple handsets to operate on different networks. In support of achieving this interoperability and roaming goals, the third generation partnership projects, 3GPP and 3GPP2 and WiMAX Forum are working to ensure:

– Interoperability between the 3GPP IMS (Internet multimedia system) mobiles and 3GPP2 IMS mobiles (a 3GPP IMS mobile can set up a session with a 3GPP2 IMS mobile and vice-versa).
– Application level inter-system IMS roaming (given that the mobile supports the visited network's access network and IP transport technology, a 3GPP IMS mobile should be able to roam into a 3GPP2 network and vice-versa).
– Interoperability between WiMAX and 3GPP, 3GPP2 networks by IMS based core network.

Another interoperability issue that should be considered is the impact of the introduction of data services with IMT-2000. Given that IMT-2000 technologies are relatively new, interoperability of software and applications on IMT-2000 terminals and across borders will be increasingly important moving forward. One organization, the Open Mobile Alliance (http://www.openmobilealliance.org), was formed with the goal to deliver open standards for the mobile industry, helping to create interoperable services that work across countries, operators and mobile terminals and are driven by user's needs.

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[14] cdmaOne is a registered trademark of the CDMA Development Group (CDG).

Other key issues to be considered in achieving this interoperability and roaming goals include:

– access to emergency services;
– location information;
– lawful interception;
– number portability.

2.7 Licensing aspects (practices)

2.7.1 Licensing conditions

Licensing conditions are among the regulatory issues that are of importance to developing countries.

– *Technology requirements*: It is worth considering whether policy makers/regulators should follow a technology neutral approach or should mandate a particular technology or technologies. A technology neutral approach could lead to considerable benefits to end users in terms of a rapid technological advancement and lower prices. In case of deployments for mobile broadband networks it is important to consider that services enabled by the more advanced technologies will be bandwidth intensive so operators will require more contiguous spectrum to deploy these new technologies.
– *Financial requirements*: These help to eliminate non-serious players and ensure a certain level of performance.
– *Coverage*: To prevent the development of information-rich and information-poor communities, the policy makers/regulators of the various countries will need to ensure ubiquitous access to IMT-2000 services. However, from the service provider’s point of view, it may not be viable to roll out expensive infrastructure in high-cost areas. It may be preferable to roll out network coverage in phases, based on demand and likely applications. Existing technologies and systems in place should have a scalable low cost evolution/migration path. Case studies have shown that operators can undertake gradual, phased upgrades to IMT-2000.
– *Timing of IMT-2000 licences*: The timing for introduction of a new service is crucial and varies from country to country. It is necessary to judge the market potential and to deploy technologies that are proven and established. Developing countries can ill-afford to experiment with technology. However, the process of introducing wideband wireless services is time consuming and would require licensing and regulatory preparedness from an early period. It would be advisable that developing countries begin consultation right as early as possible.
– *Number of operators*: The limited availability of spectrum restricts the number of operators. In developed countries three to five operators have been preferred. Another issue is who should be eligible for this licence: fixed operators, mobile operators, new operators, all or a combination of these. Japan, as an example, decided to exclude fixed operators from the licensing process.
– *Infrastructure sharing*: Infrastructure sharing is particularly important for countries with widely dispersed populations and emerging mobile markets. It reduces the cost of network deployment and can improve penetration. It would also be necessary to identify the elements that can be shared, the amount of cost reduction that such sharing would bring about, for example, antenna masts, towers, and land building. Another issue for discussion is whether the regulator should play a pro-active role to encourage infrastructure sharing or should it be left entirely for operators.
– *Number portability:* Mobile number portability ensures that customers can retain their existing mobile number when switching to another mobile network operator and gives them the freedom to choose between competing operators.
– *Calling party pays:* Calling party pays is one way for operators to facilitate access to mobile services by low income subscribers.

For more information see Report ITU-R SM.2012 – Economic aspects of spectrum management and Chapter 3 – Frequency assignment and licensing in the ITU-R Handbook [2005] National Spectrum Management.

2.7.2 Methods of spectrum licensing

There are many methods of spectrum licensing that have been used both for first and second generation mobile licences, as well as for IMT-2000 licences. Most countries have required special licences in order for operators to provide IMT-2000 services, while other countries have taken a more flexible licensing approach and allow operators to use current spectrum for IMT-2000 services and/or licence spectrum use on a more generic basis, such as for "advanced wireless services". Some regulators allow first and second-generation systems to evolve/migrate to IMT-2000 in their current bands and do not require further authorization to do so.

While not intended to be comprehensive or all-inclusive, a few of the more common methods of spectrum licensing are identified in this section, such as first-come, first-served, beauty contests, lotteries, and auctions. These guidelines do not endorse one methodology over any others, but gives some of the advantages and disadvantages of each methodology. Licensing is a national prerogative and each country must decide what methodology is appropriate for the conditions that exist within its legal, regulatory, and market framework. Spectrum cap policies have been used to address spectrum concentration in the market and to reduce market barriers to new entrants, but this approach may limit the development and growth of wireless broadband networks if applied indiscriminately. While such policies have been applied at times in the traditional cellular services, the large spectrum requirements of broadband systems need separate considerations.

For more information see Report ITU-R SM.2012 – Economic aspects for spectrum management and Chapter 6 – Spectrum economics in the ITU-R Handbook [2005] National Spectrum Management.

2.7.2.1 First-come, first-served

Originally, when spectrum was not scarce, regulators used a first-come, first-served approach to licensing spectrum. If there were fewer applicants than the number of licences to award, then the assignment of spectrum was easy. For instance, if there were 10 licences to give out and 8 applicants seeking authorization, the regulator could grant them all and have no problems. However, as spectrum has become more valuable, the regulator is unlikely to find an opportunity where it can assign frequencies on a first-come, first-served basis, except in the most remote areas.

Advantages and disadvantages of "first come, first served" spectrum licensing are summarized in Table 2.4.

TABLE 2.4

Advantages and disadvantages of "first come, first served" spectrum licensing

Advantages **First come, first served**	**Disadvantages** **First come, first served**
Speed	Licence may not end up in the hands of an entity that values it the most and can bring greatest value to the economy
Inexpensive	The value of the licence is not taken into account

2.7.2.2 Beauty contest

In a beauty contest (sometimes called a comparative hearing), the regulator or Ministry selects the winning applicant using comparative criteria that may be established either by precedent or by rule. In many countries, the first cellular licences and broadcasting licences were awarded through beauty contests. Beauty contests have also been used in some countries to issue licences for IMT-2000. When beauty contests are undertaken, criteria to compare the prospective licence applications are established and can include:

– the technical and financial stability of the applicants;

– the technical characteristics of the system being deployed;

– the coverage area being proposed;

– the schedule for build-out.

Advantages and disadvantages of "beauty contest" spectrum licensing are summarized in Table 2.5.

TABLE 2.5

Advantages and disadvantages of "beauty contest" spectrum licensing

Advantages **Beauty contests**	**Disadvantages** **Beauty contests**
Allows the regulator to determine the contender that will best serve the public interest	Can be time consuming, particularly if the licence is valuable. Applicants are often willing to exhaust all administration and litigation options
Final costs for operators are more easily predicted than other options such as auctions	Can get expensive for the applicants if they are willing to spend large sums of money to succeed in the beauty contest process
Allows for equity considerations, such as minority ownership, small business ownership, etc.	Provides no method for deciding between two applicants that are essentially equal. The regulator may ultimately have to arbitrarily award the licence
	Government is responsible for choosing between alternative business plans stretching well into the future, and relating to new products and services that have not yet been developed
	Need to be carefully structured to be fully transparent. Doubts over transparency of beauty contest process can lead to suspicions and dissatisfaction with the outcome

2.7.2.3 Lotteries

Lotteries essentially decide among pre-qualified applicants by random selection. Applicants attend a drawing set at a specified date, time and location to draw numbers to decide who will get licences.

Advantages and disadvantages of "lottery" spectrum licensing are summarized in Table 2.6.

TABLE 2.6

Advantages and disadvantages of "lottery" spectrum licensing

Advantages **Lotteries**	**Disadvantages** **Lotteries**
The process is quick	The licence may be awarded to an entity that is not qualified to build and operate the system. Any person may be able to participate in the lottery if no pre-qualification requirements are set. The regulator can establish criteria for participation in the lottery. However, this can be legally challenged and make the lottery process a lengthy one
Provides a mechanism for selecting from substantially equal applications	Speculators will participate in the lottery, with the purpose of reselling the licence and reaping huge windfall profits. Reselling the licence is known as "flipping it." So rather than the public getting the benefit of the revenues, the lottery winner will realize the revenues from the sale of licences they got for minimal investment
	If an unqualified party wins the lottery, the regulator has the challenge of deciding whether to let them sell it or not

2.7.2.4 Auctions

Auctions award the licences based upon the bidder's willingness to pay. Since the 1990s when spectrum auctions first began to be used for awarding spectrum licences, billions of dollars have been raised in spectrum auctions and a fierce debate has arisen concerning the efficiency, competitive impact and social implications of this form of allocating spectrum. There are a variety of methodologies that have been used for spectrum auctions, including continuous, simultaneous multiple-round, and package.

Advantages and disadvantages of “auction” spectrum licensing are summarized in Table 2.7.

TABLE 2.7

Advantages and disadvantages of “auction” spectrum licensing

Advantages Auctions	**Disadvantages Auctions**
Licence can be issued quickly	Auctions may lead to increased concentration in the industry. The regulator can consider placing spectrum caps to limit the amount of spectrum that one entity can hold, or limit eligibility to participate to non-incumbents. In addition, a nation can address monopoly concerns through its antitrust laws or competition policies
Less resource intensive for both the government and the private sector when compared to beauty contests	Auctions may ignore non-financial objectives that are in the public interest, such as equity considerations. The auction design can support those objectives by including strategies such as set-asides and providing bidding credits for certain groups that commit to addressing certain public interest factors
Licence goes to the entity that values it the most. Auctions promote economic efficiency, one of the goals of spectrum management. Winning bids should come from the companies that can find ways of maximizing the stream of future benefits	There may be some incentive for the government to act like any monopoly by restricting output and raising the price. In other words, if the government wanted to maximize the revenues to the treasury, it could withhold spectrum
Spectrum is a public resource and therefore the profits benefit the citizens. The proceeds of the auction go to the government for national purposes	Auctions may result in speculatively high bids for licences for services that are not commercial at the time of the auction. Auctions can also be affected by hype and other non-economic forces
Auctions can provide information about the economic value of spectrum. For instance, if applicants are willing to pay a high price to be able to provide one service, but will pay a very low price for a different service, then the regulator can determine which service has greater economic benefit and, therefore, can determine where it needs to focus its future spectrum management efforts	Full information on IMT-2000 market characteristics is not always available, leaving some or all bidders without adequate information on market conditions, the regulatory environment, demand characteristics and the likely pricing structures
	Likeliness of winner’s curse that results in high prices for the licence and leads to decreased investment capacity for operators and high end-user prices

2.7.2.5 Hybrid

A number of countries, including Austria, Italy, and Hong Kong, have adopted a “hybrid” approach to IMT-2000 licence allocation. Tenderers have to pre-qualify in terms of criteria similar to those established for beauty contests to bid. Licences are then allocated on the basis of an auction. Advantages and disadvantages of a hybrid approach are themselves a combination of the advantages and disadvantages of beauty contests and auctions.

Advantages and disadvantages of “hybrid” spectrum licensing are summarized in Table 2.8.

TABLE 2.8

Advantages and disadvantages of “hybrid” spectrum licensing

Advantages Hybrid	Disadvantages Hybrid
Ensures that contenders have appropriate resources and business plans to serve the public interest. Can require that licences meet specific policy goals	Auctions may lead to increased concentration in the industry. The regulator can consider placing spectrum caps to limit the amount of spectrum that one entity can hold. In addition, a nation can address monopoly concerns through its antitrust laws or competition policies
Licence goes to the qualified entity that values it the most. Winning bids should come from the qualified companies that can find ways of maximizing the stream of future benefits	Can be time consuming, particularly if the licence is valuable. Applicants are often willing to exhaust all administration and litigation options
Spectrum is a public resource and therefore the profits benefit the citizens. The proceeds of the auction go to the government for national purposes	Beauty contest portion needs to be carefully structured to be fully transparent. Doubts over transparency of beauty contest process can lead to suspicions and dissatisfaction with the outcome
Allows for equity considerations, such as minority ownership, small business ownership, etc.	Can get expensive for the applicants if they are willing to spend large sums of money to succeed in the beauty contest portion of the process
	There may be some incentive for the government to act like any monopoly by restricting output and raising the price. In other words, if the government wanted to maximize the revenues to the treasury, it could withhold spectrum
	Auctions may result in speculatively high bids for licences for services that are not commercial at the time of the auction. Auctions can also be affected by hype and other non-economic forces
	Full information on IMT-2000 market characteristics is not always available, leaving some or all bidders without adequate information on market conditions, the regulatory environment, demand characteristics and the likely pricing structures
	Likeliness of winner’s curse that results in high prices for the licence and leads to decreased investment capacity for operators and high end-user prices

2.8 Lawful interception and common access to emergency services

The combination of IMT-2000 technology with position location capabilities, as well as with other dedicated systems, opens the door for the development of numerous public safety and law enforcement applications, including electronic citation, locating callers requesting emergency assistance, tracking of criminals on parole, enabling officials to access back-end database without dispatcher assistance, and accessing real time information on land, air and water travel systems. In addition to security systems, IMT-2000 technologies can assist government officials with vehicular tracking and monitoring shipments en route to their destinations. Such services will be especially important for the shipment of high-risk hazardous materials such as explosives, radioactive materials, materials that are poisonous by inhalation as well as bulk shipments of flammable liquids and gases.

In addition to position location capabilities, IMT-2000 wireless networks use more elaborate authentication procedures than second-generation wireless networks, deriving longer and more robust cryptographic keys (such as 128-bit secret keys) for added security.

There may be some merit in seeking to adopt common access mechanisms for emergency services, and standard interfaces for lawful interception and other security issues, in such a way that they are independent of the network technology. This could provide improved effectiveness of the emergency service (particularly for roaming users), and reduce operational costs in other areas. Studies on this subject are ongoing in ITU-T.

CHAPTER 3

EVOLUTION/MIGRATION PATHS

There are a number of pre-IMT-2000 systems, both analogue and digital, that are in operation today providing wireless voice and data services to end-users worldwide. These systems include, but are not limited to, AMPS, NMT, cdmaOne, TDMA, and GSM. Recommendations ITU-R M.622*, ITU-R M.1033 and ITU-R M.1073 and Report ITU-R M.742* describe characteristics of pre-IMT-2000 systems.

Due to differences between the various pre-IMT-2000 systems, as well as differences between the IMT-2000 systems, the possible evolution/migration paths for each pre-IMT-2000 system differ. However, in most cases, the evolution/migration requires the addition of IMT-2000 base station equipment and/or software, necessary modifications or additions of the radio access networks (RAN), suitable upgrade/modifications of the underlying "core network" along with the introduction of new terminals, which are typically dual-mode devices capable of operating both pre-IMT-2000 and IMT-2000 radio technologies.

Several factors should be considered in the selection of an evolution/migration path towards IMT-2000. One important factor is the availability and use of spectrum for both pre-IMT-2000 and IMT-2000 systems. Other issues that will have a major impact on the choice of evolution/migration path include availability of equipment and service applications for the various technologies and their performance in the desired operating environment.

In terms of evolution/migration paths, this revised Supplement 1 does not make any comparison between the performances of different technologies or promote specific technologies.

Typical operator's experiences with evolution/migration are provided in Annex C, for both developed and developing countries.

3.1 Introduction

Considered at the highest level, evolution/migration towards IMT-2000 is characterized by operator deployment of:

– a core network with links to the public switched telephone network (PSTN), ISDN, the Internet/intranets and external mobile and data networks;

– radio access networks (RAN), eventually capable of working in several frequency bands and using complementary radio technologies (radio access networks are based on radio interfaces. IMT-2000 radio interfaces are listed in the main Handbook);

– dual-mode or multi-mode terminals allowing subscribers to enjoy services on pre-IMT-2000 and IMT-2000 networks.

If an operator intends to upgrade its system, the operator has to evaluate the target system and he has to analyse which parts of the system have to be modified to which extent and which resources (e.g. spectrum) can be reused or have to be enhanced. The operator will need to assess the evolution and migration aspects of the planned upgrade as defined in Recommendation ITU-R M.1308:

– "evolution" is characterized as "a process of change and development of a mobile radio system towards enhanced capabilities", whereas

– "migration" is characterized as "movement of users and/or service delivery from an existing telecommunciation network to IMT-2000".

* *Note by the Secretariat:* These Recommendation and Report were suppressed.

There exist basically two core network types:

– GSM (evolved) core network; and
– IS-41 (evolved) core network.

A movement of users and/or service delivery from a GSM core network to an IS-41 core network and vice versa is clearly a migration, since the core network equipment has to be replaced in both cases. But there are evolutions within both core network types. These evolutions are necessary to introduce new services and supplementary services and to support new capabilities of the radio access.

For the support of packet data services, GSM (evolved) core networks have been complemented by IP based GPRS-backbone networks providing a specific fast mobility management to the packet data services, capable of handling fast handovers for real-time packet data services; whereas IS-41 core networks have been complemented by "classical/pure" IP networks and therefore uses generic IP-protocols for mobility provision (i.e. Mobile IP).

Internet multimedia system (IMS) is an additional architecture which can be deployed on top of both the previous two core networks, and which provides specific packet data services (e.g. Voice over IP (VoIP), VoIP-conference calls, ...). It has been adopted by both 3GPP and 3GPP2 for their packet core network.

On the radio access network (RAN) side in particular, the mobile industry has developed the essential specifications and continues to work in partnership, to further evolve the technologies in order to support future market needs. The step-by-step approach minimizes the need for large re-investments in IMT-2000 and yet provides significant improvements in the capability to deliver improved services at each step along the way. Updates of standards provide backward compatibility, ensuring to the greatest extent possible a continuing service capability for existing operators and users.

Analysis of the various evolution/migration scenarios, market analysis, and forecasts of future trends show that there existed and exist certain observed network upgrades of 1G- and 2G-operators towards 2G and 3G, as summarized in Fig. 3-1. The Figure shows these upgrades for both the radio access network and the core network.

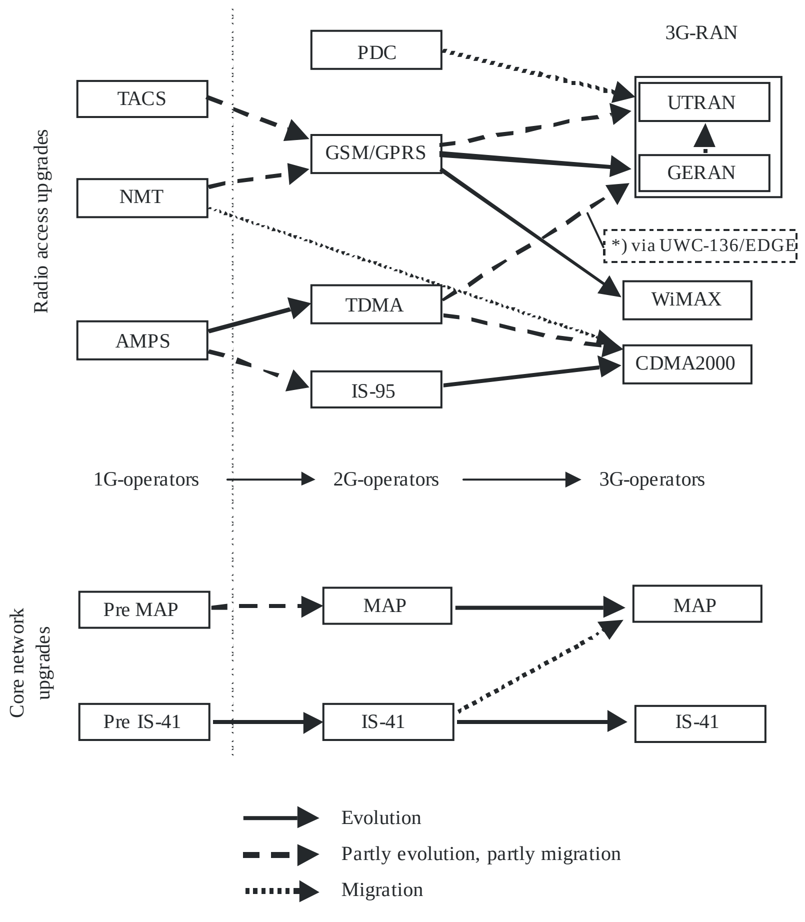
3.2 Considerations for evolution/migration

In planning the implementation of IMT-2000, the following objectives are desirable:

– to facilitate the deployment of IMT-2000, subject to market considerations and to facilitate the development and growth of IMT-2000;
– to minimize the impact on other systems and services within, and adjacent to, the bands identified for IMT-2000;
– to facilitate worldwide roaming of IMT-2000 terminals;
– to integrate efficiently the terrestrial and satellite components of IMT-2000;
– to optimize the efficiency of spectrum utilization within the bands identified for IMT-2000;
– to enable the possibility of competition;
– to facilitate the deployment and use of IMT-2000, including fixed and other special applications in developing countries and in sparsely populated areas;
– to accommodate various types of traffic and traffic mixes;
– to facilitate the continuing worldwide development of equipment standards;
– to facilitate access to services globally within the framework of IMT-2000;
– to minimize terminal costs, size and power consumption, where appropriate and consistent with other requirements;
– to facilitate the evolution of pre-IMT-2000 systems to any member of the IMT-2000 family as specified in Recommendation ITU-R M.1457.

FIGURE 3-1

Observed network upgrades of operators



In case of evolution/migration of a system from one generation to the next one, major issues are spectrum usage and system configuration. When an operator evolves/migrates to an IMT-2000 system, coverage and capacity gains occur, and the operator gains spectrum efficiencies with the more advanced system. As for spectrum usage, four scenarios are possible, subject to regulatory conditions (see Figs 3-2 and 3-3). Operators might follow one or a combination of the following scenarios based on their specific circumstances.

– *Scenario 1*: The IMT-2000 system (B) is deployed in the spectrum that is currently being used for the pre-IMT-2000 system (A). Obviously, the existing spectrum (f_1) is split and some of the spectrum is allocated for the IMT-2000 system (f_{1B}) and the rest remains in service for the pre-IMT-2000 system (f_{1A}). New spectrum (f_2) is not needed in this scenario. This allows operators to migrate users to new services utilizing the same spectrum, giving operators the opportunity to use the spectrum simultaneously for the pre-IMT-2000 and IMT-2000 systems.

– *Scenario 2*: The IMT-2000 system (B) is deployed in new spectrum. This allows the operator, for example, to migrate users to new services in new spectrum (f_2) while evolving the capabilities of the pre-IMT-2000 system in the existing spectrum (f_1)[15].

[15] In this case the time scales for the transition phase between the pre-IMT-2000 and the IMT-2000 system may be at the discretion of the operator, since new spectrum is allocated for the IMT-2000 system. It is possible that the spectrum of the pre-IMT-2000 system (f_1) may be reused after new spectrum is put into operation, but due to legacy use of the pre-IMT-2000 system, this again may not happen for some period of time.

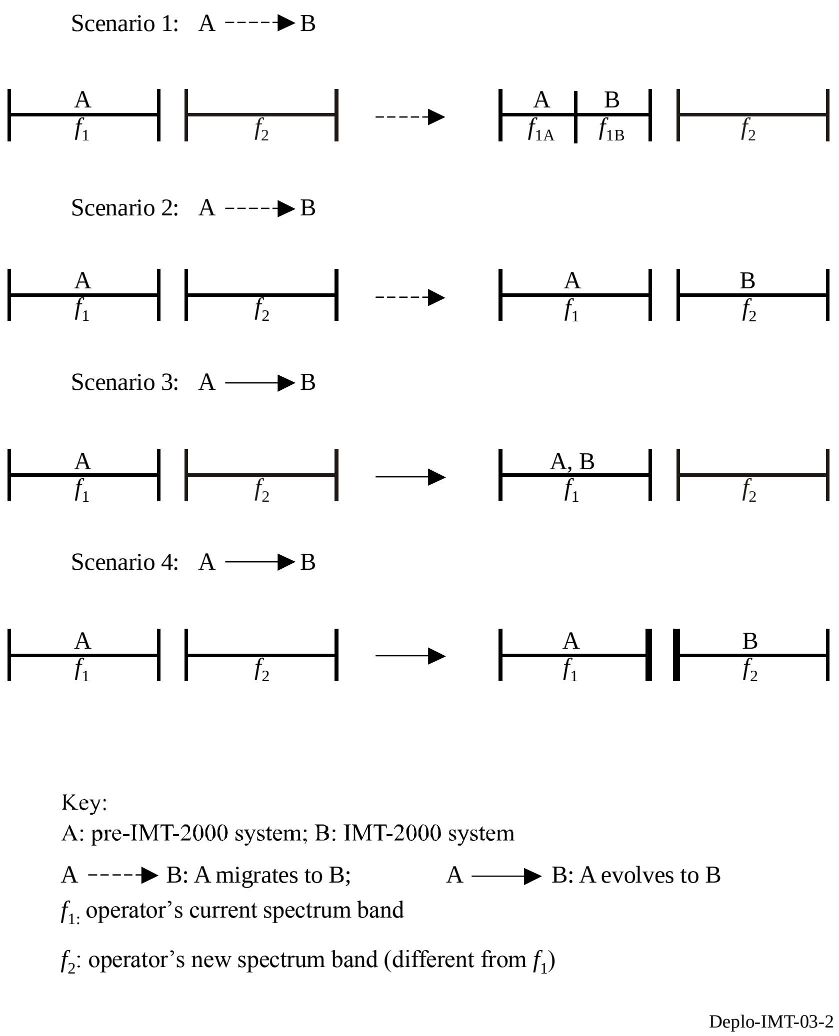
– *Scenario 3*: The IMT-2000 system (B) is an evolved version of the pre-IMT-2000 system (A) deployed through a sequence of upgrades operated in the same spectrum. The IMT-2000 system (B) can fully interoperate with the pre-IMT-2000 system (A). Obviously, new spectrum f_2 is not needed in this scenario.

– *Scenario 4*: The IMT-2000 system (B) is an evolved version of the pre-IMT-2000 system (A). It is possible, but not assumed, that IMT-2000 system (B) can fully interoperate with pre-IMT-2000 system (A). The IMT-2000 system (B) operates in new spectrum (f_2), while the pre-IMT-2000 system (A) continues to operate in the existing spectrum[16].

FIGURE 3-2

Transition scenarios in IMT-2000

(Actual examples of each transition scenario are available in Annex C – Operator experience in transitioning to IMT-2000 systems)



When one contemplates a migration of users and/or services, it has to be evaluated to which extent the network entities (e.g. core network and/or access network components) need to be replaced. This replacement does not necessarily affect the entire system. In general core networks evolve whereas access network components have limited evolutionary options. In many cases and even in case of upgrade from a preceding generation of mobile systems to a new generation, there very often exist upgrade possibilities that affect only few entities of the system.

When one contemplates an evolution from one generation to the next generation major functionalities (services, protocols, ...) and properties (spectrum) of the old systems remain, to a large extent, available and unchanged within the new system. An evolution of the system provides a maximum of up- and downward compatibility, i.e. pre-IMT-2000 equipment does not have to be replaced but can be used together with new equipment, providing the full functionality of the pre-IMT-2000 system.

FIGURE 3-3

Key aspects of transition scenarios in IMT-2000

		Spectrum bands	
		Same	Different
Possible backward compatibility	Yes	Scenario 3	Scenario 4
	No	Scenario 1	Scenario 2

Deplo-IMT-03-3

In general and not only for developing countries it can be concluded that evolutionary system upgrades are preferable from an operator and end-user point of view, because old investment can be retained to a large degree. However, in reality, pure system evolution is never possible, since even for the most flexible system design at least software updates or even hardware-updates (i.e. replacements) are necessary for some network components, if new features enhance the system. Moreover, experience shows that each technology will reach its limits concerning expandability, i.e. even evolutionary enhancements will eventually lead to an unacceptable system complexity. From that stage technology-jumps are necessary, which lead to the need of a new system, which is then incompatible to the old one and requires an appropriate migration and interoperability strategy.

These aspects should be taken into account when an operator determines his chosen path or paths towards IMT-2000.

There are likely to be four key elements to the decision by operators regarding the evolution of their particular pre-IMT-2000 systems:

1. Feasibility of evolution to IMT-2000 – ITU-R and ITU-T sectors have introduced the feasibility of evolution by providing sufficient flexibility within the scope of their IMT-2000 Recommendations for the broadest set of pre-IMT-2000 systems. Of course, providing for the evolution of pre-IMT-2000 systems does not undermine the achievement of the goals for IMT-2000.
2. Cost-effectiveness of evolving to IMT-2000 – The benefits of evolving to IMT-2000 should be weighed against the cost incurred in executing this evolution option. This cost would also be incurred when evolving to any other more advanced non-IMT-2000 standard. The ITU took all the efforts to provide flexibility within the scope of their IMT-2000 Recommendations to help minimize the cost of evolution to IMT-2000.
3. Attractiveness of evolution to IMT-2000 – Evolution to IMT-2000 must be the most attractive approach among the various directions that can be taken in the advancement of today’s mobile communications systems. As such, decision makers would need to have a clear view of what IMT-2000 is, and how it is an improvement over the pre-IMT-2000 systems.

4. Awareness of evolution to IMT-2000 – An awareness of the advantages of the IMT-2000 evolution option is important for those who control or influence either the direction of pre-IMT-2000 standards and systems or the allocation and use of spectrum in the short and long term.

At first glance it might appear that there can be some degree of prioritization among these elements. Further consideration, however, shows that each one is important and must be present for the decision makers to choose this path. Such awareness, along with the detailed information contained in this Supplement, should encourage the level of in-depth discussion needed for awareness and serious consideration of evolution to IMT-2000.

The other key elements, feasibility, cost effectiveness, and attractiveness of evolution should be used as measures for evaluating and resolving the issues associated with evolving pre-IMT-2000 systems toward IMT-2000.

The following aspects are important, if an operator has to decide for a certain path:

1. Operation in worldwide harmonized frequency bands.
2. Existing/forecasted market share/market penetration of the target technology.
3. Probability that other operators adopt similar paths.
4. Ease of the transition from existing technology.
5. The system architecture of the target technology has to be future proof (capability to expand).
6. Status of the corresponding standard.

These aspects are important, because the past shows that the success of a certain mobile communication technology depends in particular on roaming capabilities (see points 1., 2., 3.), on affordable equipment prices for terminals and also infrastructure (see points 1., 2., 3., 4., 5.), on ability to support new emerging services (see points 5., 6.).

In considering the paths from existing systems to IMT-2000, it is important to recognize that both the start and end points are moving targets. The functions and capabilities of the existing networks will themselves be changing even as evolution/migration is taking place. Likewise, the target IMT-2000 technology or technologies are undergoing constant evolution and enhancement as time passes.

Development of specific evolution/migration paths must take due account of this.

3.2.1 Characteristics of IMT-2000 radio access and core networks technologies

ITU-R has produced a series of Recommendations for IMT-2000 radio access technologies. In particular Recommendation ITU-R M.1457 provides the state-of-the-art of IMT-2000 radio access technologies since it is periodically updated to reflect further evolutions of the technologies concerned. On the other hand, ITU-T has produced its Recommendations for the core networks: Q.1741.x series for GSM Evolved Core Network on per 3GPP Release basis (e.g. Rel-99, Rel-4, Rel-5 as specified in Q.1741.1, Q.1741.2, and Q.1741.3, respectively) and Q.1742.y for IS-41 based Evolved Core Network and its evolution based on the timeline defined by 3GPP2 (e.g. Q.1742.2 as "IMT-2000 References <approved as of 11 July 2002> to ANSI-41 evolved core network with cdma2000 Access Network").

In 3GPP, work on Release 6 is in progress.

3.2.1.1 IMT-2000 CDMA Direct Spread

ITU Name: IMT-2000 CDMA Direct Spread
Common Names: **UTRA FDD**
WCDMA
UMTS

IMT-2000 CDMA Direct Spread allocates different codes for different channels, whether for voice or data, and can adjust the amount of capacity, or code space, of each channel every 10 ms. It creates high bandwidth traffic channels by reducing the amount of spreading (using a shorter code.) Packet data users can share the same codes and/or time slots as other users, or the network can assign to users dedicated channels and time slots. IMT-2000 CDMA Direct Spread is a spread-spectrum system based on direct sequence spread spectrum. It is spectrally efficient and its wideband nature provides the ability to translate the available spectrum into high data rates. This allows the flexibility to manage multiple traffic types, including voice, narrowband data, and wideband data. In IMT-2000 CDMA Direct Spread, data channels can support up to 2.4 Mbit/s of peak data throughput. Though exact throughput depends on what size channels the operator chooses to make available and the number of users active in the network, users can expect throughputs of up to 384 kbit/s.

High speed downlink packet access (HSDPA) is an enhancement to IMT-2000 CDMA Direct Spread that delivers peak data rates of about 10 Mbit/s. HSDPA is fully backwards compatible with IMT-2000 CDMA Direct Spread, and any application developed for the latter is planned to work with HSDPA. HSDPA is a feature of Release 5 of 3GPP specifications.

HSDPA achieves its high speeds through the addition of higher order modulation such as 16-QAM, variable error coding, and fast adaptation of the link to current radio conditions, adjusting modulation and coding as necessary. In addition, HSDPA uses an efficient scheduling mechanism to determine which user obtains resources. Finally, HSDPA shares its high-speed channels among users in the time domain.

3.2.1.2 IMT-2000 CDMA Multi-Carrier

ITU Name: IMT-2000 CDMA Multi-Carrier
Common Names: **CDMA2000 1x and 3x**
CDMA2000 EV-DO

IMT-2000 CDMA Multi-Carrier is designed as a direct evolution of cdmaOne™ air interface, with which it is backward compatible. It offers enhancements in voice capacity, speech quality and coverage, and is designed to provide high-speed packet data services. IMT-2000 CDMA Multi-Carrier operates in various frequency bands (450, 800, 1 700, 1 900 and 2 100 MHz).

IMT-2000 CDMA Multi-Carrier balances code assignments and power allocation to deliver voice and data services. CDMA2000 1X supports 33-40 simultaneous voice calls per sector in a single 1.25 MHz FDD channel. Using a new codec (EVRC-B) and handset interference cancellation, it can handle up to 55 voice calls. The enhancements of 1X, 1X Advanced, which was commercially available in 2010, will further boost the capacity 2.3x by using the new EVRC-B codec and introducing uplink and downlink interference cancellation, mobile receive diversity, quasi-orthogonal functions (QOF) and radio link enhancements such as improved power control, early termination and smart blanking. The forward and reverse data channels of CDMA2000 can use either turbo or convolutional coding. For higher speeds, turbo coding provides an error correcting mechanism for data transmission that improves system performance and capacity. The packet data channels of CDMA2000 1X provide data rates up to 307 kbit/s. Other new features of IMT-2000 CDMA Multi-Carrier include the quick paging channel operation, variable transmission rates, and a channel structure that supports multiple services with various QoS. With the inclusion of selectable mode vocoders (SMV) and antenna diversity techniques, CDMA2000 1X can provide a voice capacity of nearly three times that of cdmaOne systems[16].

The CDMA2000 1xEV-DO option, primarily optimized for data services, is designed to interoperate with CDMA2000 1X networks and to support high-speed data.

CDMA2000 1xEV-DO incorporates a time division multiplexed (TDM) adaptive variable rate forward link that maximizes user data rates and sector throughput by allocating the entire BTS power to one user at a time. Highly efficient implementation of channel sensitive scheduling and effective multi-user diversity achieves the highest data rates at a given time. Also, Hybrid-ARQ schemes implementing incremental redundancy help to deliver optimum efficiency which could otherwise be lost due to high mobility and variability of interference caused by varying traffic conditions.

CDMA2000 1xEV-DO Rel. 0 supports data speeds of up to 2.4 Mbit/s in the forward link and 153 in the reverse link. The more advanced standard, 1xEV-DO Rev. A, provides peak data rates of up to 3.1 Mbit/s in

[16] KNISELY, D. N., KUMAR, S., LAHA, S. and NANDA, S. [October, 1998] Evolution of wireless data services: IS-95 to cdma2000. *Communications Magazine, IEEE*. Vol. 36 Issue: 10, p. 140-149.

the forward link and 1.8 Mbit/s in the reverse link in a 1.25 MHz bandwidth. The high data capacity of EV-DO is due to incorporation of higher order modulation schemes such as 16-QAM, dynamic link adaptation, adaptive modulation, incremental redundancy, multi-user diversity, receive diversity, turbo coding and other channel-controlling mechanisms.

CDMA2000 Multicarrier and EV-DO Rev. B aggregates multiple 1xEV-DO Rev. A carriers to provide higher performance for multimedia delivery, bi-directional data transmissions and VoIP-based concurrent services through either software or hardware upgrades. By aggregating multiple 1.25 MHz Rev. A channels – up to 15 channels in 20 MHz bandwidth – Multi-Carrier and Rev. B enable data traffic to flow over higher bandwidth and hence improve user data rates and latencies on both forward and reverse link. Multi-Carrier EV-DO requires a simple software upgrade of Rev. A that triples the data rate for all users in the cell, to up to 9.3 Mbit/s in the forward link and 5.4 Mbit/s in the reverse link using 3 carriers within a 5 MHz channel. Rev. B requires a hardware upgrade and increases the peak data rate in the forward link to 14.7 Mbit/s.

In case a network evolution is required based on demand for high data services, CDMA2000 1X and CDMA2000 EV-DO carriers can be deployed in any combination to provide a flexible mix of high-quality voice channels and high data rate services. For example, in 5 MHz of cleared spectrum, the operator can choose to launch two CDMA2000 1X carriers for voice and packet data, and one single CDMA2000 EV-DO carrier dedicated exclusively to high-speed packet data or, alternatively, one single CDMA2000 1X and two CDMA2000 EV-DO carriers.

3.2.1.3 IMT-2000 CDMA TDD (time-code)

ITU Name: IMT-2000 CDMA TDD
Common Names: **UTRA TDD 3.84 mchip/s high chip rate**
UTRA TDD 1.28 mchip/s low chip rate
(TD-SCDMA)
UMTS

In IMT-2000 CDMA TDD, both uplink and downlink transmissions use the same carrier within the same frequency band. It combines CDMA with TDMA techniques to separate the various communication channels. Hence, a given radio resource element is characterized by both timeslot and CDMA code. Timeslots can be assigned to carry either downlink or uplink channels. In this way, the TDD technology can operate within an unpaired band; i.e. no duplex frequency band is necessary. Due to the TDMA structure and the joint detection algorithm, which significantly reduces the interference from the other CDMA signals present in the time slot, the system behaves more like a TDMA system. So, it neither suffers from cell breathing and the necessity to maintain the operating margin to compensate for the uncertainty, nor requires a soft handoff capability. This is of particular value for hot spot scenarios implying heavy data load and smallest cell sizes for indoor (pico environment) and outdoor (micro environment) solutions. Moreover, since timeslots for uplink and downlink can be assigned separately, IMT-2000 CDMA-TDD is particularly suited for asymmetric traffic. In the TDD mode the degree of asymmetry can be reassigned rapidly improving overall operating efficiency.

UTRA TDD (3.84 Mchip/s option) with a chip rate of 3.84 Mchip/s in a 5 MHz bandwidth channel, that is the same as the harmonized UTRA FDD radio signal, is cost-efficient for deployment as it can leverage the infrastructure of an FDD-only roll-out to offer scalable capacity for “hotspots” where combined voice and data traffic will be supported through a multi-tier architecture of macro, micro and pico cells. The minimum spectrum requirement is only half the bandwidth of WCDMA operating in the FDD mode, i.e. only one 5 MHz channel is needed when the TDD chip rate is operating at 3.84 Mchip/s.

TD-SCDMA is the low chip rate version of IMT-2000 CDMA TDD. TD-SCDMA combines two technologies – an advanced TDMA system with an adaptive CDMA component. TD-SCDMA is also called 1.28 Mchip/s TDD and uses a 1.6 MHz single band for each carrier. TD-SCDMA is designed to operate in TDD duplex mode with 5 ms period for downlink and uplink transmissions. Within one period, the frame is divided into seven traffic time slots, which can be flexibly assigned to either several users or to a single user who may require multiple time slots. TDD principles permit traffic to be uplink (from the mobile terminal to the base station) and downlink (from the base station to the mobile terminal) using the same frame and different time slots. The TD-SCDMA technology manages both symmetric circuit switched services, such as speech or video, as well as asymmetric packet switched services, such as mobile Internet data flows. For asymmetric services used with Internet access, a typical example shows that high data volumes are transmitted from the base station to the terminal, and more time slots are used for the downlink than the uplink. TD-SCDMA makes it possible to allocate the time slots according to the changes of the service module. TD-SCDMA is designed for high data rate data services – up to 2 Mbit/s. TD-SCDMA is able to use available frequency bands and has no need for paired bands, that means uplink and downlink transmissions use the same carrier with different time slot. With the key technologies such as smart antenna, joint detection, uplink synchronization and baton handover, etc., TD-SCDMA system can provide a low cost solution for implementation and operation, with high system capacity and high efficiency of fragmented frequency resources. In addition TD-SCDMA can be implemented to support various radio scenarios: rural and dense urban areas coverage, pico/micro and macro cell deployments, and pedestrian to high speed moving environment. TD-SCDMA system is suitable to support high-speed circuit switched and packet switched data, as well as high voice quality.

The core network in TD-SCDMA system has evolved from the one in GSM/GPRS/EDGE, since it is the same for the two kinds of core network in the network elements, network architectures and protocols, in other words, TD-SCDMA is based on the GSM-MAP protocol. If the TD-SCDMA Core Network supports the interface (Iu) between the access network and the core network in TD-SCDMA system and the interface (A) in the same structural level in GSM network, these two access networks could share the same core network. But, if they could not share, the MAP protocol can satisfy the connection between the two core networks. Precisely, when a user holding dual-mode terminal roams between the GSM and TD-SCDMA network managed by the same operator, the roaming strategy could either base on the same core network, or through the interworking between the two networks. When the two operators have the roaming agreement, the subscribers could roam between the GSM/GPRS/EDGE network and the TD-SCDMA network freely via the dual-mode terminals.

TD-SCDMA core network has defined the inter-system change completely. When mobile is in idle mode, it can roam between the two networks by location management procedure. When mobile is in connected mode, it can roam between the two networks by inter-system handover.

3.2.1.4 IMT-2000 TDMA Single-Carrier

IMT-2000 TDMA Single-Carrier
Common Names: **UWC-136**
EDGE
GERAN

Enhanced data rates for global evolution (EDGE) was developed to enable TDMA, GSM, and GPRS operators to provide next-generation services. EDGE uses the same radio channels and time slots as GSM and GPRS, so it does not require additional spectral resources. EDGE provides a cost-effective solution for these operators to upgrade to IMT-2000, and enables significantly higher data rates and improved efficiency. It does so by enhancing the radio interface while re-using all the other network elements, including BSC, Serving GPRS Support Node (SGSN), Gateway GPRS Support Node (GGSN), and HLR. In fact, with newer GSM/GPRS deployments, EDGE[17] is a software-only upgrade to the BTS and the BSCs, as the transceivers in these networks are already EDGE capable. The same enhanced GPRS packet infrastructure supports both GPRS and EDGE, thus EDGE is fully backwards compatible with GPRS and any application developed for GPRS will work with EDGE. Once operators have deployed EDGE, they can enhance its applications capabilities by deploying the IP Multimedia Subsystem in their core networks, which will also support an IMT-2000 CDMA Direct Spread radio access network since both use a GSM (Evolved) UMTS core network.

Compared to GPRS, EDGE increases data rates by a factor of three and doubles data capacity. Though EDGE can theoretically provide 59.2 kbit/s in each of eight time slots, adding up to a peak network rate of 473.6 kbit/s in eight time slots, actual user data rates are typically in the 130 to 192 kbit/s (RLC payload) range with four time-slot devices. By sending more data in each time slot, EDGE also increases spectral efficiency by 150% relative to GPRS that uses coding schemes 1 and 2, and by 100% relative to GPRS that uses coding schemes 1 through 4.

[17] Assumes EDGE release 99.

3.2.1.5 IMT-2000 FDMA/TDMA (frequency-time)

ITU Name: IMT-2000 FDMA/TDMA
Common Names: **DECT**

The IMT-2000 radio interface specifications for FDMA/TDMA technology are defined by a set of ETSI standards. This radio interface is called digital enhanced cordless telecommunications (DECT). The individual layers are defined in different parts of the common interface (CI) standard. The standard specifies a TDMA radio interface with TDD. The radio frequency bit rates for the specified modulation schemes are 1.152 Mbit/s, 2.304 Mbit/s and 3.456 Mbit/s. The standard supports symmetric and asymmetric connections, connection oriented and connection less data transport as well as variable bit rates up to 2.88 Mbit/s per carrier. The network layer contains the protocols for call control, supplementary services, connection oriented message service, connectionless message service and mobility management, including the security and confidentiality services.

In addition to the CI standard, access profile standards define minimum requirements for accessing specific networks and the interworking to these networks. For example, the generic access profile (GAP) standard defines the requirements when using the speech service and the DECT packet radio service (DPRS) standard defines the requirements for packet data transport.

A high level description of features and how the relevant ETSI standards interrelate to the different applications can be found in the ETSI Technical Report TR 101 178 “A high level guide to the DECT standardization”.

This radio interface is a general radio access technology for wireless telecommunications. It is a high capacity digital technology, for wide cell radii ranging from a few metres to several kilometres, depending on application and environment. It provides telephony quality voice services, and a broad range of data services, including ISDN and packet data. It can be effectively implemented in a range from simple residential cordless telephones up to large systems providing a wide range of telecommunications services, including Fixed Wireless Access.

This technology provides a comprehensive set of protocols, which provide the flexibility to interwork between numerous different applications and networks. Thus a local and/or public network is not part of the DECT specification.

3.2.1.6 IMT-2000 OFDMA TDD WMAN

ITU Name: IMT-2000 OFDMA TDD WMAN
Common Names: **WiMAX**, **WirelessMAN-OFDMA**

The IEEE standard relevant for IMT-2000 OFDMA TDD WMAN, designated as IEEE Std 802.16, is developed and maintained by the IEEE 802.16 Working Group on Broadband Wireless Access. It is published by the IEEE Standards Association (IEEE-SA) of the Institute of Electrical and Electronics Engineers (IEEE).

The radio interface technology specified in IEEE Standard 802.16 is flexible, for use in a wide variety of applications, operating frequencies, and regulatory environments. IEEE 802.16 includes multiple physical layer specifications, one of which is known as WirelessMAN-OFDMA. OFDMA TDD WMAN is a special case of WirelessMAN-OFDMA specifying a particular interoperable radio interface. OFDMA TDD WMAN as defined here operates in both FDD and TDD modes.

The OFDMA TDD WMAN radio interface comprises the two lowest network layers – the physical layer (PHY) and the data link control layer (DLC). The lower element of the DLC is the medium access control layer (MAC); the higher element in the DLC is the logical link control layer (LLC). The PHY is based on orthogonal frequency division multiple access (OFDMA) suitable for use in either a 5 MHz or a 10 MHz channel allocation. The MAC is based a connection-oriented protocol designed for use in a point-to-multipoint configuration. It is designed to carry a wide range of packet-switched (typically IP-based) services while permitting fine and instantaneous control of resource allocation to allow full carrier-class Quality of Service (QoS) differentiation.

3.2.2 Functional and service enhancements for users

Basic mobile telecommunications services – namely voice and text messaging – have proved to be a massive success for pre-IMT-2000 systems. While some initial steps have already been made into other areas such as mobile Internet access, enhanced messaging services and i-mode™, there are vast new opportunities that are now just starting to be exploited.

In particular, for the customer, ease of use and interoperability will continue to be of paramount importance. It is important to recognize that users are not interested in the IMT-2000 technology *per se* but the services and applications available to them. Different types of users have different needs and therefore it is important to consider the service platforms that will allow operators to differentiate their service offerings and allow smooth introduction of new services.

3.2.2.1 Services for users

According to a study commissioned by the UMTS Forum on the social shaping of IMT-2000[18], the handset has become an essential part of a process of intensifying personal social relations and users have a greater emotional relationship with their mobile phone than they do with any other device. An interesting result is that the small size, easy operation and personal nature of the mobile handset are essential ingredients of this, implying that it will remain the preferred form factor for IMT-2000 customers rather than a PDA or laptop. In turn, it means that IMT-2000 services must fit into this scenario in order to be successful.

Indications that such services can be successful are already emerging. Examples include pre-IMT-2000 i-mode information services that have proved enormously popular in Japan and are now being extended to Europe and the United States of America. Graphic rich information is provided in a format that fits the screen and form factor of small mobile phones, while color displays and camera phones are promoting the spread of new applications.

Photo messaging, as part of a suite of multimedia messaging services (MMS), which will also include e-postcards, audio clips, logos and text, will undoubtedly hit the mass market, and video clip messaging will evolve from transmission of still pictures. Information services to suit the consumer will include timetables, location information, local guides, news reports, movie, theatre guides, sports results (including video clips), music download, games download and multimedia broadcast. M-commerce will include payment and purchase, but mainly those items that are suited to the mobile form factor or immediate purchase rather than those that would require extensive browsing or complex transactions.

The social attractiveness using many IMT-2000 services will be greatly enhanced with the introduction of IP Multimedia Call Control. It gives the customer much better control and ease of use as well as opening the possibility for new telecommunications services.

3.2.2.2 Services for business

The mobile phone is a vital tool for business contact, and in many respects business customers use their handsets in a very similar way to users.

IMT-2000 allows handsets as well as larger-screen devices to have greater flexibility and capacity to access vital business data and applications. In addition, technologies such as Bluetooth may provide a link between handsets and other devices, increasing the flexibility of such devices for business use. While it is impossible to predict the future with absolute certainty, it is reasonably safe to assume that the wireless data capabilities of handsets, as well as PDAs and laptops, will continue to evolve, thereby influencing how each type of device is utilized by business users. As the devices and their applications evolve, business users will determine the optimal combination of devices to meet their specific needs.

3.2.2.3 Services in developing countries

It must not be forgotten that in many parts of the world the mobile phone is used as a substitute for fixed phones. This has arisen because of the relative ease, low cost and speed of deploying wireless access, compared

[18] For further details see UMTS Forum Report number 26 at: www.UMTS-Forum.org

with fixed copper or fibre. There are already hundreds of millions of subscribers who access basic telephony services in this way – a number that may soon increase to billions. In parallel with other more economically developed regions, mobile services for personal and business use will also evolve in these emerging markets. Adequate infrastructure is thus needed here in order to provide substitution for fixed access to the Internet. In developing regions, by being able to provide access to the Internet and the World Wide Web for the first time, IMT-2000 can play a major role in improving commercial opportunities for the people, health care and education.

3.2.3 Functional and service enhancements for operators

In order to support the introduction of new services, the underlying technology needs to evolve. There are no hard and fast rules – some new capabilities and services can be added to the existing network equipment through software upgrades.

Provision of a service depends on the bit rate needed for the service and the capacity of the network as well as any underlying technology to deliver the service. Many services can be introduced early on using existing technology, but then need the increased capability in order to be able to deliver it to the mass market. So, for example, picture messaging or multimedia messaging has already been introduced on various networks. However, as the mass market adopts these services there is likely to be demand for additional spectrum to meet capacity needs. On the other hand, some IMT-2000 services such as videotelephony will need the bandwidth, capacity and spectrum of IMT-2000 from the outset to be viable. Some examples of such enhancements are described below.

3.2.3.1 Pre-IMT-2000 service enhancements

A number of enhancements scenarios have already taken place within the context of pre-IMT-2000 systems.

For example, ANSI-95A[19] systems, originally introduced in 1995, provided circuit switched data at 9.6 kbit/s in addition to voice services that were more advanced that existing first-generation systems. With the advent of ANSI-95 B systems in 1998, operators were then able to provide circuit switched data at 64 kbit/s. Though the ANSI-95 A/B systems (collectively known as cdmaOne systems) provided voice and data services, they were limited to low bit rate applications. CDMA2000 systems that are developed based on the requirements of the IMT-2000 mandate are a direct evolution of the ANSI-95 A/B networks.

Another example is provided by TDMA and GSM networks, deployed by operators in several countries in a combined fashion. To maximize the efficiency and streamline the operation of these combined systems, TDMA/GSM operators and vendors have undertaken several major efforts to harmonize the TDMA and GSM radio access networks. Namely:

1. A data-only common packet based network enhancement for the two networks, GPRS, has been developed and deployed in at least one administration. In addition, interoperability between the circuit switched core networks (ANSI-41 and GSM-MAP) was developed. This effort, known as the GSM ANSI-41 Interworking Team (GAIT), has resulted in the introduction of new multi-mode TDMA/GSM/AMPS, multi-band GAIT phones.

2. Harmonization was also achieved in the area of voice/channel coding. A new concept of dynamically optimizing the voice/channel coding depending on radio conditions, known as adaptive multi-rate (AMR) coding, has been developed that utilizes a suite of speech and channel coding schemes that maintain acceptable voice quality in poor radio environments and offer capacity gains in nominal radio environments.

As a result of these technology and harmonization/interoperability efforts, the economics of continued network build out and evolution have improved significantly. At the same time, competitive pressures to introduce enhanced voice and data services and global economies of scale have combined to make it more attractive to deploy GSM/GPRS, rather than to continue to build out using the 136+ radio and the ANSI-41 network. For the benefit of existing TDMA subscribers and because there are important potential roaming revenues from hundreds of millions of international GSM subscribers, some TDMA operators are deploying GSM/GPRS in their existing spectrum.

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[19] At the time of their introduction, these systems were known as IS-95A systems.

To support the evolution to IMT-2000 of subscribers being served by GSM for voice services, a data voice (DV) version of the existing IMT-2000 TDMA Single-Carrier EDGE radio interface has been developed, and has been incorporated as part of Revision 4 of Recommendation ITU-R M.1457. As a result of the extensive harmonization already accomplished between TDMA and GSM systems, it is a relatively minor change to add a new logical channel to support additional signalling messages. Most notably, the EDGE radio interface is the same whether used within a GSM or ANSI-136 TDMA radio access network, which allows roaming between GSM and TDMA operators for EDGE data-only (EDGE-DO) services. It should be noted that GSM-MAP network signalling, which supports mobility management for the EDGE-DO subscribers, is already part of IMT-2000 TDMA Single-Carrier.

With the inclusion of this latest update into IMT-2000 TDMA Single-Carrier, operators will be able to offer common EDGE services to both their TDMA and GSM/GPRS customers. This will provide significant operational synergies that will allow greater efficiencies and simpler management of overall system resources. Such benefits are realizable by any TDMA operator considering IMT-2000 TDMA Single-Carrier as its evolution path.

3.2.3.2 IMT-2000 service enhancements

In addition to the enhancements to pre-IMT-2000 networks, it is expected that IMT-2000 standards, technologies and services will also further evolve. Following are several examples of such enhancements that are now being developed

Further evolution of UMTS is already being considered. The UMTS radio access technology will be enhanced to support high speed downlink and uplink packet access, enabling transmission at speeds of up to 14.2 Mbit/s. In the same way that EDGE increases spectral efficiency compared to GPRS, HSDPA increases spectral efficiency compared to IMT-2000 CDMA Direct Spread. The higher spectral efficiency and higher speeds not only enable new classes of applications, but also support a greater number of users accessing the network, with HSDPA providing over twice the capacity.

There will be other complementary technologies in order to provide really high data rates and very high user densities, such as would be found in conference centres, including wireless local area networks (W-LAN), which can complement UMTS in future, offering theoretical bit-rates up to 54 Mbit/s. Although public WLAN networks will also be deployed independently from the mobile networks, there are built-in advantages for the mobile operators that come from the ability to provide mobility management, subscriber management, high security and roaming.

Another enhancement is the IP multimedia subsystem (IMS). It enables real-time, person-to-person services, such as voice or videotelephony, to be provided by means of packet switched technology in common with information and data services, by using IP multimedia Call Control. It allows the integration and interaction of telecommunications and information services as well as enabling telecommunications sessions to be established simultaneously between multiple users and devices.

CDMA2000 1xEV-DO is an enhancement to CDMA2000 that is primarily optimized for data services and enables data transmission at higher speeds. The CDMA2000 1xEV-DO air interface is designed to provide complete interoperability with CDMA2000 1X networks and provides peak data rates of up to 3.1 Mbit/s in the forward link and 1.8 Mbit/s in the reverse link in a frequency carrier bandwidth of 1.25 MHz. CDMA2000 1xEV-DO allows operators an economical option to deliver the wide range of IMT-2000 data services at affordable costs. The 1xEV-DO systems that are already commercially deployed implement many advanced features of wireless telecommunication system design. CDMA2000 1xEV-DV is an enhancement to the IMT-2000 CDMA Multi-Carrier systems that combines the features of CDMA2000 1X and CDMA2000 1xEV-DO systems. Thus, it provides an option to provide either the higher voice capacity of CDMA2000 1X systems or the higher data capacity of CDMA2000 1xEV-DO systems or even provide a balanced mix of high capacity voice and data in one single carrier of 1.25 MHz.

3.3 From analogue (1G) systems (AMPS, NMT, TACS)

Operators of analogue systems are able to migrate their systems to IMT-2000 either directly, or by first migrating to a digital pre-IMT-2000 technology and then to IMT-2000.

3.3.1 To IMT-2000 CDMA Direct Spread

Where spectrum and resources are available, AMPS operators may migrate users and/or services directly to IMT-2000 CDMA Direct Spread.

For operators of AMPS systems preferring evolution, a natural path is the evolution to TDMA, then on to IMT-2000 since the AMPS and TDMA air interface both use 30 kHz RF channels which enable channel by channel changeover from AMPS to TDMA. Additionally, TDMA (ANSI-136) supports combinations of analogue and digital control channels and traffic channels easing the transition path.

Core network evolution is possible because both AMPS and TDMA can be operated on ANSI-41 core networks.

Once the AMPS system is evolved to TDMA, then a strategy of GSM/GPRS overlay can be undertaken which provides a common packet data service for both TDMA and GSM subscribers, as many TDMA operators have already embraced, leading to the deployment of GSM MAP and setting the stage for transition to IMT-2000 CDMA Direct Spread. This path allows analogue operators to take advantage of the experience of many TDMA operators in their evolution/migration to IMT-2000 TDMA-SC and IMT-2000 CDMA Direct Spread. This strategy enables an existing analogue operator to undertake an orderly transition path using technologies such as GAIT, which allows roaming between GSM and TDMA networks, thus enabling transition in smaller incremental steps as resources are available.

All NMT900 systems, TACS systems and some NMT450 systems have already migrated to GSM. Concerning the NMT core network, the change to GSM has been a migration, since a new GSM-MAP core network was necessary, although the GSM-MAP core network is based on the NMT-core network architecture.

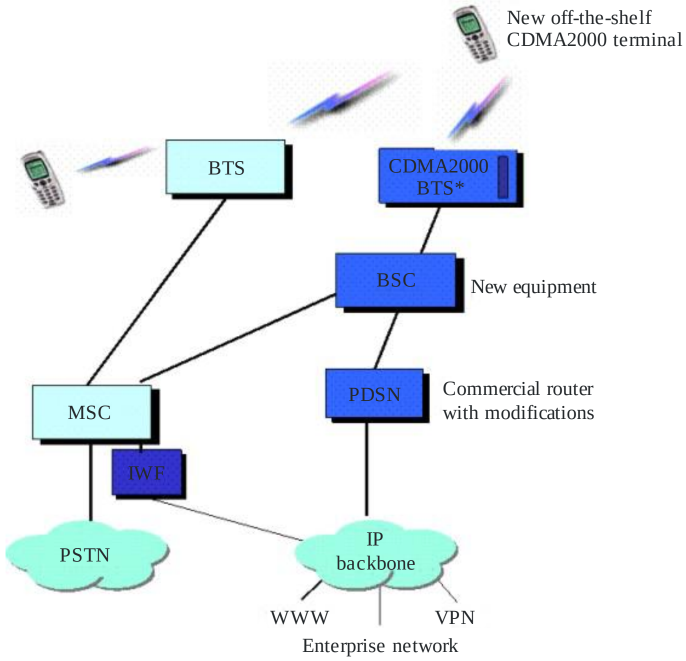
3.3.2 To IMT-2000 CDMA Multi-Carrier

AMPS systems are based on ANSI-41 core network protocols, which are also the basis of IMT-2000 CDMA Multi-Carrier core networks. This facilitates a smooth and easy evolution/migration for AMPS systems to IMT-2000 Multi-Carrier since most of the core network elements are reusable, resulting in lower deployment costs. In order to overlay IMT-2000 CDMA Multi-Carrier equipment on these analogue systems, operators need to add new base stations, base station controllers, and a packet data support node, and make software upgrades at the mobile switching centre. Figure 3-4 shows the new components required for AMPS operators to implement CDMA2000. All CDMA handsets support AMPS and hence clearing the spectrum to add CDMA2000 RF carriers is practically seamless to subscribers.

Though NMT systems do not use the ANSI-41 core network protocol, several NMT operators have found it easy to implement CDMA2000 within their NMT spectrum band (450-470 MHz), which was identified at WRC-07 for IMT. A major advantage with an IMT-2000 CDMA Multi-Carrier radio base station operating in the NMT band is its extended coverage, which is better than the coverage of an analogue NMT-450 base station at the same frequency. Therefore an operator would need fewer base stations to provide the same coverage level. In addition, IMT-2000 CDMA Multi-Carrier base station transceivers (BTSs) may be co-located with analogue NMT BTSs, which will reduce network deployment costs significantly.

FIGURE 3-4

Migration path from AMPS to IMT-2000 CDMA Multi-Carrier



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The family of IMT-2000 Multi-Carrier systems consists of CDMA2000 1X for voice and medium data rates up to 307 kbit/s and CDMA2000 1xEV-DO for high-speed data rates up to 3.1 Mbit/s in a single carrier of 1.25 MHz or higher data rates with aggregated channels using EV-DO Rev.B. Analogue pre-IMT-2000 operators have a choice to first implement CDMA2000 1X and then choose to overlay CDMA2000 EV-DO in multiple phases depending on network capacity evolution. This path to CDMA2000 also offers analogue operators a transition path with flexibility to enable IMT-2000 services within their current spectrum, resulting in substantial cost savings as CDMA2000 systems can evolve using narrower 1.25 MHz channels, which facilitate deployment of three CDMA carriers in 5 MHz of bandwidth. CDMA networks are deployed with a frequency reuse of 1 instead of higher reuse factors such as 7/21 or 4/12 that are necessary for AMPS networks. This, in turn, will simplify network planning for the operator.

CDMA2000 also allows deployment of an IMT-2000 network in successive stages, depending on the frequency band available for an operator and the required network evolution based on demand for high-speed data services. In cases where there is a limited band available (i.e., generally about 2 × 5 MHz for NMT systems) the operator can deploy CDMA2000 services successively; that is, two CDMA2000 1X carriers for voice and packet data, or one CDMA2000 1X carrier for voice and data, and one single CDMA2000 1xEV-DO carrier dedicated exclusively to high-speed packet data (up to 3.1 Mbit/s for a single EV-DO carrier, or higher for aggregated EV-DO carriers). CDMA also enables easy coexistence of CDMA2000 carriers and NMT carriers with sufficient guardbands. This allows for the smooth implementation of IMT-2000 Multi-Carrier while providing enough flexibility to operate with existing carriers without any interference to either carrier during transition. CDMA2000 operators can offer data-rich applications supported by CDMA2000 systems such as broadband Internet access multimedia messaging services (MMS) and rich video. Transition to CDMA2000 provides analogue operators the ability to launch advanced, commercially available applications relatively quickly and in a cost-effective manner.

3.3.3 To IMT-2000 TDMA Single-Carrier

For operators of AMPS systems wishing to deploy TDMA Single-Carrier, a natural path begins with the evolution to TDMA, since the AMPS and TDMA air interface both use 30 kHz RF channels which enable channel by channel changeover from AMPS to TDMA. Additionally, TDMA (ANSI-136) supports combinations of analogue and digital control channels and traffic channels easing the transition path. TDMA digital traffic channels can be assigned from analogue control channels and analogue voice channels can be assigned from digital control channels. Since AMPS and TDMA share the same 30 kHz RF channel, then a transmitter by transmitter replacement can be undertaken utilizing the same base stations.

Core network evolution is possible since both AMPS and TDMA are operated on ANSI-41 core networks.

Once TDMA is deployed then a packet-based network component can be added using GPRS with the addition of 200 kHz radio channels. The same GPRS packet backbone can then be used for the evolution to IMT-2000 TDMA Single-Carrier. Optionally, a GSM overlay can be added to the TDMA system allowing GSM/GPRS/EDGE operation immediately in the same or different frequency bands, and improving roaming opportunities for users.

3.4 From TDMA/D-AMPS systems

TDMA ANSI-136 is one of the dominant pre-IMT-2000 standards deployed throughout the Americas, and TDMA operators have various options for evolution/migration to IMT-2000, including UWC-136/IMT-2000 TDMA Single-Carrier, IMT-2000 CDMA Multi-Carrier, or IMT-2000 CDMA Direct Spread.

3.4.1 To IMT-2000 CDMA Direct Spread

Many of the major TDMA operators are deploying overlay GSM/GPRS/EDGE radio access and core networks. The GSM-based path offers TDMA operators the opportunity to deploy the combination of GPRS, EDGE and IMT-2000 CDMA Direct Spread that best meets their needs[20].

The path to IMT-2000 CDMA Direct Spread from a GSM overlaid TDMA system involves a new radio access network, but several factors will ease deployment. First is that most IMT-2000 CDMA Direct Spread cell sites can be co-located in GSM cell sites. Second is that much of the GSM/GPRS core network can be used. While the SGSN needs to be upgraded, the mobile switching centre needs only a simple upgrade and the GGSN stays the same.

Another solution for TDMA operators is to provide IMT-2000 services via IMT-2000 CDMA Direct Spread and HSDPA. In this case an IMT-2000 CDMA Direct Spread overlay would be deployed analogous to the GSM overlay described above.

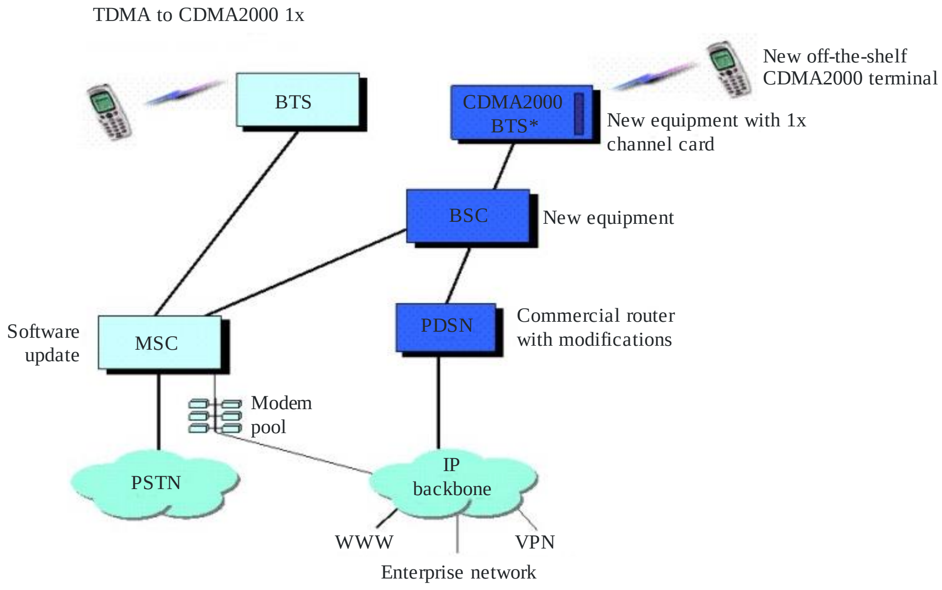
3.4.2 To IMT-2000 CDMA Multi-Carrier

Operators of digital pre-IMT-2000 TDMA (ANSI-136, ANSI-54) systems have a smooth and easy path to IMT-2000 Multi-Carrier. The digital TDMA systems are based on the ANSI-41 protocol, which is a common core network used by the CDMA2000 family that forms IMT-2000 CDMA Multi-Carrier. The common core network can be leveraged through the use of IMT-2000 CDMA Multi-Carrier which only requires operators to add CDMA2000 base stations, base station controllers (BSC), upgrade software at the mobile switching centre (MSC), and a packet data support node. In addition, IMT-2000 CDMA Multi-Carrier base station transceivers (BTSs) can be co-located with TDMA BTSs, which will reduce network deployment costs significantly. Figure 3-5 shows the new components required to implement CDMA2000. CDMA2000 also offers TDMA operators a wide selection of low-cost handsets, and mature technology with low infrastructure costs. Operators also gain from ease of network engineering as CDMA networks are deployed with a frequency reuse of 1 instead of higher reuse factors such as 7/21 or 4/12 that are necessary for TDMA networks. Also, CDMA handsets enable end users to roam from a partially built CDMA2000 1X network to the AMPS side of a TDMA-AMPS network. This in turn will simplify network planning for the operator.

[20] For more technical information on these technologies, *see* RYSAVY, Peter. [19 November, 2002] Data Capabilities for GSM Evolution to UMTS. Available at: http://www.3gamericas.org/English/technology_center/whitepapers/index.cfm. Much of the material in this section is taken from this paper.

FIGURE 3-5

Evolution/migration of TDMA to IMT-2000 CDMA Multi-Carrier



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The family of IMT-2000 Multi-Carrier systems consists of CDMA2000 1X for voice and medium data rates up to 307 kbit/s and CDMA2000 1xEV-DO for high-speed data rates up to 3.1 Mbit/s in a single 1.25 MHz channel, or higher rates, up to 14.7 Mbit/s, with aggregated channels using EV-DO Rev.B TDMA operators can first deploy CDMA2000 1X and then choose to overlay CDMA2000 EV-DO in multiple phases depending on network capacity evolution. For the operators, this path also offers the flexibility of enabling IMT-2000 services within their current spectrum resulting in substantial cost savings as these systems can evolve with narrower 1.25 MHz channels, which facilitate deployment of three CDMA carriers in a 5 MHz bandwidth.

CDMA2000 also offers the choice of phased introduction, in which spectrum is cleared for CDMA2000 in multiple stages. This allows the operators to expand their IMT-2000 networks in successive stages, depending on the frequency band available for an operator and the required network evolution based on demand for high-speed data services. CDMA RF carriers can easily coexist with TDMA RF carriers, providing a smooth transition path. CDMA and TDMA have already coexisted for some time and many techniques have been developed to minimize the impact.

In case a network evolution is required based on demand for high data services, CDMA2000 1X and CDMA2000 EV-DO carriers can be deployed in any combination to provide a flexible mix of high-quality voice channels and high data rate services. Additional CDMA RF carriers can be added as the demand grows. This provides enough flexibility to operate with existing carriers without any interference to either carrier during transition. Through this migration/transition, TDMA operators can increase voice capacity significantly, and start offering data-rich applications supported by CDMA2000 systems, such as broadband access, multimedia messaging services (MMS) and video. CDMA2000 migration/transition allows TDMA operators the ability to launch advanced, commercially available applications relatively quickly in a cost-effective manner.

3.4.3 To IMT-2000 TDMA Single-Carrier

The TDMA community (as represented by 3G Americas and GSMNA) has decided to evolve to UWC-136/IMT-2000 TDMA Single-Carrier. Many of the major operators are deploying overlay GSM/GPRS/EDGE radio access and core networks. The GSM-based path towards IMT-2000 TDMA Single-Carrier offers TDMA operators the opportunity to pick and deploy the combination of GPRS, EDGE and IMT-2000 CDMA Direct Spread and/or IMT-2000 CDMA TDD (time code) that best meets their needs.

The path to IMT-2000 TDMA Single-Carrier from TDMA and GSM/overlaid TDMA systems incorporates constant enhancements in capability and efficiency. This progression can occur in multiple phases, first with the addition of GSM/GPRS, and then adding EDGE later; or can be accomplished by adding GSM/GPRS/EDGE in a single upgrade, as some carriers in North America have done. For further flexibility, an IMT-2000 CDMA Direct Spread radio access network can also be added later, followed by evolved capability enhancements such as HSDPA. For example, an operator might initially deploy GSM/GPRS/EDGE throughout its licence area, but then implement IMT-2000 CDMA Direct Spread only in major cities, with customers handed to its EDGE or GPRS networks when they travel outside IMT-2000 CDMA Direct Spread coverage.

A TDMA operator is not required to shut down its network to begin the process of deploying GSM. TDMA operators who have chosen the GSM evolution path are deploying overlay networks that leverage existing cell-site facilities, networking transports, and central site resources. These operators have deployed GSM and GPRS simultaneously. Depending on its infrastructure vendor and the age of the equipment, it is possible for an operator to increase the capacity of the TDMA mobile switching centres (MSCs) enough to free up one or more MSCs, which then are upgraded with software to support GSM. In the radio network, the GSM base-station equipment often can share the TDMA antennas.

To deploy GPRS, a GSM operator adds a packet core infrastructure, which consists of two types of elements: GGSNs and serving GPRS support nodes (SGSNs). These elements are the foundation for future migration because they are re-used as the operator adds EDGE and IMT-2000 CDMA Direct Spread. At the cell site, the GSM base station equipment is upgraded with software and channel cards to support GPRS. In many GSM/GPRS networks, EDGE[17] is a software-only upgrade to the BTS and the BSCs, as the transceivers in these networks are already EDGE capable. Other operators might replace their equipment now to take advantage of new types of base stations that accommodate multiple combinations of GSM, GPRS, EDGE and IMT-2000 CDMA Direct Spread simultaneously, with the flexibility to devote more resources to a particular service as demand grows.

To provide additional high data rate applications beyond those supported by GPRS, operators can deploy enhanced data rates for global evolution (EDGE). EDGE is part of the IMT-2000 TDMA Single-Carrier radio interface, and further enhances this GSM/GPRS radio interface by adopting new modulation technology to achieve higher data rates using operator's existing radio spectrum. Standardization of the GERAN within 3GPP includes advanced quality of service mechanisms, enabling EDGE to offer almost all 3G services although with limited data rate compared to IMT-2000 CDMA Direct Spread. As a further enhancement to EDGE, operators can deploy the IP multimedia subsystem in their core networks, which will also support an IMT-2000 CDMA Direct Spread radio access network. This gives operators the flexibility to deploy IMT-2000 CDMA Direct Spread as a complement to EDGE with service transparency. EDGE is one solution to provide IMT-2000 services in existing pre-IMT-2000 spectrum resources.

3.5 From PDC

3.5.1 To IMT-2000 CDMA Direct Spread

Most of Japanese mobile operators have been operating Personal Digital Cellular (PDC) system, which is Japanese standard using 800 MHz and 1.5 GHz bands. The PDC standard is based on TDMA air-interface and Japan-specific core network for provisioning of voice and packet data service up to 28.8 kbit/s. Almost all the subscribers are using advanced terminals allowing a variety of mobile Internet services. 3G licences were awarded to three operators in Japan, two of which, NTT DoCoMo and J-PHONE (Vodafone K.K. at present), selected CDMA Direct Sequence (CDMA-DS) system and have already started the commercial service. Two independent networks of the PDC and CDMA-DS need to be deployed so that inter-working function was introduced.

On deployment of the CDMA-DS system, it was very difficult to build up independent cell-sites dedicated to the 3G systems, because operators already installed PDC antennas on many buildings for providing high quality services to huge number of subscribers (over 46 million as of 2000). Therefore, operators co-installed antennas for the 3G system onto the same sites with PDC, where a dual- or tri-band antenna and small-size base stations were developed for saving space and reducing weight.

3.5.2 To IMT-2000 CDMA Multi-Carrier

Another PDC operator in Japan, KDDI, chose the CDMA Multi-Carrier (CDMA-MC) system. Since PDC and CDMA-MC systems have different air-interfaces and core network protocols, migration from PDC to CDMA-MC took place by the way of an intermediate system of (2.5G) like cdmaOne (CDMA ANSI-95A/B). The PDC operator at first started the new system in frequency bands different from or the same as those of the PDC, and then terminated transmission of carriers of the PDC service. The operator shared some of the equipment, such as base station shelter, power supply, antenna, RF equipment, etc., for dual operation of the two systems of the PDC and CDMA-MC. The evolution process from cdmaOne to CDMA-MC is explained in § 3.6.1.

3.6 From cdmaOne systems

3.6.1 To IMT-2000 CDMA Multi-Carrier

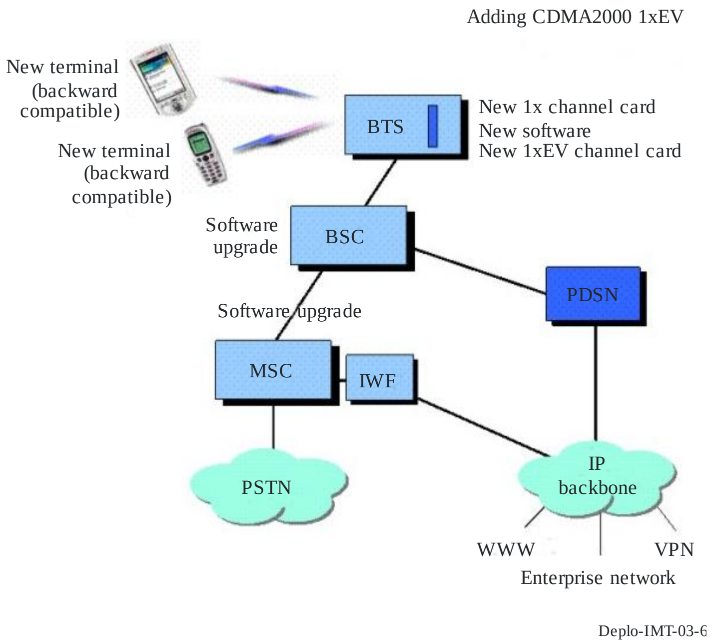
Operators of digital pre-IMT-2000 cdmaOne (CDMA ANSI-95A/B) systems can easily evolve to IMT-2000 CDMA Multi-Carrier directly. IMT-2000 CDMA Multi-Carrier was designed to be fully backward compatible with its predecessor, cdmaOne, so that the requirements of system evolution are simpler than that of other systems. The family of IMT-2000 Multi-Carrier systems consists of CDMA2000 1X for voice and medium data rates up to 307 kbit/s and CDMA2000 1xEV-DO for high-speed data rates up to 3.1 Mbit/s in a single 1.25 MHz channel, or higher rates, up to 14.7 Mbit/s with aggregated channels using EV-DO Rev.B. Operators can overlay CDMA2000 1X and CDMA2000 EV-DO in multiple phases depending on required network capacity evolution. Evolution to CDMA2000 offers cdmaOne operators the flexibility to enable IMT-2000 services within their current spectrum, resulting in substantial cost savings as these systems can evolve with narrower 1.25 MHz channels, which facilitates deployment of three CDMA carriers in 5 MHz of bandwidth.

All air interface revisions of CDMA2000 provide full backward compatibility to cdmaOne. The CDMA2000 family of systems incorporates various innovations, such as selectable mode vocoders (SMV), quick paging channels, high-speed supplemental channels, reverse link power control and pilot gating, which enable these systems to deliver enhanced voice capacities and very high data rates while ensuring efficient sleep mode procedures that result in longer battery life for handsets. In order to overlay a CDMA2000 system onto a cdmaOne system, an operator simply makes software upgrades at the base station controller and the mobile switching centre, adds new channel cards and software at the base stations, and add a packet data support node. Figure 3-6 shows the evolution path for cdmaOne to CDMA2000.

CdmaOne operators can nearly double the voice capacity of their network through migration to CDMA2000. CDMA2000 1X supports 33-40 simultaneous voice calls per sector in a single 1.25 MHz FDD channel. Using a new codec (EVRC-B) and handset interference cancellation, it can handle up to 55 voice calls. The enhancements of 1X, 1X Advanced will further boost the capacity 2.3x by using the new EVRC-B codec and introducing uplink and downlink interference cancellation, mobile receive diversity, quasi-orthogonal functions (QOF) and radio link enhancements such as improved power control, early termination and smart blanking. Overlaying CDMA2000 1xEV-DO provides an evolution path for very high data rates supporting broadband access, multimedia messaging services (MMS) and high-quality video. Evolution to CDMA2000 1xEV-DO provides a flexible framework for delivering QoS in data services through a wide range of data rates and packet types. The protocols are designed to provide seamless virtual handoffs in a service area for packet data services and also a seamless interoperation with the CDMA2000 1X air link. Provision of a quick paging channel improves stand by time significantly.

FIGURE 3-6

Evolution path from cdmaOne to CDMA2000



The family of CDMA2000 technologies thus provides for smooth evolution of cdmaOne systems to IMT-2000. CDMA Multi-Carrier ensuring higher voice capacity to support a greater number of end users and high packet data rates enabling richer and new classes of applications for the IMT-2000 service environment. CDMA2000 provides CDMA operators the ability to launch advanced, commercially available applications quickly in a cost effective manner without an interruption of services to their customers.

3.7 From GSM systems

The GSM industry has charted an evolutionary path to IMT-2000 in a logical, structured and standardized way. This includes the possibility of implementing IMT-2000 through upgrades to GSM/GPRS/EDGE, or by introducing IMT-2000 CDMA Direct Spread, or by implementing both paths. This flexibility gives operators an exceptional set of alternative deployment strategies to precisely suit their situation with regard to their legacy networks, capacity needs, spectrum availability and speed of take-up of the new services in the market.

The original GSM system, designed to support basic voice and data services, consists of a circuit switched Core Network that provides the routing of calls to mobile subscribers, the base station subsystem for radio access and the mobile station. One of the most important factors in GSM's success is the Standard Open Interfaces that have enable any vendor to supply any elements of the network and for operators worldwide, to deploy multi-vendor systems of their choice.

To improve the data capabilities of this original version of GSM, general packet radio service (GPRS) can be added. This provides an "always on", high-speed connection (up to 171 kbit/s) to packet data networks suited to the "bursty" traffic such as the Internet and World Wide Web, either directly or via operator's portals. With GPRS the core network is enhanced to embrace the packet switched domain, adding new IP-connected network elements. This extension of the core network lays the foundations of a common core network for both IMT-2000 TDMA Single-Carrier and IMT-2000 CDMA Direct Spread.

3.7.1 To IMT-2000 CDMA Direct Spread

GSM operators may choose to evolve their networks directly to IMT-2000 CDMA Direct Spread, as well as via EDGE. The pathway from GSM to IMT-2000 CDMA Direct Spread is clearly defined, starting with GPRS (and/or EDGE) and then on to CDMA Direct Spread. GPRS serves as a natural intermediate step, insofar as the core network is the same as is needed for CDMA Direct Spread. Operators with new spectrum for CDMA Direct Spread and who have an immediate need for additional capacity to deliver new services will most likely deploy WCDMA. The data rate performance of CDMA Direct Spread will be enhanced with HSDPA. They may also decide to upgrade their GSM/GPRS radio equipment with EDGE as a complementary technology in lower traffic areas.

For GSM operators who are the great majority of pre-IMT-2000-operators in developing countries, the best and most convenient, future proof path for them to IMT-2000 is the evolution to GERAN and the enhancement of the radio access by UTRAN. It has to be noted, that GERAN and UTRAN are aligned for service transparency. This allows seamless service provision, which is achieved by usage of the same core network, standardized Handover-procedures etc. The GSM to GERAN/UTRAN evolution includes the evolution of the MAP- and GPRS-core network.

IMT-2000 CDMA Direct Spread offers voice capacity advantages mainly through the benefits of interference averaging offered by its code division spread spectrum technology, combined with tight power control. One enhancement over GPRS is that the control channels that normally carry signalling data can also carry small amounts of packet data, which reduces setup time for data communications. CDMA Direct Spread will not necessarily replace GPRS or EDGE, but will in reality co-exist with them and may be built on one common core network.

GSM, due to its frequency hopping capability, can be considered as a spread-spectrum system based on TDMA. IMT-2000 CDMA Direct Spread is a spread-spectrum system based on direct sequence spread spectrum. It is spectrally more efficient than GSM, and its wideband nature provides a further advantage – the ability to translate the available spectrum into high data rates. This results in flexibility to manage multiple traffic types, including voice, narrowband data, and wideband data. In IMT-2000 CDMA Direct Spread, data channels can support up to 2.4 Mbit/s of peak data throughput. Though exact throughput depends on what size channels size the operator chooses to make available and the number of users active in the network, users can expect throughputs of up to 384 kbit/s.

IMT-2000 CDMA Direct Spread introduces improved radio access technologies based on WCDMA, providing higher bit rates (up to 14.2 Mbit/s).

The benefits of these upgrades are summarized in Table 3.1.

TABLE 3.1

Benefits resulting from technology choices towards IMT-2000 CDMA Direct Spread

Technology	Benefits
GSM/GPRS with coding schemes 1 to 2	IP packet data service delivers effective throughputs of up to 40 kbit/s for four-slot devices
GSM/GPRS with coding schemes 1 to 4	Includes an option for operators to boost speeds of GPRS service by 33%
GSM/GPRS/EDGE	Third-generation technology effectively triples GPRS data rates and doubles spectral efficiency
IMT-2000 CDMA Direct Spread	Supports flexible, integrated voice/data services with peak rates of 2 Mbit/s
HSDPA	An enhancement to IMT-2000 CDMA Direct Spread and fully backwards compatible. HSDPA will offer peak data rates of 14.2 Mbit/s

3.7.2 To IMT-2000 CDMA TDD (time-code)

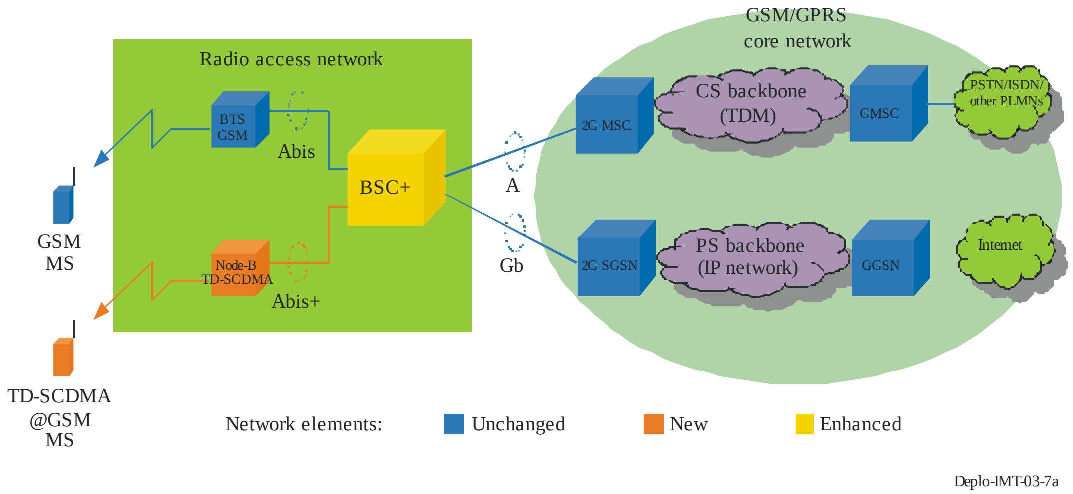
A possible path which re-uses an existing GSM network is via IMT-2000 CDMA TDD (time-code), i.e. TD-SCDMA. The process for this transition from GSM to TD-SCDMA can be divided into two gradually enhanced steps.

Step 1: A GSM/GPRS operator with large portions of TDD bands available (unpaired TDD bands) can introduce the TD-SCDMA Radio Access Network (RAN) while using the existing GSM/GPRS core network.

First the GSM/GPRS BSC is software upgraded to BSC+ to support TD-SCDMA radio subsystem. Then the new TD-SCDMA base stations (NodeBs) can be connected to the upgraded GSM/GPRS BSC to provide service based on GSM/GPRS network infrastructure. Correspondingly, the Abis interface is also upgraded to Abis+. No modification is needed for the existing A and Gb interfaces. This integration of an IMT-2000 air interface into existing and stable GSM/GPRS infrastructure results in a rapid availability of high system capacity without deployment of a completely new core network infrastructure.

FIGURE 3-7a

Step 1

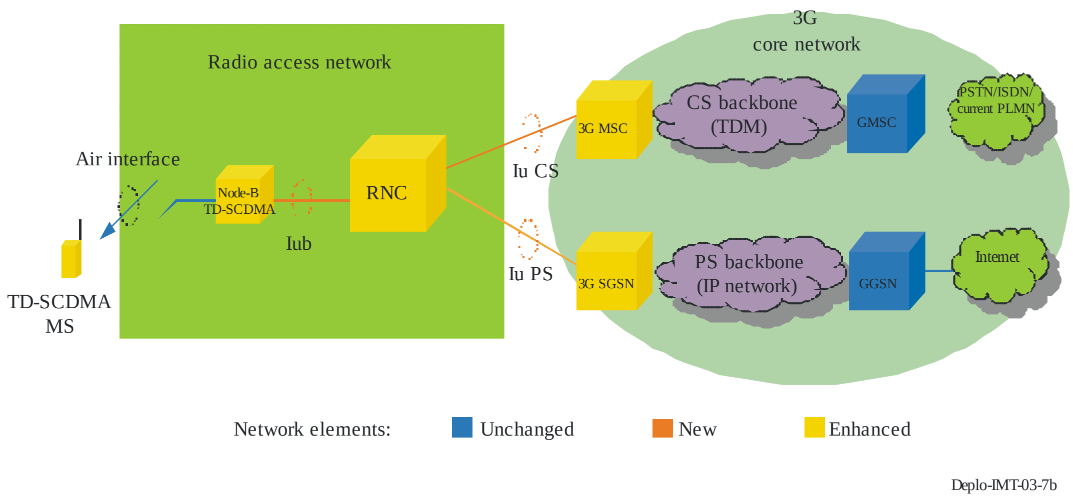


Step 2: With the service development, IMT-2000 core networks are established and co-exist with the GSM/GPRS core networks. Then parts of TD-SCDMA equipments are upgraded to be able to connect with the IMT-2000 core networks.

The interface card of the Node B is upgraded to support Iub interface. The BSC+ is upgraded to RNC to support Iub and Iu interface, which consists of Iu CS, and Iu PS interfaces. The pre-IMT-2000 MSC is upgraded to IMT-2000 MSC to support Iu CS interface. The pre-IMT-2000 SGSN is upgraded to IMT-2000 SGSN to support Iu PS interface.

FIGURE 3-7b

Step 2



The benefits of these upgrades are summarized below:

Technology	Benefits
IMT-2000 CDMA TDD (time-code)	a. Enables reuse of the existing pre-IMT-2000 GSM/GPRS core network infrastructure. b. Enables implementation of IMT-2000 services in unpaired bands of minimum 1.6 MHz. c. Allows operators to plan a staged transition. d. Flexible, integrated voice/data services with peak rate of 2 Mbit/s supported

3.7.3 To IMT-2000 TDMA Single-Carrier

A straightforward way for GSM-operators towards IMT-2000 is the evolution of the radio access network from GSM to GERAN. GERAN deploys the EDGE radio interface and is therefore a radio access network that belongs to the IMT-2000 radio technology of IMT-2000 TDMA Single-Carrier. This is a smooth and fully backward compatible enhancement of the GSM radio access without any need of a change of the frequency spectrum. To go this evolution path, the operator will add GPRS and EDGE functionality within the radio access network. The stepwise upgrade of GSM with GPRS and EDGE will evolve the pre-IMT-2000-GSM radio access to the 3G-GERAN.

EDGE is part of the IMT-2000 TDMA Single-Carrier radio interface, and enhances the GSM/GPRS radio interface by adopting new modulation technology to achieve higher data rates using operator's existing GSM radio spectrum. Standardization of the GERAN (GSM/EDGE radio access network) within 3GPP includes advanced quality of service mechanisms, enabling EDGE to offer almost all IMT-2000 services although with limited data rate compared to UMTS. EDGE is one solution to provide IMT-2000 services in existing pre-IMT-2000 spectrum resources.

The same enhanced GPRS packet infrastructure supports both GPRS and EDGE, thus EDGE is fully backwards compatible with GPRS and any application developed for GPRS will work with EDGE. It does so by re-using all the other network elements, including BSC, SGSN, GGSN, and HLR. In fact, with newer GSM/GPRS deployments, such as those being deployed in the Americas, EDGE[18] is a software-only upgrade to the BTS and the BSCs, as the transceivers in these networks are already EDGE capable. TDMA Single-Carrier also uses the same radio channels and time slots as GSM/GPRS, so it does not require additional spectral resources. Thus, it provides a cost-effective solution for operators to upgrade to IMT-2000. Once operators have deployed EDGE, they can enhance its applications capabilities further by deploying the IP multimedia subsystem in their core networks, which is the same as used by an IMT-2000 CDMA Direct Spread radio access network.

3.8 Capacity planning and system design

Once the high level specification for the network has been agreed, capacity planning can begin. Capacity planning encompasses core network planning and radio access network planning. A dimensioning exercise first establishes the key features of the required network topology, typically the nature and number of the required system modules. Using the dimensioning model, the core network and radio access network are then planned in detail. Locations for the main elements of the core network are determined, and the required transmission capacity between each is identified.

Locations for the base stations are determined, typically based around the existing network's topography, with additional base station sites inserted where necessary to achieve the required coverage and capacity. Coverage and capacity are the verified using a variety of radio planning tools. A radio network plan is developed and the radio network loading is verified. QoS, soft handover, and cell breathing are then checked.

3.8.1 Deployment aspects of UMTS

To expand capability and capacity further, operators can deploy UMTS, which is a complementary technology for EDGE, or an alternative. Worldwide, GSM and some new IMT-2000 operators are beginning UMTS deployments. Though UMTS involves a new radio access network, several factors will facilitate deployment. First is that most UMTS cell sites can be collocated in GSM cell sites, facilitated by multi-radio cabinets that can accommodate GSM/EDGE as well as UMTS equipment. Second is that much of the GSM/GPRS core network can be used. While the SGSN needs to be upgraded, the mobile switching centre needs only a simple upgrade and the GGSN stays the same. Once deployed, operators will be able to minimize the costs of managing GSM and UMTS networks, as these networks share many of the same aspects, including:

– packet-data architecture;
– quality-of-service architecture;
– mobility management;
– subscriber account management.

Deployment of UMTS will occur in several stages, beginning first with a portion of the coverage area having UMTS, progressing through continuous UMTS coverage, and then reaching highly integrated, multi-radio operation. Table 3.2 shows this progression.

TABLE 3.2

Deployment progression of UMTS

Deployment stage	Characteristics
Initial UMTS deployment	Only a portion of coverage area has UMTS. GSM provides continuous coverage. UMTS provides enhanced features and capacity relief for GSM
Enhanced interworking of UMTS and GSM/EDGE	Continuous UMTS coverage. Higher loading in UMTS. Access network chosen based on service and load demands
Full multi-radio network capability	Dense deployment of UMTS, including micro cells. Integration of GERAN and UTRAN core equipment. Seamless quality-of-service integration. Addition of new radio technologies, such as WLANs

3.8.2 Deployment aspects of CDMA2000

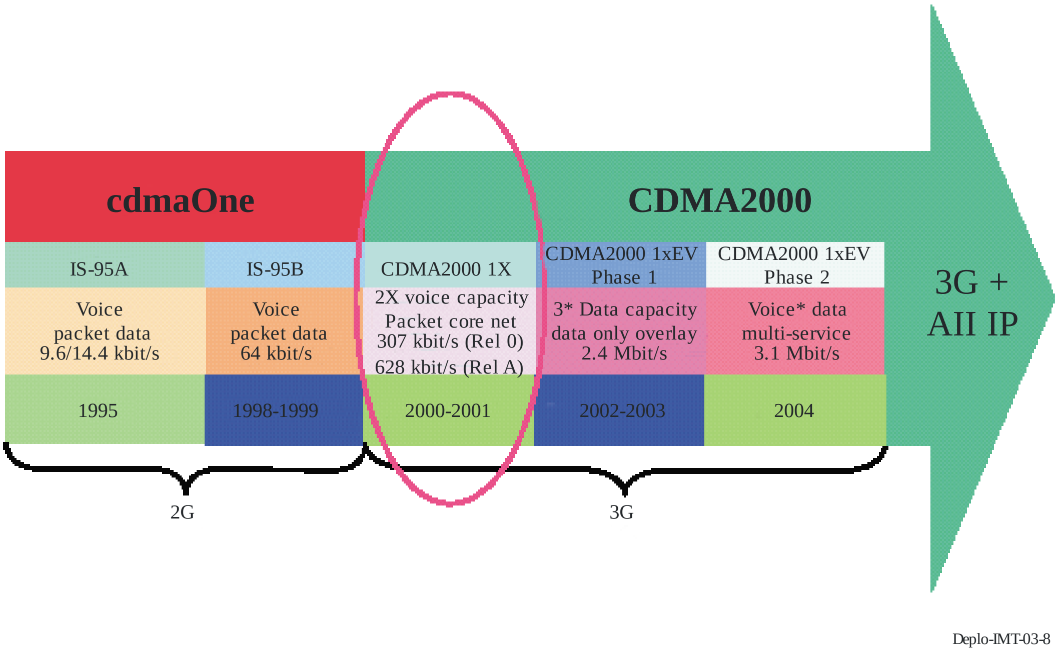
CDMA2000 offers significant spectral efficiency in terms of E/MHz and kbit/s/sector/MHz, representing several times the capacity of pre-IMT-2000 systems. Greater capacity helps minimize the frequency needed and number of base stations needed to deploy IMT-2000 services. This simplifies the cost of deployment, while also allowing an operator to maximize the investment they have in their existing network.

The availability of low-cost CDMA2000 terminals is made possible because CDMA2000 handsets use the same RF channelization components as cdmaOne handsets that were introduced in 1994. They make up a large portion of the more than 200 million commercial CDMA handsets being used worldwide. It is expected that this will continue to be true for all phases of the CDMA2000 evolutionary path, including the evolution to CDMA2000 1xEV-DO and 1xEV-DV devices and All-IP networks.

The evolution of CDMA handsets is simple given that the same RF components are used throughout the evolution, thus helping reduce costs. This will also result in improved form factors and time-to-market. There are economies of scale for CDMA2000 handsets with a large selection of models (by March 2004 there were 520 different models available commercially from 48 different manufacturers).

FIGURE 3-8

Deployment steps of IMT-2000 CDMA Multi-Carrier



CDMA2000 equipment is commercially deployed in some countries in the following frequency bands (MHz):

– 452.500-457.475; 462.500-467.475
– 824-849; 869-894
– 1 750-1 780; 1 840-1 870
– 1 850-1 910; 1 930-1 990
– 1 920-1 980; 2 110-2 170.

For details see Annex B.

It is not necessary to acquire additional spectrum to deploy CDMA2000 as it can be deployed using existing spectrum, depending on capacity and regulatory constraints.

Once operators evolve/migrate to CDMA2000 1X, they will have a complete IMT-2000 network capable of providing significantly higher voice capacity and packet data services up to 307 kbit/s (Rel 0) and 628 kbit/s (Rel A). For most operators, this will provide the beginning of their data service offerings.

The next logical step for the operator is the introduction of CDMA2000 1xEV-DO (Rel 0), otherwise known on a commercial basis as High Data Rate (HDR), which utilizes the same bandwidth as CDMA2000 1X (1.25 MHz). CDMA2000 1xEV-DO (Rel 0) networks are capable of delivering packet data rates up to 2.4 Mbit/s. These carriers can be deployed in the same frequency band as CDMA2000 1X.

The drive for high-speed data throughput efficiency reaches its next phase with the introduction of CDMA2000 1xEV-DO (Rel A) and CDMA2000 1xEV-DV (data and voice) technologies. The Release A version of data-optimized CDMA2000 1xEV-DO technology will be able to deliver increased data rates up to 3.1 Mbit/s for downlink and up to 1.8 Mbit/s for the uplink. Like CDMA2000 1xEV-DO, CDMA2000 1xEV-DV will operate in a 1.25 MHz channel, thus providing a smooth path to the next stage of the evolution process. Backward compatibility with CDMA2000 1X will be maintained for roaming, selective overlay opportunities, and protection of investment in handsets and infrastructure. CDMA2000 1xEV-DV will integrate voice and data on the same RF carrier while increasing peak data rates to 3.1 Mbit/s and maintaining the same voice capacity as CDMA2000 1X.

Operators can start with the first step of deploying CDMA2000 1X, then further evolving their networks to provide more efficient voice and data services, and eventually All-IP services.

The Mobile Internet and All-IP networks are two of the key trends to be considered when planning for future wireless systems. 3GPP2 ensures that CDMA2000 networks have a step-wise path to multimedia services using IP transport. Backward compatibility to legacy networks and terminals is also one of 3GPP2's key priorities.

3.8.3 Deployment aspects of TDMA-SC

It is not necessary to acquire additional spectrum to deploy EDGE as it can be deployed using existing spectrum, depending on capacity and regulatory constraints.

3.8.4 Modular system design

Evolution strategies should consider using a modular approach. This would allow each independent module or subsystem to evolve at its own pace.

Any module or subsystem of a pre-IMT-2000 system can be considered as being taken into IMT-2000 operation when complying with IMT-2000 Recommendations and when connected to other subsystems also complying with IMT-2000 Recommendations.

By comparing the states before and after the introduction of a module into IMT-2000, it can be maintained (no modification), enhanced (be modified) or changed (be replaced). There may be individual choices for discrete components within each module or subsystem.

The following scenario is an example of dividing a system into modules and an example of how this system may evolve into IMT-2000:

– user data (user id, subscription, ...) – is likely to be maintained or enhanced;
– terminal – is likely to be enhanced or changed;
– access subsystem – is likely to be maintained, enhanced, or changed;
– transport subsystem – is likely to be maintained, enhanced or change;
– service subsystem – is likely to be enhanced or changed;
– mobility subsystem – is likely to be enhanced or changed;
– security subsystem – is likely to be enhanced or changed.

Some general guidelines can be drawn on how IMT-2000 can make use of specific pre- IMT-2000 modules. The actual path however, for any individual system in operation, has to be planned by the individual operator in each case.

Manufacturers of IMT-2000 infrastructure equipment offerings are typically based on a modular system design. Following confirmation of the high level network specification (coverage, traffic, service offering, etc.) the physical network implementation is dimensioned using the appropriate set of modules.

CHAPTER 4

ECONOMICS OF EVOLUTION/MIGRATION TO IMT-2000

A key step in the process of finalizing a transition path toward IMT-2000 network deployment is the economic evaluation of the revenues expected from the investments over the economic life of the system, including the spectrum licence acquisition costs – where appropriate. This evaluation bases on the (cost of the) possible options and also on the assumptions about the evolution of demand and service penetration as well as tariff trends and policies[21].

In planning investments, a balance has to be struck between actions decided in the early stages of the network deployment – those that normally have long-lasting effects in terms of both shaping the network infrastructure and capital recovery – and actions which may be deferred – those that are normally taken in response to changing market trends and/or conditions, and whose economic profitability has to be measured within relatively short time frames. Whatever deployment policy is adopted, a significant margin of flexibility for adjusting the deployment plan has to be factored in from the outset.

Numerical aspects for the various parameters characterizing the IMT-2000 network deployment are introduced in the following. It is to be noted that figures have only indicative value and that conclusions based on business analysis are critically dependent on the assumptions underlying the parameter choice.

4.1 Market analysis and trends

In general, there exist many different migration possibilities. Any decision concerning the most suitable solution for a certain operator requires a thorough analysis. Additionally, the overall market situation has to be taken into account, because mobile telecommunication systems are not isolated systems per country or per operator. In particular, worldwide interconnectivity, i.e. roaming, has to be provided to subscribers.

In this section, some examples of the market analysis for particular migration paths are provided. Information about operators following these paths is included in Annexes B and C of these guidelines.

4.1.1 Market overview

In 2003 there were 1.326 billion cellular subscribers in the world using a variety of technologies, both analogue and digital. The charts (Figs 4-1a to 4-1h) give an overview of the current deployment of cellular technologies (as of November 2003)[22].

Table 4.1 provides more detail on operators, subscribers, and mobile technologies used throughout the world.

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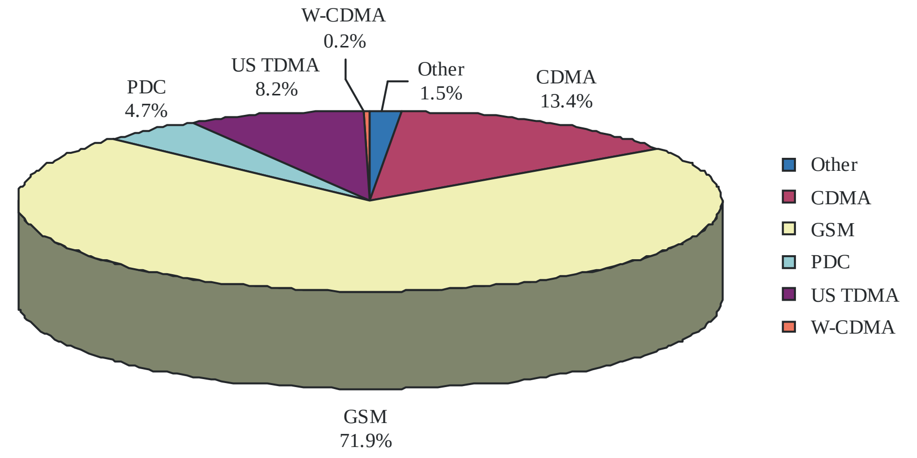
[21] A key metric in the evaluation is the net present value (NPV) understood as the net present value of the network, i.e. cumulative discounted cashflow generated to date. On a less formal level, this metric is indicative of the profitability of a business, as appreciated at Year 0, over a span of *N* years – *N* ranging from 1 to the economic life of the system.

[22] All data on operators, subscribers and technologies is sourced from the EMC World Cellular Database unless otherwise noted. Data is at November 2003.

FIGURE 4-1a

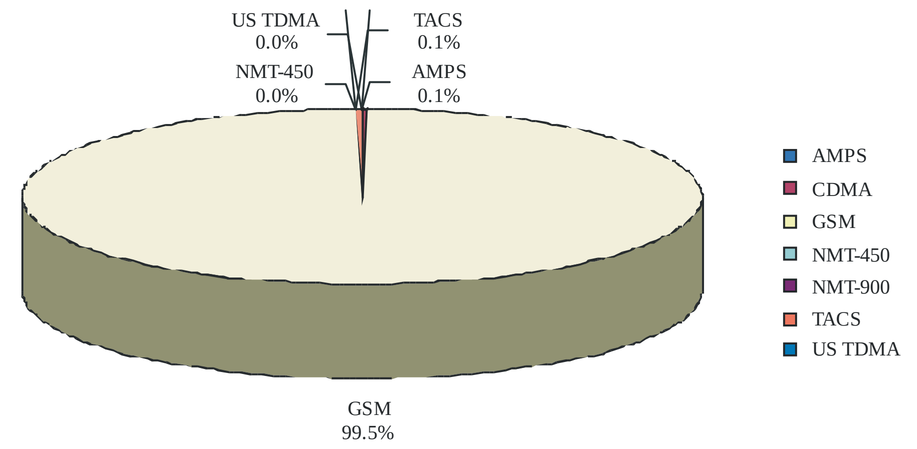
World subscriber figures



Deplo-IMT-04-1a

FIGURE 4-1b

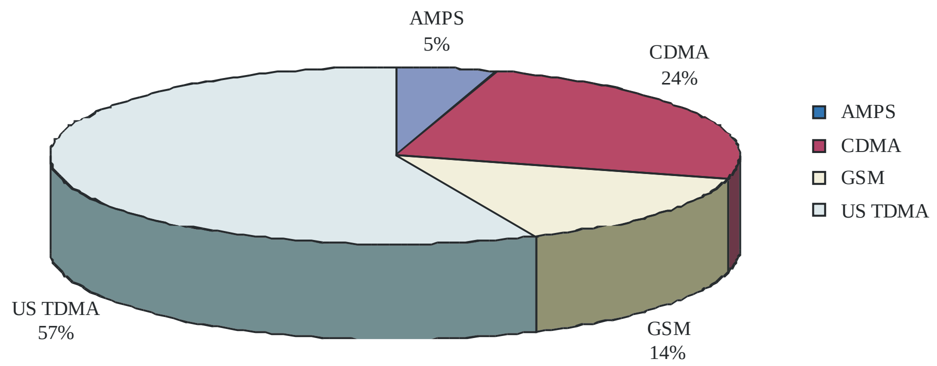
Africa: 48 million subscribers



Deplo-IMT-04-1b

FIGURE 4-1c

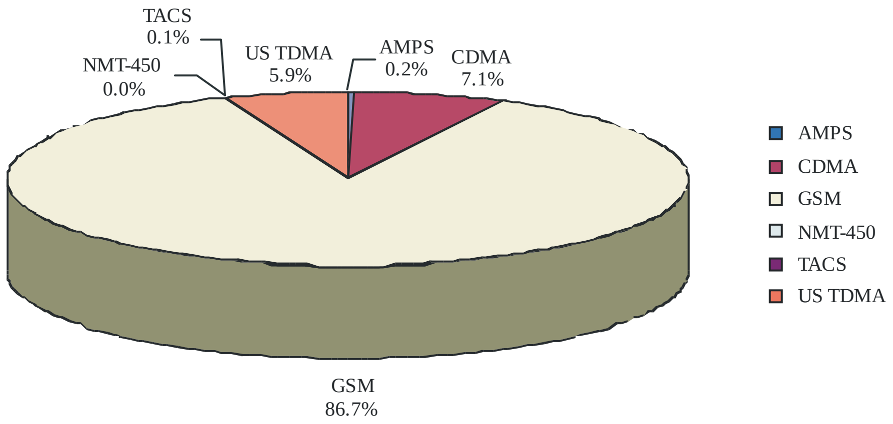
America: 120 million subscribers



Deplo-IMT-04-1c

FIGURE 4-1d

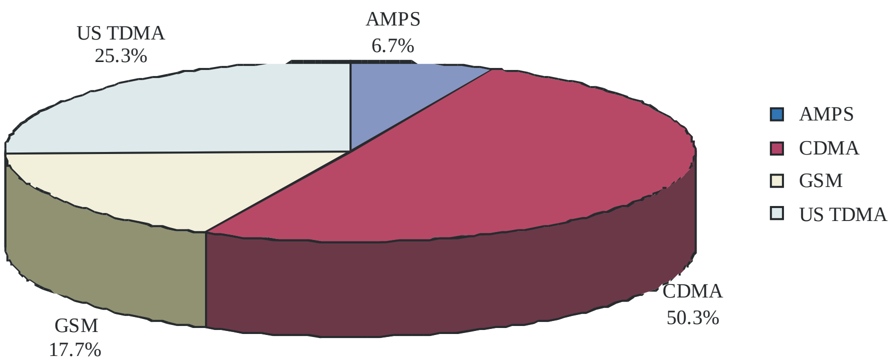
Middle East: 26 million subscribers



Deplo-IMT-04-1d

FIGURE 4-1e

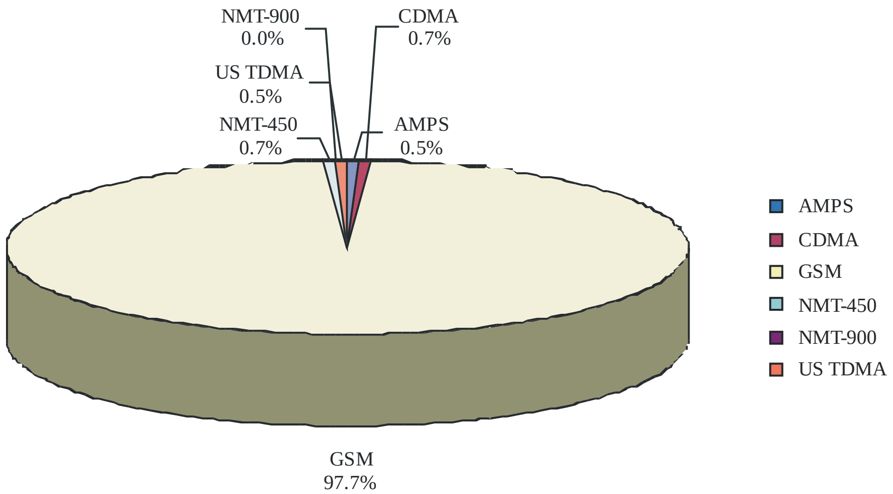
USA/Canada: 151 million subscribers



Deplo-IMT-04-1e

FIGURE 4-1f

Eastern Europe: 105 million subscribers



Deplo-IMT-04-1f

FIGURE 4-1g

Western Europe: 305 million subscribers

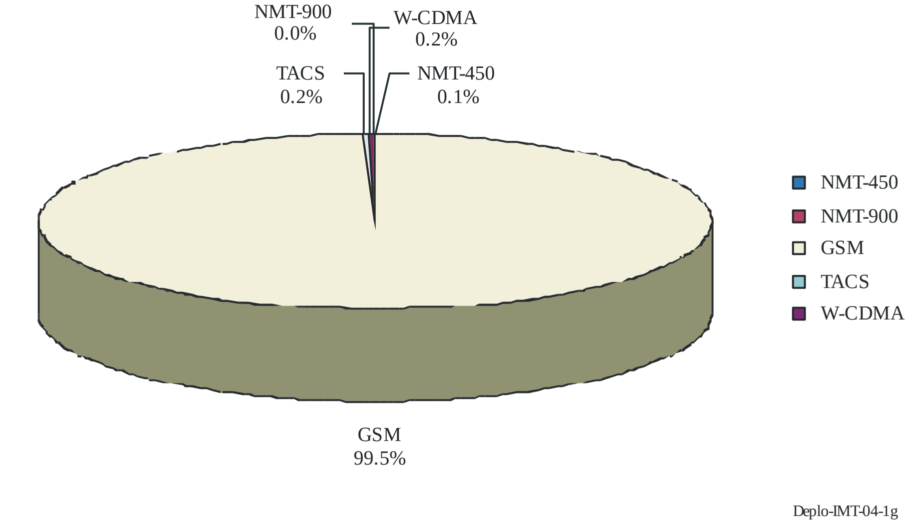


FIGURE 4-1h

Asia Pacific: 524 million subscribers

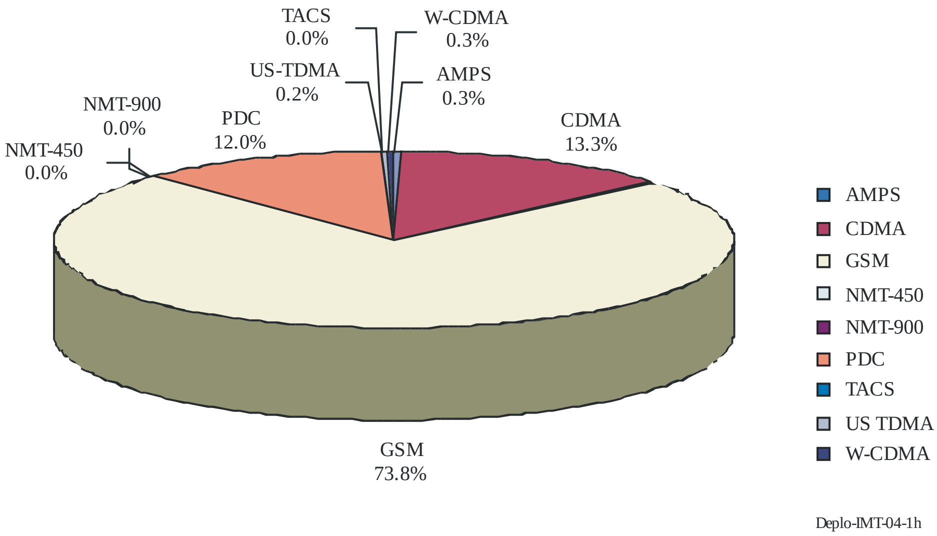


TABLE 4.1

Overview of mobile systems, number of operators and subscribers (November 2003 – January 2004)*

	Operators (also regional!)	**Number of countries**	**Subscribers worldwide (million)**
1G-systems	200	81	20
AMPS	118	52	17.95
NMT	73 (54 of them in the Russian Federation)	21	1

TACS	9	8	1.1

TABLE 4.1 (*end*)

	Operators (also regional!)	**Number of countries**	**Subscribers worldwide (million)**
Pre-IMT-2000-systems	805	291	1 304
GSM	544	191	955
D-AMPS (TDMA)	127	56	109
CDMA (IS-95)	130	43	178
PDC	4	1	62
IMT-2000-systems	128	77	N/A
WCDMA	19	16	2.77
CDMA2000	88	44	75
EDGE	21	17	N/A

* 1G data from EMC World Cellular Database; November 2003; GSM data from GSM Association; TDMA data from EMC World Cellular Database; November 2003; CDMA (IS-95) data from CDG; WCDMA data provided by GSM Association; EDGE data provided by 3G Americas.

4.1.2 Market trends

The cellular market has seen dramatic change in the last decade. Four overall trends have emerged:

– lower prices in airtime and terminals;
– increased cellular penetration;
– growing presence of developing countries;
– growth in non-voice revenue.

Increased competition in the cellular market – both operators and infrastructure vendors – has led to significant decreases in price to the end user. One example of this trend is India, where airtime rates dropped by over 75% from 1996 to 2002[23]. Handset prices have also declined. Between 1994 and 2001, the average selling price of a handset went from USD 464 to USD 157. Prices are estimated to fall an additional 5.9% per year from 2001-2008, to an estimated price of just over USD 100[24].

Falling prices have been a major driver of increased cellular penetration. GSM subscribers have increased twelve-fold since 1997. Similarly, the number of CDMA subscribers increased twenty-three-fold between 1997 and 2003. The popularity of these two mobile technologies continues to grow. In 2003, GSM accounted for 182.9 million or 81% out of the 226.9 million new digital subscriptions. During the same period, CDMA accounted for 35.4 million or 16% of the new digital subscriptions. The shift towards GSM and CDMA2000 will be even more profound in Latin America over the next 3-4 years, as operators of TDMA and analogue networks begin to migrate to IMT-2000 technologies.

Figure 4-2a shows the trend in the number of subscribers per technology from 1992-2003.

For many developing nations, wireless technology has been identified as the best medium to get telecommunication services – both voice and data to the masses. In sub-Saharan Africa, for example, wireless lines already outnumber fixed. From 1995 to 2002, the number of mobile lines has grown by 75% in Africa, 30% in the Americas, 52% in Asia, 50% in Europe and 29% in Oceania[25]. Even though growth has been impressive, there is huge space for wireless growth in developing areas – India has over a billion people with

[23] Cellular Operators Association of India (COAI) (September 2003).

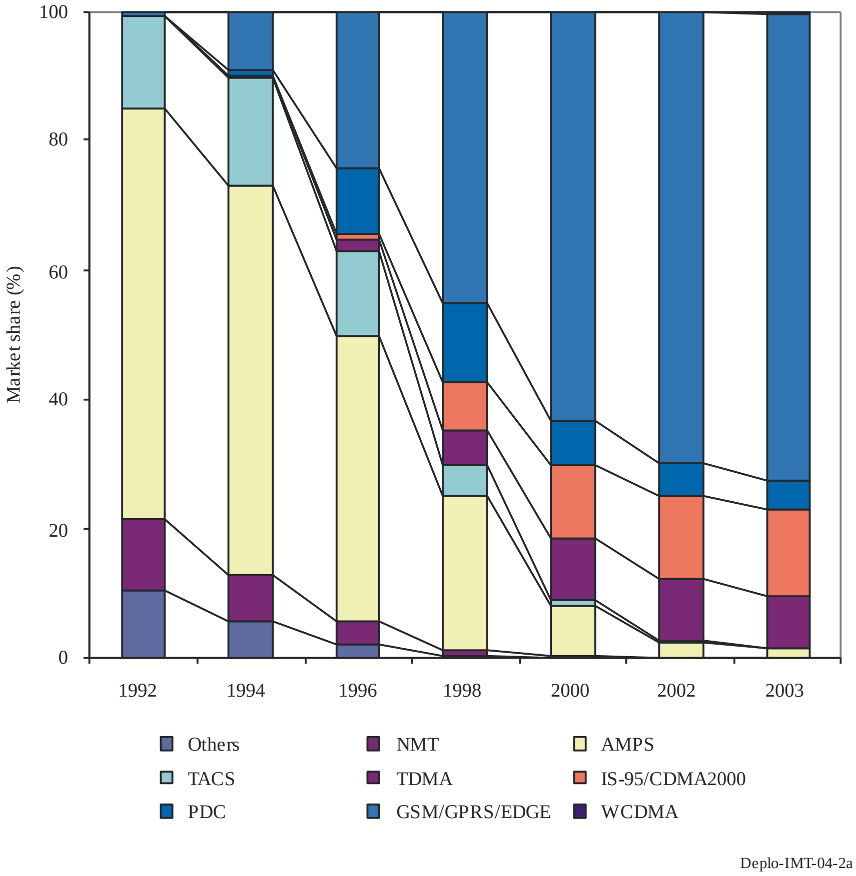
[24] Deutsche Bank Securities, Inc. (June 2003).

[25] ITU, 2002.

no telecommunications line, China just under a billion and the vast majority of the developing world would count its connected population in single figure percentages. This increased penetration is forecast to continue.

FIGURE 4-2a

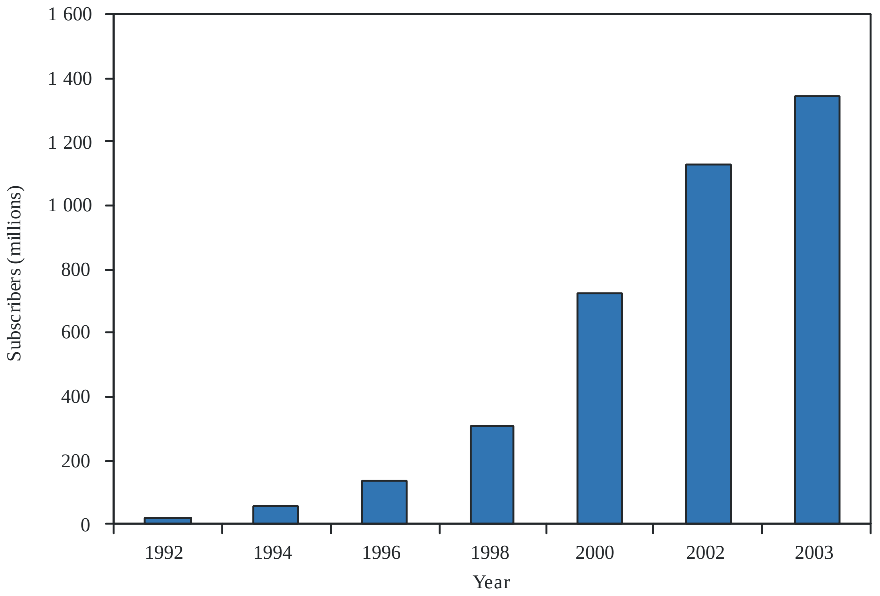
Market shares by technology from 1992-2003*



*   EMC World Cellular Database (December 2003).

FIGURE 4-2b

Growth in number of mobile subscribers from 1992-2003*



* EMC World Cellular Database (December 2003).

Deplo-IMT-04-2b

Developing countries have begun to increase their share of total cellular subscribers. At the end of 1996, Africa, the Americas (excluding the United States of America and Canada), Eastern Europe and the Middle East only represented a combined market share of 8%. By the end of 2002 this had jumped to 21%[26]. More developed markets are reaching their saturation point, which implies that future growth will be driven by the developing world. By the end of 2010, the developing world accounts for approximately 73% of global subscriptions (up 38% compared with five years earlier)[4].

Wireless data is potentially a vast new market. IMT-2000 makes possible a wide variety of new services such as location-based services, multimedia, m-commerce, and messaging, many of which were not available with pre-IMT-2000 systems. Wireless Internet devices are rapidly becoming one of the most important and personal items people carry with them, and are increasingly combining the numerous functions of today's mobile phones, personal computers, TV, newspapers, cameras, library, personal diary and scheduler, wallet, and credit cards. Wireless Internet has the power to offer complete personalization of end user applications and services.

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These services will be personalized by users to reflect their own lifestyles and the choices that they make. Many different kinds of services are necessary to suit the needs of the various market segments: from business users, to the diversity of consumer users (youth, users on the move, users on the road...) and also including the many vertical market applications that may need special adaptation.

It is difficult to identify with certainty wireless Internet's top services. Voice services are expected to remain a major revenue source for the operator. Even ten years from now, voice is expected to continue to dominate operator's ARPU, but this proportion will probably decline steadily as IMT-2000 systems enable the creation of an ever-wider range of data services. Revenues will increase steadily for the first few years of IMT-2000 deployment, accelerating more sharply some 4-5 years after first network launches.

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[26] EMC World Cellular Database (September 2003).

One of the earliest indicators of the growth potential for non-voice services is the explosive popularity of SMS, or text messaging, with over 1 billion SMS being sent daily. Other services, meanwhile, are steadily generating an increase in non-voice revenues for operators. Building on the enormous success of SMS, mobile MMS has so far attracted well over 1 million subscribers in Europe alone, allowing them to create, send, store and share their own pictorial content. Already offered by more than 115 operators[27] – chiefly in Europe and Asia – MMS provides the market with an early glimpse of the service opportunities offered by higher speed data services. Location-based services could also become an important feature for the operator.

In the early days of wireless Internet, a significant share of revenue is expected to come from business users with Intranet/extranet access. Access to personalized, selected content will provide additional operator revenue as soon as the user market begins to take off. Applications and services will drive the new revenue models that seek to leverage the increased technical capabilities and bandwidth that IMT-2000 systems deliver, therefore IMT-2000 can play an important role in bridging the "digital divide" between regions and cultures. In addition, new services and applications created by IMT-2000 can be expected to exhibit distinct regional trends in terms of user take-up. An example of this is Asia Pacific, where the UMTS Forum predicts that annual IMT-2000 revenues will reach USD 118 billion by 2010, with "customized infotainment" – personalized access to news, sports results, gaming and other forms of information and entertainment – representing 36% of all Asian IMT-2000 revenues, ahead of simple voice (28%), mobile access to the Internet and corporate networks (14%) and MMS (13%)[28].

4.2 Costs and benefits of evolution/migration

The total costs of evolution/migration are the sum of a number of separate costs:

- Licensing costs (these include up-front and on-going licence fees to the national regulator, and possible up-front and on-going royalty fees to equipment vendors).
- Marketing, advertising and promotion costs.
- Acquisition and retention of subscribers.
- Network infrastructure costs.
- Real estate costs.
- Operational costs, including salaries, training, network management and maintenance.
- Content and application development costs.

The total benefits of evolution/migration are the sum of a number of separate benefits.

- Increased subscriber numbers.
- Increase in traffic per subscriber.
- Increase in market share.
- Increase in ARPU.
- Reduced operational costs.
- Reduced churn.

4.2.1 Costs of network evolution/migration

Comparing the costs of different network evolution/migration strategies is incredibly difficult, especially as the costs and benefits associated with the evolution/migration in new spectrum as opposed to evolution/migration in the same spectrum band, are different. For example:

- The different IMT-2000 architectures employ different functional modules.
- The dimensioning rules will be different.

[27] Global Mobile, EMC, GSMA, http://www.gsmworld.com

[28] UMTS Forum Report No. 17.

– The dimensioning assumptions and options will be different, even for the same nominal network specifications.

– The cost models for each will be different.

It is therefore even more difficult to develop a generic cost model.

4.2.1.1 Costs of the network evolution/migration for the operator

New technologies must be employed in such manner that the operators could keep their core technologies and investments in place, while enhancing their systems for the third generation.

The estimates of providing or upgrading pre-IMT-2000 networks to IMT-2000 (including licence, network infrastructure, application and content development) vary widely.

Regulatory frameworks can have an important effect on the cost of migrating pre-IMT-2000 system to IMT-2000. For instance, a regulatory framework that allows an operator to migrate from pre-IMT-2000 systems to IMT-2000 in its current spectrum (in-band migration) and without having to pay for a new licence or spectrum can have significant cost savings on the total migration.

4.2.1.1.1 From GSM to IMT-2000 CDMA Direct Spread

The path from GSM to WCDMA is well understood and backed by global standards releases from 3GPP. The basic benefits of WCDMA are:

a) It was designed for effective deployment of IMT-2000 services.

b) It offers both FDD and TDD variants to offer operators the choice of how to deploy technology to make efficient use of the available spectrum in both paired and unpaired bands and for high and lower density areas.

c) WCDMA is already being deployed in many areas of the world. Of the operators that have made technology decisions for IMT-2000 so far, 85% of them have opted for WCDMA. This ensures a global market and brings the associated economies of scale that drive prices of infrastructure and handsets down and investment by vendors in R&D up.

d) WCDMA is designed to be technically backward compatible with 2G and 2.5G GSM-based systems and therefore leverage 2G investments.

e) WCDMA is operated at the same evolved GSM core network. Therefore it preserves valuable core network investments.

f) WCDMA is also backward compatible with services and business systems. It builds on the existing GSM community, which encourages developers and allows for the fast development of common approaches to data services to enable interoperability and roaming.

WCDMA provides additional capacity and QoS mechanisms, and flexibility in managing resources between voice and data services. It is designed to be a complement to IMT-2000 TDMA Single-Carrier.

4.2.1.1.2 From GSM to IMT-2000 CDMA TDD

The path from GSM to TD-SCDMA does have advantages. It is smooth and economical and meets most of the needs for developing countries. The main advantages depicted below support this point of view:

a) TD-SCDMA is a high spectral efficiency system. With the specific radio carrier characteristics of TD-SCDMA, it does not need a pair of frequency bands and could make use of fragmentary frequency bands. As it just needs 1/3 the frequency bands of UTRA TDD (3.84 Mchip/s Option), it can save on the precious spectrum resources of the world. The most important thing for operators is that it makes them save their money on buying frequency bands while achieving the same or much better services of IMT-2000.

b) One of the main objectives of introducing IMT-2000 systems is to satisfy the requirements for extensive capacity. Smart antennas, joint detection, uplink synchronization and dynamic channel allocation technologies are all implemented in TD-SCDMA system to minimize radio interference to achieve high capacity. Thus TD-SCDMA is very suitable for highly dense populated areas.

c) Wireless data is potentially a vast new market for IMT-2000. With support of asymmetric traffic and adaptability to the variety of uplink and downlink traffic rates through adjustment of timeslots, TD-SCDMA is suitable for Internet services.

d) TD-SCDMA provides a smooth evolution/migration path from pre-IMT-2000 to IMT-2000 (see above).

e) TD-SCDMA re-uses the current GSM/GPRS infrastructure that could reduce the evolution/migration cost and protect the existing investment. Operators can efficiently introduce the TD-SCDMA radio access network (RAN) while using the existing GSM/GPRS core network.

f) TD-SCDMA mode can be implemented in all radio deployment scenarios: from rural to dense urban areas, from pico to micro and macro cells. In areas, where high communication capacity is needed, micro cell and pico cell system can be deployed. Small coverage per cell site results in the need of more cells for a geographic area as compared to macro cell, it means that more spectrum is needed.

4.2.1.1.3 From GSM/TDMA to IMT-2000 TDMA Single-Carrier

IMT-2000 TDMA Single-Carrier (EDGE) provides an effective way of increasing capacity and throughput within existing spectrum for both GSM and TDMA operators. From GSM/GPRS, EDGE requires a relatively small investment to reach IMT-2000.

a) It was designed for effective deployment of IMT-2000 services.

b) Nearly all new GSM/GPRS base stations are EDGE-capable.

c) EDGE is a software-only upgrade from GSM/GPRS (there is a possibility that some hardware would be needed for additional processing capabilities if data usage is high but this is unlikely in the early stages of deployment).

d) EDGE is both backward compatible with GSM/GPRS and forward compatible with WCDMA.

The TDMA community, as represented by 3G Americas, has selected a path for TDMA to GSM/GPRS and then to EDGE[29]. The transition path followed so far is justified as follows:

a) GSM has almost twice the capacity of TDMA – and with adaptive multi-rate (AMR) codec software deployed, will quadruple TDMA capacity[30].

b) Single antenna interference cancellation, in development, will provide an additional 60-100% increase in voice capacity.

c) EDGE software more than triples the data speeds of GPRS using the same spectrum and radio frequency.

4.2.1.1.4 From cdmaOne to IMT-2000 CDMA Multi-Carrier

Transition from cdmaOne to CDMA2000 is eased by the fact that the latter is a direct evolution from the cdmaOne (IS-95) standard. The advantages can be summarized as follows:

a) CDMA2000 offers a doubling of voice capacity along with the introduction of packet data through 1X and delivering high-speed packet data through 1xEV-DO.

b) Since the CDMA2000 standard is so closely derived from the cdmaOne standard, many of the IS-95 components and equipment designs (both infrastructure and terminals) can be reutilized in CDMA2000. This evolution process has given CDMA2000 operators the benefit of product maturity leading to short time to market and economies of scale for the 1X and 1xEV-DO operators.

c) The cdmaOne operator implementing CDMA2000 has a cost effective upgrade path and is able to leverage much of the existing equipment already deployed in the IS-95 network. In order to upgrade an IS-95 base station (BTS) to 1X capability a channel card upgrade is deployed. Operators can either

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[29] Per 3G Americas.

[30] Rysavy Research [July, 2002] Voice Capacity Enhancements for GSM Evolution to UMTS. Available at: www.3gamericas.org/english/technology_Center/whitepapers

replace existing IS-95 channel cards with 1X channel cards or add a new RF carrier with 1X channel elements. Since voice services are both forward and backward compatible between IS-95 and 1X the process can be seamless.

d) Additionally, when the operator is ready to deploy high-speed data services with 1xEV-DO again a channel card upgrade at the existing base station can be utilized. This upgrade path is possible because 1X and 1xEV-DO utilize many of the same radio components and designs as the IS-95 system.

e) At the BSC level, the upgrades required are typically software related to add either 1X or 1xEV-DO to an IS-95 network. A packet data service node (PDSN) must be added for packet data functionality with the introduction of CDMA2000 into the network.

4.2.1.2 Degree of infrastructure sharing

Infrastructure sharing reduces the cost of network deployment. It is particularly important for countries with widely dispersed low-density populations and for newly emerging mobile markets.

Items that can be shared include antenna masts and towers, base site and other buildings, and radio access and transmission infrastructures.

An open question is whether the regulator should preclude infrastructure sharing, permit infrastructure sharing at the discretion of the operators, or play a pro-active role to encourage infrastructure sharing.

End user cost will be affected by the degree of infrastructure sharing permitted by the regulator and implemented by the operator. In countries or other areas where multiple IMT-2000 technologies are geographically co-located there may be reduced capability for infrastructure sharing.

4.2.2 Cost affordability for end users

In addition to the transition cost, there are other economic issues to consider.

– Regulatory issues (interconnection rate, luxury tax, etc.)

– Handset issues (availability, costs, potential need for subsidies, multi-band and/or multi-mode handsets, economies of scale).

– Competition of infrastructure vendors.

4.2.2.1 Handsets: availability, affordability, and variety

Today, IMT-2000 handsets are commercially available for both CDMA2000 and WCDMA operators.

The cost of handsets is a critical factor for any wireless operator’s success in the market. In addition to offering high-speed, full-feature, multi-media phones, which will be more expensive initially, it will be necessary for IMT-2000 operators to sell low-cost terminals that support voice, SMS and circuit-data. The key driver of handset availability, affordability and variety – particularly at the low end of the market – is market size and the associated economies of scale. In order to keep the costs of IMT-2000 handsets as low as possible, CDMA2000 handset manufacturers can leverage the common manufacturing design and common components of cdmaOne handsets, making CDMA2000 handsets only marginally more expensive than cdmaOne handsets. In addition, the implementation of zero intermediate frequency (ZIF), or direct conversion technology, will bring further cost savings in the production of IMT-2000 terminals. ZIF technology eliminates the need for an intermediate frequency and can reduce the cost of wireless devices by reducing the handset bill of materials, while also reducing the circuit board space needed by up to 50%.

Available today are a number of CDMA2000 handset chipsets designed to meet the needs of a wide range of users.

As of March 2004, there were 520 CDMA2000 devices available from 48 manufacturers, including 58 CDMA2000 1xEV-DO devices, and new devices are continuously being introduced. The economies of scale and the opportunity to leverage common design and components between generations of CDMA products have led to the continuing decrease of CDMA2000 handset prices. In addition, many existing cdmaOne and CDMA2000 handsets are dual-mode devices that also support analogue networks, an important concern for current cdmaOne and TDMA operators who still have significant analogue coverage.

As a direct migration from GSM/GPRS, WCDMA terminals are and will increasingly be developed by the same broad range of terminal manufacturers that service the GSM market that as of January 2004 offers some 700 different devices[31]. Dual-mode terminals (GSM/GPRS and WCDMA) are entering the marketplace, providing backward/forward compatibility. With the exception of the radios (and some chipset developers are even working to combine the radios into a single chip), many functions common to both can be shared in the handset chipsets to reduce space, power and processing requirements and ultimately cost. As of January 2003, several manufacturers collectively offered a total of 25 GSM 850/1900 terminals for use in the Americas[32] 12 EDGE devices are either available or will be available by Q2 2004, and most new GPRS devices will EDGE-enabled. Dual-mode EDGE/WCDMA terminals are expected in 2004[33].

4.2.2.2 Service affordability

In addition to affordable handsets, service packages must also be within the price range of end-users, including the important pre-paid market that exists in many developing countries. Administrations' decisions on critical regulatory issues such as interconnection rates, tariffs and service flexibility play a determinant role in the ultimate rates charged to users. With the advent of always-on packet-data, wireless operators may have a more flexible option of charging flat rates for data services. Other options could be to charge for services based on volume, the number of times used (for data applications), or the traditional method measured by total time used.

4.2.3 Other considerations

4.2.3.1 Roaming

Thanks to the popularity of international travel for business and pleasure alike, roaming between mobile networks is an intrinsic part of today's customer experience. International roaming is becoming significantly easier with the introduction of phones that support multiple frequency bands and modes. The increasing prevalence of multi-band/multi-mode phones is important for two reasons. First, with expanded options, operators will be able to offer their customers nationwide, region wide or even worldwide coverage. Second, as multi-band/multi-mode phones become more common, operators will be able to attract additional roaming revenue since more users can roam onto their networks.

It is likely that tomorrow's IMT-2000 customer will not be aware of the radio or the network technology they are using in the "home" or "visiting" network. They will simply utilize their personal terminal device to access a portfolio of services and applications that are available to them at that instant via their user profile. This profile is governed by subscriber/user identity modules (SIM/UIM) in every digital mobile phone today.

Interoperability – the ability for services and applications to work seamlessly between networks and terminals – is likely to be a key issue in governing the uptake of IMT-2000 globally, and considerable industry resource is being invested in this area. The first fruits of this concerted effort include MMS interoperability.

It should be noted, however, that roaming requires more than merely multi-band/multi-mode handsets, which can operate in different environments. Essential prerequisites for roaming include, for instance:

– interoperable network-network interfaces between the "home" network and the "visiting" network to which the user is roaming to;
– handsets with appropriate radio and network protocol stacks so that the handset can communicate with the "visiting" network;
– an understanding of the contents of the subscriber/user identity modules (SIM/UIM) in the different network environments so that the user can be correctly identified;
– commercial roaming and its associated service level agreements between different operators to permit the usage of respective networks by their subscribers.

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[31] GSM Association.

[32] Manufacturer's websites.

[33] Global Mobile Suppliers Association (December 2003).

4.2.3.1.1 GSM/EDGE/WCDMA roaming

WCDMA, EDGE, GPRS, GSM roaming capabilities are the result of careful development of the corresponding standards with the overall objective to assure a maximum of interoperability. For this purpose, these radio interfaces have been standardized to support handover between these radio technologies. Moreover these WCDMA, EDGE, GPRS and GSM access networks are connected to a common UMTS core network providing the possibility of seamless service usage.

Roaming has been one of the key drivers for the global success of GSM: out of a total market base approaching one billion, it is estimated that some 100 million of these are active "roamers"[34]. Mobile operators benefit from increasing growth in international roaming revenues, amounting in some instances to as much as 15% of their ARPUs (average revenue per user).

While GSM has set the norm for automatic roaming, currently for voice, SMS and MMS, it is expected that this experience will be extended to include roaming and service portability for a growing range of advanced new voice and data services. Furthermore, with increasing commitment from the industry to offer interoperability between networks, terminals and services, the user experience continues to become richer and more appealing for all its customers.

Because of its widespread deployment, GSM offers the most extensive roaming capabilities in the world. For GSM operators, and TDMA operators considering transition options, the revenue implications are considerable and an important component of the (post-transition) business case, i.e.[30]:

– At least 20 000 international roaming agreements are currently in place.
– GSM/GPRS provides roaming to over 100 countries.
– Roaming generated USD 12 billion in revenue in 1999.
– Roamers use 2 billion minutes each month.
– Roaming revenue can generate between 15% and 30% of an operator's annual revenue.

Intra-country roaming alone is a significant opportunity. In Latin America, for example, intra-country roaming revenue grew from USD 133 million in 1998 to USD 205 million in 2001. In-country roaming revenue is expected to grow to USD 391 million by 2007[35].

Roaming from GSM/GPRS/EDGE to WCDMA and vice-versa is achieved by dual mode handsets, which may also need to operate in multiple frequency bands.

4.2.3.1.2 cdmaOne/IMT-2000 CDMA Multi-Carrier roaming

Regional and international roaming is supported on pre-IMT-2000 and IMT-2000 CDMA networks, with CDMA subscribers roaming in Asia, the Americas, Australia/New Zealand and the Russian Federation[36].

Subscribers on cdmaOne (pre-IMT-2000) networks and CDMA2000 (IMT-2000) networks can roam on either network using their pre-IMT-2000 or IMT-2000 mobile phones. Since CDMA2000 1X systems are backward compatible to cdmaOne systems, voice roaming between pre-IMT-2000 and IMT-2000 CDMA networks is transparent from the user's perspective. For data roaming, an IMT-2000 subscriber will not be able to get advanced IMT-2000 data services when roaming on a pre-IMT-2000 system but will be able to receive services available on the pre-IMT-2000 system (usually a subset of the IMT-2000 services). This is similar to the experience a WCDMA or UMTS subscriber will have when roaming on a pre-IMT-2000 GSM/GPRS network.

A pre-IMT-2000 CDMA operator evolving to an IMT-2000 CDMA2000 system can do so without any impact on incoming and outgoing roamers, i.e., incoming and outgoing pre-IMT-2000 CDMA roamers can continue to roam as before but they do not acquire additional IMT-2000 service capabilities.

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[34] GSM roaming information is available at the GSM Association's website at: www.gsmworld.com

[35] Pyramid Research.

[36] CDMA roaming information is available at the CDMA Development Group's (CDG) website at: http://www.cdg.org

It is expected that the users of the two dominant IMT-2000 networks will also be able to roam using multi-mode, multi-band handsets that support CDMA2000, cdmaOne, GSM/GPRS, WCDMA and TD-SCDMA. Roaming agreements between CDMA and WCDMA operators, supported by the necessary subscription, open standard inter-core network interoperability and mobility management, open standard multi-mode multi-band handsets and unique mobile station identifier, would allow their subscribers to roam between the two dominant systems and their respective precursors using a single subscription and a single handset.

4.2.3.1.3 TDMA/AMPS to IMT-2000 CDMA MC/AMPS roaming

TDMA operators that have ANSI-41 based networks migrating to an IMT-2000 CDMA ANSI-41 based network may offer their subscribers roaming using the analogue air interface. This scenario is specifically relevant to operators who may have several TDMA properties in different countries migrating to IMT-2000 but on different schedules. During the transition period, when an operator would have both CDMA and TDMA systems operational, its TDMA and CDMA subscribers could roam from one network to the other using the analogue mode available on their dual-mode (TDMA/AMPS, CDMA/AMPS) handsets.

4.2.3.1.4 Network requirements for inter-system roaming

IMT-2000 radio interfaces rely on either of two existing core network types – ANSI-41 and GSM-Map (see § 4.2.3.1.3).

Inter-system roaming requires the standardization of network-to-network interface to allow the exchange of information such as subscriber profile, authentication keys, etc. As of January 2004, such interface is not standardized by ITU-T, hence there is no provision for inter-system roaming between the two core network types.

It is desirable to avoid the need for separate subscriptions for IS-41 networks (CDMA2000) and MAP networks (WCDMA, EDGE, TDD). Additionally, roaming agreements between IS-41 operators (CDMA2000) and MAP operators (WCDMA, EDGE, TDD) have to exist.

4.2.3.2 Terminal developments

Mirroring developments on the radio access, core network and services evolution side, mobile terminal devices are themselves evolving to become more diverse, powerful, flexible and feature-rich.

This evolution can already be seen with the proliferation of colour screens and in-built digital cameras with email, browser and PDA-type functions as well as increasingly customizable user features on current phones. IMT-2000 phones are now capable of performing functions that have traditionally been limited to PCs and laptops. Powerful operating systems and execution environments are being incorporated into IMT-2000 devices to handle a wide variety of user entertainment and enterprise applications. They are also evolving to provide the end-users a more enjoyable experience through enhanced user interfaces, personalization and roaming capabilities. While previous generations of mobile phones have been essentially “hard wired” to perform a finite set of functions, network operators are now offering downloadable software applications – such as games or information services.

Similar to the introduction of multi-band phones that allowed users to roam between 800 MHz and 1 900 MHz AMPS/CDMA networks and other users to roam between 900 MHz, 1 800 MHz and 1 900 MHz GSM networks; phones are increasingly becoming multimode and multi-band devices capable of operating on different networks.

Today and in the near future, multi-mode and multi-band IMT-2000 phones will be available commercially to enable global usage in some or all of the 800 MHz, 900 MHz, 1 800 MHz, 1 900 MHz and 2 100 MHz bands:

- GSM/GPRS/EDGE/WCDMA
- GSM/GPRS/EDGE/WCDMA/HSDPA

– GSM/GPRS/CDMA2000 1X[37]
– GSM/GPRS/CDMA2000 1X and 1xEV-DO
– WCDMA/CDMA2000 1X
– GSM/ANSI-136[38]/GPRS/EDGE.

As mentioned above, the existence of multi-mode, multi-band terminals facilitates but is not sufficient to ensure roaming between operator's networks.

4.3 Business plan and analysis

A key step in the process of finalizing a transition path toward IMT-2000 network deployment is evaluating the network economics. Specifically, operators should consider choosing the migration path that yields the most economic value, including revenues, spectrum licence acquisition costs[39, 40], where appropriate, capital expenditures (CAPEX), and operating expenditures (OPEX) over the economic life of the system. Economic evaluation may have to be based on assumptions about the evolution of demand and service penetration as well as tariff trends and policies.

To implement a financial model where all of the described aspects are properly taken into account, specially designed tools are normally used. This implies a sequence of steps to go through to associate values to the input parameters and to acquire the network engineering rules. Running the model generates the technical and financial outputs driven by geographical data and service demand. The implementation of a financial model is normally conceived so that further information on specific aspects may be obtained by increasing the level of detail in the description of the network infrastructure and/or network components.

4.3.1 The business plan process

A key metric in the evaluation is the net present value (NPV) understood as the net present value of the network, i.e. cumulative discounted cash flow generated to date. On a less formal level, this metric is indicative of the profitability of a business, as appreciated at Year 0, over a span of *N* years – *N* ranging from 1 to the economic life of the system.

4.3.1.1 Business plan outline

The economic evaluation comprises the following logical phases:

a) the year traffic demand[41] over the considered period is estimated. This, in turn, involves several steps, a) to e)
   - estimation of the potential user population
   - estimation of the service penetration considering dimensions such as: service class (i.e. bit rate of circuit switched and packet switched services), operation environment (i.e. dense urban, urban, suburban, rural), user age class, etc.
   - estimation of the activity factor per service type and class;
   - estimation of OPEX (operational expenses including network and non-network related, handset subsidies, marketing and sales, etc.)

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37 Devices with CDMA2000 will support assisted-global positioning (A-GPS) services using the 1 500 MHz band.

38 GAIT devices.

39 The UMTS Third Generation Market – Structuring the Service Revenues opportunities. UMTS Forum Report No. 9, http://www.umts-forum.org

40 The impact of licence cost levels on the UMTS business case. UMTS Forum Report No. 3. Available at: http://www.umts-forum.org

41 As for capacity planning, the traffic demand results from the superposition of the demands related to the individual services. These may have different trends and, in general, different start-up times. In the following, unless stated otherwise, "demand" will indicate the superposition of the demands for the individual services.

b) the radio access network is planned on a year basis considering the increase in the traffic demand, point a) above, and the resulting need for incremental additions of network infrastructure (base stations and mobile switching centres) to meet capacity requirements. This stage considers that different operation environments are differently covered from a service point of view, both in time and as target coverage, with dense urban environments receiving priority;

c) the core network is also planned on a year basis considering the impact of traffic demand under points a) and b) above. As part of this planning, re-engineering of network components such as serving GPRS support node/gateway GPRS support node (SGSN/GGSN) or packet controller function/packet data serving node (PCF/PDSN) is also accounted for. This includes both HW and SW upgrading, i.e. processing power increase as well as architecture and functional enhancements due to implementation of successive IMT-2000 releases. This stage considers that packet switching equipment will, as a tendency, substitute circuit switching equipment;

d) a revenue structure for each service is assumed. This structure considers both the charges on the end-user and the balance between costs and revenues associated with possible agreements with third parties involved in the service support (e.g. content providers, brokers, etc). The service revenue is then subjected to a "price erosion" along the economic life of the system. This erosion depends mainly on the general trend of telecommunication service tariffs, and the operator's policy for attracting and/or preserving the customer base and face competition;

e) the NPV computation is carried out and, based on the analysis of the results, refinements of the IMT-2000 deployment strategy may be considered.

The phases comprising the business plan are summarized in Fig. 4-3. Due to the many parameters on which the business plan may depend, a sensitivity analysis on the impact of critical parameters (such as demand estimation uncertainty ranges, slope in the service price erosion, etc), normally complements the business plan exercise[42].

4.3.1.2 Service penetration and demand scenarios

The service demand and traffic scenarios are input to the dimensioning and planning process, and ultimately to the economic considerations of the business plan. The service and traffic scenarios are derived through a combination of data regarding, among others, demography, social aspects, service coverage areas, prospected acceptance of service offerings, traffic source activity and bit rate of offered services.

Processing the data, quite naturally, starts with identifying the service area and the overall population insisting on it (see Fig. 4-3). From the overall population, the potential customer population is identified as the one confined within specified age limits. Further, assuming a stated percentage for the population service coverage, the final customer base population is derived. From this, by assuming stated percentages of the service area for dense urban, urban, suburban and rural operation environment, and also assuming that the share of business and consumer customers are specific to each operation environment, the user population can be classified according to the joint criteria of operation environment and subscription type. Finally, assuming that the service penetration for circuit and packet switched services are also specific to the operation environment and subscription type, it is possible to derive the actual user population subscribed to IMT-2000 services. This population is now assumed evenly distributed over the service area for the purposes of estimating the offered traffic and, hence, carrying out the radio access network planning. To this end, an activity factor specific to each service class is introduced and the overall traffic offered estimated (see Fig. 4-3).

To obtain the evolution of the radio access network planning, the above exercise is repeated for each year along the economic life of the system, as indicated in Fig. 4-3. This involves updating of the overall population and adjusting all other input data having a dependence on time, such as the service penetration. Normally, the number and location of base stations and mobile switching centres for year $N+1$ correspond to those for year

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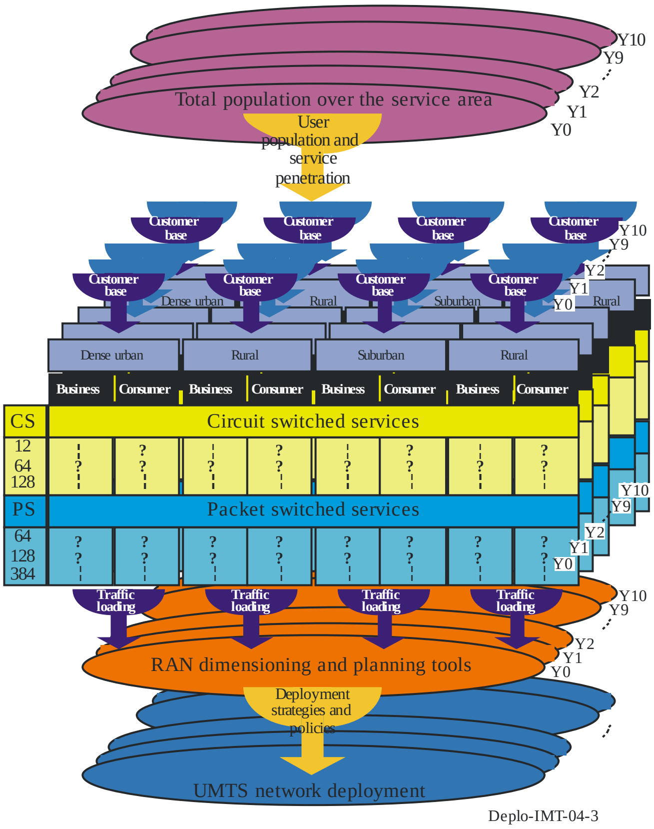
[42] In addition to accounting for uncertainty margins, the business plan may be made more sophisticated by including additional aspects having a bearing on costs and revenues, such as promotional actions and tariffs, co-location of 2G/3G radio infrastructure, risk and benefit sharing following agreements with service/content providers and/or brokers, and so on.

N plus the ones due to the increase in the customer base from year *N* to year *N* + 1. In other words, no rearrangement of the radio network infrastructure in place at any time is normally considered.

FIGURE 4-3

Radio access network planning and IMT-2000 deployment over the economic life of the system



4.3.1.3 Sensitivity analysis

As anticipated, several parameters having a bearing on the economic aspects of IMT-2000 deployment – and hence NPV – are either inherently affected by estimation inaccuracy or may vary depending on operator choices which, in turn, may vary in time in response to changing market and business conditions. Typical parameters considered in sensitivity analysis include:

– traffic demand;

– service penetration;

– tariff erosion;

– service offering.

4.3.2 The business plan exercise

4.3.2.1 Introduction

Many operators are challenged by debt burdens resulting from sometimes huge IMT-2000 licence fees and large initial investments in infrastructure, existing and new operators find themselves largely dependent on the materialization of their business plans in order to create shareholder value and drive strategic go-/no-go-decisions (new entrants are additionally burdened by significant initial fixed costs of market entry).

Considering the realities of increasingly saturated mobile subscriber markets and of declining voice ARPUs, the IMT-2000 vision shifts the focus from subscriber-driven growth to ARPU-driven growth. IMT-2000 business plans routinely factor in a large revenue portion originating from data applications: "IMT-2000 is fundamentally about applications". In order to make these projections come true, the take-up of the new services and the amount of usage of the single services must be actively driven by the operators. With this paradigm shift, introducing solid methodologies of subscriber churn simulation and revenue forecasting into the art of business planning, become crucial success factors.

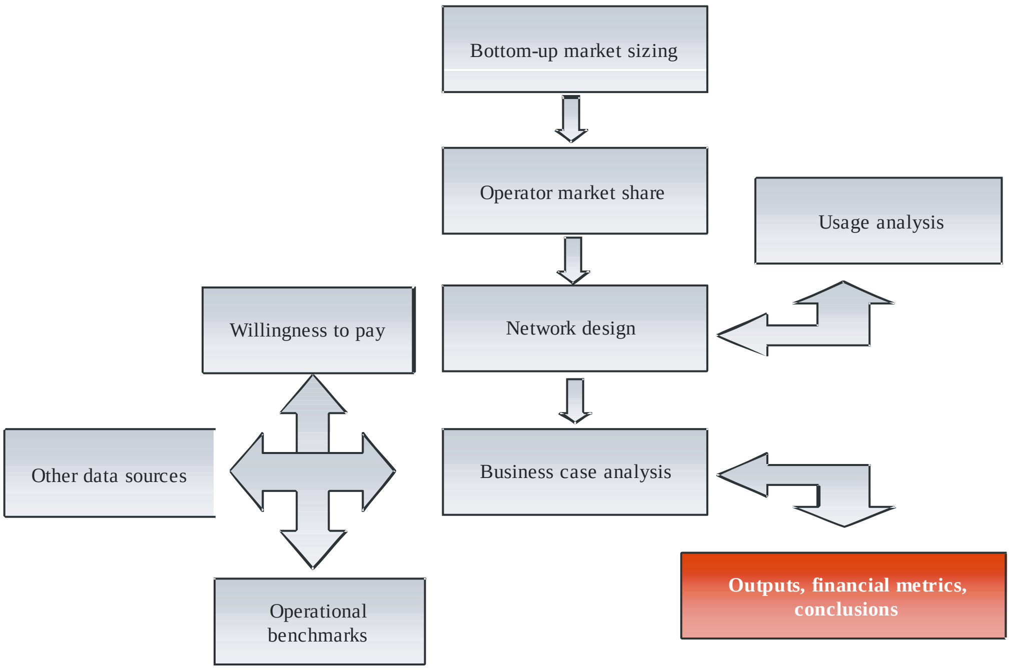
This section highlights a structured approach towards IMT-2000 business plan development and real-life findings of an IMT-2000 business case, which is based on the representative, "real-life" example of a pre-IMT-2000 incumbent.

4.3.2.2 A modular approach to business planning

A possible business plan model is shown in Fig. 4-4.

FIGURE 4-4

Structure of the business plan model



Deplo-IMT-04-4

The subscriber projections stand at the beginning and in the centre of the business plan development process. Here, a forecast for the total mobile market in terms of penetration or subscribers is generated, then split into technologies (pre-IMT-2000, IMT-2000) and broken down to market share and subscriber projections for the individual operators. Finally, customer segmentation is introduced.

The revenue module uses different ways to forecast ARPU levels and ARPU trends. Budgetary and affordability approaches are top-down approaches usually used as "sanity checks": The budgetary approach is deployed for saturated or "quasi-saturated" markets (i.e. it is not economically attractive to the operators to increase penetration at the expense of price any further); the affordability or market ceiling approach applies to developing markets and does a reconciliation of penetration increase and ARPU decline (feasible penetration and ARPU level relative to GDP per capita are obviously correlated). The bottom-up approach goes the other way and consists of a per-segment and per-application model simulating pricing, take-up rates and usage of the services. Therefore it can be used to study the demand-driven dynamics of ARPU development and draw conclusions regarding the going-to-market strategy, e.g. optimal application calendars and application lifecycles.

The OPEX module uses a combination of multiples (driven by revenues, by subscriber numbers, by network topology, etc.), "brownfield" operator benchmarks (for the long-term margins after a "stable-state" is reached) and estimates for the initial "one-time" OPEX to generate an OPEX structure and development over the planning period.

CAPEX are usually determined using network component numbers resulting from an indicative or refined network planning along with pricing information to generate an investment plan. CAPEX are coverage-driven (usually in the first years) and capacity-driven (usually long-term). Outputs influence the cash flow (annual investments) and the profit and loss accounting (depreciation).

Accounting marks the final step in the business planning process: Here P&L and cash flow statements are generated as standard deliverables of a bankable business plan, and investor-side performance metrics – e.g. internal rate of return (IRR) and net present value (NPV) – as well as creditor-side metrics – e.g. debt service cover ratio (DSCR) and financial covenants – can be calculated.

4.3.2.3 Assumptions for a "real-life" business case

As anticipated, the business case is based on a hypothetical pre-IMT-2000 operator with an IMT-2000 licence and exercising its IMT-2000 business case in order to optimize investments and maximize returns and shareholder value. The market and competitive environment are as follows:

The country has 24 million inhabitants and an annual GDP per capita of USD 3 600, which is forecasted to grow by nearly 4% yearly during the next decade. After some consolidation has taken place, there will be three active mobile operators employing pre-IMT-2000 technology: "Champion", "Public", and "Mini". Champion and Public have recently been awarded additional IMT-2000 licences, virtually free of charge (beauty contest), so that no significant CAPEX impact will originate from the licence. Mini has been reluctant to engage in IMT-2000, and long-term perspectives for it are not yet clear. We are going to look at a planning period from 2002 to 2015. This example is a "worst case" business scenario where the operator has had to acquire new IMT-2000 spectrum – many operators worldwide will already have sufficient spectrum available and not have to acquire new spectrum.

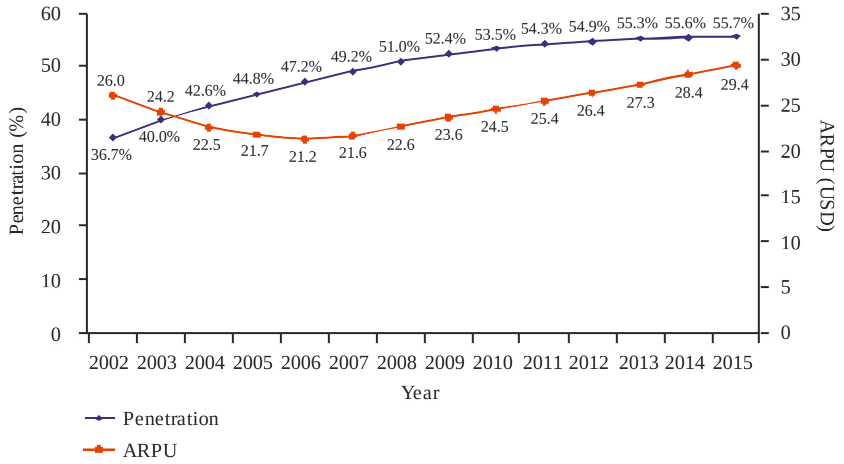
4.3.2.4 Subscriber model

4.3.2.4.1 Total mobile market

The forecast for the development of the total mobile penetration is shown in Fig. 4-5.

FIGURE 4-5

Penetration forecast and "sanity" check



Deplo-IMT-04-5

A "sanity check" employing an affordability-driven market ceiling model was done in order to reconcile the penetration assumptions with a top-down ARPU development estimate. This means that later, when the ARPU is modelled bottom-up, results may be produced up to that level without inhibiting the penetration projections. It is evident that in the current phase of a still strong market growth (from 36.7% in YE 2002 to 47.2% in 2006) ARPUs are set to fall, while later, when penetration approaches a level of 56% (considered a long-term "quasi-saturation" for this market). ARPUs may rise again following budgetary considerations, since for this country an annual GDP per capita growth of nearly 4% is assumed. Considering that voice prices are likely to decline and voice usage to remain flat, the gap in ARPU could be filled with revenues from data applications in the 2.5G, but especially in the IMT-2000 context.

4.3.2.4.2 Technology transition

Next, assumptions on the future technology split must be taken. For this business case, two distinct technology segments, pre-IMT-2000 and IMT-2000 are considered.

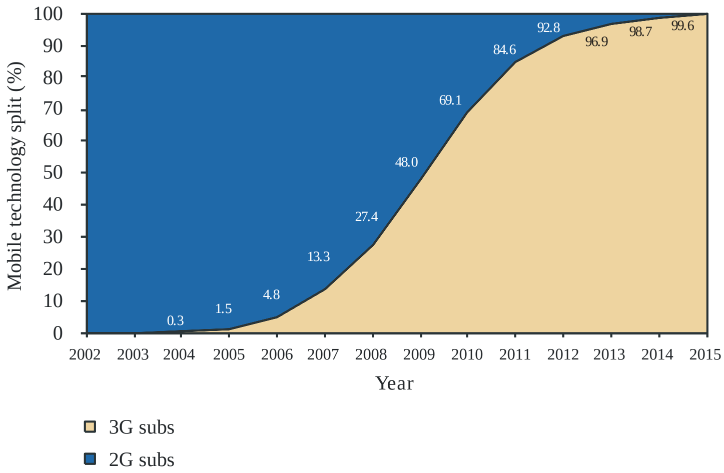
Note that an IMT-2000 subscriber is defined as a subscriber who has an IMT-2000 capable handset and uses a contract or prepaid package which allows him to use IMT-2000 services (the individual take-up and usage are assessed later in the revenue section). As is the case in a multitude of innovation adoption cycles observed in real-life, an S-curve type transition from pre-IMT-2000 to IMT-2000 seems fit for the purpose of describing the technology split. Pre-IMT-2000 and SMS adoption curves of the past provide a good benchmark for this qualitative behaviour, with timing and slope of the S-curve remaining to be determined. To this end, separate assessment is performed of the acceptance of IMT-2000 in the "fresh market" (first time mobile users) and within the current pre-IMT-2000 subscribers, i.e. the "technology churners".

As with the launch of any new technology, the initial IMT-2000 handsets will be priced at a premium and operators will have to decide whether to price the new data services as prestigious new offerings or low-cost services to attract new subscribers. In this exercise, it is assumed that high-end pre-IMT-2000 customers will be the first to become IMT-2000 subs, while the remaining lower-end and highly price-sensitive "fresh market" not yet using any mobile services will purchase basic services for a low price. On the other hand, a certain number of pre-IMT-2000 subscribers are also likely to be "inactive users" who are not really aware of innovations and rarely reassess their choice of product/service.

The technology assumptions also have an impact on the differentiation of pre-IMT-2000 and IMT-2000 ARPU, which will be modelled later. Adding the different factors, the technology transition curve is as shown in Fig. 4-6a. Combining penetration and technology split, the projections for the subscribers per technology are as shown in Fig. 4-6b.

FIGURE 4-6a

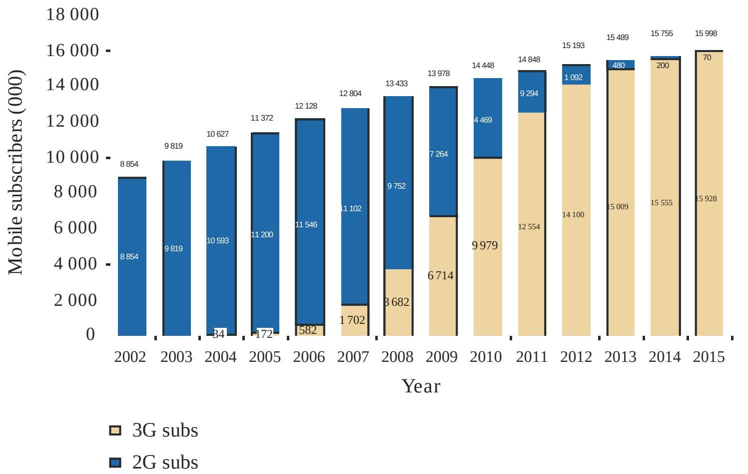
Technology split



Deplo-IMT-04-6a

FIGURE 4-6b

Subscriber base growth



Deplo-IMT-04-6b

4.3.2.4.3 Market shares

Often-used methods of the business planning and analyst community to project market shares are "share of net adds" and "share of gross adds": The first method distributes the net additions according to certain percentages of the market between the operators; however, when the existing base is not negligible (as in every somehow developed market), this method is inaccurate, since it ignores churn.

The second method distributes the gross additions between the operators, i.e. the yearly churn is added to the net additions defining a pool of subscribers which can be attracted by either operator; this is obviously better than the first method, but becomes inadequate when a large and some smaller operators coexist in a market, because the large operator will lose more churners in absolute numbers, given its large base, and these churners are subtracted from its addressable market, so that its share of churners will then be much smaller than its share of "fresh market". Furthermore, most analysts do not model different technologies as distinct sub-markets, so that the effect of some operators being active only in one technology, or having different launch schedules for the new technology cannot be distinguished.

These problems can be solved by modelling two distinct sub-markets, pre-IMT-2000 and IMT-2000, which are linked through the technology migration, and by defining different “churn pots” (i.e. addressable churners) for each operator. Technological churn (between the two sub-markets) is considered separate from competitive churn (within each sub-market). Key drivers are the “market attractiveness” of each operator, determined through a scoring model, the churn rates, and the “retention rates” of technology migrators, i.e. the percentage of those who stay with the same operator, provided that it also offers the new technology.

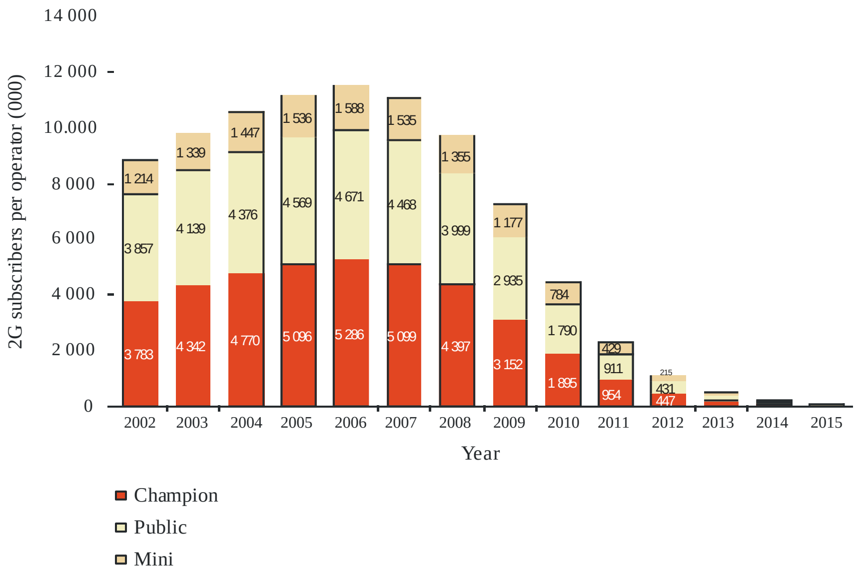
The outcome of the market share and subscriber simulation is shown in Figs 4-7a to 4-7d, for the pre-IMT-2000, IMT-2000 and total market respectively. The pre-IMT-2000 market should be shrinking after 2006. Champion is expected to perform strongly. However, only Mini may be able to achieve a significant change in market share, given its small existing base; the two incumbents are likely to stabilize their market shares at ~40%. With a decreasing pre-IMT-2000 market, this will give Mini only a modest benefit regarding subscribers in absolute terms, however. With IMT-2000 taking place, the incumbent’s attention and competition will likely be shifted towards the IMT-2000 context in the later years. Mini is no player in that market, which would – if IMT-2000 migration will be complete – lead to Mini’s extinction.

Other options might include Mini introducing an Mobile Virtual Network Operator (MVNO) model with either Champion or Public as network partner. By counting the subscribers towards the “real” network operators, the “disappearance” of Mini as an IMT-2000 network operator will in any case open up the market for a split between Champion and Public, where a (small) advantage for Champion has been forecast.

Figure 4-7e shows the structure of the gross additions to the IMT-2000 sub-market and gives some interesting information for a recommendable going-to-market strategy: Net additions to IMT-2000 come solely from retained and non-retained technology migrators from pre-IMT-2000, and from “fresh market” starting directly with IMT-2000. The latter is nearly negligible, and the incumbents will clearly focus on first retaining their technology migrators, second acquire technology churners from Mini, and third compete between themselves.

FIGURE 4-7a

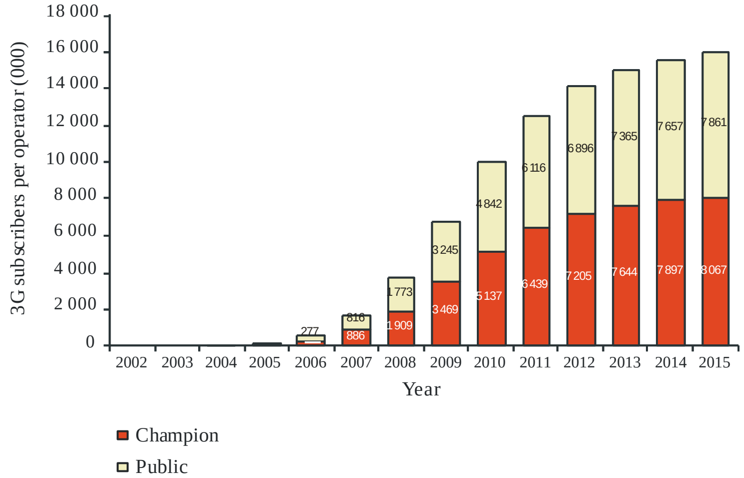
2G subscribers per operator



Deplo-IMT-04-7a

FIGURE 4-7b

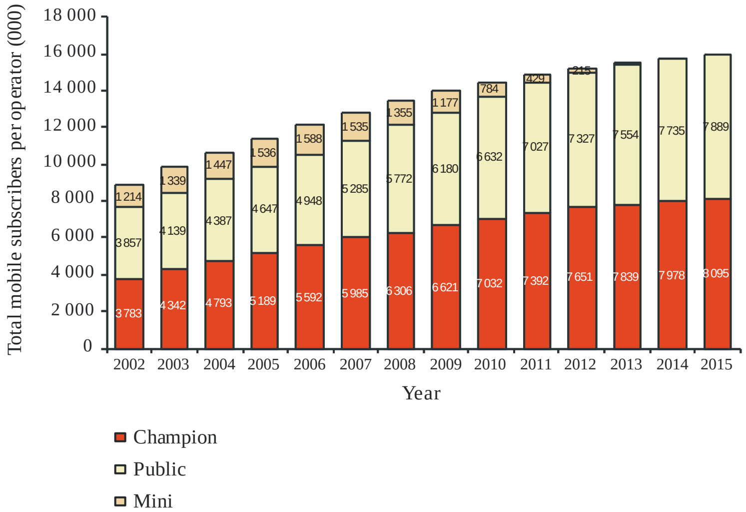
IMT-2000 subscribers per operator



Deplo-IMT-04-7b

FIGURE 4-7c

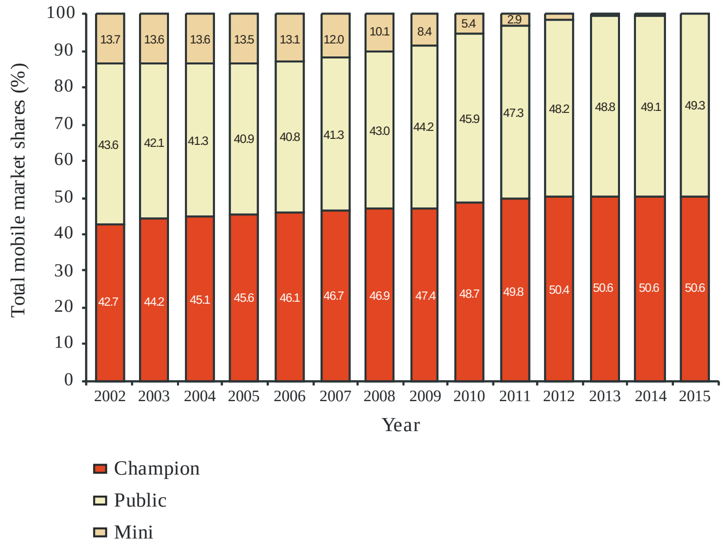
Total subscribers per operator



Deplo-IMT-04-7c

FIGURE 4-7d

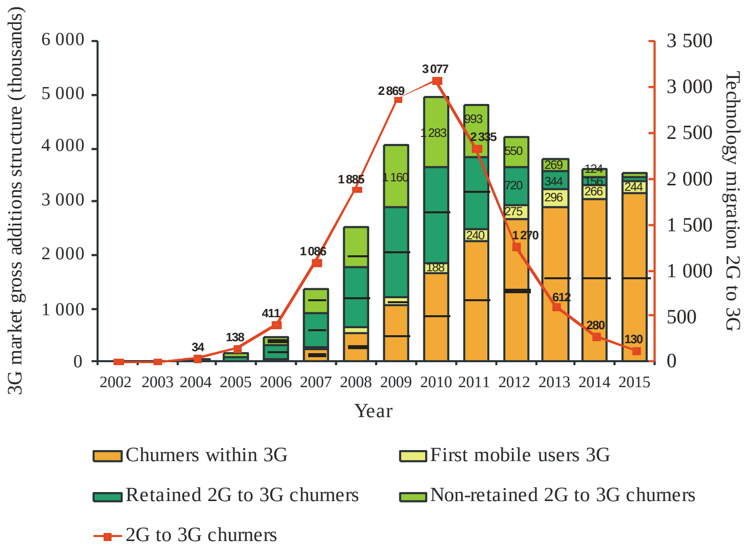
Total market shares per operator



Deplo-IMT-04-7d

FIGURE 4-7e

IMT-2000 market gross additions structure



Deplo-IMT-04-7e

4.3.2.4.4 Segmentation

Champion's subscribers need to be segmented in order to hand over the data needed for the revenue calculation, since ARPU modelling will be done bottom-up per segment. The results are shown in Figs 4-8a to 4-8c. As can be seen, most of the growth is assumed to come from the residential prepaid segment, which long-term will account for 70% of the subscriber base (now: 60%), while residential postpaid will give 20% (now: 25%), corporate and business 10% (now: 15%). The quality of the subscriber mix in pre-IMT-2000 is set to deteriorate much quicker and more than overall, because higher-end subscribers will gradually adopt IMT-2000, which in turn enjoys a very high-end subscriber base from the beginning (business and residential postpaid) and will converge towards the long-term total market ratios, as stated above.

FIGURE 4-8a

Champion's year average subscribers

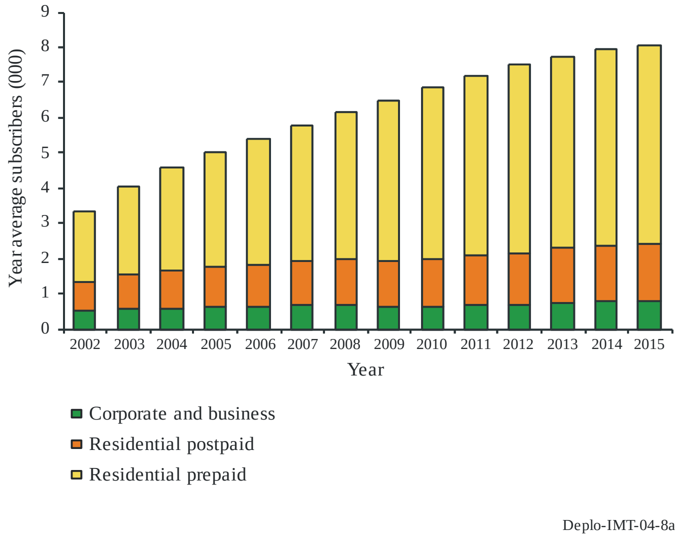


FIGURE 4-8b

Pre-IMT-2000 subscriber segment split

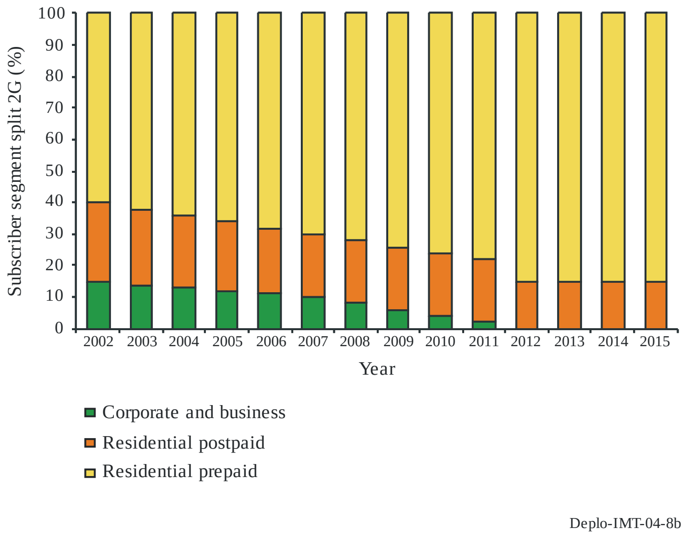
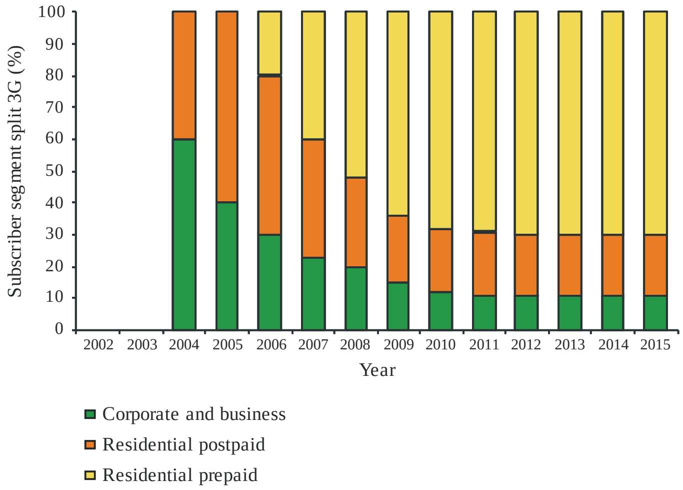


FIGURE 4-8c

IMT-2000 subscriber segment split



Deplo-IMT-04-8c

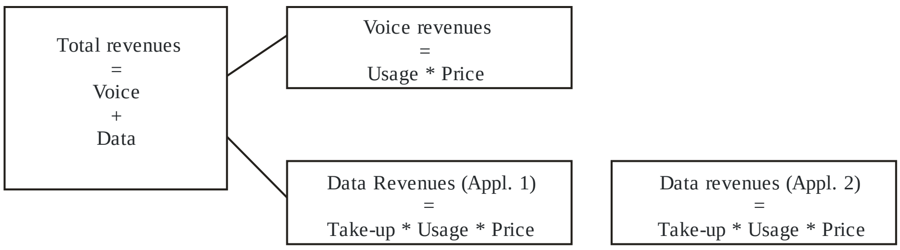
4.3.2.5 Revenues

After having used top-down revenue modelling already to check the plausibility of the penetration projections, consideration can be give to bottom-up modelling of the revenues per technology (pre-IMT-2000, IMT-2000), per segment (corporate and business, residential postpaid, residential prepaid) and, regarding data revenues, per application, following the schematics of Fig. 4-9. Note that for data revenues, take-up rate (i.e. how many subscribers of a segment use a certain application) and usage (how much the active users use the application) are treated separately.

Figure 4-10 illustrates the ARPU, Fig. 4-11 the revenue outcome of the business model. Because of the initially very high-end subscriber mix in IMT-2000, IMT-2000 ARPUs start at a much higher level than pre-IMT-2000 ARPUs. Data share of IMT-2000 ARPU (starting at 13%, growing to 32%) is obviously much higher than data share of pre-IMT-2000 ARPU (~3%) at all times. Pre-IMT-2000 ARPU will decline fast not only due to decrease in voice ARPU, but also because pre-IMT-2000 subscribers will be gradually lower-end, while high-end subscribers will migrate towards IMT-2000 fast. However, with migration going on, also the IMT-2000 subscriber quality will converge towards market level, bringing falling IMT-2000 ARPUs. Taking all ARPU effects and subscriber migration effects together, blended monthly ARPU shows a decrease from USD 27.2 to USD 16.3 until 2006, and then a ramp-up again resulting from increasing IMT-2000 data revenues. The ARPU curve is also in line with the affordability and budgetary considerations discussed with the penetration projections.

FIGURE 4-9

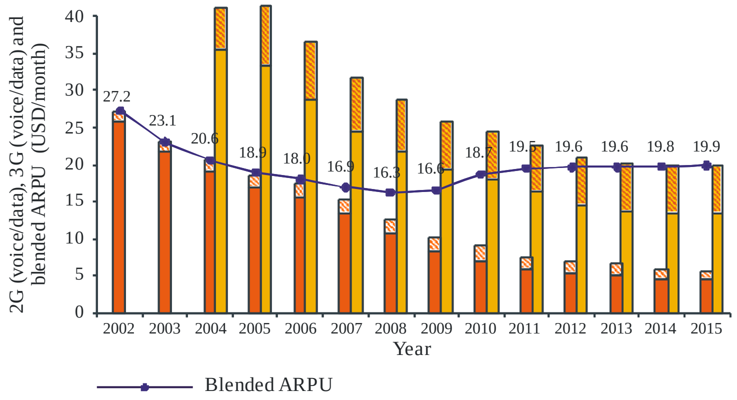
Revenue calculation (per technology and segment)



Deplo-IMT-04-9

FIGURE 4-10

ARPU



Deplo-IMT-04-10

In the revenues, the increase in subscribers until 2006 will overcompensate the decrease in ARPU. After 2007, the benefits of IMT-2000 begin to materialize, adding ~50% to the revenues until 2015. After 2007, revenues from IMT-2000 become a crucial factor in Champion’s business.

Figure 4-12 details the blended ARPU structure. The contributions to the blended ARPU resulting from IMT-2000 data applications appear to become beneficial after 2007, when the “fan out” of applications starts to translate into money for the operator. Before that, most of data revenues are expected to originate still from SMS usage, at least in blended ARPU. In pure IMT-2000 ARPU, the situation is different, of course, since there will be a higher data share of ARPU right from the beginning, and even in the beginning the IMT-2000 application portfolio will comprise multiple applications.

FIGURE 4-11

Revenues

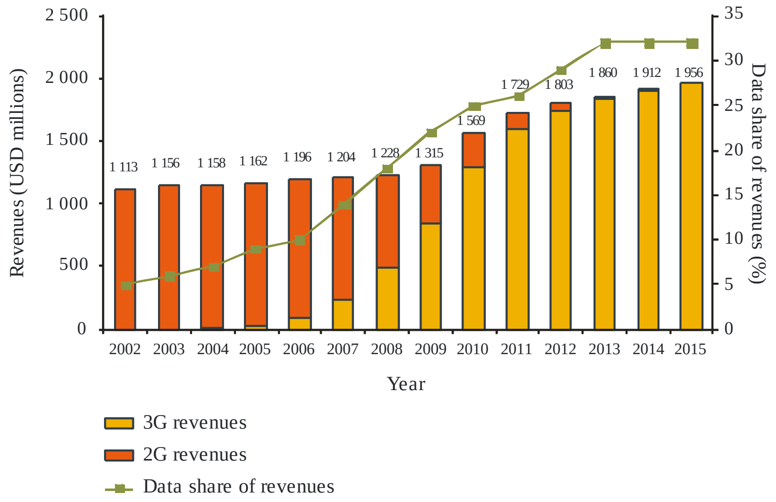


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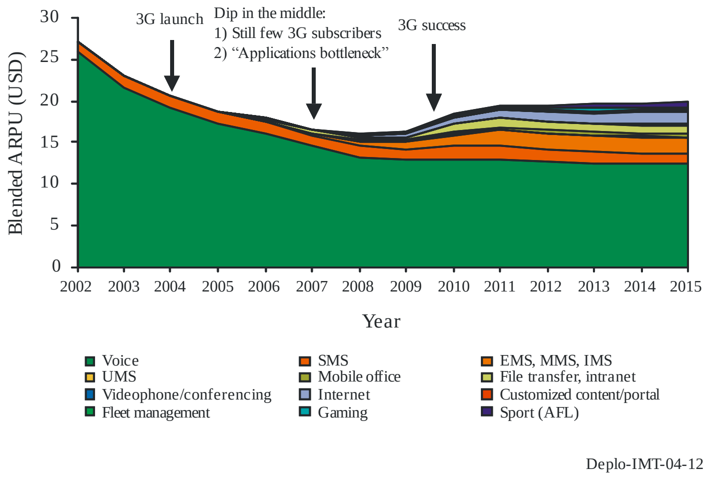
FIGURE 4-12

Blended ARPU breakdown



There are two effects that lead to this "dip in the middle" in blended ARPU that is typical for a technological innovation situation such as IMT-2000 migration:

Firstly, in the beginning the subscriber base is still dominated by pre-IMT-2000 subscribers, so that the higher ARPU of the IMT-2000 subscriber only contributes little to the blended ARPU; secondly, even IMT-2000 ARPU may not culminate right at the start, because applications first have to get acceptance among the customers. The combination of these two factors results in a time lag between introduction of the new technology and the "cash out" phase for the operator. Actually, the two issues are linked by the fact that an attractive portfolio of applications will both trigger faster subscriber migration and higher IMT-2000 ARPUs (another facilitator to speed up subscriber migration would be to offer more heavily subsidized IMT-2000 handsets, however the resulting increase in OPEX could offset the short term gain when looking at the level of earnings before interest and taxes, depreciation and amortization (EBITDA). Of course, beyond these considerations there is also the strategic imperative to retain high-value customers who are likely to be first movers, and will give IMT-2000 a good customer mix right from the start, although at limited absolute numbers. The early adopter of IMT-2000 among the operators is likely to maintain this advantage in subscriber quality over the time.

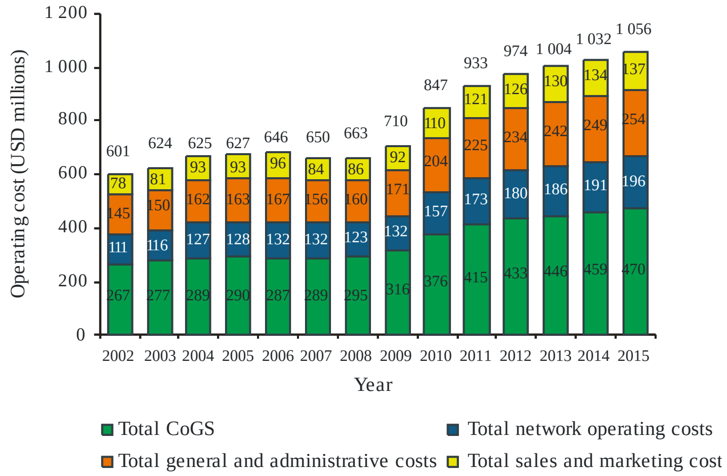
4.3.2.6 OPEX

Champion operates its pre-IMT-2000 business efficiently and has therefore established a typical OPEX structure of a "brownfield" operator, meaning that: the various OPEX categories represent stable percentages of revenue, there are no significant one-time costs, and EBITDA margins of 46%, Earnings Before Interest and Taxes (EBIT) margins of 33% have been established. The introduction of IMT-2000 means not only investment into assets and their depreciation, but also a certain volume of one-time and fixed costs, while IMT-2000 revenue has yet to rise, so that the business case of the incumbent is destined to "suffer" in the initial years, regarding operating results.

In this analysis, the EBITDA margin is estimated to fall to 42% in 2004 and 2005 and to reach back at a stable long-term level of 46% in 2007/2008. The OPEX breakdown is shown in Fig. 4-13.

FIGURE 4-13

OPEX breakdown



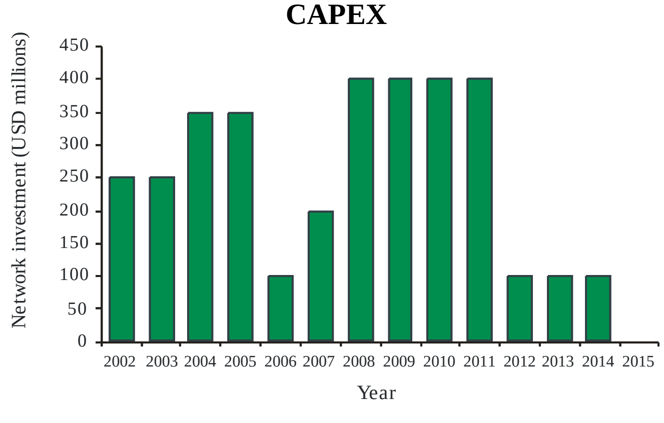
Deplo-IMT-04-13

4.3.2.7 CAPEX

Indicative CAPEX for Champion are shown in Fig. 4-14. Until 2005, strong pre-IMT-2000 subscriber growth implies that a large portion of the investment is still dedicated to the pre-IMT-2000 infrastructure. IMT-2000 investment starts in 2004 and is initially coverage driven; after 2007, further significant IMT-2000 CAPEX should be planned in order to increase capacity. After 2011, there should be little further CAPEX related to IMT-2000.

FIGURE 4-14

CAPEX



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4.3.2.8 Accounting

Revenues, EBITDA and EBIT are shown in Fig. 4-15a. Revenues have already been discussed. EBITDA margin is 46% in the beginning, will decrease to 42% temporarily with the launch of IMT-2000, and reach back at 46% in 2007/2008. EBIT margin is 33% in the beginning, will decrease to 26.5% in 2005, and then slowly rise to 34.8% in 2015.

Cash flow projections are shown in Fig. 4-15b. The two strong investment cycles (pre-IMT-2000-extension/IMT-2000-introduction and IMT-2000-extension) can be seen as large gaps between operating cash flow and cash flow after financing. The operating cash flow will double between 2002 and 2015, the cash flow after investing even grow three times.

FIGURE 4-15a

Revenues, EBITDA, EBIT

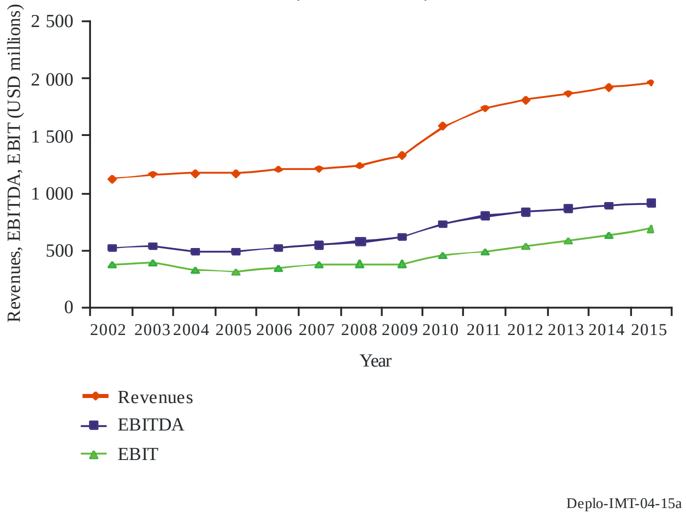
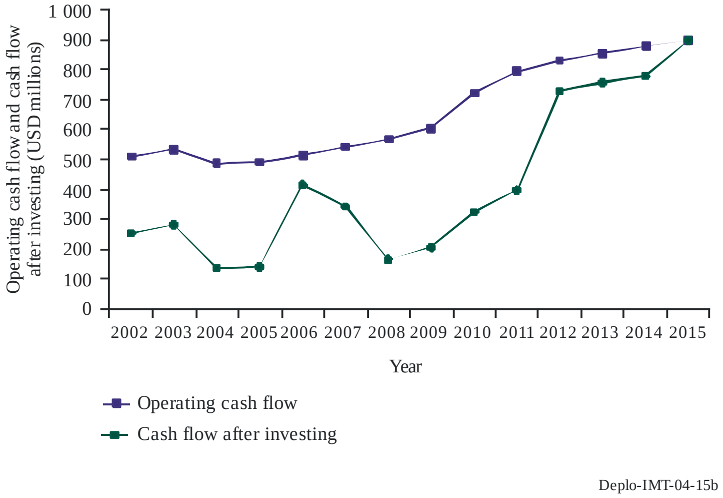


FIGURE 4-15b

Cash flow



4.3.2.9 What happens if "Champion" abandons IMT-2000?

If Champion abandoned its IMT-2000 plans, the following implications on the market and its own business would result (the results are shown in Figs 4-16a to 4-16d):

– In this market with two large and a smaller operator, the decision of the smaller operator not to introduce IMT-2000 was assumed not to have a big impact on the overall technology migration. The decision of the big players on IMT-2000 launch and respective timing, however, would have an impact on the general IMT-2000 migration. If Champion did not start IMT-2000, IMT-2000 migration would be slower, and a larger "residual" 2G/2.5G base would most likely be carried forward within the planning period.

– Champion would obviously offer some 2.5G services to its clients. However, the high-end mobile users would still want to use IMT-2000, and therefore churn to the only IMT-2000 operator, Public.

– These both factors would give Champion a smaller addressable market in the future, less subscribers, and a lower-quality subscriber mix with lower ARPUs. Subscriber numbers in the pre-IMT-2000-only case should be roughly half than with IMT-2000 in the long term. ARPUs without IMT-2000 should also be about half than in the original case. Therefore, revenues without IMT-2000 should be ¼ of the originally projected revenues, i.e. with IMT-2000 revenues would double, without IMT-2000 revenues would half in the long term.

– On the OPEX side, there would be no one-time effects on EBITDA margins from a IMT-2000 launch, but on the other side the lower ARPU level would also drive down profitability (many OPEX are linear with subscriber number, not with revenues!), leading to a lower stable-state EBITDA margin that may well be only 40% in the long run.

– On the CAPEX side, the impact of not introducing IMT-2000 would mean that only some capacity-driven investments into 2G/GPRS equipment during the pre-IMT-2000 subscriber growth from 2002 to 2006 would have to be carried out (which is necessary in any case).

– EBIT would not be lowered by IMT-2000 assets depreciation, but the residual investment into pre-IMT-2000 extension would still have to be depreciated.

– Without IMT-2000, cash flow after investing would be higher between 2004 and 2010. In the long-term, however, it would decrease dramatically, in line with the falling revenues.

FIGURE 4-16a

Subscriber comparison

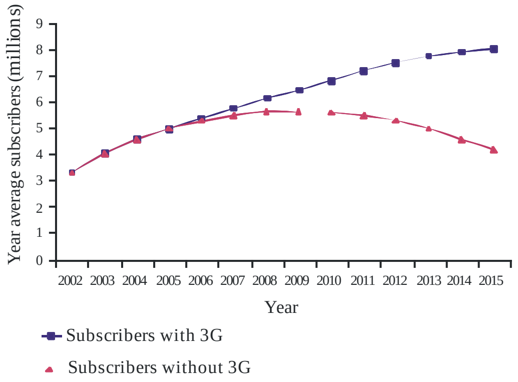


FIGURE 4-16b

ARPU comparison

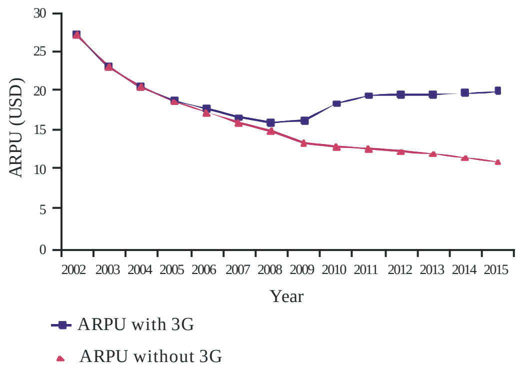


FIGURE 4-16c

Cash flow comparison

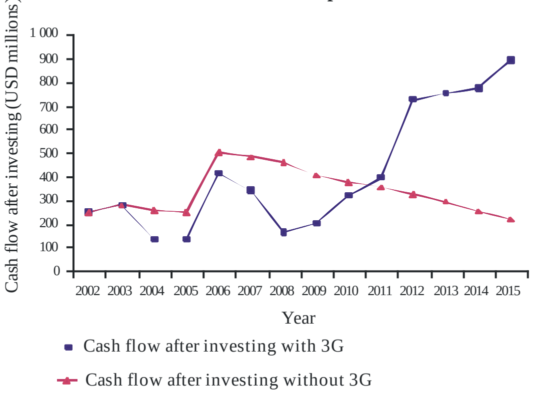
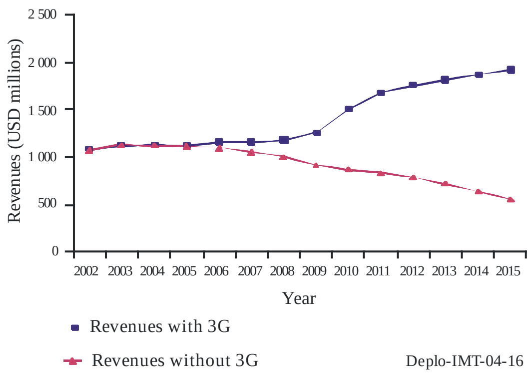


FIGURE 4-16d

Revenue comparison



4.3.2.10 Conclusions

The findings of the business case suggest that Champion is well advised to take a “go” decision with respect to IMT-2000 deployment. In fact, the additional investment in infrastructure appears to have only limited impact on Champion’s business case, both in terms of numbers and in terms of time-frame. Champion will be able to double subscriber numbers, recover high ARPU levels, double revenues, reestablish good EBITDA and EBIT margins, get solid cash flows. On the other side, to abolish IMT-2000 seems to be a clear way out of business, in the long term: The addressable market shrinks, as users migrate to the new technology; market share decreases; technology migration offsets market growth, subscriber numbers decrease; the best customers leave first, ARPU declines; revenues fall dramatically; EBITDA margins become worse not better; falling operating cash flow pulls down cash flow after investing, even without investment.

CHAPTER 5

CONCLUDING REMARKS

This revised Supplement 1 to the Handbook offers additional information and guidance to operators and administrations on the radio aspects associated with the evolution/migration of pre-IMT-2000 systems to IMT-2000 systems. It makes use of further studies and the experience that has been gained since the Handbook was published. The Supplement illustrates that the net effect of the gradual substitution of pre-IMT-2000 systems with IMT-2000 systems worldwide will be the result of the combination of substitution processes in many countries where local conditions and investment policies will determine the actual path taken and, ultimately, the speed of the transition.

A range of requirements and expectations inform the decision to move from pre-IMT-2000 to IMT-2000 systems – with those associated with capitalizing on investments in infrastructure already in-place playing a key role. Although these motivations are generally common to different countries and different operators, it is their perceived relative importance, as well as the attitude towards transitioning, that determine the actual path in developed and developing countries. In particular, the former base their decisions on when and how to go for IMT-2000 systems on an investment-against-revenue trade-off, whereas the latter tend to consider the transition to IMT-2000 as a way of bridging the digital divide and solve the service delivery/distribution problem – provided that costs be affordable. In this respect, further important requirements for developing countries include low investments for entry networks and economic provision of service coverage in sparsely populated areas.

The path to IMT-2000 is determined by economic and strategic decisions. In general, not only for developing countries, evolutionary system upgrades are preferable from the operator and user points of view, because earlier investment can be largely reused. However, in reality pure system evolution is never possible, since even for the most flexible system design at least software updates or even hardware-updates (i.e. replacements) are necessary for some network components, if new features enhance the system. Moreover, experience shows that in time every technology will reach its expansion limits (i.e. even evolutionary enhancements will eventually lead to unacceptable system complexity).

ANNEX A

DEFINITIONS AND ABBREVIATIONS

A1 Definitions

For the purposes of this Supplement, the following definitions will apply.

Term	Source	Definition
Evolution	ITU Handbook	A process of change and development of a mobile radio system towards enhanced capabilities (Recommendation ITU-R M.1308).
Evolution towards IMT-2000	ITU Handbook	A process of change and development of a mobile radio system towards the capabilities and functionalities of IMT-2000 (Recommendation ITU-R M.1308).
Migration to IMT-2000	ITU Handbook	Movement of users and/or service delivery from existing telecommunication network to IMT-2000 (Recommendation ITU-R M.1308).
Pre-IMT-2000	ITU Handbook	Mobile systems that are currently in service or will be introduced prior to IMT-2000 (Recommendation ITU-R M.1308). NOTE – In the context of these guidelines the definition of “Pre-IMT-2000”applies to all deployments of systems conforming to pre-IMT-2000 standards, as covered in Recommendations ITU-R M.622, ITU-R M.1033 and ITU-R M.1073.
3GPP Release	3GPP TR 21.900 V5.0.1	Specifications are grouped into “Releases”. A mobile system can be constructed based on the set of all specifications, which comprise a given Release. A Release differs from the previous Release by having added functionality introduced as a result of ongoing standardization work within the Groups. Specifications pertaining to a given Release shall be distinguished by the first field of the version number (“x” in x.y.z: the meaning of the three fields is defined in 3GPP TR 21.900 V5.0.1[43]). A given specification may simultaneously exist in several versions, each corresponding to a different Release. In principle, a Release of the specification can be identified as consisting of all those specifications with a “major” version field of a given value.
3GPP Specification	3GPP TR 21.900 V5.0.1	Generic term standing for Technical Specification and Technical Report. Each specification is associated with a “version number” in the form x.y.z which uniquely identifies the document. In general, a 3GPP Technical Specification (TS) is identified by: – the specification number, e.g. 3GPP TS <aa.bbb>; – the version number, e.g. V <x.y.z>; – the specification title; – the release number, e.g. for UMTS, Release 5. The significance of the fields <aa.bbb> and <x.y.z> is defined in 3GPP TR 21.900 V5.0.1. In particular, the range of the field “aa” depends on the type of system. For the UMTS system (Release 1999 onwards), the field “aa” ranges from 21 to 35, for identifying coverage of aspects related to: requirements specifications, service, technical realization, signalling protocols, radio access and core network, SIM/UIM, security, test specifications, etc.

[43] 3GPP TR 21.900 V5.0.1 "... outlines the working methods to be used by the 3GPP Technical Specification Groups and their Working Groups and their Sub-Groups, and by the 3GPP Support Team in relation to document management, i.e. handling of specifications, updating procedures, change request procedures, version control mechanisms, specifications status information etc. It complements the rules and procedures defined for 3GPP. ...”

Term	Source	Definition
3GPP Version	3GPP TR 21.900 V5.0.1	Unique identifier in the form x.y.z for a specification at a given point in time. Example: version 3.12.3.
3GPP2 Publication	3GPP2 S.R0097	Any document published by a 3GPP2 constituent body (Technical Specification Group, or Steering Committee). A publication must conform to the Publication Numbering Scheme, briefly defined as follows: A.Bcccc[-ddd]-X version y.z Where: A [A] identifies the publishing TSG/body [A, C, S, X or SC] B denotes project, report or specification [P, R, S] cccc is the 4-digit document number [0000-9999] ddd is the optional 3-digit part number for multi-part documents [000-999] X denotes revision [0, A-Z]: 0 is the initial release (0^{th} revision) A is the first revision, and so on y is the “point release” number 0 is used when the document is first created 1 number is incremented whenever the document is approved for publication (e.g., 1 is the first approval by the plenary for publication) z is an internal edit level 0 internal edit level z, always reset to 0 when the document is approved for publication 1 internal edit level is incremented by the entity (e.g., working group) that is developing the document. The Publication Process completes the development life cycle of a new revision of a 3GPP2 specification (see definition of “3GPP2 Document Revision”). The development cycle is a three-stage process.
3GPP2 System Release	3GPP2 S.R0052	The System Release is a set of specifications and features defined in the System Release Guide (SRG). SRG for a System Release provides an overview for and reference of the 3GPP2 wireless telecommunication system (cdma2000) capabilities, features, and services. The features and capabilities provided by a cdma2000 System Release are listed and briefly outlined. References and specification numbers for the features are provided. Any given System Release includes only features and capabilities that are part of at-that-time-published 3GPP2 specifications.
3GPP2 Document Revision	3GPP2 S.R0099	Document revisions are indicated by the revision level designator X (see “3GPP2 Publication” definition above) and are used to identify significant technical changes or additions to a specification (which will typically be supported independently in product implementations). Revisions are not mutually exclusive, meaning that manufacturers may continue to build products in conformance with revision 0 of a specification even after revision A has been published.

A2 IMT-2000 terrestrial radio interfaces

The IMT-2000 standardization process was established by the ITU, which followed thorough and meticulous steps that considered the user’s expectations, markets needs, market forces, technology evolution, transition of pre-IMT-2000 systems to IMT-2000, necessities of the developing countries, etc.

The process led to the concept of “IMT-2000 family of systems” in ITU-T, where an IMT-2000 family is a group of IMT-2000 systems providing IMT-2000 capabilities to its users as identified in IMT-2000 capability sets, as specified in ITU-T Recommendations[44]. However, individual family members may have different intra-system specifications (e.g., functionalities in physical entities, signalling protocols, etc.). The set of IMT-2000 radio interfaces is defined in Recommendation ITU-R M.1457 – Detailed specifications of the terrestrial radio interfaces of International Mobile Telecommunications 2000 (IMT-2000), which ensure interoperability and other performance aspects of the IMT-2000 radio access networks.

IMT-2000 consists of a number of radio access and core network systems.

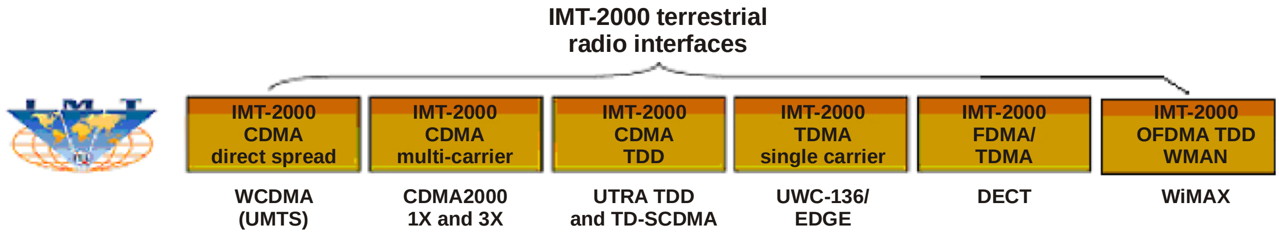
The IMT-2000 terrestrial radio access technologies are based on various combinations of code division multiple access (CDMA), time division multiple access (TDMA), TD-SCDMA (time division synchronous code division multiple access), OFDMA (orthogonal frequency division multiplex access), single-carrier, multi-carrier, frequency division duplex (FDD), and time division duplex (TDD). None of the IMT-2000 technologies uses pure FDMA where a single radio channel is completely used to support a single user.

The radio interfaces of IMT-2000 are specified in Recommendation ITU-R M.1457. The IMT-2000 radio interfaces and systems are described in more detail in the Handbook – Deployment of IMT-2000 Systems.

IMT-2000 standards provide a highly flexible system, capable of supporting a wide range of services and applications. The standards accommodate six possible radio interfaces based on four different access techniques (FDMA, TDMA, CDMA and OFDMA).

FIGURE 5

IMT-2000 Terrestrial Radio Interfaces



Deplo-IMT-05

Full Name	Common Names
IMT-2000 CDMA Direct Spread	UTRA FDD WCDMA UMTS
IMT-2000 CDMA Multi-Carrier	CDMA2000 1x and 3x CDMA2000 1xEV-DO (including Rel. 0, Rev.A and Rev.B)
IMT-2000 CDMA TDD (time-code)	UTRA TDD 3.84 Mchip/s high chip rate UTRA TDD 1.28 Mchip/s low chip rate (TD-SCDMA) UMTS
IMT-2000 TDMA Single-Carrier	UWC-136 EDGE
IMT-2000 FDMA/TDMA (frequency-time)	DECT
IMT-2000 OFDMA TDD WMAN	WiMAX

44 ITU-T Recommendation Q.1701 – Framework for IMT-2000 networks. Available at: http://www.itu.int/rec/T-REC-Q.1701/en

A3 Abbreviations/glossary

1G	first generation
2G	second generation
3G	third generation
3GPP	third Generation Partnership Project
3GPP2	third Generation Partnership Project 2
AAA	authentication, authorization and accounting
ANSI	American National Standard Institute
ARPU	average revenue per user
ATM	asynchronous transfer mode
CAPEX	capital expenditure
CDMA	code-division multiple access
CEPT	European Conference of Postal and Telecommunications Administrations
CITEL	Comision Interamericana de Telecomunicaciones
CN	core network
CS	circuit switching
CSCF	call session control function
DECT	digitally enhanced cordless telecommunications
EBIT	earnings before interest and taxes
EBITDA	earnings before interest and taxes, depreciation and amortization
EDGE	enhanced data rates for global evolution
EDGE DO	EDGE data only
ETSI	European Telecommunication Standards Institute
FDD	frequency division multiplexing
FDMA	frequency-division multiple access
GERAN	GSM EDGE radio access network
GGSN	gateway GPRS support node
GPRS	general packet radio service
GSM	global system for mobile communications
HA	home agent
HLR	home location register
HSDPA	high speed downlink packet access
IEEE	Institute of Electrical and Electronics Engineers
IETF	Internet Engineering Task Force
IMS	IP multimedia subsystem
IMT-2000	International mobile telecommunications-2000
IP	Internet protocol
ISDN	integrated services digital network
IT	information technology
ITU	International Telecommunication Union
ITU-D	International Telecommunication Union – Telecommunication Development Sector

ITU-R	International Telecommunication Union – Radiocommunication Sector
ITU-T	International Telecommunication Union – Telecommunication Standardization Sector
MAP	mobile application part
MGCF	media gateway control function
MMS	multimedia message service
MSC	mobile switching centre
MT	mobile terminal
MVNO	mobile virtual network operator
NPV	net present value
OFDMA	Orthogonal frequency-division multiple access
OPEX	operational expenditure
PCF	packet controller function
PDC	personal digital cellular
PDSN	packet data serving node
PDSN	public data switched network
PS	packet switching
PSTN	public switched telephone network
RAN	radio access network
RNS	radio network system
SDMA	space division multiple access
SDO	standard development organization
SGSN	serving GPRS support node
SIM	subscriber identification module
SMS	short message service
SCDMA	synchronous code-division multiple access
TD-CDMA	time division-code division multiple access
TDD	time division duplexing
TDMA	time-division multiple access
TD-SCDMA	time-division synchronous code-division multiple access
TIA	Telecommunications Industry Association
UIM	user identity module
UMTS	universal mobile telecommunication system
UTRA	UMTS terrestrial radio access
UTRAN	UMTS terrestrial radio access network
UWC	Universal Wireless Consortium (now, 3G Americas)
VLR	visitor location register
VNO	virtual network operator
VoIP	voice over IP
WCDMA	Wideband code division multiple access
WiMAX	worldwide interoperability for microwave access.

ANNEX B

INFORMATION ON OPERATOR EVOLUTION/MIGRATION PATHS

B1 IMT-2000 CDMA multi-carrier information

TABLE B.1

Commercial IMT-2000 CDMA multi-carrier systems migrated from pre-IMT-2000 systems

Country	Operator	Date	Frequency bands (MHz)	Pre-IMT-2000 technology
South Korea	SK Telecom	Oct. 1, 2000	800	cdmaOne
South Korea	LG Telecom	Oct. 1, 2000	1 700	cdmaOne
South Korea	KT Freetel	May 1, 2001	1 700	cdmaOne
USA	Western Wireless	July 1, 2001	800	TDMA, cdmaOne
USA	Monet Mobile Networks	Oct. 15, 2001	1 900	N/A
Romania	Zapp Mobile	Dec. 7, 2001	450	NMT450
Brazil	Vivo	Dec. 12, 2001	800	AMPS, cdmaOne
USA	Leap Wireless	Dec. 10, 2001	1 900	cdmaOne
USA	Verizon Wireless	Jan. 28, 2002	800 and 1 900	AMPS, cdmaOne
Canada	Bell Mobility	Feb. 12, 2002	800 and 1 900	AMPS, TDMA, cdmaOne
USA	MetroPCS	Feb. 21, 2002	1 900	N/A
Japan	KDDI	Apr. 1, 2002	Japan 800	cdmaOne
Puerto Rico	Centennial de Puerto Rico	Apr. 4, 2002	1 900	cdmaOne
Canada	Telus Mobility	June 3, 2002	800 and 1 900	AMPS, cdmaOne, IDEN
New Zealand	Telecom Mobile Limited	July 22, 2002	800	AMPS, TDMA, cdmaOne
Chile	Smartcom PCS	July 26, 2002	1 900	cdmaOne
USA	Sprint	Aug. 11, 2002	1 900	cdmaOne
Puerto Rico	Sprint Puerto Rico	Aug. 11, 2002	1 900	cdmaOne
U.S. Virgin Islands	Sprint U.S. Virgin Islands	Aug. 11, 2002	1 900	cdmaOne
USA	Cellular South	Sept. 9, 2002	800	AMPS, TDMA
Israel	Pele-Phone	Sept. 30, 2002	800	cdmaOne
Moldova	JSC Interdnestrcom	Sept. 30, 2002	800	cdmaOne
USA	NTELOS	3Q 2002	1 900	cdmaOne
Venezuela	Telecel BellSouth	Nov. 13, 2003	800	cdmaOne
Colombia	EPM-Bogota	Oct. 2, 2002	1 900	cdmaOne
USA	U.S. Cellular	Oct. 6, 2002	800 and 1 900	AMPS, TDMA

TABLE B.1 *(continued)*

Country	Operator	Date	Frequency bands (MHz)	Pre-IMT-2000 technology
India	Tata Teleservices	Nov. 7, 2002	800	cdmaOne
USA	Kiwi PCS (Comscape)	Nov. 14, 2002	1 900	cdmaOne
Venezuela	Movilnet	Nov. 20, 2002	850	TDMA
Canada	Aliant Mobility	Nov. 25, 2002	800	AMPS, cdmaOne
Canada	MTS Mobility	Nov. 27, 2002	1 900	cdmaOne
Poland	SFERIA	Nov. 2002	800	
Australia	Telstra	Dec. 2, 2002	800	cdmaOne
Ecuador	BellSouth Ecuador	Dec. 3, 2002	800	AMPS, TDMA
Panama	BellSouth Panama	Dec. 3, 2002	800	AMPS, TDMA
Indonesia	PT Telekomunikasi	Dec. 5, 2002	800	
Russia	Delta Telecom	Dec. 16, 2002	450	NMT450
India	Reliance Infocomm	May 1, 2003	800	N/A
México	IUSACELL	Jan. 23, 2003	1 900	cdmaOne
USA	Illinois Valley Cellular	Jan. 2003	800	TDMA
Puerto Rico	Verizon Wireless Puerto Rico	Feb. 4, 2003	1 900	TDMA
Belarus	Belcel	Feb. 1, 2003	450	NMT450
Thailand	Hutchison CAT	Feb. 24, 2003	800	N/A
Brazil	Tmais	Mar. 21, 2003	1 900	N/A
Nicaragua	BellSouth Nicaragua	Mar. 26, 2003	800	TDMA
Nigeria	Multi-Links	Mar. 26, 2003	1 900	TDMA
Dominican Republic	Centennial Dominicana	Mar. 27, 2003	1 900	cdmaOne
China	China Unicom	Mar. 28, 2003	800	cdmaOne
USA	ALLTEL	Mar. 2003	800 and 1 900	cdmaOne, TDMA
Pakistan	TeleCard Limited	Mar. 2003	1 900	cdmaOne
Canada	SaskTel Mobility	Apr. 10, 2003	800	cdmaOne
Brazil	Vesper	Apr. 28, 2003	1 900	cdmaOne
Colombia	BellSouth Colombia	May 5, 2003	800	TDMA
Russian Federation	SOTEL-Video	May 10, 2003	450	
India	Mahangar Telephone Nigam Ltd. (MTNL)	May 19, 2003	800	cdmaOne
Guatemala	BellSouth Guatemala	May 20, 2003	1 900	cdmaOne
USA	Midwest Wireless	June 2, 2003	800	TDMA
Azerbaijan	Caspian American Telecom	June 15, 2003	800	
Jamaica	Oceanic Digital Jamaica	June 17, 2003	800	cdmaOne
Brazil	Brasil Telecom	2Q 2003	1 900	cdmaOne
Uzbekistan	JSC Uzbektelecom	1H 2003	450	
Vietnam	S Telecom	July 1, 2003	800	N/A

TABLE B.1 *(end)*

Country	Operator	Date	Frequency bands (MHz)	Pre-IMT-2000 technology
Guatemala	SERCOM	July 15, 2003	1 900	cdmaOne
Taiwan (China)	Asia-Pacific Broadband Wireless Communications	July 29, 2003	800	N/A
Indonesia	PT Wireless Indonesia	July 29, 2003	1 900	N/A
Nigeria	Starcomms Limited	July 2003	1 900	cdmaOne
Chile	BellSouth Chile	Aug. 11, 2003	1 900	TDMA
Bermuda	Bermuda Digital Communications	Aug. 17, 2003	800	AMPS, TDMA
India	Shyam Telelink	Sept. 5, 2003	800	cdmaOne
Indonesia	PT Radio Telepon Indonesia	Sept. 12, 2003	800	
Kazakhstan	JSC ALTEL	Oct. 12, 2003	800	AMPS
Russia Federation	Moscow Cellular Communications	Nov. 1, 2003	450	NMT450
Kyrgyzstan	AkTel LLC	Nov. 18, 2003	800	N/A
Peru	Telefonica Moviles Peru	Nov. 27, 2003	800	cdmaOne
Japan	KDDI	Nov 28, 2003	2 100	cdmaOne
Ecuador	TELESCA	Dec. 1, 2003	1 900	N/A
Argentina	Movicom BellSouth Argentina	Dec. 1, 2003	1 900	cdmaOne
Dominican Republic	CODETEL	Dec. 3, 2003	1 900	cdmaOne
Peru	BellSouth Peru	Dec. 5, 2003	800	TDMA
Indonesia	PT Mobile-8 Indonesia	Dec. 8, 2003	800	

For additional information see for example:
http://www.cdg.org/worldwide/index.asp?h_area=0&h_technology=999

B2 IMT-2000 CDMA Direct Spread and IMT-2000 CDMA TDD (time code) information

Launched:

TABLE B.2a

Country	Operator	Status
Australia	Hutchison 3G	In service
Austria	Connect Austria	In service
Austria	Hutchison 3G	In service
Austria	Mobilkom	In service
Austria	T-Mobile Austria	In service
Austria	tele.ring	In service

TABLE B.2a *(end)*

Country	Operator	Status
Bahrain	MTC Vodafone	In service
Denmark	HI3G Denmark	In service
Greece	STET Hellas	In service
Hong Kong	Hutchison	In service
Italy	H3G	In service
Japan	J-Phone	In Service
Japan	NTT DoCoMo	In Service
Korea	KT ICOM	In service
Korea	SK IMT	In service
Luxembourg	Tele2	In service
Sweden	HI3G	In service
UAE	Etisalat	In service
UK	Hutchison 3G	In service
USA	AT&T Wireless Services	In service

In trial/planned:

TABLE B.2b

Country	Operator	Status
Australia	Vodafone	Planned
Belgium	BASE (KPN Orange)	Planned
Brazil	CTBC	Planned
Brazil	Oi	Planned
Brazil	Sercomtel	Planned
Brazil	Vivo	Trial planned
Canada	Rogers AT&T Wireless	Planned
Finland	TeliaSonera	In trial
France	Orange France	In trial
Germany	O2	In trial
Germany	T-Mobile	Planned
Germany	Vodafone D2	In trial
Hong Kong	SmarTone 3G	Planned
Ireland	Hutchison Whampoa	In trial
Ireland	O2	In trial
Ireland	Vodafone Ireland	In trial
Isle of Man	Manx Telecom	In trial
Israel	Partner Communications – Orange	Planned
Italy	TIM	Planned
Monaco	Monaco Telecom	In trial
Netherlands	KPN Mobile	Planned

TABLE B.2b *(end)*

Country	Operator	Status
Netherlands	Vodafone Libertel	In trial
Poland	Centertel	Planned
Portugal	Vodafone Telecel	In trial
Russian Federation – Moscow	Mobile TeleSystems	In trial
Russian Federation – Moscow	Megafone	In trial
Russian Federation – Moscow	VimpelCom	In trial
Russian Federation – St Petersburg	North-West GSM	In trial
Singapore	MobileOne	In trial
Singapore	Singapore Telecom	Planned
Slovenia	Mobitel	In trial
Spain	Amena	Planned
Spain	Telefónica Móviles	In trial
Spain	Vodafone España	Planned
Spain	Xfera	Planned
Sweden	Svenska UMTS-Nät	Planned
Switzerland	Orange	Planned
UK	Orange	Planned
UK	Vodafone	Planned

Licence awarded:

TABLE B.2c

Country	Operator	Status
Australia	3G Investments	Licence awarded
Australia	Optus	Licence awarded
Australia	Telstra	Licence awarded
Belgium	Belgacom Mobile	Licence awarded
Belgium	Mobistar	Licence awarded
Czech Republic	Eurotel Praha	Licence awarded
Czech Republic	RadioMobil	Licence awarded
Denmark	Orange Denmark	Licence awarded
Denmark	TDC Mobil	Licence awarded
Denmark	Telia Denmark	Licence awarded
Finland	Finnish 3G	Licence awarded
Finland	Radiolinja	Licence awarded
Finland – Republic of Åland	Alands Mobiltelefon AB	Licence awarded
Finland – Republic of Åland	Song Networks	Licence awarded
France	Bouygues Telecom	Licence awarded
France	SFR	Licence awarded
Germany	E-Plus	Licence awarded
Greece	Cosmote	Licence awarded

TABLE B.2c (*continued*)

Country	Operator	Status
Greece	Panafon SA	Licence awarded
Greece	STET Hellas	Licence awarded
Hong Kong	Hong Kong CSL	Licence awarded
Hong Kong	Sunday	Licence awarded
Israel	Cellcom Israel	Licence awarded
Israel	Pelephone	Licence awarded
Italy	Ipse 2000	Licence awarded
Italy	Vodafone Omnitel	Licence awarded
Italy	Wind	Licence awarded
Latvia	LMT	Licence awarded
Latvia	Tele2	Licence awarded
Liechtenstein	Orange	Licence awarded
Liechtenstein	Tele2	Licence awarded
Luxembourg	Orange Communications	Licence awarded
Luxembourg	P&T Luxembourg	Licence awarded
Malaysia	Maxis Communications	Licence awarded
Malaysia	Telekom Malaysia	Licence awarded
Netherlands	3G Blue	Licence awarded
Netherlands	Dutchtone	Licence awarded
Netherlands	O2	Licence awarded
New Zealand	Maori Spectrum Trust	Licence awarded
New Zealand	Telecom New Zealand	Licence awarded
New Zealand	TelstraClear	Licence awarded
New Zealand	Vodafone New Zealand	Licence awarded
Norway	Netcom	Licence awarded
Norway	Tele2 Norway AS	Licence awarded
Norway	Telenor Mobil	Licence awarded
Poland	Centertel	Planned
Poland	Polkomtel SA	Licence awarded
Poland	Polska Telefonia Cyfrowa	Licence awarded
Portugal	OniWay	Licence awarded
Portugal	Optimus	Licence awarded
Portugal	TMN	Licence awarded
Singapore	StarHub	Licence awarded
Slovak Republic	EuroTel Bratislava	Licence awarded
Slovak Republic	Orange	Licence awarded
Sweden	Orange Sweden	Licence awarded
Sweden	Vodafone Sweden	Licence awarded
Switzerland	Swisscom Mobile	Licence awarded
Switzerland	TDC dSpeed	Licence awarded
Switzerland	Team 3G	Licence awarded

TABLE B.2c (*end*)

Country	Operator	Status
Taiwan (China)	Asia Pacific Broadband Wireless Communications	Licence awarded
Taiwan (China)	Chunghwa Telecom	Licence awarded
Taiwan (China)	FarEasTone	Licence awarded
Taiwan (China)	Taiwan Cellular Corporation	Licence awarded
Taiwan (China)	Taiwan PCS	Licence awarded
Thailand	CAT/TOT	Licence awarded
UK	O2	Licence awarded
UK	T-Mobile	Licence awarded

Source: EMC World Cellular Database, November 2003, GSM Association.

EDGE operators worldwide – Status of deployments at September 2004.

Source: 3G Americas, Global mobile Suppliers Association, GSM Association.

Launched:

TABLE B.2d

Country	Operator	Status
Algeria	Djezzy (Orange Telecom Algeria)	Launched
Argentina	Telecom Personal	Launched
Argentina	CTi Mòvil	Launched
Barbados	Cellular Communications Wireless / AT&T Wireless	Launched
Bahrain	MTC Vodafone	Launched
Bermuda	Telecom/AT&T Wireless	Launched
Bolivia	NuevaTel PCS	Launched
Brazil	Claro	Launched
Brazil	Oi	Trial
Canada	Rogers AT&T Wireless	Launched
Caymen Islands	AT&T Wireless	Launched
Chile	Telefonica Movil	Launched
China	Unicom	In trial
Croatia	VIP Net (Telecom Austria)	Launched
Czech Republic	Eurotel	In trial
Czech Republic	T-Mobile Czech Republic	In trial
Estonia	EMT	Launched
Finland	TeliaSonera	Launched
Finland	DNA Finland (Finnet Networks)	Launched
Finland	Elisa	Launched
Hong Kong	Hong Kong CSL	Launched
Hong Kong	Sunday	In trial

TABLE B.2d (*end*)

Country	Operator	Status
Hong Kong	Peoples Telephone	Launched
Hungary	Pannon GSM	Launched
Hungary	T-Mobile Hungary	Launched
India	Bharti	Launched
India	IDEA Cellular	Launched
India	Hutchison Max Telecom	Launched
Indonesia	Telkomsel	Trial
Israel	Cellcom	Launched
Italy	TIM	Launched
Kuwait	MTC Vodaphone	Launched-nationwide by end 2004
Lithuania	Bite GSM	Launched
Malaysia	DiGi	Launched
Mexico	Telefónica Moviles	Launched
Netherlands	Telfort	In Trial
Puerto Rico	AT&T Wireless	Launched
Romania	Orange Romania	In Trial
Serbia	Mobtel Srbija	Pilot network
Slovak Republic	Eurotel Bratislava	Launched
Slovenia	Si. Mobil – Vodafone	Launched
South Africa	MTN	In Trial
Sri Lanka	Dialog GSM	Launched
Thailand	AIS	Launched
Thailand	DTAC	Commercial field testing
USA	AT&T Wireless Group	Launched
USA	Cingular Wireless	Launched

In deployment:

TABLE B.2e

Country	Operator	Status
Bahrain	Batelco	In deployment
Bolivia	Movil de Entel	In deployment
Brazil	Brasil Telecom	In deployment
Brazil	Sercomtel	In deployment
Brunei	DST	Early 2004 launch
Caribbean: Anguilla	Cable & Wireless	In deployment
Caribbean: Antigua & Barbuda	Cable & Wireless	In deployment
Caribbean: Barbados	Cable & Wireless	In deployment
Caribbean: Cayman Islands	Cable & Wireless	In deployment
Caribbean: Dominica	Cable & Wireless	In deployment

TABLE B.2e (*continued*)

Country	Operator	Status
Caribbean: Grenada	Cable & Wireless	In deployment
Caribbean: Jamaica	Cable & Wireless	In deployment
Caribbean: Montserrat	Cable & Wireless	In deployment
Caribbean: St Kitts & Nevis	Cable & Wireless	In deployment
Caribbean: St Lucia	Cable & Wireless	In deployment
Caribbean: St Vincent & The Grenadines	Cable & Wireless	In deployment
Caribbean: Turks & Caicos Islands	Cable & Wireless	In deployment
Chile	Entel PCS	Early 2004 launch
China	China Mobile	In deployment
Colombia	Colombia Móvil	In deployment
Cypress	Scancom Cyprus	In deployment
Faroe Islands	Faroese Telecom	In deployment
Finland	Ålands Mobiltelefon AB	In deployment
Ghana	Scancom	In deployment
Greece	TIM Hellas	In deployment
Guatemala	Sercom SA	In deployment
Hong Kong	New World Mobility	In deployment
Jordan	MobilCom	In deployment
Kuwait	Wataniya Telecom (NMTC)	Q1 2004
Libya	GPTC	In deployment
Mexico	Telcel	In deployment
Norway	Telenor Mobil	In deployment
Norway	Telcel	In deployment
Paraguay	Personal Peraguay	Network ready for launch
Peru	TIM Peru	Test phase from Q1 2004
Philippines	SMART Communications	In deployment
Philippines	Globe	In deployment
Philippines	Sun Cellular (Digitel)	In deployment
Poland	Polkomtel S.A. Plus GSM	In deployment
Russian Federation	Vimpelcom	In deployment
Russian Federation	SMARTS	Q4 2004 launch target
Russian Federation	Mobile TeleSystems	Q4 2004 launch target
Switzerland	Swisscomm	In deployment
Thailand	TA Orange	Early 2004 launch
Ukraine	Kyivstar GSM	In deployment
Ukraine	DCC/Astelit	In deployment
USA	Corr Wireless	In deployment
USA	Dobson Communications	In deployment
USA	T-Mobile USA	In deployment

TABLE B.2e (*end*)

Country	Operator	Status
USA	Triton	In deployment
USA	Cincinnati Bell	In deployment
USA	Western Wireless	In deployment
USA	WestLink (Kansas)	In deployment
Venezuela	Digital Venezuela	October 2004 launch target

Planned:

TABLE B.2f

Country	Operator	Status
Bermuda	Bermuda Telephone Company	EDGE capable
Brazil	CTBC	Planned
Canada	Microcell	Planned
Colombia (East)	Comcel	Planned
Colombia (West)	Occel	Planned
Ecuador	Conecel	Planned
France	Bouygues Telecom	Planned 2004/05
Guyana	Cel*Star Guyana	Planned
Turkey	TIM	Planned 2005
USA	Cellular One of NE Arizona	Planned
USA	Centennial Nid-West & South East	Planned
USA	EDGE Wireless (AWS affiliate)	Planned
USA	Viaero	Planned

For additional information see for example:
http://www.gsmamobilebroadband.com/networks/default.asp

ANNEX C

OPERATOR EXPERIENCE IN TRANSITIONING TO IMT-2000 SYSTEMS

This Annex provides operator experiences in transitioning to IMT-2000 systems. Table C.1 cross-references these operator experiences with the transition scenarios listed in § 3.2.

TABLE C.1

Transition scenario of operator experiences

Scenario	Operator experiences	Pre-IMT-2000 network (frequency)	IMT-2000 network (frequency)
1	Russian Federation	NMT 450 (450 MHz)	CDMA2000 1x (450 MHz)
2	Chile (Telefónica Móvil de Chile)	AMPS/TDMA (850 MHz)	GSM/GPRS/EDGE (1900 MHz)
2	Japan (NTT DoCoMo)	PDC (800 MHz)	WCDMA (2000 MHz)
3	Hong Kong (Hong Kong CSL Ltd.)	GSM/GPRS (900/1800 MHz)	GSM/GPRS/EDGE (900/1800 MHz)
3	Japan (KDDI: au)	cdmaOne (800 MHz)	CDMA2000 1x (800 MHz)
3	Thailand (Advanced Info Service Public Co. Ltd.)	GSM/GPRS (900 MHz)	GSM/GPRS/EDGE (900 MHz)
3	Venezuela	TDMA (800 MHz)	CDMA2000 1x (800 MHz)
4	Hungary (Pannon GSM Telecommunications Ltd.)	GSM (900 MHz)	GSM/GPRS/EDGE (1800 MHz)

CHILE – Implementation of IMT-2000 technology (EDGE) and TDMA migration in Chile

Source: Telefónica Móvil de Chile

1 Background

Telefónica Móvil de Chile has been providing wireless telecommunication solutions in Chile since 1989. Telefónica Móvil de Chile is part of the Telefónica group of companies present in 14 countries and covering a potential 514 million subscribers. Telefónica group companies in Latin America make up over half of the 50 million Telefónica subscribers worldwide.

Telefónica Móvil de Chile draws on the experience in design and implementation of networks provided by its parent and partners to ensure they provide a high quality of both voice and data services to its customers nationwide.

In the first quarter of 2003 Telefónica launched GSM/GPRS in the 1 900 MHz band and this launch was followed in October by the launch of EDGE.

2 Infrastructure implementation

Telefónica's new GSM network was granted as part of Chile's last 30 MHz spectrum auction in the 1 900 MHz band. This process included a technical proposal where coverage and implementation times were evaluated. In order to obtain the necessary spectrum, Telefónica Móvil de Chile had to outline a fast nationwide roll out project.

Currently in the process of migrating from AMPS/TDMA mobile technology at the 850 MHz band, Telefónica Móvil de Chile selected the GSM/GPRS/EDGE family of technologies. The move was a decision that was based on global penetration, cost, services, and handsets considerations.

Telefonica's GSM network was set up in approximately four months. All base stations were purchased new and a significant proportion were fitted with EDGE transceivers. Nationwide roll out was not affected by the later implementation of EDGE because as a radio feature EDGE can be activated per transceiver.

3 Spectrum efficiency

EDGE provides a cost effective way to offer advanced services without increasing existing spectrum. All EDGE devices will support GSM/GPRS and work on multiple spectrum bands including variations of 800/900/1 800/1 900 MHz. EDGE is compatible with GPRS (Telefónica Móvil de Chile have nationwide GPRS coverage) so when customers move out of an EDGE enabled area GPRS packet data services will remain available. Telefónica Móvil de Chile has initially concentrated EDGE deployment in high demand data areas only.

Telefónica Móvil de Chile currently have commercially available class 2 multi-slot terminals (up to 2 TSL in downlink and 1 TSL in uplink), and have seen average rates of around 40 to 80 kbit/s for static applications with peaks of up to 100 kbit/s. Given the low cost and effort required to deploy EDGE these are pleasing results. Spectrum efficiency has also improved showing an increment of around 2.5 times compared with that of GPRS.

4 GSM migration

With the addition in 2003 of GSM/GPRS/EDGE Telefónica Móvil de Chile now have a very robust network platform to compete in the Chilean mobile market. Providing to its customers a complete profile of advanced voice services, a wide range of terminals and enhanced mobile data services.

The service portfolio includes games download (MOVIL GAMES), ring-tones download (MOVIL MUSIC) and Multimedia Messaging (MOVIL IMAGES). In terms of Mobile Data Telefónica Móvil de Chile provide MOVIL INTERNET and have recently launched the VPN MOVIL that is very much enterprise oriented. These services allow customers added mobility and a complete set of applications will become available in their own mobile office.

In general, Telefónica Móvil de Chile have found that the key is to concentrate the marketing of EDGE on giving mobility to data users and not to sell data mobility to voice users. Telefónica Móvil de Chile believe that EDGE will assist them to improve the users experience with mobile data and that this will in turn expand the market, and as a result increase revenues.

HONG KONG – Implementation of IMT-2000 technology (EDGE) in Hong Kong

Source: Hong Kong CSL Limited

1 Background

CSL launched its mobile services in 1983, and today operates a world-class GSM/dual band network through its mobile brands: 1O1O and One2Free. The Company also provides comprehensive pre-paid mobile services and international roaming services. It offers leading-edge mobile technology including WAP (wireless applications protocol), HSCSD (high speed circuit switched service data) and GPRS (general packet radio service).

2 EDGE services

In August 2003 CSL launched Hong Kong's first commercial EDGE network. Customers in Hong Kong can now enjoy data applications at a faster data transfer rate when using an EDGE capable device. Mr. Hubert Ng, CSL's Chief Executive Officer says, "The adoption of EDGE is a natural evolution of the existing GPRS network. The EDGE deployment is also aimed at accelerating the adoption of mobile data services, and prepares the market when the next generation of mobile data gets widely accepted."

EDGE services offered include the GPRS suite of MMS, Java games, email and WAP browsing plus a new range of video downloads. Video downloads will work on video equipped GPRS terminals however the EDGE addition is geared towards the social premium segment of the market.

3 Evolution from 2GSM

Upgrading the existing HKCSL GPRS network was a relatively straightforward process, since in effect EDGE is an upgrade of GPRS. The upgrade became attractive due to the rapidly increasing demand for data transmission driven by the growing number of MMS and GPRS terminals attached to the network. Customers with these camera equipped colour screen handsets initially want to personalize them with their choice of polyphonic ringtone and colourful wallpaper. The more adventurous extend this use of data into uploads or downloads of MMS pictures and video clips of their favourite obsessions or download java games for offline time killing. The combination of the S curve growth in MMS terminals plus the larger file sizes for downloads of these features has driven a need for more capacity and quicker processing by the network.

The process of upgrade was relatively straightforward, much like a version upgrade of the network software, however it was accompanied by a revised radio plan in order to optimize the network performance for data. Remote sites were upgraded initially until the software and network performance was stable and then the major data traffic areas were progressively cut over to the EDGE. Since this was fully integrated with the current GPRS network, any slip-ups in the cut over of a particular base station were likely to affect the entire customer base, so the stakes were high. In practice the event ran smoothly without significant incidents.

4 Network performance

Part of what makes EDGE so attractive is that the network has performed very closely to theoretical data rates, which are roughly three times that of GPRS, which gives plenty of headroom for expansion in both scope and scale of applications. This has enabled a range of video "channels" to be created for downloads, which then allows customers a richer experience in their use of mobiles.

5 EDGE roaming

CSL then quickly implemented EDGE roaming with AIS, who was also in the process of upgrading to EDGE. The speed, with which this was completed utilizing the normal GPRS roaming process, was a graphic illustration of the ease of global rollout of new higher speed data services. Thailand is an important business and recreational roaming destination to CSL customers, who can now use all of their favourite data applications whilst abroad.

6 EDGE, market reality

Since the launch of EDGE in August subscriber growth to date has exceeded CSL's expectations. The Nokia 6220, the first EDGE terminal is currently the best selling handset in Hong Kong, in part because it offers the novelty of video on an affordable cool handset.

Data usage by the subscribers has been double that of normal MMS handset buyers, where package subscription is currently 50% for EDGE data transport package subscription has been near 100%. In effect this means that those currently buying this handset plan to use it on an ongoing basis for data services. This indicates that we have turned the corner in data service adoption for segment, although it is still an early adopter/fast follower phenomenon.

EDGE network topology has provided CSL a cost effective way of offering 3G like services and thus satisfying immediate customer demand. EDGE is paving the way to a full and harmonized 3G rollout and will allow CSL to deliver optimum performance, flexibility and coverage at the lowest possible cost.

HUNGARY – Implementation of IMT-2000 technology (EDGE) in Hungary

Source: Pannon GSM

1 Background

Pannon GSM Telecommunications Ltd launched its 900 MHz frequency in March 1994 and in 1999 they won the tender for the 1 800 MHz frequency in Hungary. In November of 2000 Pannon GSM rolled out its 1 800 MHz frequency in Budapest, this network was built at record speed. Pannon GSM then began to operate its 1800 MHz band nationwide in 2001. In May 2003 Pannon made the first EDGE (IMT-2000) test call in Europe and since October 2003 the service is being tested in several parts of Budapest. With over 2.785 million subscribers on its GSM900/1800 network Pannon GSM holds a 36% share of the Hungarian mobile market.

Since first launching its mobile services 26 March 1994, Pannon GSM have followed a continuous development process. Development has been aimed at ensuring coverage of the motorways, county seats and the Balaton area, followed by single-digit national highways. As a result of the ongoing, detailed network expansion efforts, as well as the expansion of the capacity of the existing network, 75% of the population had access to the digital services provided by Pannon GSM by the end of 1995. By the end of 1996, this number had reached 99%. Building on its existing voice and data capabilities Pannon GSM introduced WAP services in 2000 and in 2001 were the first to launch GPRS technology in Hungary. Pannon GSM also provides WLAN services in Ferihegy Airport, making a high-speed connection to a local computer network and thus to the Internet, WLAN provides extremely fast access to data stored on the network and the World Wide Web.

While awaiting government decision on 3G licences in Hungary Pannon GSM are continuing their evolutionary path to 3G by testing EDGE technology at several Budapest spots.

2 EDGE services

EDGE is a significant enhancement to GPRS, offering traditional GPRS services at a higher data speed and ensuring better quality of service. EDGE is capable of data transfer faster than that of fixed lines and paves the way for a huge increase in the popularity of non-voice applications. Mobile based broadband applications such as mobile Internet access, MMS, television and video streaming, interactive games and the ability to remotely access workplace networks will become available. Hungarian users now require such services as increased data speeds for non-voice services and eventually total telecommunication mobility. EDGE implementation will allow Pannon GSM to bring users closer to these requirements.

3 Evolution costs

EDGE technology utilizes existing GSM/GPRS infrastructure, enabling Pannon GSM to implement EDGE at only incremental cost. EDGE enabled terminals will continue to work on both GSM and GPRS enabled networks and will also work on WCDMA networks. The compatibility of the GSM family of technologies that includes GSM/GPRS/EDGE/WCDMA ensures that Pannon GSM can avail of economies of scale when implementing EDGE.

4 EDGE implementation

Pannon GSM is currently performing EDGE trials before rolling out commercially. Trials began on the 20 October 2003 and a pre-selected group of users in Budapest are currently testing the new technology. To date tests have proven positive. Current tests that have taken place in Budapest's largest shopping mall have shown a significant increase in data rates to end users and improved mobile services usability. By upgrading existing GSM network elements to include EDGE capability, Pannon GSM will greatly enhance user experiences with mobile services, while leveraging the most from its current network investment. EDGE will allow Pannon GSM to provide its Hungarian operators 3G like services both immediately and cost efficiently.

JAPAN – Implementation of IMT-2000 technology (FOMA) in Japan

Source: NTT DoCoMo

1 Introduction

Japan's mobile telecommunications company, NTT DoCoMo, provides wireless voice and data telecommunications to more than 47 million customers. The company provides a wide variety of leading-edge mobile multimedia services. These include i-mode®, a very popular mobile Internet service, which provides email and Internet access to over 40 million subscribers, and FOMA®, launched in 2001 as the world's first 3G mobile service based on WCDMA. At the heart of our operations is a commitment to providing customers with cutting-edge, cost-effective service and a belief that ongoing, focused research and development can help us to continually reinvent the concept of mobile telecommunications. In addition to wholly owned subsidiaries in Europe and North and South America, the company is expanding its global reach through strategic alliances with mobile and multimedia service providers in Asia-Pacific, Europe and North and South America.

2 FOMA launch

In October 2001, NTT DoCoMo launched the world's first fully commercialized third-generation mobile telecommunications service under the brand name of "FOMA", which stands for "Freedom of Mobile multimedia Access". Using the WCDMA technology, one of the IMT-2000 global 3G standards, FOMA enables high-capacity, high-speed data transmissions and offers an exciting new range of services including videophone and video mail. Ever since the launch of FOMA, NTT DoCoMo has continued expand its network coverage at a rapid pace and released a number of new handsets equipped with advanced functionality. As a consequence, the total number of subscribers to the 3G FOMA service nationwide exceeded 1.6 million in November 2003, approximately two years after the commencement of the service.

3 FOMA services

FOMA has made mobile video and high-speed data transmissions a reality. Since its fully commercialized service launch in October 2001, new handsets offering advanced features have been released one after another to satisfy the needs of ever-expanding number of subscribers. With the evolution of FOMA far from over, NTT DoCoMo is committed to move further ahead in its efforts to create a richer mobile telecommunications environment, in which users can access virtually any information they require, free from the constraints of time or location.

3.1 i-mode

Following the functional enhancements enabled by "i-appli", i-mode service has become even more advanced with the use of FOMA 3G technologies. FOMA's high-speed packet transmission speeds of up to 384 kbit/s makes i-mode service significantly faster and able to handle greater volumes of data such as email messages of up to 10 000 characters, and to attach files of melodies and still images. The latest handset models also feature an enhanced data capacity, increasing the size of each "i-appli" content to as large as 200 KB. The i-mode service has always offered enhanced convenience to its users, whereas FOMA's new capabilities realize entirely new potentials.

3.2 Visual communications/videophone

Mobile telecommunications became infinitely more expressive with the introduction of videophone capability on FOMA. The service, which allows subscribers to speak to each other face-to-face, is extremely useful for personal communications as well as in business situations, as it enables business users to provide an initial view of products to their clients and customers, and maintain closer contacts between office and field operations, or personal users to place a video call to a friend over a mobile phone.

3.3 High-speed data telecommunications

– High-speed packet transmission at rates of up to 384 kbit/s[45] allowing users to access to email and web sites at faster speeds.

– 64 K circuit-switched data transmission, an ideal solution for sending a large volume of data, such as video images, in real time.

3.4 Multi-access

FOMA’s multi-access capability allows subscribers to simultaneously engage in multiple modes of telecommunications. For instance, in a business setting, this capability allows salespersons to talk to customers while accessing their corporate database, and for personal use, the service is convenient for chatting with friends while searching restaurants on i-mode. The latest handset models even enable subscribers to take still pictures and send them as email attachments while talking on a phone.

3.5 i-motion

i-motion service allows subscribers to download exciting content combining audio and video data. The service is offered in three formats – video with sound, still picture frames with sound, and sound-only files. The number of compatible content sites has been increasing, providing subscribers with a greater variety of information services, such as movie previews, promotional music videos, and news and sport highlights, among others.

The “i-motion mail” video message service enables subscribers to send video, recorded by the mobile phone’s built-in camera or downloaded from a web site, by attaching it to an email. The maximum file size has been dramatically extended from previously only 100 kB to 300 kB, and users are now able to play back videos of up to 30 s containing more expressive content and higher-definition images.

4 A vision for growth

Futuristic 3G telecommunications capabilities have long been anticipated worldwide, but they could not be realized until the advent of WCDMA technology. NTT DoCoMo launched its WCDMA-based 3G FOMA service ahead of the rest of the world and continues to progress by streamlining its operations to achieve greater business efficiency, enhancing the functionality of its state-of-the-art mobile handsets, supplementing its product line-up with advanced new offerings, and aggressively expanding the FOMA service area. With many high value-added functions superior to the second-generation PDC service, FOMA has proven itself capable of reliably meeting the most demanding business needs and is well on the way to becoming one of our mainstream mobile telecommunications service offerings.

In addition to introducing sophisticated new functions and further expanding the service area of FOMA, NTT DoCoMo’s future plans include the reduction of handset weight to less than 100 g and the extension of handset battery life to more than 300 h. To accelerate the uptake of FOMA service in Japan, NTT DoCoMo aims to extend its nationwide population coverage to 99% by the end of March 2004. Meanwhile, indoor coverage will also be expanded in parallel to enable customers to use FOMA in buildings and underground shopping malls, etc.

[45] The uplink transmission of data is carried out at rates of up to 64 kbit/s. This is, however, provided on a best-effort basis, and the actual transmit speed varies depending on the propagation conditions and network traffic.

5 3G global

Through technical exchange and joint studies with leading operators abroad, NTT DoCoMo is stepping up its efforts to facilitate an early implementation of 3G mobile telecommunications services worldwide. Leveraging its extensive technical R&D capabilities, its expertise pertaining to the WCDMA technology, one of the global 3G standards for which the company played a primary role in the standardization activities, and its experience and know-how as a world pioneer in commercial 3G services, NTT DoCoMo aims to further proliferate 3G mobile telecommunications services on a global scale.

JAPAN – CDMA2000 1X deployment and associated multimedia services launched in Japan[46]

Source: KDDI (JAPAN)

1 Wireless market outlook in Japan

The total number of wireless subscribers in Japan at the end July 2003 was 77 795 800. The total number of mobile Internet subscribers in Japan jumped up from 12 720 000 (as of end June 2000) to 65 174 100 (as of end July 2003) – an increase of 512% just in 37 months. KDDI attributes much of this dramatic growth to the launch of its commercial CDMA2000 1x service, known as "au".

2 CDMA2000 1x launch by au

In July of 1998, au launched its second-generation cdmaOne system throughout Japan, offering new high-quality voice services to its existing TACS and PDC customers, while continuing to run those other networks. In April of 1999, au began offering its "Ezweb" service, which enabled the provision of Web-based applications to mobile devices. In April of 2000, au began offering international roaming with other cdmaOne operators, while in July of 2000, au launched IS-95B, the packet service upgrade to cdmaOne, which provides data rates of 64 kbit/s.

By November of 2001, only three years after deploying its cdmaOne network, au had reached a total of 10 million subscribers. In the same time-frame, au terminated its TACS operations and decided that to shut down its PDC operations by the end of March 2003.

In April of 2002, au upgraded its cdmaOne system to CDMA2000 1x, covering 54% of the Japanese population initially and expanding to cover 90% by December of 2002. Less than 16 months after its initial commercial launch, there were 9 million CDMA2000 1x subscribers on the au network.

3 Secret of au's success in CDMA2000 1x launch

Due to CDMA2000 1x's inherent backward compatibility with cdmaOne, which enables cdmaOne terminals to operate on CDMA2000 systems and vice versa, service coverage for the CDMA2000 1x system was practically equivalent to the existing cdmaOne service coverage from day one. In addition, the straightforward upgrade path from cdmaOne enabled a rapid and low cost CDMA2000 1x roll-out. Moreover, the technology maturity inherited from cdmaOne, led to the development of CDMA2000/IMT-2000 CDMA Multi-Carrier handsets that were the same size or smaller than cdmaOne handsets, had the same battery life and operational stability, with a minimal increase in cost.

In deciding how to rollout its CDMA2000 1x network, au considered two different options:

– an upgrade approach; or

– an overlay approach.

In an upgrade approach, a cdmaOne operator upgrades all of its existing infrastructure equipment and software to CDMA2000 1x in one step. This approach has the advantage of requiring less capital expenditure for the upgrade to CDMA2000, but results in some disruption of services while the cdmaOne software was modified.

In the overlay approach, a cdmaOne operator deploys a CDMA2000 network alongside its existing cdmaOne network, migrates customers over to the new network, and then upgrades the cdmaOne network equipment. This approach has the advantage of not requiring an initial modification to the cdmaOne network, enabling ongoing, uninterrupted services. However, this approach requires more capital expenditures.

After weighing these options, KDDI adopted the "upgrade" approach in its rollout of CDMA2000 1x.

[46] More detailed information is available at the ITU-D IMT-2000 website at: www.itu.int/ITU-D/IMT-2000/documents/Case%20studies%20ITU-D%20Meetings/KDDI_Japan_Annex.pdf

4 Mobile multi-media services by au

With its fully commercial CDMA2000 1x system in place, au has been offering a variety of multimedia services to its customers, including:

– Ezweb – WAP2.0-based Internet Access and Browsing Platform

– Ezweb@mail – IMAP4-based email platform

– Ezplus – JavaTM application services, with support of mobile agent function using HTTP, and automatic application update from servers

– Eznavigation – Accurate position location-based services powered by gpsOne

– Ezmovie – Video distribution available nationwide, using industry standards, i.e. MPEG-4 for video coding and MP4 for video file format

– Photo-mail (including eznavigation associated with Photo-mail, which stores location information along with pictures to provide vivid memories for travellers, the ability to provide easy recommendations on locations, and a number of business applications).

5 Objectives and goals for 3G migration: au's next step

As au continues to expand its successful CDMA2000 1x services, it is looking down the road to determine what is driving customer demand. Based on its experience with IMT-2000 services, au has discovered, to no one's surprise, that customers want large-volume content with low prices. An obstacle to providing advanced applications with rich content is the cost per bit of data. Therefore, a low-cost infrastructure for data transactions is required. Reducing cost per bit is essential for the provision of content-rich services and applications.

In order to further reduce the cost per bit and offer its customers more content-rich applications, au plans to add CDMA2000 1x EV-DO later in 2003. CDMA2000 1x EV-DO is specifically tailored for asymmetric high data rate packet telecommunication with mobility. It uses the same carrier width that cdmaOne and CDMA2000 1x occupy (1.25 MHz), and has similar RF characteristics and link budgets, allowing collocation of CDMA2000 1xEV-DO carriers and base stations with those of CDMA2000 1x network. The forward link (base station to mobile) sector throughput of CDMA2000 1x EV-DO is 600 kbit/s or higher on average, with 2.4 Mbit/s as the peak, which performs very much higher (kbit/s/Hz) than CDMA2000 1x or WCDMA.

RUSSIAN FEDERATION – Evolution and migration of 1st generation NMT450 analogue mobile networks to IMT-2000

Source: Russian Federation

1 Background on NMT450 evolution and migration

Nordic Mobile Telephone (NMT)[47] is a first-generation analogue mobile cellular network standard that was first deployed in 1981 in Scandinavia in the 450 and then in the 900 MHz band, and later in 12 other Eastern European and CIS countries including the Russian Federation in the 450 MHz frequency band[48]. NMT450 was the first federal cellular standard deployed in Russia in 1991. The number of users of NMT450 in Russia once reached 1 million, but is now declining.

In 1998 a need for digital technology for future migration of NMT networks was identified at the NMT MoU Plenary. After studying three different technology options for digitization of the NMT systems, two technologies were selected in 1999 for future evolution of the NMT450 networks: GSM400 and CDMA450. After deployment of two trial GSM400 networks, this evolution path was abandoned by manufacturers who supported it. Between October of 2000 and December of 2002, trials of CDMA450 (also known as IMT-MC-450, or Band Class 5 of IMT-2000 CDMA Multi-Carrier[49]) were conducted by different NMT operators in Russia, Hungary, Romania, Sweden, Georgia and Belarus. Trials have led to successful commercial launches in Romania, Belarus and then in Russia.

2 IMT-MC-450 studies and trial networks

The Russian Administration, in support of requests from leading NMT450 operators, has initiated a study on effective use of the 450 MHz frequency band by digital technologies for smooth migration of NMT450 networks. The studies included studies of NMT network evolution options and implications, EMC and sharing studies of CDMA technology. Studies were carried out by leading Russian scientific research institutes. Studies have shown that IMT-MC-450 is an effective solution for evolution of NMT450 networks in Russia.

In order to practically support the results of theoretical studies trial networks were deployed first in Moscow by Moscow Cellular Communications (December 2001) and then in St. Petersburg by DeltaTelecom. The trials were aimed at testing system coverage and capacity, high-speed packet data capabilities, electro-magnetic compatibility (EMC)/sharing with NMT450 network and other users of the band and adjacent bands, and roaming capability.

The following trial results were reported by operators:

– single cell radio coverage of up to 50 km;
– capacity claims proved;
– approximately 100 kbit/s average packet data transfer rate (download and upload) achieved in urban environment, in movement;
– excellent voice quality experienced;
– roaming successfully tested;
– EMC: two networks, analogue and digital, may coexist in the band, if the guardbands are used at both sides of CDMA carrier.

Based on the studies results and trial network tests IMT-MC-450 was chosen by the Ministry of Telecommunications and Informatics of the Russian Federation as the technology evolution path for existing

[47] See Report ITU-R M.742-4, Annex 3 for a general description of the NMT standard; See NMTA, website at: http://www.nmtworld.org for more information on NMT450 operators.

[48] Almost all of NMT450 networks operate in the 450-470 MHz frequency band.

[49] See Recommendation ITU-R M.1457-3.

NMT450 networks in Russia. The IMT-MC-450 standard was adopted as a federal standard in the Russian Federation.

3 IMT-MC-450 commercial network deployments

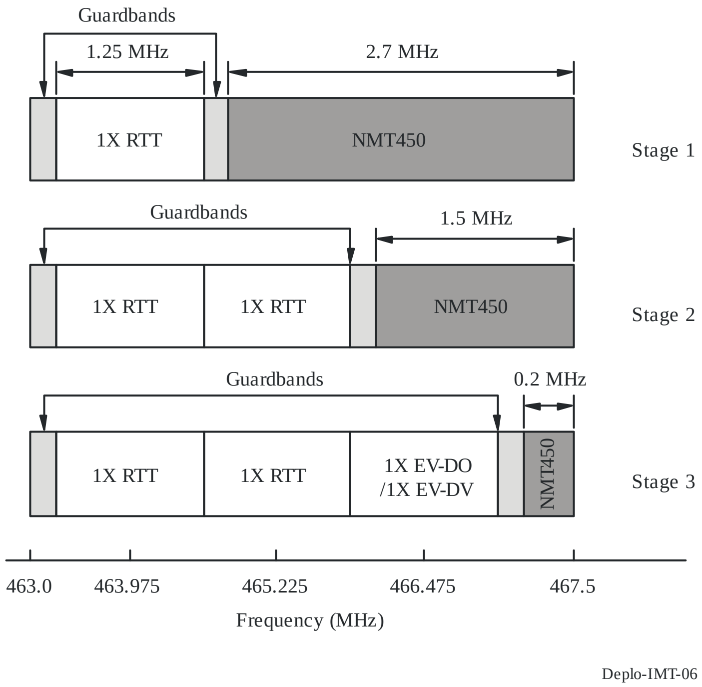
Following the trials and decision of the administration mentioned above, DeltaTelecom deployed a full scale commercial IMT-MC-450 network in St. Petersburg, Leningradskaya Oblast (Region), and several other regions in the north-west of Russia under the trademark “SkyLink”. Moscow Cellular Communications (MCC) is currently deploying an IMT-MC-450 network in Moscow and the Moscow Region to provide services under SkyLink name starting this autumn. There are other NMT450 operators in Russia currently deploying IMT-MC-450 networks in other parts of the country.

3.1 Stages of IMT-MC-450 network deployment

Studies have shown that smooth migration to digital technology in the 450 MHz band may be performed in several stages, as illustrated in Fig. 6. In most cases, the NMT450 operators have limited bandwidth available (2 × 4.5 MHz on average), which allows usage of three IMT-MC-450 carriers (1.25 MHz each). The need to move from one stage to another may appear at different times in different parts of the network. Traffic demands may greatly vary across the covered territory. Thorough analysis and careful planning should be used to achieve high efficiency and quality.

FIGURE 6

Spectrum usage (BS Tx band) in 3 stages of network evolution



1 *First stage: initial deployment*

First, a single IMT-MC 1X carrier is introduced. This requires the NMT450 operator to clear 2 × 1.79 MHz of spectrum used by the analogue NMT system (2 × 1.25 MHz for the 1X carrier, and 2 × 2 × 0.27 MHz for a guardbands between the IMT-MC and analogue narrow-band carriers). At this time, the NMT analogue network is still operational and providing service to the customers in parallel with the new IMT-MC system.

2 *Second stage: network growth*

With growth of voice and data traffic in parts of the network, a second IMT-MC 1X carrier can be introduced. This requires the operator to clear an additional 2 × 1.25 MHz of spectrum used by the analogue NMT system. No guardbands between the IMT-MC carriers is needed. Depending on traffic demand, one IMT-MC carrier can be used mainly for voice, while the second carrier can be used for voice and data. During this stage, NMT analogue subscribers are still being served by the network, but with limited quality due to restricted bandwidth of 1.5 MHz.

3 *Third stage: high demand for data services*

When the data traffic in the network increases substantially and higher bit rates are desirable by end users, a data-optimized carrier – (1xEV-DO) and furthermore 1xEV-DV can be introduced[50].

3.2 Commercial IMT-MC-450 services

When SkyLink began its IMT-MC-450 commercial operations, the cellular mobile radio telecommunications market in St. Petersburg was well developed with nearly 37% penetration and with three competing operators, Megafon and MTS (GSM), and Fora (analogue).

SkyLink's objectives for its IMT-MC-450 deployment were to:

– replicate coverage of its analogue NMT network and continue provision of high-quality voice services, and
– provide a variety of new data services to compete with the GPRS services offered by its competitors.

1 *Coverage*

SkyLink began offering commercial IMT-2000 services over its IMT-MC-450 network in December of 2002. Initially, the network deployment was limited to St. Petersburg and its nearest suburbs. In order to cover the same geographic area as its analogue NMT system, SkyLink deployed IMT-MC-450 base stations (BTSs) on top of 60 of the 67 existing analogue NMT cell-sites. It was shown that the coverage quality of IMT-MC-450 network is significantly better than that of the analogue NMT system.

2 *Services*

In addition to providing high-quality voice services, SkyLink is offering the following advanced data services over its IMT-MC-450 network:

– high-speed access to the Internet (with data rates up to 153 kbit/s) using computers, notebooks and PDAs;
– access to specialized Web-portals using mobile terminals or PDAs[51];
– email reception and transmission with SMTP/POP3 protocols using mobile terminals or computers;
– mobile games and specialized applications, such as "Search of objects" with option to receive a city map with the found objects on PDA screen.

When it began providing these services, SkyLink decided to offer three different pricing plans, see Table C.2.

The duration of voice conversations was not limited, and the cost for data transmissions over the limit is USD 0.3 per MByte.

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50 Assuming 2 × 4.5 MHz, continued analogue NMT operation is not possible in areas where all three IMT-MC 450 carriers are in use.

51 The SkyLink network is developed and constantly modified the Web-portal SkyMobile on which is collected the most important, operatively updated information on the user's account, dealers, cash departments, news, exchange rates, weather, help phones, etc.

TABLE C.2

Pricing plans (Tariffs)	Subscriber's number	Voice minutes included	MBytes of data included	Monthly fee (USD)
1	7-digit (local StP numbering area)	Unlimited	75	72
2	7-digit (local StP numbering area)	Unlimited	30	60
3	10-digit: (8-901+ 7-digit)	Unlimited	30	50

3 *Network and service offering expansion*

Once it completed its initial network deployment in the St. Petersburg region, SkyLink began to expand its IMT-MC-450 network and services to the Leningrad Region. Wireless service penetration in the St. Petersburg and Leningrad Region had increased to 45%, with four GSM operators (Megafon, MTS, BeeLine and Tele2), which were offering a variety of services using GPRS, including MMS.

Under these conditions, SkyLink decided to focus its IMT-MC-450 network deployment and service offering in the Leningrad Region area where the majority of the population (more than 50%) lives, and to offer a wider variety of higher quality voice and data services.

The new pricing plans included: the Manager Tariff (USD 30 monthly fee, includes 300 min to public telephone network (PTN) numbers and an unlimited number of minutes to mobile phone numbers); and the Special Tariff (exclusively for analogue NMT subscribers that migrate to the IMT-MC-450 network).

The expanded list of data services included: protected access to intranet (based on VPN); a significantly extended list of services through the Web portal; and preparation for introduction of special platforms of online access to wireless applications using binary runtime for wireless (BREW).

3.3 Lessons learned from commercial IMT-MC-450 operations

Based on its experience with a commercial IMT-MC-450, SkyLink has made the following observations:

1. Actual capacity and network throughput of the IMT-MC-450 network met declarations made by equipment manufacturers.
2. Electromagnetic compatibility between the analogue NMT and IMT-MC-450 systems was achieved when guardbands were implemented between the analogue and digital carriers.
3. No serious electromagnetic compatibility problems occurred between the IMT-MC-450 system and other wireless systems operating in adjacent frequency bands.
4. The adopted market entry strategy, including tariff plans, was justified: Despite a high entrance fee (> USD 400) there is a steady demand for offered services;
   - More than half of subscribers use data services;
   - Average monthly data traffic volume is approximately 10 Mbytes per subscriber;
   - More than 5% of subscribers have monthly data traffic volumes significantly exceeding the amount included in the pricing plan (30 MBytes per month for pricing plan 1 and 2, see Table C.2);
   - Average revenue per subscriber (ARPU) of IMT-MC-450 network is eight times more than the ARPU of analogue NMT450 network;
   - Stable growth of subscriber base of IMT-MC-450 network.
5. The further reduction of analogue NMT subscriber base in 2004 will enable to enter the deployment of a second IMT-MC-450 carrier, that will double the network capacity.

4 Conclusion

The evolution path for the 1st generation NMT450 analogue mobile networks to IMT-2000 has been explored in Russia by studies and trial networks, and has proved successful by commercial launches in Russia and elsewhere in Eastern Europe.

The use of IMT-MC in the 450 MHz frequency band may serve as an efficient solution not only for NMT450 operators seeking to evolve their networks, but also for new operators interested in providing IMT-2000 services across vast territory with less investment. At the same time experience of rolling out of IMT-MC-450 network in St. Petersburg has shown that the system also allows operators to build IMT-2000 systems in the 450 MHz range in territories with high density of traffic.

The experiences of the NMT operators in the Russian Federation demonstrates that there is a demand for wireless data services and Internet access, particularly as subscribers get used to paying not for session duration, but for information volume. In addition, in the absence of advanced wireline infrastructure, IMT-MC-450 networks provide a unique opportunity to deliver high-speed data services (especially access to the Internet) to subscribers in both urban and rural areas.

In conclusion, the Russian Federation anticipates that the experience of its NMT450 operators in evolving their 1st generation analogue systems to IMT-2000 using IMT-MC-450 will be useful to other countries and operators as they investigate their options for IMT-2000 deployment.

THAILAND – Implementation of IMT-2000 technology (EDGE) in Thailand

Source: Advanced Info Service Public Company Limited

1 Introduction

Advanced Info Service Public Company Limited (AIS) started out in the information technology field as a computer service provider and today we have firmly established ourselves in the wireless telecommunications sector as an analogue mobile phone service provider of cellular 900 and digital GSM systems. With over 13 million subscribers AIS is not content with being Thailand's leading mobile phone service provider, AIS continues to integrate the latest in advanced technology and deliver more than just voice telecommunication into the hands of its subscribers. In return for their confidence and support, AIS is committed to exceeding customer expectations in all aspects of mobile phone technology provision and service.

2 EDGE

In October 2003 AIS began to roll out EDGE technology in Bangkok's financial district and Chonburi, other major cities will be upgraded by December or January 2004. The decision was made by AIS to deploy EDGE to satisfy customer demand. Current customer demand expects wireless data to provide the same data rates as wireline data does. WLAN technology is currently used in hotspots to ensure that these data rates were satisfied however it has been found that these rates were demanded in a wider area.

AIS see EDGE as the technology that is essential to cater for user demand and improve quality of service (e.g. faster FTP/MMS/email). EDGE will provide AIS customers with mobile data and multimedia services such as video streaming, Internet browsing, email and corporate data access. The enhancements will enable customers in Thailand to access mobile multimedia services at higher speeds, and improve the quality of service such as video message, multimedia messaging service, Java games, email and WAP browsing.

3 Marketing

The marketing of EDGE today is not different from that of marketing GPRS. AIS have been focusing on the marketing of services and applications rather than technologies behind the services. Customers are educated about how they can receive better QoS using bandwidth consuming services and applications if they switch to using an EDGE capable phone. The special marketing promotion will be advertising the bundle of EDGE/GPRS and WLAN package. This promotion is set up to give more benefit to heavy data users and convince them to switch to using EDGE capable phones.

4 Spectrum efficiency

EDGE stimulates the growth of mobile data traffic, increasing throughput by up to three times that of GPRS. The increase in quality and speed means that user experience with data services will improve for both private user and business customers. High-speed access will become available to MMS, video and audio streaming, intranet/Internet access and corporate email.

EDGE was first rolled out in the main centres of Thailand because of the high data traffic in that area. AIS expected that heavily consuming data users mostly would adopt new bandwidth consuming applications. Speed provided by GPRS may not be able to satisfy their QoS demand on those applications.

In that area, AIS dedicated four time slots (TS) for EDGE/GPRS traffic channels. Assuming that a user with GPRS phone would like to download 120 kByte video mail. With GPRS phone (1 Tx + 4 Rx), it takes around (120*8)/(4*10) = 24 s: but with an EDGE phone (1 Tx + 2 Rx) it only takes around (120*8)/(2*30) = 16 s. In addition there are 2 TS left available for other EDGE/GPRS users to use also. So, QoS on data usage is better. The QoS on voice usage will be achieved only when all data users switch to use EDGE phone and remain downloading same data volume; then, some EDGE/GPRS TS can be freed up for voice calls.

5 3G evolution/compatibility

3G licences have not yet been awarded to operators in Thailand so by implementing EDGE, AIS are able to provide 3G like services at a relatively low cost. Given that EDGE shares the same packet core network with WCDMA and that is it also backward compatible with GPRS, EDGE will enable AIS to provide a seamless and standardized migration to 3G in the future.

UGANDA – GSM networks bring health care to rural Uganda

Reprinted with permission, Cellular News – 23 September 2003

The launch of a nationwide, wireless network to improve Uganda's ability to treat patients and combat the spread of disease was announced yesterday. The network is built around the country's well-established cell phone network, inexpensive handheld computers, and innovative wireless servers called "Jacks". The technology allows health care workers to access and share critical information in remote facilities without fixed telephone lines or regular access to electricity.

The announcement was made by Canada's International Development Research Center (IDRC), WideRay, a wireless technology company based in San Francisco, and SATELLIFE, a non-profit organization focused on improving health in developing countries.

The Jack servers, which are about the size of a thick textbook and use long lasting industrial-grade batteries – a single charge lasts up to a year – are being installed in health care facilities across Uganda. Health workers can link to the device using the infrared port on their handheld computers to retrieve or submit information, and to access email.

"This is going to be a giant leap forward for Ugandan health care. It could save thousands of lives and have significant benefits in health outcomes for Uganda's citizens", said Holly Ladd, Executive Director of SATELLIFE.

This project will provide health practitioners in the field with tools that were previously unavailable or outdated. For example, users can now access the latest treatment guidelines for tuberculosis and malaria and learn of the most cost-effective approaches to fight HIV/AIDS, which infects one in 10 adults in Uganda. They can also read the latest medical journals and textbooks from around the world, in a digital form.

The technology should also improve health care administration by reducing the time taken to submit, analyse and respond to reports and requests for supplies.

Recognizing the potential of this technology for Uganda, Connectivity Africa, a Canadian government initiative managed by IDRC and funded from Canada's Fund for Africa, contributed USD 565 000 to the development of this information network.

"The convergence of new technologies low-cost handhelds, broad and reliable wireless coverage and WideRay's innovative use of it have made applications that once seemed impossible in Africa a reality," said Richard Fuchs, Director of IDRC's Information and Communication Technologies for Development (ICT4D) programme area. "This project will be a powerful example to the rest of the world of what is possible with wireless technology".

VENEZUELA – Venezuelan experience on the implementation of a CDMA 1x network by one existing TDMA operator in the 800 MHz band (824-849 MHz/869-894 MHz)

Source: Venezuela

1 Background

By 2001, one Venezuelan mobile operator, completed studies on the feasibility and revision of the business case for deployment of a new technology in the 800 MHz band, with two options: GSM and CDMA, and several requirements, such as: substantial increase in network capacity, greater compatibility with existing infrastructure, better positioning to provide 3G services, and substantial reduction of future CAPEX and OPEX requirements.

In studies of the two options, six main aspects were taken into account by the operator:

– Availability of technologies in the 800 MHz band.

– Efficiency of frequency use (traffic handling capacity).

– Compatibility with existing infrastructure.

– Positioning to offer 3G services.

– International experiences.

– Availability of terminals.

2 Study of options

2.1 Availability of technologies in the 800 MHz band

By 2001, only one digital technology could provide solutions that met the requirements considered by the operator: CDMA 1x. Some manufacturers had announced their intent to provide a GSM solution for the 800 MHz band, but thus far, this had not materialized.

The operator had then to choose either the CDMA 1x component option, with successful experiences in other countries of the Americas, or GSM, without knowing whether that solution would be developed, and without previous experiences to draw upon. In addition to the infrastructure problem, there was major concern in connection with the GSM option regarding the availability of user terminals as, thus far, no manufacturer was offering GSM terminals in the 800 MHz band.

2.2 Efficiency of frequency use (traffic handling capacity)

To date, on this item, CDMA has shown itself to be the technology making the most efficient use of the spectrum and, therefore, providing greatest traffic handling capacity. Nonetheless, we must note another important problem that had to be resolved: radio frequency engineering.

Having to implement the new network in the very congested 800 MHz band, it was necessary to revise frequencies plan to provide for the coexistence of a new technology. This involved considerable effort to make room for the new technology in part of that band without affecting the quality of the existing TDMA system.

2.3 Compatibility with existing infrastructure

As GSM is a form of TDMA technology, some people had the impression that there was greater compatibility between these two technologies (GSM and TDMA) than between TDMA and CDMA. However, the fact that IS-136 and GSM are two forms of TDMA does not mean that they are at all compatible from either the user terminal or the operator network standpoint, while TDMA and CDMA networks share the same telecommunications protocol in the core network (ANSI-41).

Such a feature of compatibility enabled the operator to share the same TDMA applications and systems on a new CDMA 1x network. In concrete terms, it meant sharing such important platforms as HLRs, voice mail, SMS, WIN, prepaid, etc., enabling customers to migrate from the TDMA to the CDMA platform while retaining their telephone numbers and user profiles.

2.4 Positioning to provide 3G services

Careful study of a TDMA operator's options in migrating toward 3G shows that the GSM route requires additional spectrum (UMTS spectrum), as well as two additional platforms: the GSM network and the UMTS network. However, the CDMA2000 route does not require additional spectrum, as it can be implemented in the 800 MHz band on only one platform: the CDMA2000 network.

2.5 International experiences

By 2001, the European operators that had invested heavily to obtain licences for use of the spectrum required to implement UMTS were in a critical situation from a financial point of view. Many could not make payments while others were asking governments to relieve them of their payment obligations. Problems were aggravated by delays in the development of UMTS technology and none of the implementation commitments had been fulfilled. In fact, new delays were announced regularly.

On the other hand, Korean and Japanese experiences with the CDMA 1x platform had been very successful. The number of users was growing rapidly and new applications and terminals were appearing every day.

2.6 Availability of terminals

For purposes of the decision, the terminal issue was one of the more studied aspects. The operator had already learned from experience how advantageous it was to have a wide variety of terminals tailored to the different customer segments, as well as manufacturers willing to provide in the terminals the latest technological innovations in the technology used by the operator. Thus, the decision had to take into account the existence of a wide range of manufacturers, committed to delivering terminals tailored to the applications to be implemented and to market requirements, taking into account the Korean and Japanese experience, as well as the decision taken by one large North American operator, and one large Brazilian operator to implement the technology CDMA 1x, generated confidence that terminals would be available.

3 Network construction and commissioning

The project to install and bring into operation the CDMA 1x component platform consisted, as mentioned above, of building a network parallel to the TDMA network (over 400 cells), retuning the entire existing network (AMPS and TDMA) to free the necessary spectrum to raise the CDMA 1x carrier, adaptation of sites for installation of the new radio base stations and the MTX, interconnection, connecting platforms and common nodes to the AMPS, TDMA, and CDMA 1x, and adjustment of operating systems, billing, and administrative procedures.

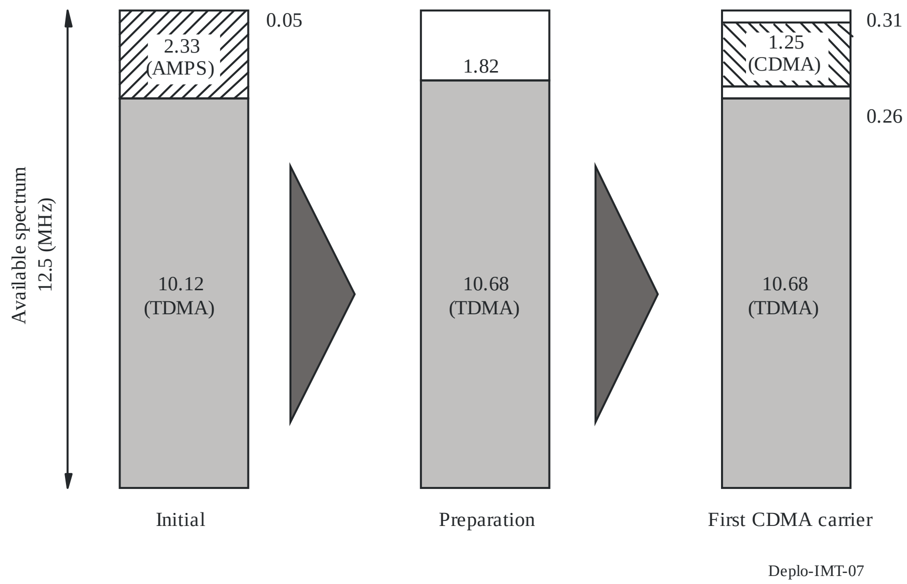
One of the project's main challenges was to integrate the TDMA and CDMA 1x networks into the core network, operations support systems (OSS), and business support systems (BSS). The objective was to ensure number portability between networks, transparency of services, and compatibility of the two networks by reutilizing platforms providing basic and value added services, such as SMS (Moviltexto), voice mail (Movilmensaje), HLRs, the other voice services, SCP, and Wireless Intelligent Network (WIN), both for the prepaid service collection platform and for calling records to bill for the new network's services. Processes and systems to support the new wireless data services also had to be designed.

At the time the project began, no platform existed enabling subscriber's profiles and locations to be stored (HLR) that was capable, for both networks simultaneously, of handling and managing subscribers to ensure the transparency of the process.

At the same time, an exhaustive study had to be made of the services associated with the WIN network and their current support procedures so as to be able to integrate them with the new network.

FIGURE 7

Plan for spectrum migration to CDMA 1xRTT



The possibility of coverage of 1x subscribers under the analogue network had to be evaluated, as several services required fundamental changes in treatment. Even basic services such as voice messaging required adjustments to call routing procedures owing to existing differences among providers.

Prepaid service had been operating over TDMA with manufacturer's proprietary protocols which, with introduction of the new network and a new provider, became an obstacle to integration with 1x. For this service, solutions were more sophisticated. Negotiations were conducted with providers and competitors to ensure deployment of a system based on the standard IS-826 telecommunications protocol for prepaid mobile telephony systems. This involved designing a new network architecture, in order to meet the objectives by the deadlines without affecting existing systems.

Within nine months – from January to October 2002 – all these efforts had met with success, with participation by all company units, while simultaneously satisfying the installation and operating requirements of the existing AMPS, TDMA, and CDPD networks.

4 Tests of operation

The commercial certification process consisted of validating the network's commercial operation through the use of general testing protocols for calls, services, and systems supporting commercial operation and customer services. The certification process was conducted on different call and service systems, that is, postpaid and prepaid on-line systems, agents' extranet, voice activation, on-line, operator and operational intranet (Switch-MTX and short message service, postpaid and prepaid calls and services, tests in outdoor locations; indoor tests in each region's most important structures; handoff: maintenance tests for calls when the receiving radio base station changes, for both digital and analogue radio base stations; IVR: card activation, data transmission).

Tests were divided into postpaid and prepaid categories, and a multidisciplinary certification team was formed. Its structure was: the fault repair group, responsible for monitoring and correcting problems on systems operated on; the operator; the testing group, organized into regions by the regional managers; and a group of regional manager's office employees, responsible for call and service tests. The test protocol explained the objective, scope, and execution of each test, as well as the anticipated result. This tool was highly important in team coordination, for which a small group was required, which acted as liaison between the regions of each commercial area.

SOUTH KOREA – Implementation of IMT-2000 OFDMA TDD WMAN technology (referred to as SHOW WIBRO) by KT Corporation in the Republic of Korea

1 Introduction

KT Corp.(www.kt.com), top integrated wired and wireless communication service provider with more than 30 million customers in Korea, has been leading the development of the information and communication business for the last 28 27 years. Consequently, KT has performed a dominant role to turn Korea into IT powerhouse with the cutting edge technologies in broadband services.

With the commercial launch of OFDMA TDD WMAN technology (mobile WiMAX) in June 2006 under the service name of SHOW WIBRO (formerly KT WIBRO), KT entered into mobile personal broadband market.

2 Network deployment

From October 2008, network coverage has been expanded to Seoul and 19 surrounding cities in Gyeonggi province and major cities around the nation to pave the way for U-Korea with ubiquitous infrastructure through which people can share information wherever they are. The whole service area encompasses almost 50% of total Korean population.

During coverage expansion, KT has deployed Wave 2 type base stations, which support MIMO technology, so that we had coverage expansion and increase in throughput almost twice. Currently, SHOW WIBRO enables mobile access even in the fast moving vehicles such as a bus and subway up to 120 km/h with the data rate 37.4 Mbit/s in downlink and 8 Mbit/s in uplink.

Simple network architecture of OFDMA TDD WMAN technology enables lower CAPEX and OPEX for service providers than other standards. In addition, all-IP based network of OFDMA TDD WMAN technology has the advantage of providing FMC(Fixed Mobile Convergence) services. With all these benefits, SHOW WIBRO is now dominant leader with 58% of market share in Korea's mobile broadband market.

3 Business strategy

Even though penetration rate of fixed broadband in Korea is more than 85%, there are still needs for mobile personal broadband service. SHOW WIBRO focuses on users who demand heavy data usage with affordable price and meets their needs since the data rate is faster and price is more affordable compared to other available standards. This leaded to phased approach in marketing strategy as first phase aimed to lead the mobile broadband market shares. Second phase targeted more personal approach by providing personalized services and applications. Now SHOW WIBRO has broadened business area into vertical and M2M market delivering solutions for not just the personal broadband users but also business users.

KT has opened the way trial users can experience and share SHOW WIBRO services experience more naturally. "W-Style shop" is one good example. For example, users can make their own contents and upload them in the UGC (User Generated Contents) studio or they can enjoy various group activities. KT is not only selling product itself but also giving people a chance of experiencing mobile 2.0 culture and life so that SHOW WIBRO applications naturally penetrates the mobile broadband market.

4 User devices and services

SHOW WIBRO offers various types of user devices to meet all user's needs. USB dongle is regarded as the best companion for laptops since it allows internet access with mobility support. Some users prefer embedded type devices. WiMAX modem is embedded in various types of devices such as smartphone, PMP (Portable Multimedia Player), UMPC (Ultra Mobile PC), car navigation system, etc. These embedded devices are made to satisfy user's special needs since device specific service is offered to users. Smartphones support multimode functions such as WCDMA and WiMAX. Currently, USB dongle is the most popular type of user device. Recently, portable WiMAX-WiFi router, which supports maximum of 3 WiFi devices, is gaining popularity as most people already have WiFi-enabled devices.

Five key service features of SHOW WIBRO are UGC, WebMail, Multiboard, PC control, and MyWeb. The basic concept of these SHOW WIBRO services is to provide mobile triple play service (M-TPS). M-TPS enables data, media, and communication in one single network. As technology develops, these services will also be evolved.

– UGC: enables users to generate and share user generated contents in real time.
– WebMail: integrates all web-based mail accounts to SHOW WIBRO user ID so that e-mails can be checked in one single step.
– Multiboard: provides real-time online multimedia communications with internet messenger and sharing user's application between SHOW WIBRO users.
– PC control: allows to access subscriber's home PC remotely with subscribers handheld device.
– MyWeb: customizes mobile content for subscriber's personal preference.

5 Lessons from SHOW WIBRO operations

– Subscribers: Our main subscribers are businessmen (50.5%) and students (26.0%) aged between twenty and thirty-five.
– Services:
  – Most of our subscribers use SHOW WIBRO to surf the Internet.
  – Smartphone users prefer services such as webmail, PC control, etc.
– User device:
  – USB dongle is the most popular (88%) user device.
  – Portable WiMAX-WiFi router is gaining popularity.
– Tariff: User prefers "Free type (flat rate)" charging plan.

6 Future migration of the 6th IMT-2000 air interfaces

At the ITU Radiocommunication Assembly 2007, the OFDMA TDD WMAN specifications were added as the 6th IMT-2000 air interface. SHOW WIBRO's air interface technology is specified in IEEE 802.16-2005(OFDMA TDD WMAN). SHOW WIBRO uses the 2.3 GHz frequency band that has been identified for IMT.

WirelessMAN-Advanced was proposed as a Radio Interface Technology (RIT) for IMT-Advanced which will provide backward compatiblity with the 6th IMT-2000 radio interface, OFDMA TDD WMAN. Show WIBRO is expected to provide smooth and standardized migration to IMT-Advanced.

Some of the IMNT-2000 OFDMA TDD WMAN operator case studies can be found at:
http://www.wimaxforum.org/resources/documents/marketing/casestudies

SOUTH KOREA – CDMA 1x EV-DO-Rev.A deployment 3G Service (OZ) launched by LG Telecom in the Republic of Korea

1 Introduction

LG Telecom (www.lgtelecom.com) was founded in July, 1996 based on LG's technology, which had succeeded in the commercialization of CDMA technology first in the world, and since its start of nation-wide PCS commercial service in October, 1997, the company has thrived with its customers.

LG Telecom has built a nation-wide single digital network, and is trying to provide its customers with best quality mobile communications services. In particular, LG Telecom's switching and transport networks were built using optical cables enabling a superior call quality. Also the optical repeaters, notch repeaters(wireless), and mini-BTS, which LG Telecom has developed and commercialized first in the world, has been recognized as an innovative new mobile communications technology enabling the elimination of coverage holes with economical investments.

In February 1998, it has launched a first commercial mobile data service in the world, and has succeeded in the commercialization of EZ-I, the first mobile internet service in Korea. Since May 2001, it has been providing a nation-wide service of CDMA2000 1x, enabling high-speed multimedia services such as image and video services. With these, it has solidified its position in the mobile internet market.

Moreover it has completed an early deployment of 3G EV-DO Rev.A network, making possible the maximization of call quality, and strengthening its competitive power in service content and pricing areas with its convenient, low-priced open data services.

LG Telecom has developed a differentiated marketing strategy adjusting to the communication life-style of the customers, and at the same time has been securing a stable business foundation through an increase of its subscriber basis.

2 1x EV-DO Rev.A Launch and start 3G data service (OZ)

LG Telecom has been actively deploying the EV-DO Rev.A network since 2007. In April 2008, it has completed the nation-wide deployment, and launched the OZ, a new brand name for 3G data service. With the catch-phrase, "Searching on the internet with a convenience and an ease on a high-resolution big-screen handset anytime and anywhere, and checking emails and attachments should be possible", it has started a life-changing next-generation data service providing needed values in everyday life such as web-surfing and email services, and this was the breaking of the then prevalent notion that 3G service is synonymous with only the video telephony service. The OZ service provides an open mobile internet by changing the closed mobile internet model to an open model. The company achieved a tremendous success by attracting 130 000 subscribers during only 50 days after the launch, and the subscriber basis is steadily on the rise.

3 OZ service

OZ is a word in ancient Hebrew which symbolizes "power" or "authority", and conveys the intent of LG Telecom that it would provide the customers with power and practical values in the center of their lives. The OZ service provides the "open internet environment" in which it would be easy and convenient to access various contents and services of the wired internet via a mobile handset.

– Mobile messenger: Buddy list (always on), Person to person and person to multi-person chatting, "Emoticon"/"Flashcon", Sending Image.
– Widget: Providing direct path for connection of needed contents.
– Web surfing: "real" internet.
– E-mail: web-mail (POP3) access and viewing attachment file (MS Office, image ...).
– Affordable price.

4 3G Migration and next step

LG Telecom is achieving a brilliant growth of 3G data service through the OZ service. The next step for LG Telecom is to maintain the continuous success of the 3G service and to prepare thoroughly for the next generation service. To achieve these, LG Telecom is planning to continue its steady growth of 3G by providing higher data rate via the multi-carrier bundling function on the EV-DO Rev.A network and developing variety of value-added services.

LG Telecom has developed multi-mode base stations for next generation service, which would enable a simultaneous support for all access network technologies. It is preparing for an efficient network planning by enabling support for an access network of any technology by changing only the base station units in the future next generation network deployment.