



ITU-D

STUDY GROUP 2

4th STUDY PERIOD (2006-2010)

QUESTION 18-1/2:

*Implementation aspects
of IMT-2000 and
information-sharing
on systems beyond IMT-2000
for developing countries*



THE STUDY GROUPS OF ITU-D

In accordance with Resolution 2 (Doha, 2006), WTDC-06 maintained two study groups and determined the Questions to be studied by them. The working procedures to be followed by the study groups are defined in Resolution 1 (Doha, 2006) adopted by WTDC-06. For the period 2006-2010, Study Group 1 was entrusted with the study of nine Questions in the field of telecommunication development strategies and policies. Study Group 2 was entrusted with the study of ten Questions in the field of development and management of telecommunication services and networks and ICT applications.

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This report has been prepared by many experts from different administrations and companies. The mention of specific companies or products does not imply any endorsement or recommendation by ITU.

ABSTRACT

The document contains a draft supplement to the Supplement to Guidelines on the Smooth Transition of existing mobile networks to IMT-2000 (GST) for developing countries.

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QUESTION 18-1/2

Supplement to Guidelines on the Smooth Transition of existing mobile networks to IMT-2000 (GST) for developing countries

1. Introduction

International Mobile Telecommunications-2000 (IMT-2000) systems provide access to a wide range of telecommunication services, supported by the fixed telecommunication networks (e.g. PSTN/ISDN/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.

1.1 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. As of June 2009, WP 5D has developed Revision 9 to Recommendation ITU-R M.1457. This revision will be considered for adoption by the 7-8 December 2009 SG 5 meeting.

1.2 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/Internet protocol (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.

1.3 Driving forces for IMT-2000

Some of the key features and objectives of IMT-2000 were the desire for a global system offering new services and capabilities, which could evolve or migrate from existing systems and which would be capable of operating in multiple environments.

The global system envisioned would be one that employed a global family of standards using common frequency bands,¹ enabling worldwide roaming, and compatible off-the-shelf equipment at reasonable prices.

The new services and capabilities would be significantly more advanced than pre-IMT-2000 technologies. The services would include a range of voice and non-voice services, including packet data and multimedia services. The system would support significantly higher user bit rate capability and offer a flexible radio bearer. It was considered essential that IMT-2000 support both symmetrical and asymmetrical data capabilities, Intelligent network (IN) based service creation and service profile management based on ITU-T Q.1200-series of Recommendations, and coherent systems management based on ITU-T M.3000-series of Recommendations. The capability to provide bandwidth on demand supporting a wide range of data rates, from simple low rate paging messages through voice to high rates associated with video or file transfer was also desired.

Users would experience higher service quality and integrity, comparable to the fixed network. They would also receive the benefits of improved security and ease of operation.

The development of IMT-2000 was also driven by the need for the flexible evolution of systems, and migration of users, both from pre- IMT-2000 and evolution within IMT-2000² including the ability to coexist and interwork with pre- IMT-2000. An open architecture was desired, which would permit easy introduction of advances in technology and of different applications, compatibility of services within IMT-2000 and with the fixed telecommunications network (e.g., PSTN/ISDN).

The flexibility envisioned for IMT-2000 would offer multi-environment capabilities, such as integrated satellite/terrestrial networks, operation in aeronautical and maritime environments, provision of services to both mobile and fixed users in urban, rural and remote regions, and support for high and low density areas.

Within the family of standards, it was desired that there be the maximum level of interworking between networks of different types to provide customers with greater coverage, seamless roaming and consistency of

¹ Although a worldwide common frequency band was the original objective of IMT-2000 (e.g., Rec. ITU-R M.1308), several frequency bands are now identified in the Radio Regulations as the result of decisions of WARC-92, WRC-2000 and WRC-07.

² “Evolution within IMT-2000” means the evolution of the individual IMT-2000 terrestrial radio technologies.

services. Similarly, there was a need to be able to use adaptive software downloadable terminals to support multiband and multi-environment capabilities.

The development of IMT-2000 was also driven by the desire for a modular structure which would allow the system to start from as small and simple a configuration as possible and grow as needed, in size and complexity. Finally, it was desired that IMT-2000 address the needs of developing countries and offer better use of the radio spectrum than pre- IMT-2000 systems, consistent with providing services at acceptable costs, taking into account their differing demands for data rates, symmetry, channel quality, and delay. In developing countries, the task of bridging the digital divide has arrived at a juncture where most of the countries are still grappling with the problem of providing voice access. Large-scale computerization and growth of e-services require the availability of higher bandwidth on the access loop. In these countries, most of the access lines are likely to use wireless technology and, therefore, options such as xDSL or CATV or ISDN are not suitable for mass scale consideration. High-speed wireless data capability, using IMT-2000 would provide mobile wireless access technology giving IMT-2000 a unique opportunity in these markets.

In the developed countries the local copper loop has been unbundled to promote competition in broadband. It is not possible to carry out such unbundling in the wireless network. Consequently, wireless technologies can be an alternative to provide competing broadband services.

2. Update on “From existing mobile networks to IMT-2000”

The transition from pre-IMT-2000 to IMT-2000 systems will happen over a period of time, thus allowing operators to fully exploit and capitalize on investments made in their pre-IMT-2000 infrastructure. Potentially, there are several transition scenarios for wireless operators to move from existing systems towards IMT-2000. Administrations and operators alike should consider what solutions are available at the time the transition is considered and conduct extensive financial and technical analyses before making decisions on the best approach.

Most mobile network operators in developed countries have already identified evolution paths to IMT-2000 networks. By and large, operators of GSM, the Americas’ TDMA and Japan’s PDC (Personal Digital Cellular) networks have identified evolution paths to IMT-2000 CDMA Direct Spread (WCDMA) and IMT-2000 TDMA Single Carrier solutions. cdmaOne (IS-95) operators and some TDMA operators have identified evolution paths to IMT-2000 CDMA Multi-Carrier (CDMA2000) solutions, while some operators are transitioning to the new IMT-2000 standard, OFDMA TDD WMAN.

The chosen transition paths reflect local situations and conditions – 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 operational and economic implications of the network deployment be assessed. By taking into considerations all these aspects, it is apparent that there is no single solution that is right for every operator.

3. Update of IMT-2000 terrestrial technologies

The IMT-2000 standardization process was established by the ITU, which followed thorough and meticulous steps that considered the users’ 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-R and the development of Recommendation ITU-R M.1457 “Detailed specifications of the terrestrial radio interfaces of International Mobile Telecommunications 2000 (IMT-2000).”

IMT-2000 consists of a number of Radio Access and Core Network systems which are described in the following subsections.

3.1 IMT-2000 Radio Access Networks and Standards³

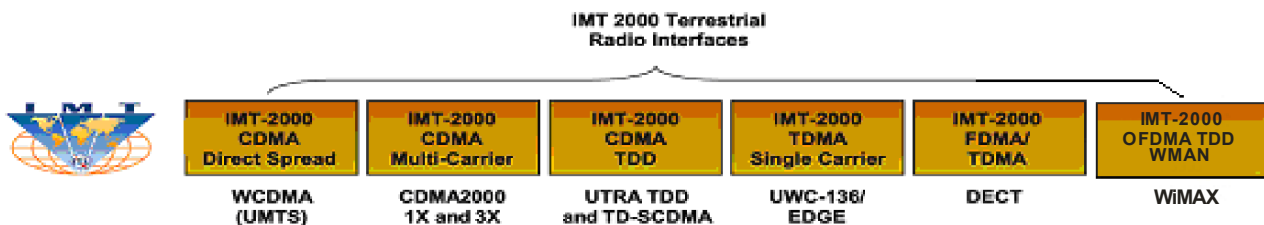
The IMT-2000 terrestrial radio access technologies are based on various combinations of code division multiple access (CDMA), time division multiple access (TDMA), TD-SCDMA (time division synchronous code division multiple access), OFDMA (orthogonal frequency division multiplex access), single-carrier, 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.

3.2 IMT-2000 Terrestrial Radio Standards

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 3.1: IMT-2000 Terrestrial Radio Interfaces⁴



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

³ As used in this document, the term “standard” means a specification published by a Standards Development Organization, for example, ITU-R or ITU-T Recommendations.

⁴ UWC-136 is no longer a term being utilized for IMT-2000 TDMA Single Carrier.

3.2.1 Radio Network

A Radio Access Network consists of one or more Radio Network Systems. The Radio Network System (RNS) is the system of base station equipment (transceivers, controllers, etc.) which is viewed by the MSC as the entity responsible for communicating with Mobile Stations in a certain area. The radio equipment of an RNS may support one or more cells. An RNS may consist of one or more base stations. In the case of UTRA FDD and UTRA TDD both radio interfaces can be supported within a single radio access network.

3.3 IMT-2000 Core Networks

In addition to the Radio Network, the other essential component of the IMT-2000 terrestrial family is the Core Network. This section provides information on the core networks for the IMT-2000 Family members specified by each of the 3G Partnership Projects and transposed into standards by their respective partner Standard Development Organizations (SDOs). There are two such IMT-2000 Family Members and they are further described in the following sections.

ITU-T is addressing a number of aspects of harmonization of core networks of IMT-2000 family members. One area is the investigation of the differences between the IP Multimedia Subsystems (IMS) of the two 3G Partnership Projects. This work is converging within the 3G Partnership Projects, and it is anticipated that it will form the basis for a harmonized core network for systems beyond IMT-2000.

Asynchronous Transfer Mode (ATM) and Internet Protocol (IP) are the two technologies and protocols of fundamental importance for the implementation of the IMT-2000 Core Networks. The Handbook "Deployment of IMT-2000 Systems" provides a description of these network transport technologies.

The two⁵ IMT-2000 Core Network types recommended by ITU are shown in the following table:

IMT-2000 core networks for the two family members are defined by ITU-T with two sets of Recommendations Q.1741 for GSM evolved UMTS core network and Q.1742 for ANSI-41 evolved core network with CDMA2000 access network.

⁵ The Handbook on Deployment of IMT-2000 identifies three core network standards. However within ITU-T only the first two have been formally defined as ITU Recommendations (Q.1741.x and Q.1742.x).

Table 3.2: IMT-2000 Core Network Recommendations

Full Name	ITU-T Recommendations regarding the core network	IMT-2000 radio technologies supported by the core network
GSM evolved UMTS Core Network	Q.1741.1 (referring to 3GPP Release 99) Q.1741.2 (3GPP Release 4) Q.1741.3 (3GPP Release 5) Q.17.41.m (m signifies future releases)	IMT-2000 CDMA Direct Spread IMT-2000 CDMA TDD IMT-2000 TDMA Single-Carrier
ANSI-41 evolved Core Network with CDMA 2000 Access Network	Q.1742.1 (3GPP2 specifications as of 17 July 2001) Q.1742.2 (3GPP2 specifications as of 11 July 2002) Q.1742.3 (3GPP2 specifications as of 30 June 2003) Q.1742.4 (3GPP2 specifications as of 30 June 2004) Q.1742.4 (3GPP2 specifications as of 31 December 2005) Q.1742.6 (3GPP2 specifications as of 31 December 2006) Q.1742.7 (3GPP2 specifications as of 30 June 2008) Q.1742.n (n signifies future releases)	IMT-2000 CDMA Multi-Carrier

This IMT-2000 Core Network type is defined in the series of ITU-T Recommendations Q.1741.x. and Q.1742 and are extracted and presented for information Annexes A and B of the Midterm Guidelines (MTG) (<http://www.itu.int/itudoc/itu-d/question/studygr2/87040.html>).

4. Information on IMT-2000 Satellite Technologies

4.1 Satellite considerations

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 Recommendations ITU-R M.[1457-SAT] and a new interface is proposed to be introduced. 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.

This Supplement to the Guidelines concentrates on the terrestrial component of IMT-2000 systems.

5. Update to 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 5.1.

Table 5.1: 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

Progress and status reports of ITU Recommendations/Reports/Handbooks on IMT-2000 can be found at http://www.itu.int/ITU-D/imt-2000/ProgressStatus_textIMT2000.PDF.

6. IMT-2000 service offerings

Typical mobile and IMT-2000 service offerings include but are not limited to: voice, video, streaming video, interactive multimedia, file and image transfer, web browsing (internet and intranet access), e-mail, information services of various types (health, education, government, commerce), telemetry, messaging (SMS, MMS), mobile money, location based services, ITS-enabled services,, games and entertainment, mobile multimedia-broadcasting/multicasting, emergency calling, public alerting, priority service, and lawful intercept.

Functional and service enhancements for operators and users are explained in more detail in Sections 3.2.2 and 3.2.3 of the MTG. Additional details can also be found in Annex F of the MTG and in Recommendation ITU-R M.1822:

Framework for services supported by IMT.

7. Spectrum requirements

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.

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

Also, some administrations may deploy IMT-2000 systems in bands other than those identified in the RR.⁶

7.1 Update on frequency arrangements

In ITU Working Party 5D work on the frequency arrangement for the IMT bands 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 cheaper devices.

ITU-R WP 5D is currently updating Recommendation ITU-R M.1036-3 and has a working document including the frequency arrangements that are recommended for implementation in the bands identified for IMT in the Radio Regulations (RR).⁷ 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.

7.2 Matters for developing countries

Specific concerns of developing countries include the selection of spectrum bands identified at WARC-92, WRC-2000 and WRC-07 as well as re-allocation of pre-IMT-2000 spectrum.

Many developing countries expressed the need for the usage of lower frequency bands below those already identified for IMT-2000 for better coverage and lower cost implementation of IMT-2000. Some administrations might consider the use of the lower bands below 600 MHz for the deployment of IMT-2000 systems in cases where it is desirable to evolve an existing second generation system to IMT-2000 or to take advantage of coverage benefits for sparsely populated and low traffic density areas. A solution, appropriate for developing countries, was studied and frequency bands below 1 GHz were identified at WRC-07 to facilitate the deployment of IMT systems.

⁶ Source: Working document towards a revised Recommendation ITU-R M.1036-3, ITU-R WP 5D, Doc. R07-WP5D-C-0413!H05!MSW

⁷ Source: Working document towards a revised Recommendation ITU-R M.1036-3, ITU-R WP 5D, Doc. R07-WP5D-C-0413!H05!MSW

7.3 Principles for use of spectrum for IMT

Some of the principles underlying the use of spectrum for IMT systems are reflected in Recommendation ITU-R M.1036. In addition, regulators can use Rec. ITU-R M.1036 to define their frequency arrangements for implementation of the terrestrial component of International Mobile Telecommunications (IMT).

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

Recognizing the advantages to be gained by the transition of 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 transition from one generation to another on those bands. One of the problems faced with reallocation of pre-IMT-2000 spectrum is the fact that the IMT-2000 system would reside on frequency channels located between other channels used by the pre-IMT-2000 systems.

Worldwide, operators are using first and second generation mobile spectrum for IMT-2000. For example, operators in Brazil, Canada, Ecuador, India, Japan, Korea, Mexico, New Zealand, Venezuela and the United States, 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, and Sweden have upgraded first generation systems in the 450 MHz band to IMT-2000.

Given the significant initial capital expenditures necessary to deploy entirely new IMT-2000 systems, these operators are finding that upgrading networks in existing spectrum is a more economically viable option. Furthermore, 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 economies of scale.

8. Update on 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 in general (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 are available as commercial networks become a reality. SIM (Subscriber Identification Module) cards are another solution that can help overcome some of the interoperability issues between networks, but nevertheless require the use of multimode or multiple handsets to operate on different networks. In support of achieving these interoperability and roaming goals, 3GPP, 3GPP2, and WiMAX Forum are working to ensure:

- Interoperability between the 3GPP IMS 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 Alliance⁸, 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 users' needs.

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

- Access to emergency services.

⁸ www.openmobilealliance.org

- Location information.
- Lawful interception.

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 data base 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 advanced authentication procedures than second generation wireless networks, deploying 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.

9. Update on Transition Paths

9.1 Introduction

There are a number of pre-IMT-2000 systems, both analog 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, M.1033 and 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 transition paths for each pre-IMT-2000 system differ. However, in most cases, the transition requires the addition of IMT-2000 base station equipment and/or software, necessary modifications of or additions to 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 a transition 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 transition include availability of equipment and service applications for the various technologies and their performance in the desired operating environment.

Typical operators’ experiences of transition are provided in Annex I, for both developed and developing countries.

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

- A core network with links to the PSTN (Fixed Telephone Network), ISDN, the Internet/Intranets and external mobile and data networks.
- A Radio Access Networks (RAN), eventually capable to work in several frequency bands and using complementary radio technologies (Radio Access Networks are based on radio interfaces. IMT-2000 radio interfaces are listed in section 1.3.2.1).
- 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 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 necessary modification of the system can be basically classified into evolution of components or transition of the entire system. As defined in Recommendation ITU-R M.1308:

- “evolution” is characterized as “A process of change and development toward enhanced capabilities”, whereas
- “migration” is characterized as “Movement of users and/or service delivery from an existing system to a new system”.

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.

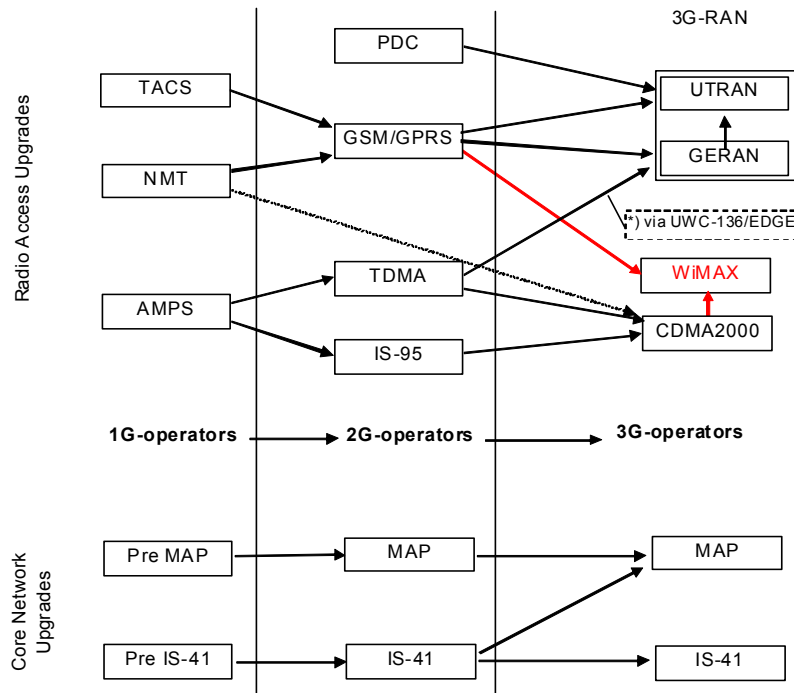
For the support of packet data services, GSM (Evolved) Core Networks have been complemented by IP based GPRS-backbone networks providing a specific fast Mobility Management to the packet data services, capable of handling fast handovers for real-time packet data services; whereas IS-41 Core Networks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

IMS (IP Multimedia Subsystem) 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, Voice-over-IP-based conference calls, etc.). 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 standards provide backward compatibility, ensuring to the greatest extent possible a continuing service capability for existing operators and users.⁹

Analysis of the various transition 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 Figure 3.1. The figure shows these upgrades for both the Radio Access Network and the Core Network.

⁹ See details of 3GPP Release Process in Annex E of the MTG.

Figure 9.1: Observed network upgrades of operators


9.2 Considerations for transition

The following aspects are important for an operator to decide on a certain transition path:

- Operation in worldwide harmonized frequency bands;
- Existing/forecasted market share/market penetration of the target technology;
- Probability that other operators will adopt similar transition paths;
- Ease of the transition from existing technology to the desired technology;
- The system architecture of the target technology has to be future proof (i.e., capability to expand to cope with new requirements and new emerging services);
- Status of the corresponding standards.

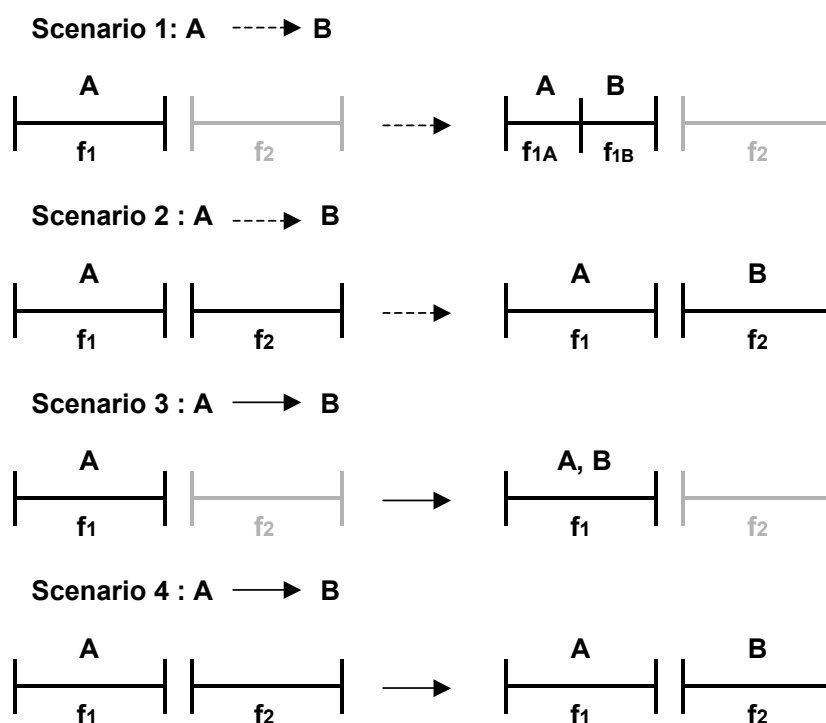
These aspects are important because the past shows that the success of a certain mobile communication technology depends in particular on roaming capabilities (see points a to c above), on affordable equipment prices for terminals and also infrastructure (see points a to e above), and on the ability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

In case of transition of a system, the major issues are spectrum usage and system configuration. When an operator transitions to an IMT-2000 system, coverage and capacity gains occur. Therefore as users transition from the pre-IMT-2000 system the operator can gain spectrum efficiencies with the more advanced system. As for spectrum usage, four scenarios are possible, subject to regulatory conditions (see Figure 3.2-1 and Figure 3.2-2):

- 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 (f1) is split and some of the spectrum is allocated for the IMT-2000 system (f1b) and the rest remains in service for the pre-IMT-2000 system (f1a). New spectrum (f2) 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 (f2) while evolving the capabilities of the pre-IMT-2000 system in the existing spectrum (f1).
- 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). New spectrum f2 is not needed in this scenario.
- Scenario 4: The IMT-2000 system (B) is an evolved version of the pre-IMT-2000 system (A). The IMT-2000 system (B) can therefore fully interoperate with the pre-IMT-2000 system (A). The IMT-2000 system (B) operates in new spectrum (f2), while the pre-IMT-2000 system (A) continues to operate in the existing spectrum. Scenario 4 is often combined with Scenario 3. Therefore, the IMT-2000 system (B) is in many cases also operated in the existing spectrum.

Figure 9.2-1: Transition scenarios in IMT-2000



KEY:

A: pre-IMT-2000 system; **B:** IMT-2000 system

A -----> B: A migrates to B; **A -> B:** A evolves to B

f1: operator's current spectrum band

f2: operator's new spectrum band (different from f1)

(Actual examples of each Transition Scenario are available in Annex I "Operator experience in transitioning to IMT-2000 systems").

Figure 9.2-2: Key aspects of transition scenarios in IMT-2000

		Spectrum Bands	
		Same	Different
Backward Compatibility	Yes	Scenario 3	Scenario 4
	No	Scenario 1	Scenario 2

If the transition requires 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 when access network components are changed out. In many cases and even in the case of upgrading from a preceding generation of mobile systems to a new generation, there very often exist upgrade possibilities that affect only a few entities of the system.

If the transition is from one generation to the next generation major functionalities (services, protocols, etc.) and properties (spectrum) of the old systems remain, to a large extent, available and unchanged within the new system. An evolution of system components 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.

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 transition 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 made every effort to provide flexibility within the scope of the 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 Report, 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.

In considering transition 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 network that is the starting point of the transition will themselves be evolving even as transition is taking place. Likewise, the target IMT-2000 technology or technologies are undergoing constant evolution and enhancement as time passes. Development of specific transition paths must take due account of this.

9.2.1 Characteristics of IMT-2000 Radio Access and Core Networks Technologies

9.2.1.1 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 milliseconds. 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.

HSDPA (High Speed Downlink Packet Access) 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.

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

9.2.1.3 IMT-2000 CDMA TDD

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 from 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 for 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 only one 5 MHz channel is needed when the TDD chip rate is operating at 3.84 Mbit/s.traffic. In the TDD mode the degree of asymmetry can be reassigned rapidly improving overall operating efficiency.

UTRA TDD (3.84 Mbit/s option) with a chip rate of 3.84 Mbit/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.

TD-SCDMA is the Low Chip Rate version of IMT-2000 CDMA TDD, being therefore a radio transmission technology for IMT-2000 communication. TD-SCDMA combines two technologies – an advanced TDMA system with an adaptive CDMA component. TD-SCDMA is also called 1.28 Mbit/s TDD or LCR (low chip rate) 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 7 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 technologies such as Smart Antenna, Joint Detection, Uplink Synchronization and Baton Handover, TD-SCDMA system can provide a low cost solution for implementation, operation and transition, 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.

9.2.1.4 IMT-2000 TDMA Single-Carrier

ITU Name: IMT-2000 TDMA Single-Carrier

Common Names: 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, SGSN (Serving GPRS Support Node), GGSN (Gateway GPRS Support Node), and HLR. In fact, with newer GSM/GPRS deployments, EDGE 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.

9.2.1.5 IMT-2000 FDMA/TDMA

ITU Name: IMT-2000 FDMA/TDMA

Common Name: 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 time-division duplex (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 meters to several kilometres, depending on application and environment. It provides telephony quality voice services, and a broad range of data services, including Integrated Services Digital Network (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.

9.2.1.6 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 only in TDD mode.

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.

9.3 Transition 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.

9.3.1 Transition 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.

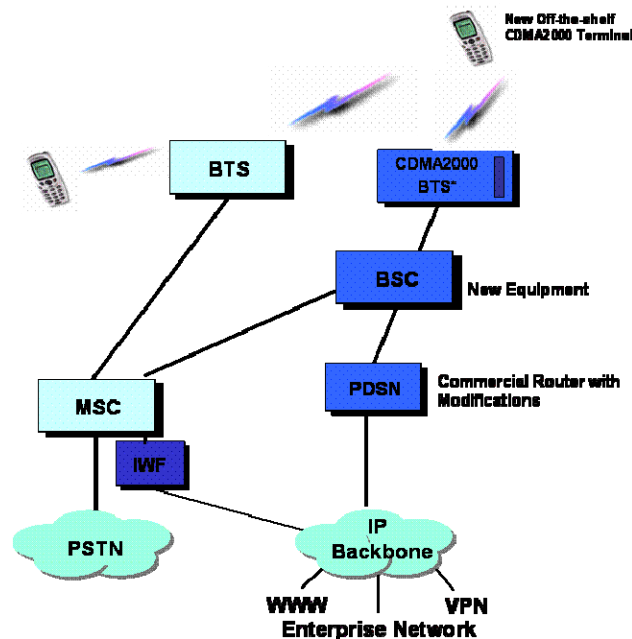
Once the transition from AMPS to TDMA has been accomplished, then a strategy of GSM/GPRS overlay can be undertaken which provides a common packet data service for both TDMA and GSM subscribers, as many TDMA operators have already embraced, leading to the deployment of GSM MAP and setting the stage for transition to IMT-2000 CDMA Direct Spread. This path allows analogue operators to take advantage of the experience of many TDMA operators in their transition 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 the NMT900 systems, the TACS systems and some of the NMT450 systems in Western Europe have already undertaken the transition to GSM. The transition from NMT required a new GSM-MAP core network, although the GSM-MAP Core Network is conceptually based on the NMT-Core Network architecture.

9.3.2 Transition 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 transition 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 center. Figure 3.3.2 shows the new components required for the transition from AMPS to CDMA2000. Many CDMA handsets support AMPS and hence clearing the spectrum to add CDMA2000 RF carriers is practically seamless to subscribers.

Figure 9.3.2: Migration path from AMPS to IMT-2000 CDMA Multi-Carrier



Though NMT systems do not use the ANSI-41 core network protocol, several NMT operators have found it easy to make the transition to 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.

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 with aggregated channels using EV-DO Rev. B. Analogue pre-IMT-2000 operators have a choice to first make the transition to CDMA2000 1X and then choose to overlay CDMA2000 EV-DO in multiple phases depending on network capacity evolution. The transition 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 EV-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 smooth transition to 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.

9.3.3 Transition to IMT-2000 TDMA Single-Carrier

For operators of AMPS systems wishing to deploy TDMA Single-Carrier, a natural path begins with the transition 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 analog voice channels can be assigned from digital control channels. Since AMPS and TDMA share the same 30 kHz RF channel, then a TRX by TRX 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 insuring a smooth transition, and improving roaming opportunities for users.

9.4 Transition 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 transition to IMT-2000, including the transition to UWC-136/IMT-2000 TDMA Single Carrier, IMT-2000 CDMA Multi-Carrier, or IMT-2000 CDMA Direct Spread.

9.4.1 Transition 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 migration/transition¹⁰ path offers TDMA operators the opportunity to deploy the combination of GPRS, EDGE and IMT-2000 CDMA Direct Spread that best meets their needs thus facilitating simplified migration/transition to IMT-2000 CDMA Direct Spread as a future option, if not selected as an initial choice.

This migration/transition 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 center needs only a simple upgrade and the GGSN stays the same.

¹⁰ The expression "migration/transition" is used to indicate a change obtained through both evolution and migration.

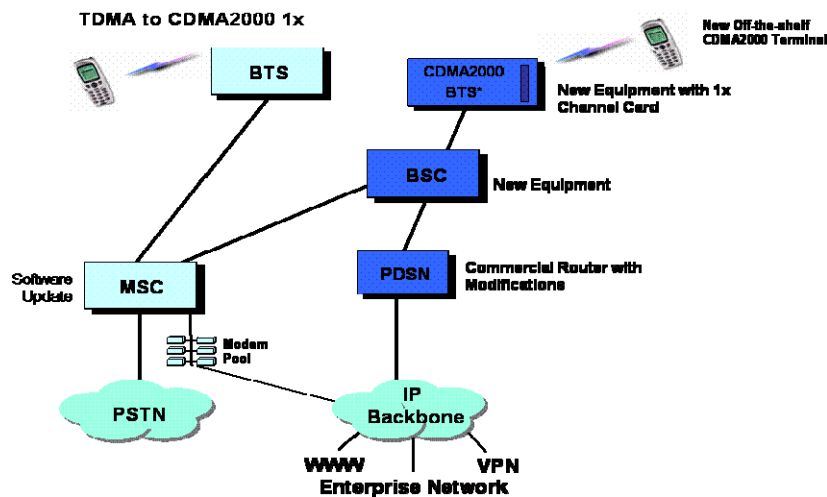
Another solution for TDMA is the migration/transition directly to IMT-2000 services via IMT-2000 CDMA Direct Spread and HSDPA. In this case an IMT-2000 CDMA Direct Spread overlay would be deployed analogous to the GSM overlay described above.

9.4.2 Transition to IMT-2000 CDMA Multi-Carrier

Operators of digital pre-IMT-2000 TDMA (ANSI-136, ANSI-54) systems have a smooth and easy migration/transition 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 a migration/transition to IMT-2000 CDMA Multi-Carrier which only requires operators to add CDMA2000 base stations, base station controllers (BSC), upgrade software at the mobile switching center (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 3.4.2 shows the new components required to make the migration/transition from TDMA to CDMA2000. CDMA2000 migration/transition 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.

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 make the transition to CDMA2000 1X and then choose to overlay CDMA2000 EV-DO in multiple phases depending on network capacity evolution. For the operators, this transition 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.

Figure 9.4.2: Transition path from TDMA to IMT-2000 CDMA Multi-Carrier



Transition to CDMA2000 also offers the choice of phased evolution, in which spectrum is cleared for migration/transition to 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. During the transition, CDMA carriers can

easily coexist with TDMA carriers, providing a smooth migration/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 carriers can be added as the demand grows. This allows for smooth migration/transition to IMT-2000 Multi-Carrier while providing 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.

9.4.3 Transition 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 transition 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 thus facilitating simplified migration/transition to the IMT-2000 CDMA Direct Spread and/or IMT-2000 CDMA TDD (time code) as a future options.

The transition from TDMA and GSM/overlaid TDMA systems to IMT-2000 TDMA Single Carrier 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 license 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 centers (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 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 operators' existing 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 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.

9.5 Transition from PDC

9.5.1 Transition to IMT-2000 CDMA Direct Spread

Most of Japanese mobile operators have been operating PDC (Personal Digital Cellular) system, which is a 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 licenses were awarded to three operators in Japan, two of which, NTT DoCoMo and J-PHONE (SoftBank Mobile at present), selected IMT-2000 CDMA Direct Spread system and have already started the commercial service. Two independent networks of the PDC and IMT-2000 CDMA Direct Spread need to be deployed so that inter-working function was introduced.

On deployment of the IMT-2000 CDMA Direct Spread 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.

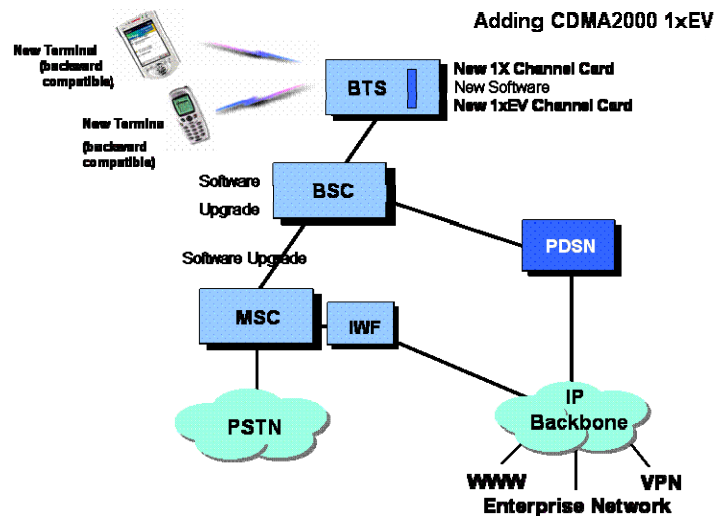
9.5.2 Transition to IMT-2000 CDMA Multi-Carrier

Another PDC operator in Japan, KDDI, chose IMT-2000 CDMA Multi-Carrier system. Since PDC system and IMT-2000 CDMA Multi-Carrier system have different air-interfaces and core network protocols, transition from PDC to IMT-2000 CDMA Multi-Carrier took place by way of cdmaOne (CDMA ANSI-95A/B). The PDC operator at first started 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 and etc for dual operation of two systems of the PDC and IMT-2000 CDMA Multi-Carrier. The transition process from cdmaOne to IMT-2000 CDMA Multi-Carrier is explained in Section 3.6.1.

9.6 Transition from cdmaOne Systems

9.6.1 Transition 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.

Figure 9.6.1: Evolution path from cdmaOne to IMT-2000 CDMA2000 Multi-Carrier


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 center, adds new channel cards and software at the base stations, and a packet data support node. Figure 3.6.1 shows the evolution path for cdmaOne to CDMA2000.

CDMAOne operators can nearly double the voice capacity of their network through evolution 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.

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.

9.7 Transition from GSM Systems

The GSM industry has charted a transition path to IMT-2000 in a logical, structured and standardized way. This includes the possibility of making the transition to 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 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 Operators' 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.

9.7.1 Transition to IMT-2000 CDMA Direct Spread

GSM operators may choose to transition 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 High Speed Downlink Packet Access (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 Time Division Multiple Access (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 9.7.1.

Table 9.7.1: Benefits resulting from technology choices in the transition to 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 Mbit/s.

9.7.2 Transition to IMT-2000 CDMA TDD (time-code)

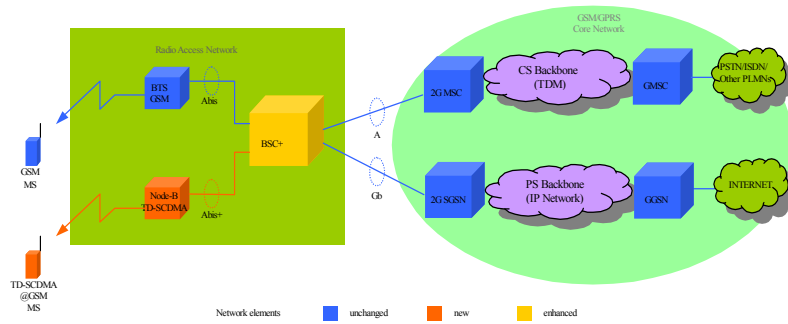
A possible transition path which re-uses an existing GSM network is via IMT-2000 CDMA TDD (time-code), i.e., TD-SCDMA. The process for this transition from GSM to TD-SCDMA can be divided into two gradually enhanced steps.

Step 1

TD-SCDMA provides a migration/transition alternative from the current existing GSM/GPRS network to IMT-2000 networks. 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 (Node Bs) 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 9.7.2-1: Transition Step 1



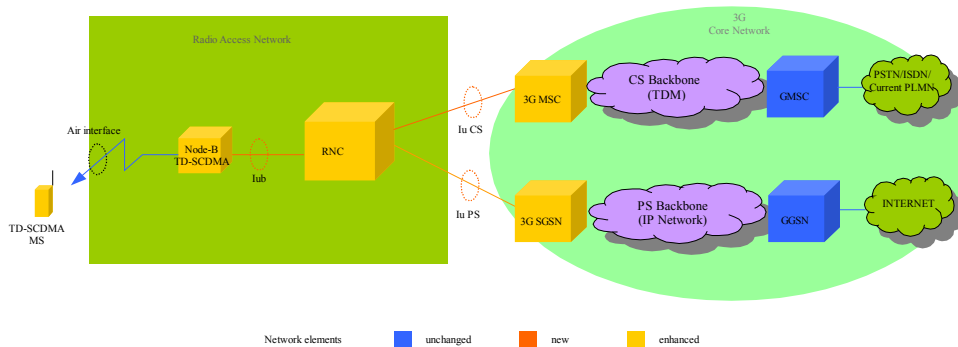
Step 2

With the service development, IMT-2000 Core Networks are established and co-exist with the GSM/GPRS Core Networks. Then parts of TD-SCDMA equipment 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. For a TD-SCDMA system, all the upgrading and migration paths related to Core Network is the same as WCDMA system.

After the upgrading, the system has made the transition to IMT-2000.

Figure 9.7.2-2: Transition Step 2



The benefits of these upgrades are summarized below:

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

9.7.3 Transition to IMT-2000 TDMA Single-Carrier

A straightforward way for GSM-operators to make the transition 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 operators' 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, EDGE¹¹ 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 will also support an IMT-2000 CDMA Direct Spread radio access network. In fact, as described in section 3.7.1, a big advantage deriving from the addition of IMT-2000 CDMA Direct Spread is that it can be operated together with the same Core Network as GSM/GERAN.

A further option that has already been chosen by many GSM-operators is the additional operation of the UMTS Terrestrial Radio Access Network (UTRAN). UTRAN is operated in a new frequency spectrum and enhances therefore the traffic capacity of existing GSM-operators. Especially in micro and pico cell environments, data rates of up to 14 Mbit/s can be reached by means of HSDPA. If the data rate and the load per cell are limited to smaller values, UTRAN (in particular the FDD-mode) can also be used to achieve coverage with very large cell-sizes. GSM operators who do not have new IMT-2000 spectrum can evolve to IMT-2000 by deploying EDGE as an upgrade to their GSM/GPRS networks.

¹¹ Assumes EDGE release 99.

9.7.4 Transition to IMT-2000 OFDMA TDD WMAN

GSM operators may choose to transition directly to IMT-2000 OFDMA TDD WMAN. The addition of an OFDMA-MIMO mobile broadband data overlay network involves deployment of new base station line cards and clients, as well as upgrades to the core network to support high amounts of IP (Internet Protocol) traffic. GSM operators can co-locate WiMAX base station equipment in their existing 2G cell sites. In mobile WiMAX commercial deployments to date, the cell site re-use rate has typically been around 70%.

Once the data overlay network is in place, operators may offer multi-mode devices as it makes sense to enable seamless roaming across their voice-optimized and data-optimized networks as mentioned earlier.

IMS based core network provides interworking between WiMAX and 3GPP based networks (GSM, UMTS etc.)

9.8 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 then 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.

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.

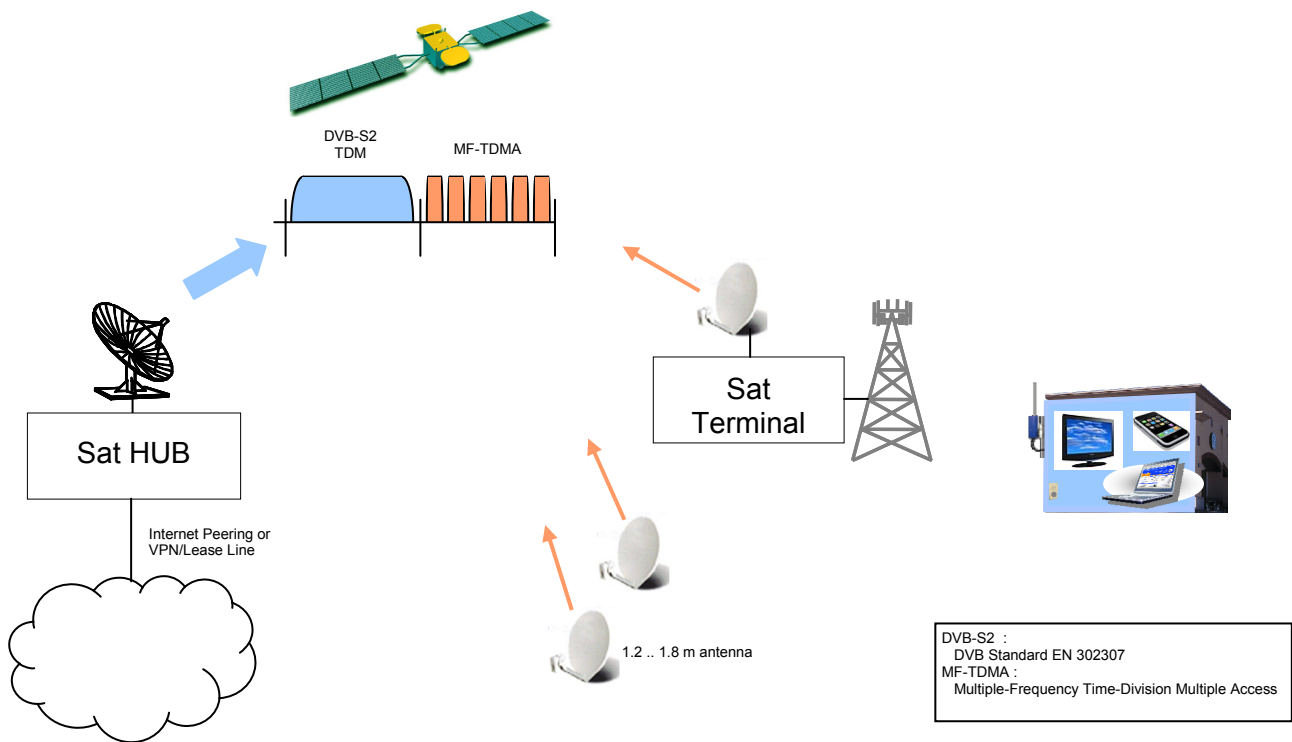
10. Miscellaneous issues

10.1 Satellite Backhaul

Satellite-based backhaul has played an increasingly important role in extending the reach and coverage of mobile telephony networks throughout the globe, particularly in developing markets. Advancements in technologies have led to more cost-effective and robust satellite solutions, making them an integral component of mobile network deployment. As countries transition to IMT-2000, satellite backhaul will continue to play a role in providing connectivity to regions where fibre or terrestrial wireless technology alone are not an economically viable solution.

Using satellite backhaul to extend IMT-2000 networks offers benefits in terms of coverage, cost, security and redundancy. Geostationary Orbit (GSO) satellites can provide backhaul services for a large region with only minimum expenditure on infrastructure. Satellite backhaul solutions enable operators to position IMT-2000 base stations where they would provide the most benefit to citizens, with little reference to the constraints usually placed on IMT-2000 deployment due to the location of terrestrial infrastructure.

The use of satellite backhaul also provides redundancy of connectivity. Damage to the fibre backbone network could lead to terrestrial base stations being cut off from key networks, while the extra diversity that satellite backhaul provides will ensure that connectivity remains un-interrupted, even if there is serious damage to terrestrial infrastructure. This diversity allows each base station with the capability to access satellite backhaul to operate independently of regional events, such as natural disasters, which can cause significant damage to the local and regional infrastructure.



Example of Satellite Backhauling Network

As satellite technologies continue to advance and IMT-2000 is deployed more widely, satellite backhaul solutions are expected to play an increasingly critical role in closing the digital divide for advanced services such as IMT-2000.

10.2 Update of Definitions and Abbreviations and Glossary based on content

Abbreviations/Glossary

1G	First Generation
2G	Second Generation
3G	Third Generation
3GPP	Third Generation Partnership Project
3GPP2	Third Generation Partnership Project 2
A	
AAA	Authentication, Authorization and Accounting
ANSI	American National Standard Institute
ARPU	Average Revenue per User
ATM	Asynchronous Transfer Mode
B	
C	
CAPEX	Capital Expenditure
CDMA	Code Division Multiple Access
CEPT	European Conference of Postal and Telecommunications Administrations
CITEL	Comisión Interamericana de Telecomunicaciones (Inter-American Telecommunication Commission)
CN	Core Network
CS	Circuit Switching
CSCF	Call Session Control Function
D	
DECT	Digitally Enhanced Cordless Telecommunications
E	
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
F	
FDD	Frequency Division Multiplexing
FDMA	Frequency Division Multiple Access
G	
GGSN	Gateway GPRS Support Node
GPRS	General Packet Radio Service
GSM	Global System for Mobile Communications
H	
HA	Home Agent
HLR	Home Location Register
HSDPA	High Speed Downlink Packet Access

I	
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 Data Network
IT	Information Technology
ITU	International Telecommunication Union
ITU-D	International Telecommunication Union – Development Sector
ITU-R	International Telecommunication Union – Radiocommunication Sector
ITU-T	International Telecommunication Union – Telecommunication Sector
J	
K	
L	
M	
MAP	Mobile Application Part
MGCF	Media Gateway Control Function
MMS	Multimedia Message Service
MSC	Mobile Switching Center
MT	Mobile Terminal
MVNO	Mobile Virtual Network Operator
N	
NPV	Net Present Value
O	
OFDMA	Orthogonal Frequency-Division Multiple Access
OPEX	Operational Expenditure
P	
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
Q	
R	
RAN	Radio Access Network
RNS	Radio Network System
S	
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

T	
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
U	
UIM	User Identity Module
UMB	Ultra Mobile Broadband System
UMTS	Universal Mobile Telecommunication System
UTRA	UMTS Terrestrial Radio Access
UTRAN	UMTS Terrestrial Radio Access Network
UWC	Universal Wireless Consortium (now, 3G Americas)
V	
VLR	Visitor Location Register
VNO	Virtual Network Operator
VoIP	Voice Over IP
W	
WCDMA	Wideband Code Division Multiple Access
WiMAX	Wireless Mobile Access System
Y	
Z	

10.3 Update Annex 1 to include case studies for IP OFDMA TDD WMAN

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

10.3.1 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 led 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 Migration to IMT-Advanced

In ITU-R Radiocommunication Assembly 2007, OFDMA TDD WMAN Technology has been added as the 6th IMT-2000 air interface. SHOW WIBRO's air interface technology is specified in IEEE 802.16-2005(OFDMA TDD WMAN). Also, SHOW WIBRO's 2.3 GHz frequency band has also been identified as additional spectrum for IMT in WRC-07.

With the fact that IEEE 802.16m technology is one of candidate RIT (Radio Interface Technology) for IMT-Advanced and also provides backward compatibility with OFDMA TDD WMAN Technology, SHOW WIBRO is expected to provide smooth and standardized migration to IMT-Advanced.

10.3.2 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 EVDO Rev.A Launch and start 3G data service (OZ)

LG Telecom has been actively deploying the EVDO 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 & 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 & 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 EVDO 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.

10.4 Other

10.4.1 Special policy needs of Governments, operators, regulators and users in developing countries

The number of mobile subscribers in developing countries is low compared to developed ones, but the number of subscribers is increasing significantly, calling party pays has helped some developing countries to rapidly increase 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. But due to economic conditions, users in developing countries may be able to allocate very little of their income to telecommunications. With additional services like video conferencing and high speed mobile Internet, some usage fees of the IMT-2000 services are expected to be higher than those of current mobile services. As a result, some pre-IMT-2000 subscribers in developing countries may wish to continue to use the current services under the same conditions. Therefore, an important issue is to protect the rights of present subscribers preferring not to migrate.

10.4.2 Special needs of users

For the user, 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.

Due to lower income levels, the users' 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 10.4.2: Special needs of users

Item	User Needs and Rationale
Costs	<ul style="list-style-type: none"> • User affordability for services and terminals. • Tariffs should be affordable to the end-users. • Pre-paid services. • Calling party pays.
Terminals	<ul style="list-style-type: none"> • Ease of use and convenience of terminals, including long battery life. • The terminals should support local requirement in terms of language and must take into consideration the literacy level across the country.
Easy roaming	<ul style="list-style-type: none"> • 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	<ul style="list-style-type: none"> • Use of IMT-2000 for tele-education, e-Health and e-Commerce in remote villages, rural economic development, access to Internet at affordable price. • Taking into consideration female user needs. • Training of users on wireless data applications.
Number portability	<ul style="list-style-type: none"> • Gives users the opportunity to choose between operators without losing their phone number, which can often be important for business or personal reasons.

10.4.3 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.

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. ITU-R Recommendation M.1036 states that administrations may deploy IMT-2000 systems in bands other than those identified in the Radio Regulations, but these bands may lack economies of scale.

10.4.4 Licensing aspects

10.4.4.1 Licensing conditions

Licensing conditions are among the regulatory issues that are of importance.

- **Technology Requirements:** It is worth considering whether policy-makers/regulators should follow a technology neutral approach or should mandate a particular technology and related transition path. A technology neutral approach could lead to benefits to end users in terms of a rapid technological evolution 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:** They 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 in each country 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 transition path. Case studies have shown that operators can undertake gradual, phased upgrades to IMT-2000.
- **Timing of IMT-2000 licenses:** 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 3 to 5 operators have been preferred. Another issue is who should be eligible for this license: fixed operators, mobile operators, new operators, all or a combination of these.
- **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. The regulator may play a pro-active role to encourage infrastructure sharing.
- **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 2012-1 "Economic aspects for spectrum management" and Chapter 3 "Licensing" of the ITU-R "National spectrum" handbook.

10.4.4.2 Methods of spectrum licensing

There are many methods of spectrum licensing that have been used both for first and second generation mobile licenses, as well as for IMT-2000 licenses. Most countries have required special licenses 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 license spectrum use on a more generic basis. Some regulators allow the transition of first and second generation systems to IMT-2000 in their current bands and do not require further authorization to do so.

A few of the more common methods of spectrum licensing are first-come, first-served, beauty contests, lotteries, and auctions. 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 are used to ensure that there is no spectrum concentration in the market and to reduce market barriers to new entrants, but they may limit the development and growth of wireless broadband networks.

For more information on spectrum licensing see Report ITU-R SM 2012-1 “Economic aspects for spectrum management” and Chapter 6 “Economic aspects” of the ITU-R “National Spectrum” handbook and Section 2.7.2 of the MTG.

11. Introduction to IMT-Advanced

ITU-R has commenced the process of developing ITU-R Recommendations for the terrestrial components of the IMT-Advanced radio interface(s). This work is guided by Resolution ITU-R 57.

Invitation for submission of proposals for candidate radio interface technologies for the terrestrial components of the radio interface(s) for IMT-Advanced and invitation to participate in their subsequent evaluation are deliberated in the Circular Letter 5/LCCE/2 and the addendums.

The first invitation for the submission of proposals for candidate radio interface technologies (RITs) or a set of RITs (SRITs) for the terrestrial components of IMT-Advanced was issued with Circular Letter 5/LCCE/2 on 7 March 2008. The Circular Letter initiated an ongoing process to evaluate the candidate RITs or SRITs for IMT-Advanced, and invited the formation of independent evaluation groups and the subsequent submission of evaluation reports on these candidate RITs or SRITs. On 13 August 2008, Addendum 1 to Circular Letter 5/LCCE/2 announced the availability of further information associated with the IMT-Advanced submission and evaluation process, including the three ITU-R Reports which providing details of the IMT-Advanced requirements, evaluation criteria and submission templates.

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.

IMT-Advanced systems support low to high mobility applications and a wide range of data rates in accordance with user and service demands in multiple user environments. IMT-Advanced also has capabilities for high-quality multimedia applications within a wide range of services and platforms providing a significant improvement in performance and quality of service.

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;
- 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; and,
- 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).

In the document IMT-ADV/2 Rev.1, there is description in detail about the processes and activities identified for the development of the IMT-Advanced terrestrial components radio interface Recommendations.

The main deliverables on IMT-Advanced are listed below for reference:

- [Circular Letter 5/LCCE/2 and Addendums 1 and 2](#)
- [IMT-ADV/2 Rev.1](#)
- [Report ITU-R M.2133](#)
- [Report ITU-R M.2134](#)
- [Report ITU-R M.2135](#).

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