International Telecommunication Union

QUESTION 18/2

Strategy for migration of mobile networks to IMT-2000 and beyond

ITU-D STUDY GROUP 2 3rd STUDY PERIOD (2002-2006)

Guidelines on the smooth transition of existing mobile networks to IMT-2000 for developing countries (GST)

International Telecommunication Union

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PREFACE

The report "Mid-Term Guidelines on the smooth transition of existing mobile networks to IMT 2000 for developing countries" (MTG, for short) is now available free of charge on the ITU-D Study Group 2 website: www.itu.int/itudoc/itu-d/question/studygr2/87040.html. The MTG represents one output of the study of Question 18/2 (Strategy for migration of mobile networks to IMT-2000 and beyond).

Study Group 2 also recommended abridging the MTG into more easy-to-use Guidelines.

To streamline the MTG to a concise Guidelines format was in itself another challenge.

These Guidelines for the Smooth Transition (GST) from the Existing Mobile Networks to IMT-2000 have been conceived to provide essential information for those who are concerned with this transition.

The reader will find three threads running through the Guidelines: 1) development of policies for the transition of existing networks to IMT-2000, 2) possible transition paths, and 3) economic aspects of the transition to IMT 2000. They also provide references to related literature and ITU Recommendations.

The Telecommunication Development Bureau thanks all the distinguished experts of the Rapporteur's Group on Question 18/2 who took time to contribute to these Guidelines.

Our sincere hope is that this version of the Guidelines will be helpful to the developing countries.

Hamadoun I. Touré
Director

Telecommunication Development Bureau

SUMMARY

These Guidelines are intended for use of telecom operators, policy-makers and regulators to facilitate development of their respective strategies for the transition from pre-IMT-2000 networks to IMT-2000. While it is desirable for pre-IMT-2000 systems to be able to evolve to IMT-2000, the decision whether or not to evolve is not within the scope of the ITU. In each case the decision, as a policy matter, must be made by those responsible for each particular system/service. These Guidelines intend to present an objective and neutral view of the issues to be addressed in the transition from existing mobile networks to IMT-2000 and have been prepared in response to a specific request to ITU-D, as indicated in ITU-D Doc 2/001 of 3 May 2002, http://www.itu.int/md/meetingdoc.asp?type=sitems&lang=e&parent=D02-SG02-C-0001.

Following a decision of ITU-D Study Group 2, the present document represents a concise version of MTG with a more typical Guidelines format, intended, among others, for use at the WTDC in Doha, Qatar, in 2006.

While this document aims at providing the reader with a quick appreciation of the issues involved in the transition process, MTG remains the prime reference for all the matters related to transitioning from the present systems to IMT-2000 systems in the developing countries. In addition, while this document is based on the MTG, it has been updated and certain sections have been rearranged for clarity.

These Guidelines do not make any comparison between performance of different technologies nor do they promote any specific technologies.

This document provides facts about the various mobile systems and technologies that might help to decide on the appropriate transition path and are a natural complement to the ITU "Handbook on Deployment of IMT-2000 Systems", in which more detailed technical information can be found.

Disclaimer

Some sections of these Guidelines incorporate material from published ITU-R and ITU-T Recommendations. As a result, minor misalignment in the use of names, acronyms and/or terms between this text and the rest of the Guidelines text may have occurred due to the different epochs in which the source material has been generated. In the few cases in which this may have occurred, either more recent names and/or acronyms have been retained.

Acknowledgements

These Guidelines have been prepared using information provided by a variety of administrations, companies, industry groups and associations, including examples of their products, systems, models and case studies.

The contribution and advice of ITU-R WP8A and WP8F, as well as ITU-T SSG and SG 19, are gratefully acknowledged.

1 Introduction

1.1 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.

As a matter of course, the possible transition paths reflect local situations and conditioning – including the competitive service provision environment, the service penetration policy, and the strategic and financial aspects. Before and during the transition process, it is required that 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.

1.2 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.

---

[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 and WRC-2000.

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-2000[2] 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 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.

1.3 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-T and the issue of Recommendation ITU-R M.1457 "Detailed specifications of the radio interfaces of International Mobile Telecommunications 2000 (IMT-2000), in the year 2000."

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

---

[2] "Evolution within IMT-2000" means the evolution of the individual IMT-2000 terrestrial radio technologies.

1.3.1 IMT-2000 Radio Access Networks and Standards[3]

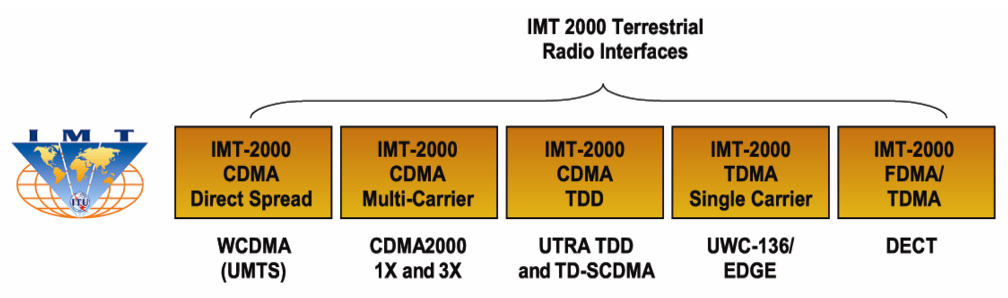
The IMT-2000 terrestrial radio access technologies are based on various combinations of CDMA, TDMA, TD-SCDMA, single-carrier, multi-carrier, FDD, and TDD. None of the IMT-2000 technologies uses pure FDMA where a single radio channel is completely used to support a single user.

1.3.1.1 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 five possible radio interfaces based on three different access techniques (FDMA, TDMA and CDMA):

Figure 1.3.1.1 – IMT-2000 Terrestrial Radio Interfaces[4]



[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.

Table 1.3.1.1 – IMT-2000 Terrestrial Radio Interfaces

Full Name	Common Names
IMT-2000 CDMA Direct Spread	UTRA FDD WCDMA UMTS
IMT-2000 CDMA Multi-Carrier	CDMA2000 1x and 3x CDMA2000 1xEV-DO CDMA2000 1xEV-DV
IMT-2000 CDMA TDD	UTRA TDD 3.84 mcps high chip rate UTRA TDD 1.28 mcps low chip rate (TD-SCDMA) UMTS
IMT-2000 TDMA Single-Carrier	EDGE
IMT-2000 FDMA/TDMA (frequency-time)	DECT

1.3.1.2 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.

1.3.2 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 two[5] IMT-2000 Core Network types recommended by ITU are shown in the following table:

---

[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 1.3.2.1 – IMT-2000 Core Network Recommendations

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.

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.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).

1.4 Satellite considerations

The satellite and terrestrial components of IMT-2000 in general complement each other by providing service coverage to areas which either alone may not economically serve. Each component has particular advantages and constraints. The satellite component will provide coverage to areas which may not be within the economic range of the terrestrial component; this applies additionally to rural and remote regions. Providing satellite coverage, in more densely populated areas could encourage later coverage by the terrestrial component. IMT-2000 satellite systems can also provide a multicast layer as a complement to the IMT-2000 terrestrial mobile networks.

There are currently six satellite systems defined as part of the IMT-2000 family through their radio interfaces (see Recommendations ITU-R M.1455 and ITU-R M.1457), 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.

These Guidelines concentrate on the terrestrial component of IMT-2000 systems.

1.5 Standards Development Organizations dealing with IMT-2000

The ITU Recommendations for IMT-2000 have been developed taking into consideration the results achieved by the radio interface technology proponent organizations, global partnership projects and national and regional standards development organizations (SDOs). Each of the radio interfaces defined by an external organization is shown in Table 1.5.

Table 1.5 – 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

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.

2 Development of policies for strategies regarding transition of existing networks to IMT-2000

The variety of situations in developing countries relating to the technology and the development of existing mobile networks implies the need for diverse and different transition policies toward IMT-2000. The identification of a transition policy is based on the analysis of key aspects, that impact demand, investments and revenues. Although these aspects are common to all countries, their implications for developing countries deserve special treatment (a description of evolution methodology and scenarios can be found in Annex C of the MTG). The Government in its role of determining policy should make policies that favor the implementation of IMT-2000 taking into consideration its local conditions.

2.1 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. 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.

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

It is also important to recognize that the needs of developing countries should not be just related to topographic and technical issues, but they should also be expressed in terms of commonly defined societal conditions to allow all the population to move towards the Information Society as per the WSIS Declaration of Principles and Action Plan.

Security

The advantages expected from IMT-2000 with regards to cyber services and cyber applications can only be achieved if the problems of security and confidentiality are addressed by new technologies such as IMT-2000.

In this regard, it is necessary to guarantee that any IMT-2000 technology:

– is not harmful to the users and to the population;

– is protected against attacks (viruses, etc.);

– is protected against piracy (access to information, modification, destruction of information, etc.);

– ensures the protection of the life of the individual and the privacy of the transmitted data.

Adopting such an approach shall enable the local authorities and decision makers to choose a system by taking into consideration the degree to which it guarantees security and gives maximum assurance to the companies, the users and the rest of the citizens.

Training

As a third generation (3G) technology, IMT-2000 is not only a new technology but also among the latest technologies whose techniques and mode of operation differs from that of the first and second generation technologies. In this regard, the migration from existing networks to the IMT-2000 networks requires sufficient expertise in the studies, deployment, operation and maintenance of the new systems, without which the installation of the IMT-2000 networks will not bring the expected benefits.

This training will ensure that the developing countries have sufficient number of persons to guarantee a smooth technological transition towards IMT-2000. Such training could be carried out in three major ways:

– through seminars, conferences and training workshops organised in developing countries;

– by basic training (through partnerships with local, subregional and regional training institutions in the developing world);

– by distance learning.

Fostering local industry

The reduction of the cost of services is one of the goals of telecommunications operators and the users of IMT-2000-related services. In order to achieve this goal, it would be advisable to promote the emergence of industries for the manufacturing of IMT-2000 equipment and the support of the development of local content in developing countries.

These local industries will not only enable the reduction of the cost of IMT-2000 equipments and services but they will also ensure the transfer of technology as well as the adaptation of IMT-2000 equipment to the local conditions (language, literacy level, etc.).

Development of local content for IMT-2000 applications will create new employment opportunities in developing countries, as well as having a positive effect on education and information services.

Providing universal access/service

As far as communication infrastructures are concerned, the gap between developed countries and developing countries, on the one hand, and the gap between the urban areas and the rural areas, on the other hand, are widening.

Administrations of developing countries, in the framework of their telecommunication policy, envisaged IMT-2000 as important access to the information society and a universal service tool. This means that IMT-2000, which offers basic and advanced communication services for a majority of end users, should be accessible in all areas of the national territories.

A good quality and cost effective coverage of low density and underserved areas are key to providing access to all to the Information Society and reducing the digital divide. For many areas, mobile communications and IMT-2000 in particular will provide the only possibility for universal services that can bridge the digital divide and obtain the benefits of the objectives of the WSIS Declaration of Principles and Action Plan for Information Society.

2.1.1 Special needs of operators

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

Operator needs and rationale are listed in Table 2.1.1.

Table 2.1.1 – Special needs of operators

Item	Operator Needs and Rationale
Costs	Transition costs should be minimized as much as possible. Existing infrastructure should be utilized as much as possible. Recovery of evolution/migration capital expenditure (CAPEX) and operating (OPEX) costs.
Fixed wireless access	Some operators may provide fixed wireless access for IMT-2000 services in urban and rural areas.

Table 2.1.1 – Special needs of operators

Coverage and deployment obligations	Target coverage/service penetration and roll-out schedule set by regulators in some cases. The goal for coverage for IMT-2000 systems, which will be realized over time, should be co-terminus with existing pre-IMT-2000 systems. Roll-out obligations must be set keeping in view the business case of the operator and the user's interest.
Transition time	Time frame for transition from existing "mobile"/"fixed" towards IMT-2000. Operators should have maximum flexibility in determining and finalizing the transition.
Mass application	Applications such as tele-education, tele-medicine, e-government may require IMT-2000 technologies.
Government support	Role of government subsidy for infrastructure and/or advanced applications (not for infrastructure but for affordability of services by all including universal service obligations).
Depreciation	Possible depreciation of infrastructure investments while waiting for IMT-2000 demand.
IMT-2000 bands	Access to appropriate frequency bands and adequate spectrum is required. Use of frequencies below 1 GHz and allocation of future frequency bands as per WRC/WARC may be advantageous in providing cost-efficient coverage. Use of harmonized IMT-2000 bands decreases equipment costs and facilitates worldwide roaming.
Technical and administrative conditions	Conditions for use of spectrum (licensing/roaming/coverage/other operator obligations/).
Infrastructure sharing	Sharing of (radio/network) resources for rapid rollout and coverage (VNO, Virtual Network Operator) can be encouraged to facilitate speedy deployment of new technologies and lower the costs to operators.
Satellite component	Usage of satellite component of IMT-2000.
Market analysis and business cases	How to develop market analysis/business case? (population literacy, disposable income, etc.)
Services and applications	• Low entry fees would reduce the entry cost of service provider; • Use of IMT-2000 for access to education in remote villages, rural economic development, access to Internet at affordable price.
Availability of equipment from multiple vendors	• Existence of multiple vendors increases competition with positive price effects for operators; • Dependency of operators on vendors should be minimized; • Multivendor systems require standardization by a broad community and lead to open standards.

2.1.2 Special needs of regulators

Regulators in developing countries may wish in particular to set up a regulatory/legal framework that minimizes network deployment costs while facilitating the provision of extensive network coverage and of specific "socially efficient" services and applications (e.g., e-health, e-education). Education policies that improve literacy rates will increase the population's ability to utilize IT (Information Technology) services. For more detail on regulatory flexibility, please refer to Section 2.2 below.

Table 2.1.2 – Special needs of regulators

Item	Regulator Needs and Rationale
License handling and allocation	Capitalize on experience of developed countries on • license awarding method, • license conditions, • license fees, • number of licenses.
Databases	Capitalize on experience of developed countries on • RFP (Request for Proposal) issued for awarding IMT-2000 licenses; • Rationale behind the preferred license awarding methods; • Information on the method of determination of lowest bid rates; • Standard concession agreements – including provisions related to QoS numbering, interconnection, roaming, coverage, infrastructure sharing, etc. – that were signed with the IMT-2000 operators; • A list of rights and obligations of the IMT-2000 operators, including the rationale behind each.

2.1.3 Special needs of users

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. 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.

Female users make up a large proportion of the mobile market that requires special consideration regarding services and applications. Wireless communications technologies can be exploited by women in order to considerably improve their social status, specifically in the areas of employment, health, and education. For example, the Village Grameen Phone programs in Bangladesh and Uganda, women are providing micro-loans to purchase mobile phones in order to resell the voice services in their villages to people that did not otherwise have access to phone services. This micro-business pulled in significant profits for most of the women who participated, thus greatly enhancing their economic and social power within their own communities.[6]

Table 2.1.3 – Special needs of users

Item	User Needs and Rationale
Costs	• User affordability for services and terminals. • Tariffs should be affordable to the end-users. • Pre-paid services.
Terminals	• 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	• Users want to use their usual terminals when traveling. • Roaming is facilitated by low prices and by the availability of compatible technologies/terminals in foreign countries.
Services and applications	• Use of IMT-2000 for education in remote villages, rural economic development, access to Internet at affordable price. • Taking into consideration female user needs. • Training of users on wireless data applications.
Number portability	• Gives users the opportunity to choose between operators without losing their phone number, which can often be important for business or personal reasons.

[6] The Village Grameen Phone programs in Bangladesh and Uganda provided women in rural villages with loan capital to purchase of starter kits (approx USD 250/kit), mobile phone and battery, SIM card, 100 000 minutes of airtime, signage and marketing, recharging solution (automobile battery/solar), and Village Phone Operator manual. The program has been a tremendous success. In addition to expanding coverage to more than 60 million users and increasing the status of women, the program has been shown to break the cycle of poverty as the women operators have an average net income of USD 58 and their children are more likely to finish school. http://www.gfusa.org/technology_center/village_phone/.

While the Grameen phone example is a second generation application, it shows that if women have access to IMT-2000 technologies in the developing world they will reap even greater benefits from the advanced features and higher data rates if given the opportunity to utilize or experience these technologies in a meaningful way. One benefit that is recognized through the use of IMT-2000 technologies is improvements in the healthcare industry, where too often women from developing countries are extremely disadvantaged because they do not have facilities in their villages and cannot travel the distance to obtain proper healthcare. IMT-2000 technology enables healthcare services to be delivered directly to these communities in need. Today in rural Australia, a mobile breast screening service that visits women in remote areas via a medically equipped van, performs the mammogram on site, records the test results and patient information into their client information management system and then transfers their digital files back to their assessment centres via the IMT-2000 network.[7]

2.2 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 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.

Some countries have licensed IMT-2000 systems in bands not currently being used for pre-IMT-2000 systems, but identified in the Radio Regulations for IMT-2000. Moreover, in some countries, system upgrades to IMT-2000 are taking place in the 800 MHz, 900 MHz, 1 800 MHz and 1 900 MHz bands. There are various possibilities to facilitate in-band transition. The regulators should evaluate these options carefully and select the one which best meets their needs.

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

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

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

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[7] Telstra and Victoria Regional Health Alliance; CDMA2000 1xEV-DO: Virtual Remote Mammography Service.

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

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

2.3 Accommodating special needs for transitioning to IMT-2000

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

2.3.1 Solutions for low density areas

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

2.3.2 Solutions for high density areas

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

IMT-2000 can be used to realize small cell radii as required in densely populated areas utilizing an inverse relationship that exists between maximum achievable average data rate and maximum cell range. In general, it can be engineered to balance between traffic capacity and higher data rates.

2.3.3 Solutions for mixed low-high density areas

In developing countries, there are often wide areas of limited population and smaller areas of extremely high population density. IMT-2000 technologies are designed to operate at a range of frequencies, from lower frequency band to higher, to respond to the specific needs of operators. In order to address this mix of needs, an operator can deploy complementary versions of IMT-2000 in different frequency bands. For example, GERAN (GSM/EDGE Radio Access Network) is more suitable for large cells, while UTRAN (UMTS Terrestrial Radio Access Network) can be used as a complement to GERAN to enhance the traffic capacity and to offer significantly higher data rates for more densely populated areas. In a similar way, CDMA2000 1X operating at lower frequency bands can provide coverage for wide areas, while CDMA2000 1x EV-DO can offer higher capacity and higher data rates to more densely populated areas.

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

2.3.4 Universal service/access to basic and advanced services

In addition to improving access to basic voice services, developing countries are also looking to expand the definition of universal service/access to include data services, such as Internet access. IMT-2000 technologies with their higher data rates can bring advanced services to a wider range of users, while meeting important social needs such as providing high speed connectivity to clinics, schools, libraries, governments, telecenters and other priority users, especially women and youth in rural areas. Operators may use IMT-2000 technologies to meet universal service obligations, particularly in rural areas where the penetration of the fixed network is low or non-existent.

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

Wireless technologies, including IMT-2000, can be used for either mobile or fixed applications. Often, regulators decide to allocate spectrum for Fixed Wireless Access (FWA) systems to help increase teledensity, create competition and build out the local loop. Operators of FWA systems are able to charge different tariffs for fixed and mobile services, even though each service may be provided using the same equipment. Also, due to the high-speed data capabilities of IMT-2000 technologies, users may decide to utilize such technology for Internet access. In addition to accessing the Internet directly with wireless handsets or personal digital assistants, IMT-2000 handsets can be used as a modem connected to a laptop or desktop computer via Bluetooth or cables. Also available are IMT-2000-capable PCMCIA cards, which are wireless modem cards that plug into laptop or traditional desktop computers.

Requirements for the use of fixed networks in the role of fixed access networks are addressed in Q.1761[8].

2.4 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), games and entertainment.

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8 Recommendation Q.1761 "Principles and Requirements for Convergence of Fixed and Existing IMT-2000 Systems", November 2003.

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.

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

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

Many developing countries have 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. However, a solution, appropriate for developing countries, is being studied under WRC-07 agenda item 1.4 and could consist of the global identification of frequency bands lower than those already identified for IMT-2000.

2.5.1 Current spectrum identification for IMT-2000

IMT-2000 will operate in the frequency bands identified in the Radio Regulations (RR) as intended for use on a worldwide basis by administrations wishing to implement IMT-2000, as follows[9]:

WARC-92 identified the bands 1 885-2 025 MHz and 2 110-2 200 MHz and WRC-2000 identified the bands 806-960 MHz[10], 1 710-1 885 MHz and 2 500-2 690 MHz.

for possible use by IMT-2000 systems, noting (in accordance with RR 5.388) that identification of these bands does not establish priority in the RR and does not preclude use of the bands for any other services to which these bands are allocated. Also, some administrations may deploy IMT-2000 systems in bands allocated to the mobile service other than those identified in the RR.

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

a) that the RR identify the bands 806-960 MHz, 1 710-2 025 MHz, 2 110-2 200 MHz and 2 500-2 690 MHz as intended for use on a worldwide basis by administrations wishing to implement IMT-2000, as indicated in RR 5.388 (Rev.WRC-2000), 5.384A (WRC-2000), 5.317A (WRC-2000), Resolution 212 (Rev.WRC-97), Resolution 223 (WRC-2000), Resolution 224 (WRC-2000) and Resolution 225 (WRC-2000); by taking these footnotes and resolutions into account, flexibility should be afforded to administrations to decide on using these bands at the national level according to each administration's evolution/migration plan;

b) that in some countries, other services are in operation in the bands identified for IMT-2000 as indicated in Resolution 225, RR 5.389A, RR 5.389C, RR 5.389D, RR 5.389E and Recommendations ITU-R M.1073-1 and ITU-R M.1033-1;

c) that a minimized number of globally harmonized frequency arrangements in the bands identified for IMT-2000 by one or more Conferences will facilitate worldwide compatibility and international roaming; and also reduce the overall cost of IMT-2000 networks and terminals by providing economies of scale;

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

[10] The whole band 806-960 MHz is not identified on a global basis for IMT-2000 due to variation in the primary mobile service allocations and uses across the three ITU Regions.

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

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

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

g) that some Administrations are planning to use parts of the bands 698-806 MHz or 2 300-2 400 MHz for IMT-2000.

2.5.2 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.

Operators are using first and second generation mobile spectrum for IMT-2000. For example, it is worth noting that operators in Brazil, Canada, Japan, Korea, New Zealand and the United States 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, Russia, Uzbekistan and Sweden are upgrading existing systems in the 450 MHz band to IMT-2000 Operators of analog systems in the 800 MHz and 450 MHz bands can upgrade their networks to IMT-2000 with commercial equipment that is available today. Similarly, second-generation operators of TDMA, cdmaOne and GSM are able to purchase commercially available IMT-2000 equipment to upgrade their systems.

It could be more costly to deploy IMT-2000 systems in non-harmonized frequency bands than in those that are harmonized and utilized by the majority of operators due to a lack of economies of scale. However, there are many operators who are migrating their analogue systems to IMT-2000 in existing bands in a cost-effective way. Given the significant initial capital expenditures necessary to deploy entirely new IMT-2000 systems, operators are finding that upgrading networks in existing spectrum is a more economically viable option.

2.6 Interoperability with existing networks and among IMT-2000 technologies

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

Inter-working 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, the third generation partnership projects 3GPP and 3GPP2 have agreed to work 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).

Another interoperability issue that should be considered is the impact of the introduction of data services with IMT-2000. Given that IMT-2000 technologies are relatively new, interoperability of software and applications on IMT-2000 terminals and across borders will be increasingly important moving forward. One organization, the Open Mobile Alliance[11], 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.
- 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.

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[11] www.openmobilealliance.org

2.7 Licensing aspects

2.7.1 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.

- *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.

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.

2.7.2 Methods of spectrum licensing

There are many methods of spectrum licensing that have been used both for first and second generation mobile 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.

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.

3 Transition paths

3.1 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 analyze 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 ITU-R Recommendation 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, coordinated via 3GPP and 3GPP2 at the global level, to further evolve the technology in order to support future market needs. The step-by-step approach minimizes the need for large re-investments in IMT-2000 and yet provides significant improvements in the capability to deliver improved services at each step along the way. Updates of 3GPP and 3GPP2 standards provide backward compatibility, ensuring to the greatest extent possible a continuing service capability for existing operators and users.[12]

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.

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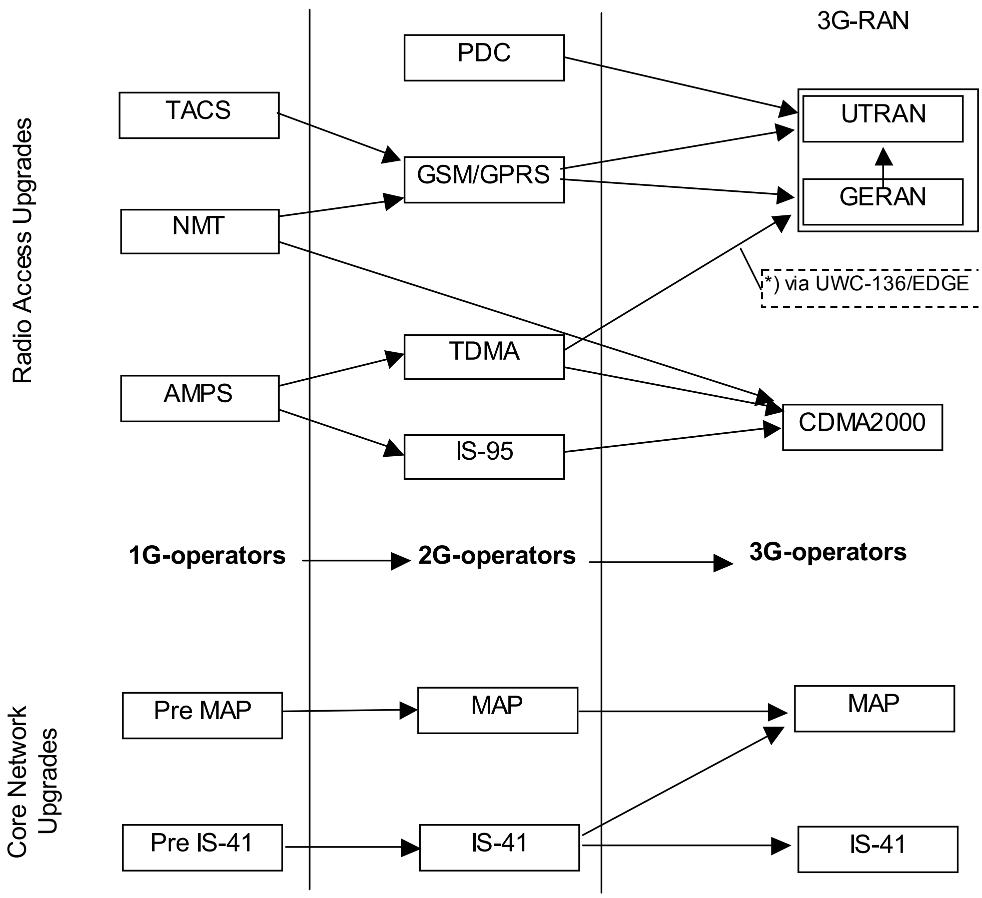
[12] See details of 3GPP Release Process in Annex E of the MTG.

Figure 3.1 – Observed network upgrades of operators



3.2 Considerations for transition

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

a) Operation in worldwide harmonized frequency bands;

b) Existing/forecasted market share/market penetration of the target technology;

c) Probability that other operators will adopt similar transition paths;

d) Ease of the transition from existing technology to the desired technology;

e) 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);

f) 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):

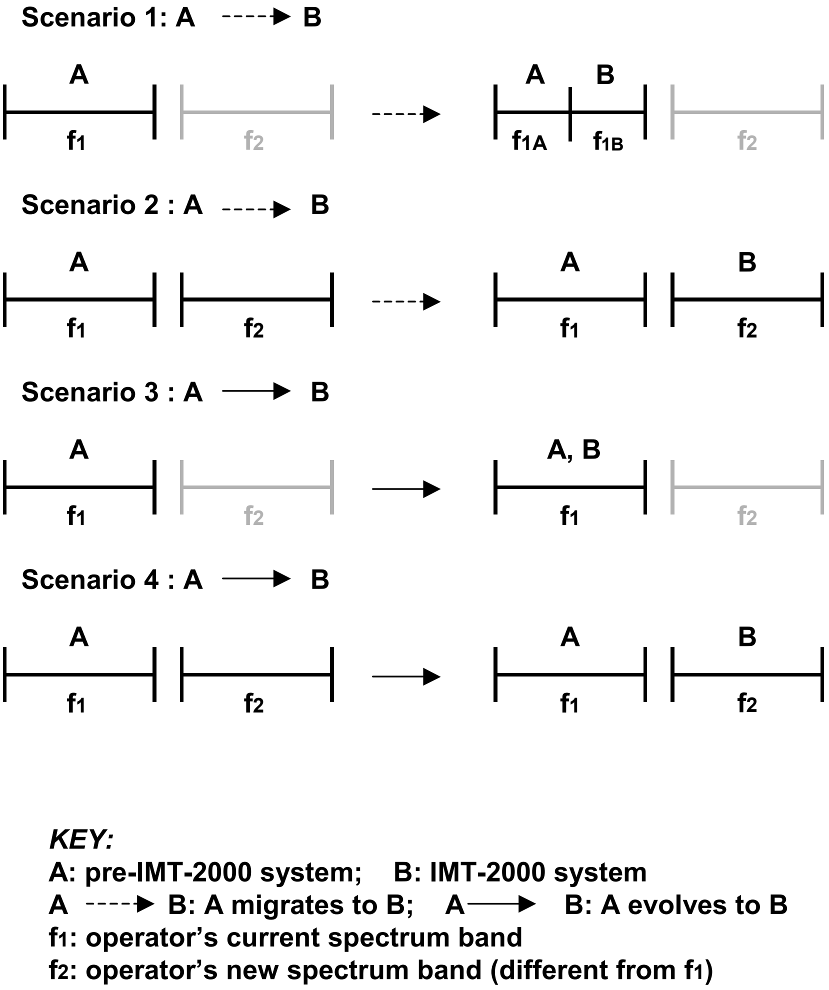
- Scenario 1: The IMT-2000 system (B) is deployed in the spectrum that is currently being used for the pre-IMT-2000 system (A). Obviously, the existing spectrum (f1) is split and some of the spectrum is allocated for the IMT-2000 system (f1b) and the rest remains in service for the pre-IMT-2000 system (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 3.2-1 – Transition scenarios in IMT-2000



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

Figure 3.2-2 – 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.

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

3.2.1.1 IMT-2000 CDMA Direct Spread

ITU Name: IMT-2000 CDMA Direct Spread

Common Names: UTRA FDD
WCDMA
UMTS

IMT-2000 CDMA Direct Spread allocates different codes for different channels, whether for voice or data, and can adjust the amount of capacity, or code space, of each channel every 10 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.

3.2.1.2 IMT-2000 CDMA Multi-Carrier

ITU Name: IMT-2000 CDMA Multi-Carrier

Common Names: CDMA2000 1X and 3X
CDMA2000 1xEV-DO
CDMA2000 1xEV-DV

IMT-2000 CDMA Multi-Carrier is designed as a direct evolution of cdmaOne systems, 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, 900, 1 700, 1 800, 1 900 and 2 100 MHz).

IMT-2000 CDMA Multi-Carrier balances code assignments and power allocation to deliver voice and data services. 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 628 kbit/s. Other new features of IMT-2000 CDMA Multi-Carrier include the Quick Paging Channel Operation, variable transmission rates, and a channel structure that supports multiple services with various QoS. With the inclusion of Selectable Mode Vocoders (SMV) and antenna diversity techniques, CDMA2000 1X can provide a voice capacity of nearly three times that of cdmaOne systems.

In case a network evolution is required based on demand for high data services, CDMA2000 1X and CDMA2000 1xEV-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 1xEV-DO carrier dedicated exclusively to high-speed packet data (up to 3.1 Mbit/s) or, alternatively, one single CDMA2000 1X and two CDMA2000 1xEV-DO carriers.

The CDMA2000 1xEV-DO option, primarily optimized for data services, is designed to interoperate with CDMA2000 1X networks. CDMA2000 1xEV-DO 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 1xEV-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 1xEV-DO incorporates a time division multiplexed (TDM) adaptive variable rate forward link that maximizes user data rates and sector throughput by allocating entire BTS power to one user at a time. Highly efficient implementation of channel sensitive scheduling and effective multi-user diversity achieves highest data rates at a given time. Also, Hybrid-ARQ schemes implementing incremental redundancy help deliver optimum efficiency which could otherwise be lost due to high mobility and variability of interference caused by varying traffic conditions.CDMA2000 1xEV-DV is an enhancement to IMT-2000 CDMA Multi-Carrier that combines the features of CDMA2000 1X and CDMA2000 1xEV-DO systems. Thus, it can provide either the voice capacity of CDMA2000 1X or the data capacity of CDMA2000 1xEV-DO, or provide a mix of voice and data capacity in one single carrier of 1.25 MHz.

3.2.1.3 IMT-2000 CDMA TDD

ITU Name: IMT-2000 CDMA TDD

Common Names: UTRA TDD 3.84 mcps high chip rate
UTRA TDD 1.28 mcps 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 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. only one 5 MHz channel is needed when the TDD chip rate is operating at 3.84 Mbit/s.

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.

3.2.1.4 IMT-2000 TDMA Single-Carrier

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.

3.2.1.5 IMT-2000 FDMA/TDMA

ITU Name: IMT-2000 FDMA/TDMA

Common Names: DECT

The IMT-2000 radio interface specifications for FDMA/TDMA technology are defined by a set of ETSI standards. This radio interface is called Digital Enhanced Cordless Telecommunications (DECT). The individual layers are defined in different parts of the common interface (CI) standard. The standard specifies a TDMA radio interface with 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 kilometers, 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.

3.3 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.

3.3.1 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.

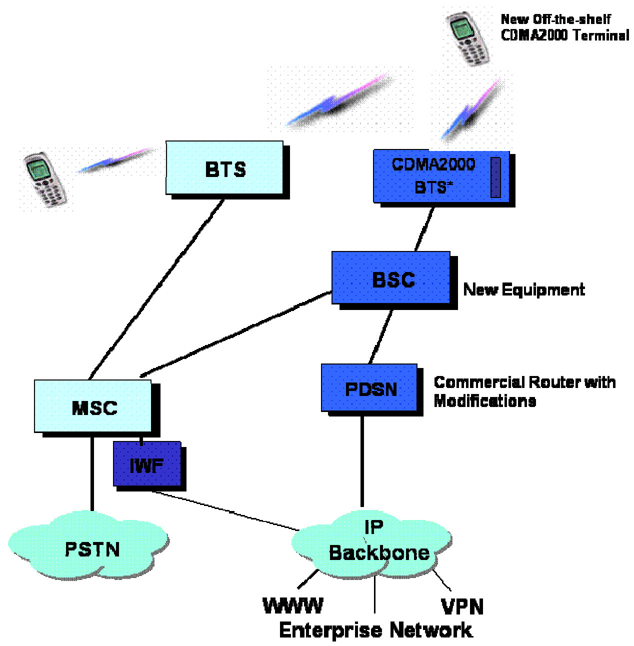
Once the transition from AMPS to TDMA has been accomplished, then a strategy of GSM/GPRS overlay can be undertaken which provides a common packet data service for both TDMA and GSM subscribers, as many TDMA operators have already embraced, leading to the deployment of GSM MAP and setting the stage for 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.

3.3.2 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 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 3.3.2 – 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, which is one of the IMT-2000 CDMA Multi-Carrier bands. 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 628 kbit/s, CDMA2000 1xEV-DO for high-speed data rates up to 3.1 Mbit/s and CDMA2000 1xEV-DV for combined voice and high-speed data rates up to 3.1 Mbit/s in a single carrier of 1.25 MHz. Analogue pre-IMT-2000 operators have a choice to first make the transition to CDMA2000 1X and then choose to overlay CDMA2000 1x-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 1xEV-DO carrier dedicated exclusively to high-speed packet data (up to 3.1 Mbit/s). 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. The operator has an option to make the transition to CDMA2000 1xEV-DV systems if necessary at a later stage to provide the combination of high voice and data capacity in a single carrier.

With CDMA2000 1X deployments, analogue operators can increase the sector voice capacity 31-45 times depending on the type of SMV. Receiver diversity can further enhance these capacities to 59 times when SMV1 is used. They can start offering data-rich applications supported by CDMA2000 systems such as multimedia messaging services (MMS) and video gaming. CDMA2000 systems also support circuit switch connections as an upgrade to current CDMA2000 networks and handsets, thus enabling video conferencing with high-quality voice. Transition to CDMA2000 provides analogue operators the ability to launch advanced, commercially available applications immediately in a cost effective manner so that they can gain competitive advantage over other IMT-2000 service providers.

3.3.3 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.

3.4 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.

3.4.1 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/transition[13] 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.

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.

3.4.2 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 add 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.

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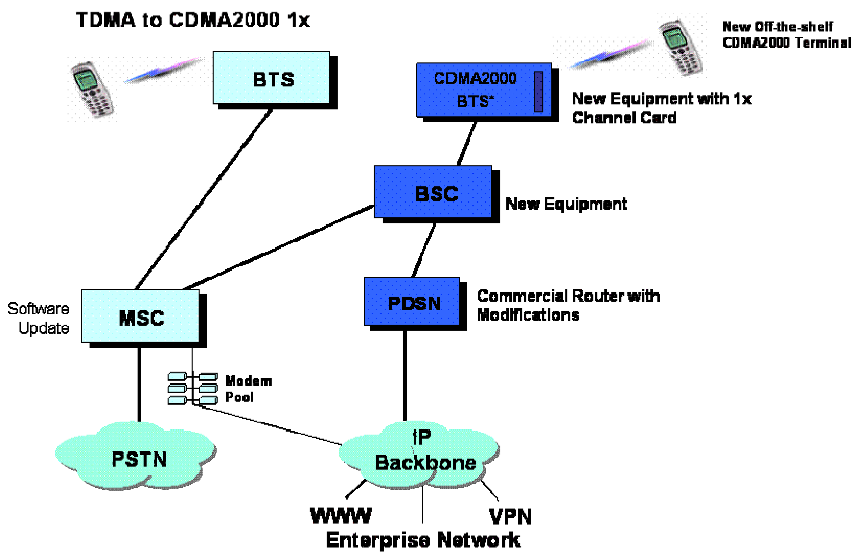
[13] The expression “migration/transition” is used to indicate a change obtained through both evolution and migration.

The family of IMT-2000 Multi-Carrier systems consists of CDMA2000 1X for voice and medium data rates up to 628 kbit/s, CDMA2000 1xEV-DO for high-speed data rates up to 3.1 Mbit/s and CDMA2000 1xEV-DV for combined voice and high-speed data rates up to 3.1 Mbit/s. TDMA operators can first make the transition to CDMA2000 1X and then choose to overlay CDMA2000 1xEV-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 3.4.2 – 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 the past 8 years 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 1xEV-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. The operator has an option to make the transition to CDMA2000 1xEV-DV systems if necessary at a later stage to provide the combination of high voice and data capacity in a single carrier.

Through this migration/transition, TDMA operators can increase voice capacity manifold and start offering data-rich applications supported by CDMA2000 systems such as multimedia messaging services (MMS) and video gaming. CDMA2000 systems also support circuit switch connections as an upgrade to current CDMA2000 1X networks and handsets, which enable video conferencing with high-quality voice. CDMA2000 migration/transition allows TDMA operators the ability to launch advanced, commercially available applications immediately in a cost effective manner so that they can gain competitive advantage over other IMT-2000 service providers.

3.4.3 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.

3.5 Transition from PDC

3.5.1 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 (Vodafone K.K. 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.

3.5.2 Transition to IMT-2000 CDMA Multi-Carrier

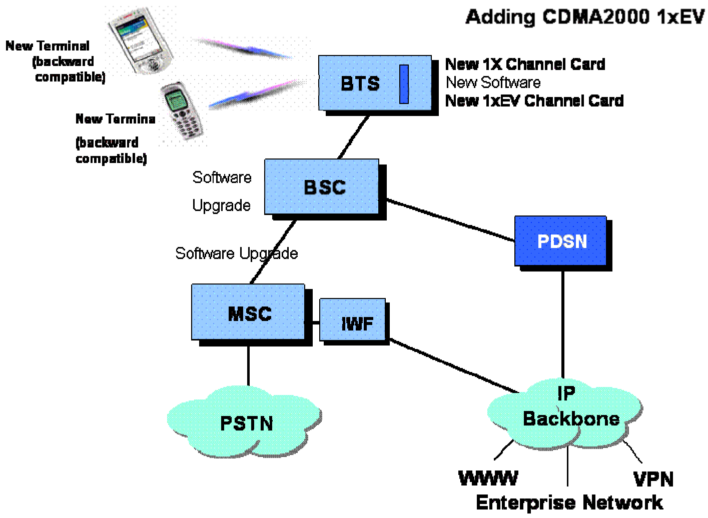
Another PDC operator in Japan, KDDI, chose IMT-2000 CDMA Multi-Carrier system. Since PDC system and IMT-2000 CDMA Multi-Carrier system have different air-interfaces and core network protocols, transition from PDC to IMT-2000 CDMA Multi-Carrier took place by way of cdmaOne (CDMA ANSI-95A/B). The PDC operator 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.

3.6 Transition from cdmaOne Systems

3.6.1 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 3.6.1 – 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 628 kbit/s, CDMA2000 1xEV-DO for high-speed data rates up to 3.1 Mbit/s and CDMA2000 1xEV-DV for combined voice and high-speed data rates up to 3.1 Mbit/s. Operators can overlay CDMA2000 1X, CDMA2000 1xEV-DO and CDMA2000 1xEV-DV 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. CDMA2000 enables a wide selection of handsets and infrastructure. Timely availability of advanced feature-rich multi-mode ASICs ensures continued support for low-cost mobile handsets and network infrastructure.

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 needs to simply make software upgrades at the base station controller and the mobile switching center, add new channel cards and software at the base stations, and add a packet data support node. Figure 3.6.1 shows the evolution path for cdmaOne to CDMA2000.

Evolution from cdmaOne to CDMA2000 requires relatively small capital investment. The low POP cost, minimal spectrum requirements, and efficient and low-cost technology contributed to Moody's favourable view of the upgrade path to IMT-2000 provided by CDMA technology. POP prices have decreased for cdmaOne carriers upgrading to CDMA2000 1X since 2001.

CdmaOne operators can nearly double the voice capacity of their network through evolution to CDMA2000 and provide high-quality speech using well proven selectable mode vocoders (SMV). Use of SMV at an average speech coding rate of 5.9 kbit/s and 4.5 kbit/s for mode 1 and mode 2, results in a voice capacity of 116 Erlangs and 133.9 Erlangs respectively in a bandwidth of 5 MHz. In addition, dual antenna mobile receivers employing receiver diversity techniques, together with optimal diversity combining strategy, enhance the capacity gains further and improve the number of simultaneous voice connections supported as well as device battery life.

Overlaying CDMA2000 1xEV-DO provides an evolution path for very high data rates up to 3.1 Mbit/s supporting various multimedia messaging services (MMS), video gaming and other applications such as video conferencing. 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.

Further enhancements to CDMA2000 1xEV-DO include higher peak rates and data capacities both in forward and reverse link that provide a peak data rate of 3.1 Mbit/s on the forward link and 1.8 Mbit/s on the reverse link. Smooth rate transitions using finer rate quantization up to 1.8 Mbit/s is introduced in the reverse link with Hybrid-ARQ methods. These enhancements are expected to support even a wider range of physical layer packet types for smaller payloads to improve packing efficiencies as well as larger payloads to support higher data rates up to 3.1 Mbit/s. An additional equalizer in CDMA2000 1xEV-DO enhances faster Internet access and quicker downloads in low mobility environments, facilitating richer applications.

The CDMA2000 operator has an option to evolve to CDMA2000 1xEV-DV systems if necessary at a later stage to provide the combination of both high-quality voice as well as high-speed data sessions over a single carrier. CDMA2000 1xEV-DV mixes voice and data optimally thereby creating extra capacity to further enhance data rates. This is achieved by introducing a high rate packet data channel that uses dynamic modulation and coding based on channel conditions, fast and efficient retransmissions, and dynamic resource allocation mechanisms. CDMA2000 1xEV-DV is fully backward compatible with ANSI-95A/B and CDMA2000 1X. ANSI-95A/B or newer mobile stations can operate in a CDMA2000 1xEV-DV cell and CDMA2000 1xEV-DV capable mobiles can deliver data on older systems.

The family of CDMA2000 technologies thus provides for smooth evolution of cdmaOne systems to IMT-2000 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 supporting the IMT-2000 service environment, such as multimedia messaging services (MMS) and video gaming. CDMA2000 systems also support circuit switch connections as an upgrade to the current CDMA2000 1X networks and handsets that enable video conferencing with high-quality voice. CDMA2000 provides CDMA operators the ability to launch advanced, commercially available applications immediately in a cost effective manner so that they can gain competitive advantage over other IMT-2000 service providers.

3.7 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.

3.7.1 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 signaling 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 3.7.1.

Table 3.7.1 – 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.

3.7.2 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.

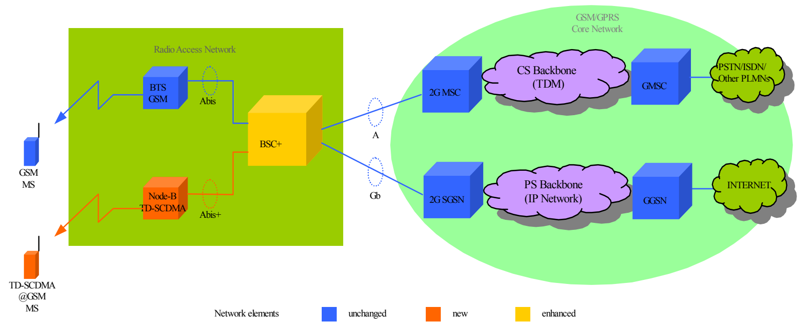
Step 1

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 (NodeBs) can be connected to the upgraded GSM/GPRS BSC to provide service based on GSM/GPRS network infrastructure. Correspondingly, the Abis interface is also upgraded to

Abis+. No modification is needed for the existing A and Gb interfaces. This integration of an IMT-2000 air interface into existing and stable GSM/GPRS infrastructure results in a rapid availability of high system capacity without deployment of a completely new core network infrastructure.

Figure 3.7.2-1 – Transition Step 1



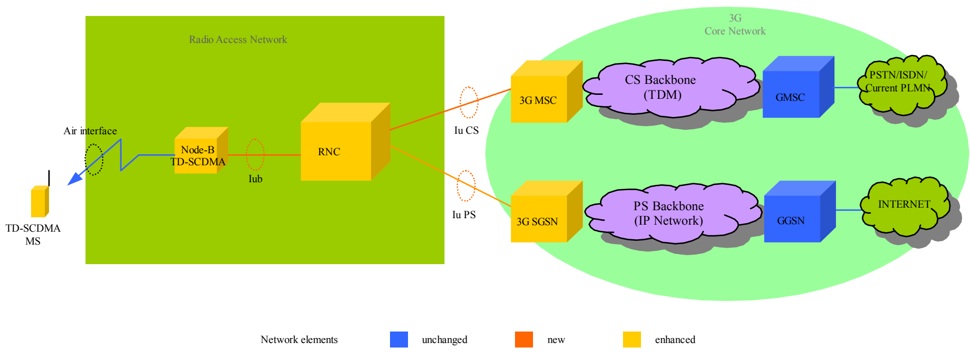
Step 2

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 3.7.2-2 – 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.

3.7.3 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, EDGE[14] 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.

[14] Assumes EDGE release 99.

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.

3.8 Capacity planning and system design

Once the high level specification for the network has been agreed, capacity planning can begin.

Capacity planning encompasses core network planning and radio access network planning. A dimensioning exercise first establishes the key features of the required network topology, typically the nature and number of the required system modules.

Using the dimensioning model, the core network and radio access network are then planned in detail.

Locations for the main elements of the core network are determined, and the required transmission capacity between each is identified.

Locations for the base stations are determined, typically based around the existing network's topography, with additional base station sites inserted where necessary to achieve the required coverage and capacity.

Coverage and capacity are 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.

4 Economics of transition to IMT-2000

A key step in the process of planning a transition path toward IMT-2000 network deployment is the economic evaluation of the revenues expected from the investments over the economic life of the system, including the spectrum license acquisition costs – where appropriate. This evaluation is based on the cost of the possible options and also on the assumptions about the evolution of demand and service penetration as well as tariff trends and policies.[15]

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

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

Various parameters characterizing the IMT-2000 network deployment are introduced in the following sections to enable economic evaluation.

4.1 Market analysis and trends

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

In this section, some examples of the market analysis for particular migration paths are provided. Information about operators following these paths is included in Annex F of the MTG.

Data on market overview and trends can be found in Section 4.1.1 and 4.1.2 of the MTG.

4.2 Costs of Transition

4.2.1 Costs of the network transition for the operator

The estimates of providing or upgrading pre-IMT-2000 networks to IMT-2000 (including license, network infrastructure, application and content development) vary widely. These Guidelines do not indicate specific costs, but instead articulate some of the factors affecting cost.

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

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

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

4.2.2 Cost affordability for end users

Issues affecting the cost for the end user are influenced by handset issues (availability, costs, potential need for subsidies, multi-band and/or multi-mode handsets, economies of scale), service affordability, as well as tariffs, interconnection rates, taxes, including luxury taxes, etc. In many markets, it has been shown that increased competition results in lower costs to end users.

4.2.2.1 Handsets: Availability, affordability, and variety

Today, IMT-2000 handsets are commercially available.

The cost of handsets is a critical factor for any wireless operator’s success in the market. In addition to offering high-speed, full-feature, multi-media phones, which will be more expensive initially, it will be necessary for IMT-2000 operators to sell low-cost terminals that support voice, SMS and circuit-data. The key driver of handset availability, affordability and variety – particularly at the low end of the market – is market size and the associated economies of scale. In addition, the implementation of Zero Intermediate Frequency (ZIF), or direct conversion technology, will bring further cost savings in the production of

IMT-2000 terminals. ZIF technology eliminates the need for an intermediate frequency and can reduce the cost of wireless devices by reducing the handset bill of materials, while also reducing the circuit board space needed by up to 50%.

Available today are a number of CDMA2000 handset chipsets designed to meet the needs of a wide range of users. The economies of scale and the opportunity to leverage common design and components between generations of CDMA products have led to the continuing decrease of CDMA2000 handset prices. In addition, many existing cdmaOne and CDMA2000 handsets are dual-mode devices that also support analogue networks, an important concern for current cdmaOne and TDMA operators who still have significant analogue coverage.

As a direct transition from GSM/GPRS, WCDMA terminals are and will increasingly be developed by the same broad range of terminal manufacturers that service the GSM market Dual-mode terminals (GSM/GPRS and WCDMA) are entering the marketplace, providing backward/forward compatibility. With the exception of the radios (and some chipset developers are even working to combine the radios into a single chip), many functions common to both can be shared in the handset chipsets to reduce space, power and processing requirements and ultimately cost. EDGE devices are available, and most new GPRS devices will be EDGE-enabled. Dual-mode EDGE/WCDMA terminals are available.

With the development of TD-SCDMA technology, more terminals are being developed and the variety of TD-SCDMA terminals is expected to increase. TD-SCDMA and GSM/GPRS dual-mode terminals are entering the market, which roam freely between GSM and TD-SCDMA networks. By sharing the common functions and promoting the integration of handset chipsets, it is expected to reduce handset prices and power requirements.

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

4.2.2.2 Service affordability

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

4.2.2.3 Regulatory issues

Administrations' decisions on critical regulatory issues such as interconnection rates, tariffs, taxes and service flexibility play a determinant role in the ultimate rates charged to users.

4.2.3 Roaming considerations

International roaming is becoming significantly easier with the introduction of phones that support multiple frequency bands and modes. The increasing prevalence of multi-band/multi-mode phones is important for two reasons. First, with expanded options, operators will be able to offer their customers nationwide, region wide or even worldwide coverage. Second, as multi-band/multi-mode phones become more common, operators will be able to attract additional roaming revenue since more users can roam onto their networks.

It is likely that tomorrow's IMT-2000 customer will not be aware of the radio or the network technology they are using in the "home" or "visiting" network.

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

It should be noted, however, that roaming between IMT-2000 family members requires more than merely multi-band/multi-mode handsets, which can operate in different environments. Essential prerequisites for roaming within the same IMT-2000 family members include:

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

ITU-T and 3GPP/3GPP2 are working to enhance roaming capabilities between IMT-2000 networks.

4.3 Business plan and analysis

A key step in the process of planning a transition path toward IMT-2000 network deployment is evaluating the network economics. Specifically, operators should consider choosing the transition path that yields the most economic value, including revenues, spectrum license acquisition costs[16], where appropriate, capital expenditures (CAPEX), and operating expenditures (OPEX) over the economic life of the system. Economic evaluation may have to be based on assumptions about the evolution of demand and service penetration as well as tariff trends and policies.

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

4.3.1 The Business Plan process

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

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[16] http://www.umts-forum.org/reports.html

4.3.1.1 Business Plan outline

The economic evaluation comprises the following logical phases:

a) the year traffic demand[17] over the considered period is estimated. This, in turn, involves several steps, i.e.,

- estimation of the potential user population;
- estimation of the service penetration considering dimensions such as: service class (i.e., bit rate of circuit switched and packet switched services), operation environment (i.e., dense urban, urban, suburban, rural), user age class, etc.;
- estimation of the activity factor per service type and class;
- estimation of OPEX (Operational Expenses including network and non-network related, handset subsidies, marketing and sales, etc.);

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

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

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

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

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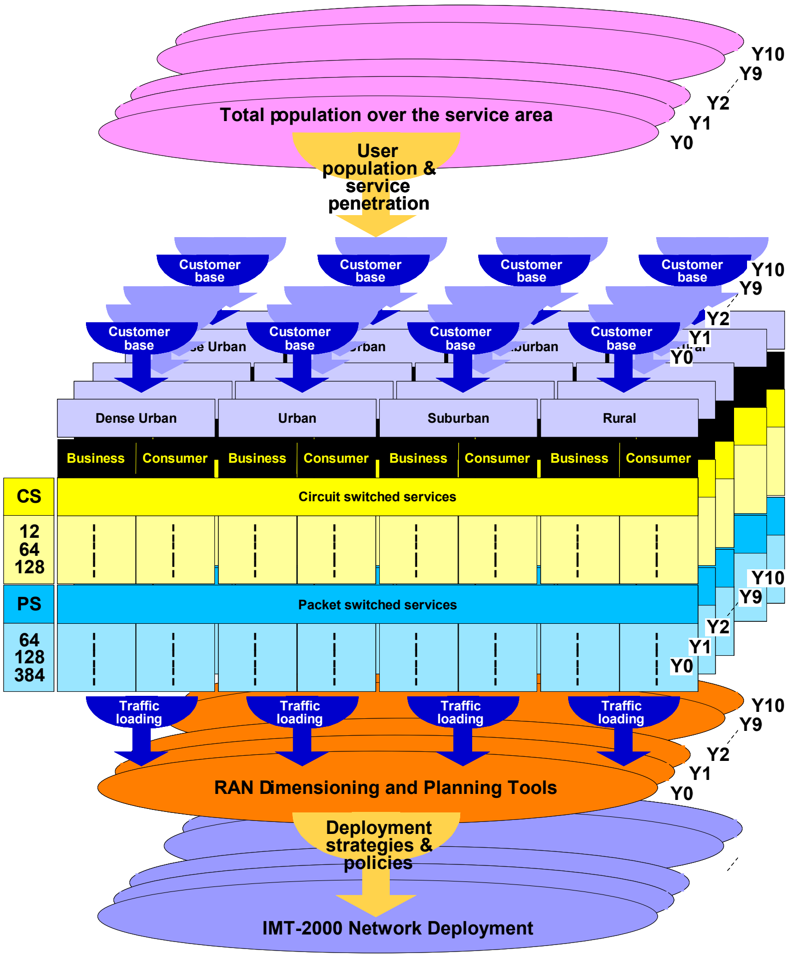
[17] As for capacity planning, the traffic demand results from the superposition of the demands related to the individual services. These may have different trends and, in general, different start-up times. In the following, unless stated otherwise, "demand" will indicate the superposition of the demands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

Figure 4.3.1.1 – Radio Access Network planning and IMT-2000 deployment over the economic life of the system



The phases comprising the business plan are summarized in Figure 4.3.1.1. Due to the many parameters on which the business plan may depend, a sensitivity analysis on the impact of critical parameters (such as demand estimation uncertainty ranges, slope in the service price erosion, etc.), normally complements the business plan exercise[18].

4.3.1.2 Service penetration and demand scenarios

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

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

Processing the data, quite naturally, starts with identifying the service area and the overall population insisting on it (see Figure 4.3.1.1). From the overall population, the potential customer population is identified as the one confined within specified age limits. Further, assuming a stated percentage for the population service coverage, the final customer base population is derived. From this, by assuming stated percentages of the service area for dense urban, urban, suburban and rural operation environment, and also assuming that the share of business and consumer customers are specific to each operation environment, the user population can be classified according to the joint criteria of operation environment and subscription type. Finally, assuming that the service penetration for circuit and packet switched services are also specific to the operation environment and subscription type, it is possible to derive the actual user population subscribed to IMT-2000 services. This population is now assumed evenly distributed over the service area for the purposes of estimating the offered traffic and, hence, carrying out the radio access network planning. To this end, an activity factor specific to each service class is introduced and the overall traffic offered estimated (see Figure 4.3.1.1).

To obtain the evolution of the radio access network planning, the above exercise is repeated for each year along the economic life of the system, as indicated in Figure 4.3.1.1. This involves updating of the overall population and adjusting all other input data having a dependence on time, such as the service penetration. Normally, the number and location of base stations and mobile switching centers for year N+1 correspond to those for year N plus the ones due to the increase in the customer base from year N to year N+1. In other words, no rearrangement of the radio network infrastructure in place at any time is normally considered.

4.3.1.3 Sensitivity analysis

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

4.3.2 The Business Plan exercise

4.3.2.1 Introduction

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

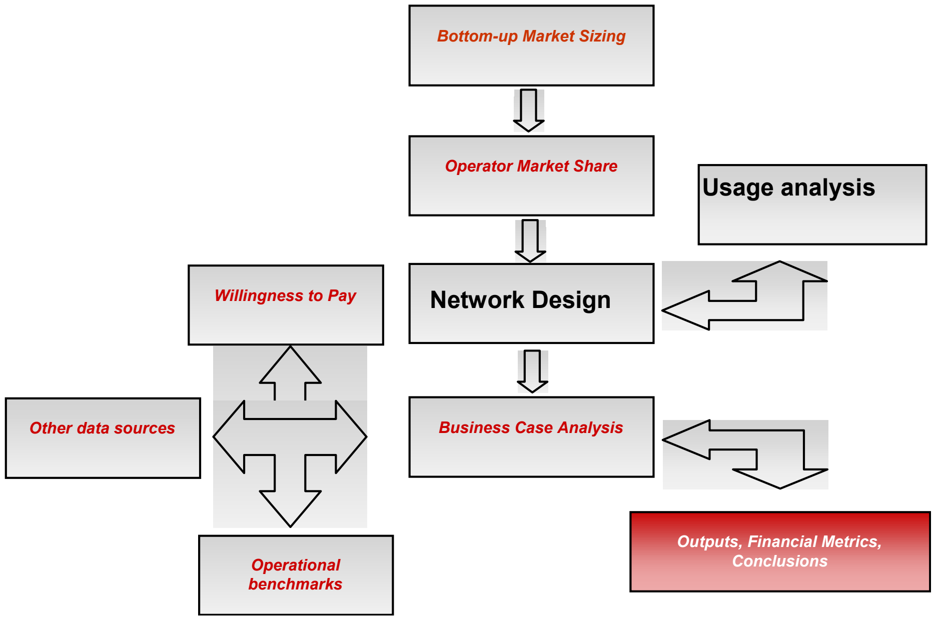
Considering the realities of increasingly saturated mobile subscriber markets and of declining voice ARPUs, the IMT-2000 vision shifts the focus from subscriber-driven growth to ARPU-driven growth. IMT-2000 business plans routinely factor in a large revenue portion originating from data applications: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

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

4.3.2.2 A modular approach to business planning

A possible business plan model is shown in Figure 4.3.2.2.

Figure 4.3.2.2 – Structure of the business plan model



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

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

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

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

Accounting marks the final step in the business planning process: here P&L and cash flow statements are generated as standard deliverables of a bankable business plan, and investor-side performance metrics – e.g. IRR (Internal Rate of Return) and NPV (Net Present Value) – as well as creditor-side metrics – e.g. DSCR (Debt Service Cover Ratio) and financial covenants – can be calculated.

It is to be noted that figures have only indicative value and that conclusions based on the business analysis are critically dependent on the assumptions underlying the parameter choice.

Section 4.3.2 of the MTG elaborates on a real life business case and readers who are interested in more detail are encouraged to refer to that part of the MTG.

5 Concluding remarks

The transition from pre-IMT-2000 systems to IMT-2000 systems is being driven by a set of benefits to both users and operators that have been envisioned as IMT-2000 is deployed around the world. Among the benefits are:

- Global benefits: common frequency bands, a high degree of commonality of system design and off-the-shelf equipment, and support for a variety of terminal types

- New services and capabilities: higher quality and more efficient voice services, advanced data and multimedia capabilities, improved security, and support for a variety of data rates in either direction

- Evolution and migration: flexible evolution both to and within IMT-2000, compatibility of services within IMT-2000 and with the fixed telecommunications network, and ability to coexist and interwork with pre-IMT-2000 systems.

- Flexibility and multi-environment capabilities: support for customization of services across different regions and environments, accommodation of a maximum level of interworking between networks of different types, provision of services over a wide range of population density, topographical, and mobility scenarios, and more efficient use of radio spectrum.

These benefits are very important to developing countries, as they all feed into more tangible benefits for operators and users. With the flexibility to transition their existing systems to IMT-2000, developing countries have the ability to significantly advance the state of their telecommunications service offerings beyond where they currently stand, in some cases even leapfrogging the capabilities of the existing wireline networks. The flexibility to choose from different IMT-2000 technologies that were designed to coexist with or replace pre-IMT-2000 systems affords operators the ability to implement the system or systems that provide the best balance of user benefits and leverage on existing investments. The transition to IMT-2000 provides users with higher-quality and more efficient updates to the voice and data services offered by pre-IMT-2000 networks, thereby offering developing country users tangible improvements to familiar services.

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

Evolution and migration are the phases through which a transition materializes, with the mix and sequence determined on the basis of economic and strategic decisions. In general, not only for developing countries, evolutionary system upgrades are preferable from the operator and user points of view, because earlier investment can be largely reused. However, experience shows that in time every technology will reach its expansion limits (i.e., even evolutionary enhancements will eventually lead to unacceptable system complexity). At that stage, technology jumps are necessary, leading to the need for a new system, which is then incompatible with the old one and requires an appropriate migration and interoperability strategy.

Preliminary data has shown that improved and more widespread mobile networks, such as those enabled by IMT-2000 technologies, have a correlation with economic improvements, which is arguably one of the most valuable potential benefits of the transition to an advanced wireless network. In addition to improving existing services, as IMT-2000 networks are deployed across the developing world, their advanced data and multimedia capabilities provide users and service providers with new tools for driving economic development, and enabling the implementation of infrastructure for the emerging Information Society (see WSIS Declaration of Principles and Action Plan).

In conclusion, the full potential of mobile communications systems, including IMT-2000, to improve access to information and communications services for the underserved and unserved parts of the world is key to providing access for all in the Information Society and reducing the digital divide.

6 Definitions

For the purposes of these Guidelines, the following definitions will apply.

Term	Source	Definition
Evolution	ITU Handbook	A process of change and development of a mobile radio system towards enhanced capabilities (Rec. ITU-R M.1308).
Evolution towards IMT-2000	ITU Handbook	A process of change and development of a mobile radio system towards the capabilities and functionalities of IMT-2000 (Rec. ITU-R M.1308).
Migration to IMT-2000	ITU Handbook	Movement of users and/or service delivery from existing telecommunication network to IMT-2000 (Rec. ITU-R M.1308).
Pre-IMT-2000	ITU Handbook	Mobile systems that are currently in service or will be introduced prior to IMT-2000 (Rec. ITU-R M.1308). Note – In the context of these guidelines, the definition of "Pre-IMT-2000" applies to all deployments of systems conforming to pre-IMT-2000 standards, as covered in Recommendations ITU-R M.622, M.1033 and M.1073.

Term	Source	Definition
3GPP Release	3GPP TR 21.900 V5.0.1	Specifications are grouped into "Releases". A mobile system can be constructed based on the set of all specifications, which comprise a given Release. A Release differs from the previous Release by having added functionality introduced as a result of ongoing standardization work within the Groups. Specifications pertaining to a given Release shall be distinguished by the first field of the version number ("x" in x.y.z: he meaning of the three fields is defined in 3GPP TR 21.900 V5.0.1[19]). A given specification may simultaneously exist in several versions, each corresponding to a different Release. In principle, a Release of the specification can be identified as consisting of all those specifications with a "major" version field of a given value.
3GPP Specification	3GPP TR 21.900 V5.0.1	Generic term standing for Technical Specification and Technical Report. Each specification is associated with a "version number" in the form x.y.z which uniquely identifies the document. In general, a 3GPP Technical Specification (TS) is identified by: • the specification number, e.g. 3GPP TS <aa.bbb>; • the version number, e.g. V <x.y.z>; • the specification title; • the release number, e.g. for UMTS, Release 5. The significance of the fields <aa.bbb> and <x.y.z> is defined in 3GPP TR 21.900 V5.0.1. In particular, the range of the field "aa" depends on the type of system. For the UMTS system (Release 1999 onwards), the field "aa" ranges from 21 to 35, for identifying coverage of aspects related to: requirements specifications, service, technical realization, signaling protocols, radio access and core network, SIM/UIM, security, test specifications, etc.
3GPP Version	3GPP TR 21.900 V5.0.1	Unique identifier in the form x.y.z for a specification at a given point in time. Example: version 3.12.3.
3GPP2 Publication	3GPP2 S.R0097	Any document published by a 3GPP2 constituent body (Technical Specification Group, or Steering Committee). A publication must conform to the Publication Numbering Scheme, briefly defined as follows. <u>A.Bcccc[-ddd]-X version y.z</u>

[19] 3GPP TR 21.900 V5.0.1 "… outlines the working methods to be used by the 3GPP Technical Specification Groups and their Working Groups and their Sub-Groups, and by the 3GPP Support Team in relation to document management, i.e. handling of specifications, updating procedures, change request procedures, version control mechanisms, specifications status information etc. It complements the rules and procedures defined for 3GPP. …"

For the purposes of fully clarifying 3GPP specification process and release concept, 3GPP TR 21.900 V5.0.1 is given in Annex E of the Medium-Term Guidelines (MTG).

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

NOTE – All 3GPP and 3GPP2 technical specifications are normally submitted through their organizational partners as input to ITU-T and/or ITU-R to serve as the basis for most of the ITU-T Recommendations on the IMT-2000 core network and ITU-R Recommendations on the IMT-2000 radio access.

7 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	
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	
OPEX	Operational Expenditure
P	
PCF	Packet Controller Function
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
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
Y	
Z	

ANNEX I

Operator experience in transitioning to IMT-2000 systems

This Annex provides operator experiences in transitioning to IMT-2000 systems. Table I.1 cross-references these operator experiences with the transition scenarios listed in Section 3.2. In addition, information on the deployment of commercial and trial systems can be found on the ITU's IMT-2000 web page at http://www.itu.int/ITU-D/imt-2000/index.html.

Table I.1 – Transition scenario of operator experiences

Scenario	Operator Experiences	Pre-IMT-2000 Network (Frequency)	IMT-2000 Network (Frequency)
Scenario 1	Russian Federation	NMT 450 (450 MHz)	CDMA2000 1X (450 MHz)
Scenario 2	Chile (Telefónica Móvil de Chile)	AMPS/TDMA (850 MHz)	GS+M/GPRS/EDGE (1 900 MHz)
Scenario 2	Japan (NTT DoCoMo)	PDC (800 MHz)	WCDMA (2 000 MHz)
Scenario 3	Hong Kong (Hong Kong CSL Ltd)	GSM/GPRS (900/1 800 MHz)	GSM/GPRS/EDGE (900/1 800 MHz)
Scenario 3	Japan (KDDI: au)	cdmaOne (800 MHz)	CDMA2000 1X (800 MHz)
Scenario 3	Thailand (Advanced Info Service Public Co. Ltd)	GSM/GPRS (900 MHz)	GSM/GPRS/EDGE (900 MHz)
Scenario 3	Venezuela	TDMA (800 MHz)	CDMA2000 1X (800 MHz)
Scenario 4	Hungary (Pannon GSM Telecommunications Ltd)	GSM (900 MHz)	GSM/GPRS/EDGE (1 800 MHz)

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

Source: Telefónica Móvil de Chile

1 Background

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

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

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

2 Infrastructure Implementation

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

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

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

3 Spectrum Efficiency

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

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

4 GSM Migration

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

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

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

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

Source: Hong Kong CSL Limited

1 Background

CSL launched its mobile services in 1983, and today operates a world-class GSM/Dual Band network through its mobile brands: 1O1O and One2Free. The Company also provides comprehensive pre-paid mobile services and international roaming services. It offers leading-edge mobile technology including WAP (Wireless Applications Protocol), HSCSD (High Speed Circuit Switched Service Data) and GPRS (General Packet Radio Service).

2 EDGE Services

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

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

3 Evolution from 2GSM

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

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

4 Network Performance

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

5 EDGE Roaming

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

6 EDGE, Market Reality

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

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

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

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

Source: Pannon GSM

1 Background

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

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

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

2 EDGE Services

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

3 Evolution Costs

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

4 EDGE Implementation

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

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

Source: NTT DoCoMo

1 Introduction

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

2 FOMA Launch

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

3 FOMA Services

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

3.1 i-mode

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

3.2 Visual Communications/Videophone

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

3.3 High-speed data telecommunications

- High-speed packet transmission at rates of up to 384 kbit/s[20] allowing users to access to e-mail and web sites at faster speeds.
- 64 K circuit-switched data transmission, an ideal solution for sending a large volume of data, such as video images, in real time.

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

3.4 Multi-access

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

3.5 i-motion

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

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

4 A Vision for Growth

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

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

5 3G Global

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

JAPAN – CDMA2000 1X Deployment and Associated Multimedia Services Launched in Japan[21]

Source: KDDI (JAPAN)

1 Wireless Market Outlook in Japan

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

2 CDMA2000 1X Launch by au

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

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

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

3 Secret of au's Success in CDMA2000 1X Launch

Due to CDMA2000 1X's inherent backward compatibility with cdmaOne, which enables cdmaOne terminals to operate on CDMA2000 systems and vice versa, service coverage for the CDMA2000 1X system was practically equivalent to the existing cdmaOne service coverage from day one. In addition, the straightforward upgrade path from cdmaOne enabled a rapid and low cost CDMA2000 1X roll-out. Moreover, the technology maturity inherited from cdmaOne, led to the development of CDMA2000IMT-2000 CDMA Multi Carrier handsets that were the same size or smaller than cdmaOne handsets, had the same battery life and operational stability, with a minimal increase in cost.

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

1) an upgrade approach; or

2) an overlay approach.

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

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

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

After weighing these options, KDDI adopted the "upgrade" approach in its roll-out of CDMA2000 1X.

4 Mobile Multi-media Services by au

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

- Ezweb – WAP2.0-based Internet Access and Browsing Platform.
- EZweb@mail – IMAP4-based e-mail platform.
- Ezplus – Java^{TM} application services, with support of mobile agent function using HTTP, and automatic application update from servers.
- Eznavigation – Accurate position location-based services powered by gpsOne.
- Ezmovie – Video distribution available nationwide, using industry standards, i.e. MPEG-4 for video coding and MP4 for video file format.
- Photo-mail (including eznavigation associated with Photo-mail, which stores location information along with pictures to provide vivid memories for travellers, the ability to provide easy recommendations on locations, and a number of business applications).

5 Objectives and Goals for 3G Migration: au's Next Step

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

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

RUSSIAN FEDERATION – Evolution and Migration of 1st Generation NMT450 Analogue Mobile Networks to IMT-2000

Source: Russian Federation

1 Background on NMT450 Evolution and Migration

NMT (Nordic Mobile Telephone)[22] is a first-generation analogue mobile cellular network standard that was first deployed in 1981 in Scandinavia in 450 and then in 900 MHz band, and later in 12 other Eastern European and CIS countries including Russian Federation in 450 MHz frequency band[23]. NMT450 was a first federal cellular standard deployed in Russia in 1991. Number of users of NMT450 in Russia once reached 1mln is now declining.

In 1998 a need for digital technology for future migration of NMT networks was identified at the NMT MoU Plenary. After studying three different technology options for digitization of the NMT systems, two technologies were selected in 1999 for future evolution of the NMT450 networks: GSM400 and CDMA450. After deployment of two trial GSM400 networks, this evolution path was abandoned by manufacturers who supported it. Between October of 2000 and December of 2002, trials of CDMA450 (also known as IMT-MC-450, or Band Class 5 of IMT-2000 CDMA Multi-Carrier[24] were conducted by different NMT operators in Russia, Hungary, Romania, Sweden, Georgia and Belarus. Trials have led to successful commercial launches in Romania, Belarus and then in Russia.

2 IMT-MC-450 studies and trial networks

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

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

The following trial results were reported by operators:

- Single cell radio coverage of up to 50 km.
- Capacity claims proved.
- Approximately 100 kbit/s average packet data transfer rate (download and upload) achieved in urban environment, in movement.
- Excellent voice quality experienced.

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

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

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

- Roaming successfully tested.
- EMC: two networks, analogue and digital, may coexist in the band, if the guardbands are used at both sides of CDMA carrier.

Based on the studies results and trial network tests IMT-MC-450 was chosen by the Ministry of Telecommunications and Informatics of the Russian Federation as the technology evolution path for existing NMT450 networks in Russia. The IMT-MC-450 standard was adopted as a federal standard in the Russian Federation.

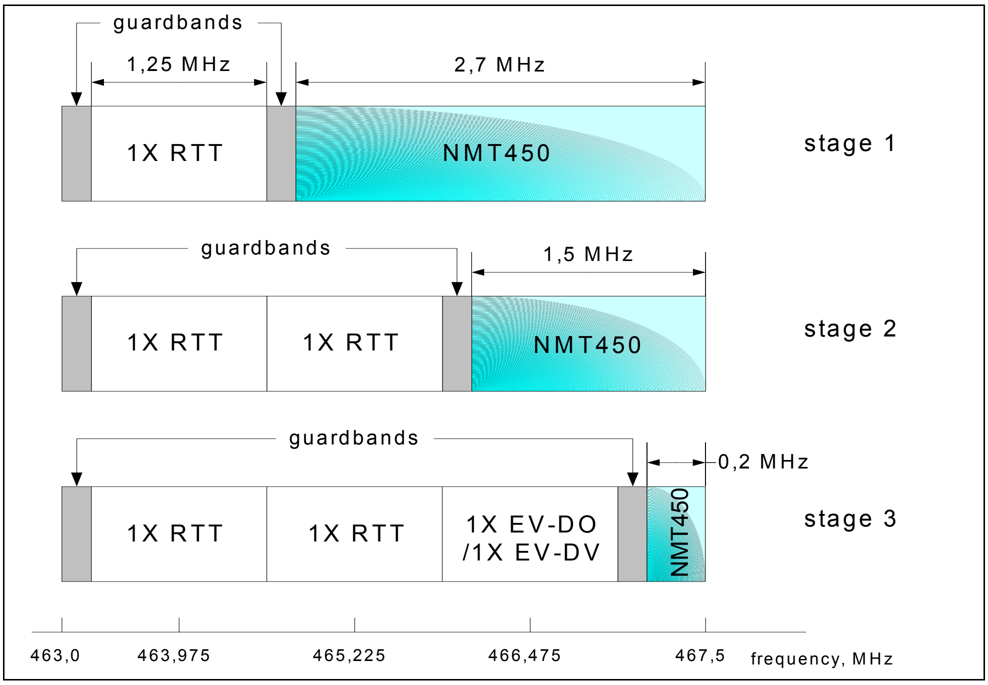
3 IMT-MC-450 Commercial Network Deployments

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

3.1 Stages of IMT-MC-450 Network Deployment

Studies have shown that smooth migration to digital technology in the 450 MHz band may be performed in several stages, as illustrated in Figure I.1. In most cases, the NMT450 operators have limited bandwidth available (2 × 4.5 MHz on average), which allows usage of three IMT-MC-450 carriers (1.25 MHz each). The need to move from one stage to another may appear at different times in different parts of the network. Traffic demands may greatly vary across the covered territory. Thorough analysis and careful planning should be used to achieve high efficiency and quality.

Figure I.1 – Spectrum usage (BS Tx band) in 3 stages of network evolution



1) *First stage: initial deployment*

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

2) *Second stage: network growth*

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

3) *Third stage: high demand for data services*

When the data traffic in the network increases substantially and higher bitrates are desirable by end users, a data-optimized carrier – (1xEV-DO) and furthermore 1xEV-DV can be introduced.[25]

3.2 Commercial IMT-MC-450 Services

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

SkyLink's objectives for its IMT-MC-450 deployment were to 1) replicate coverage of its analogue NMT network and continue provision of high quality voice services, and 2) provide a variety of new data services to compete with the GPRS services offered by its competitors.

1) *Coverage*

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

2) *Services*

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

- High-speed access to Internet (with data rates up to 153 kbit/s) using computers, notebooks and PDAs.
- Access to specialized Web-portals using mobile terminals or PDAs[26].

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

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

- E-mail reception and transmission with SMTP/POP3 protocols using mobile terminals or computers.
- Mobile games and specialized applications, such as “Search of objects” with option to receive a city map with the found objects on PDA screen.

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

Table I.2 – Pricing plans

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

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

3) *Network and service offering expansion*

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

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

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

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

3.3 Lessons Learned from Commercial IMT-MC-450 Operations

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

1) Actual capacity and network throughput of the IMT-MC-450 network met declarations made by equipment manufacturers.

2) Electromagnetic compatibility between the analogue NMT and IMT-MC-450 systems was achieved when guardbands were implemented between the analogue and digital carriers.

3) No serious electromagnetic compatibility problems occurred between the IMT-MC-450 system and other wireless systems operating in adjacent frequency bands.

4) The adopted market entry strategy, including tariff plans, was justified:

   - Despite a high entrance fee (> USD 400) there is a steady demand for offered services.
   - More than half of subscribers use data services.
   - Average monthly data traffic volume is approximately 10 Mbytes per subscriber;
   - More than 5% of subscribers have monthly data traffic volumes significantly exceeding the amount included in the pricing plan (30 MBytes per month for pricing plan 1 and 2, see Table I.2).
   - Average Revenue Per Subscriber (ARPU) of IMT-MC-450 network is eight times more than the ARPU of analogue NMT450 network.
   - Stable growth of subscriber base of IMT-MC-450 network.

5) The further reduction of analogue NMT subscriber base in 2004 will enable to enter the deployment of a second IMT-MC-450 carrier, that will double the network capacity.

4 Conclusion

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

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

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

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

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

Source: Advanced Info Service Public Company Limited

1 Introduction

Advanced Info Service Public Company Limited (AIS) started out in the information technology field as a computer service provider and today we have firmly established ourselves in the wireless telecommunications sector as an analog mobile phone service provider of cellular 900 and digital GSM systems.

With over 13 million subscribers AIS is not content with being Thailand's leading mobile phone service provider, AIS continues to integrate the latest in advanced technology and deliver more than just voice telecommunication into the hands of its subscribers. In return for their confidence and support, AIS is committed to exceeding customer expectations in all aspects of mobile phone technology provision and service.

2 EDGE

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

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

3 Marketing

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

4 Spectrum Efficiency

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

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

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

5 3G Evolution/Compatibility

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

UGANDA – GSM networks bring health care to rural Uganda

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

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

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

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

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

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

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

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

VENEZUELA – Venezuelan Experience on the Implementation of CDMA 1xRTT Network by one Existing TDMA Operator in the 800 MHz Band (824-849 MHz/869-894 MHz)

Source: Venezuela

1 Background

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

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

- Availability of technologies in the 800 MHz band.
- Efficiency of frequency use (traffic handling capacity).
- Compatibility with existing infrastructure.
- Positioning to offer 3G services.
- International experiences.
- Availability of terminals.

2 Study of Options

2.1 Availability of technologies in the 800 MHz band

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

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

2.2 Efficiency of frequency use (traffic handling capacity)

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

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

2.3 Compatibility with existing infrastructure

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

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

2.4 Positioning to provide 3G services

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

2.5 International experiences

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

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

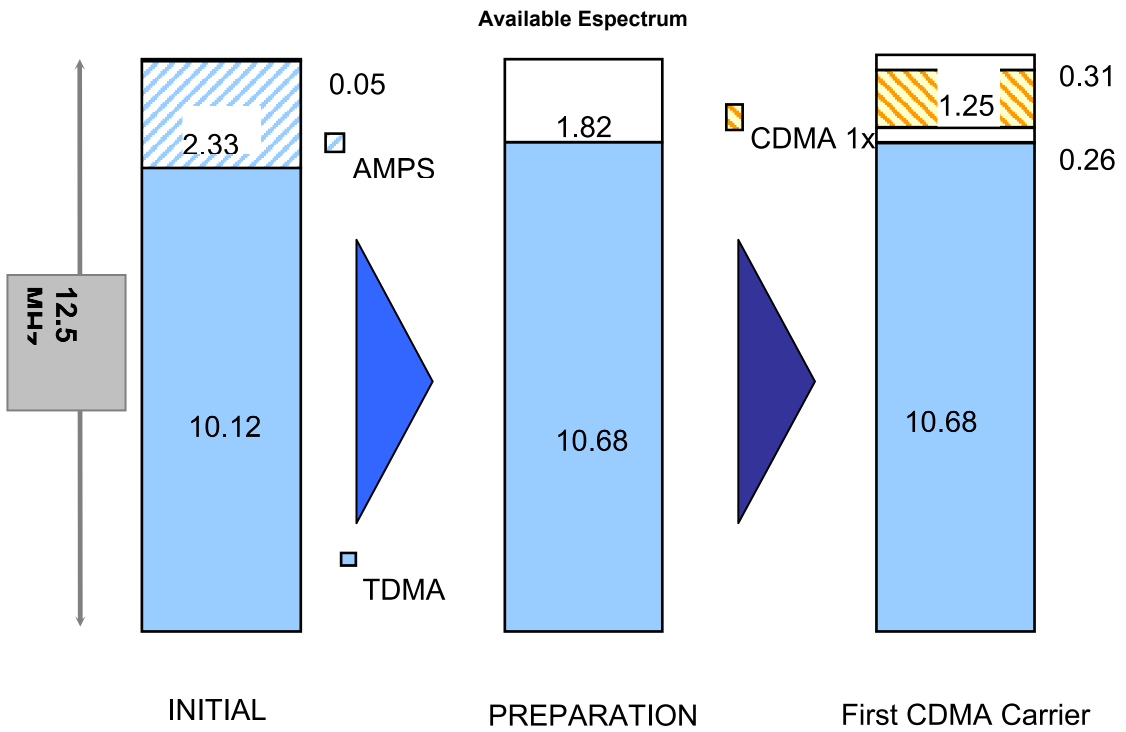
2.6 Availability of terminals

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

3 Network Construction and Commissioning

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

Figure I.2 – Plan for Spectrum Migration to CDMA 1xRTT



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

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

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

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

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

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

4 Tests of Operation

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

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

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