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Preliminary draft new Recommendation (PDNR): Vision framework and overall objectives of the future development of IMT-2000 and of systems beyond IMT-2000

PRELIMINARY DRAFT NEW RECOMMENDATION (PDNR)

Vision, framework and overall objectives of the future development of IMT-2000 and of systems beyond IMT-2000

1 Introduction

The specifications for the initial releases of IMT-2000, which are defined in Recommendation ITU-R M.1457-2, have been completed, and the commercial deployment of IMT-2000 has begun. Work is already underway in various external organisations to extend the capabilities of the initial releases in line with market expectations and technology trends.

To help meet the ever increasing demands for wireless communication, and the expected higher data rates needed to meet user demands, the ITU Radiocommunication Assembly approved Question ITU-R 229/8 on the future development of IMT-2000 and systems beyond IMT-2000. That Question asks generally about the overall objectives and the technical, operational, and spectrum issues related to the future development of IMT-2000 and systems beyond IMT-2000. One of the initial steps in the process of addressing this Question is producing this Recommendation on the vision of the future development of IMT-2000 and of systems beyond IMT-2000. Additional Recommendations and Reports will be developed to address specific issues in more detail.

2 Scope

This Recommendation defines the radio access network vision, framework and overall objectives of the future development of IMT-2000 and systems beyond IMT-2000. This vision is based on global market and technology trends, including the needs of developing countries. The Recommendation explores the high-level features of the future development of IMT-2000 and systems beyond, specifically addressing:

a) Evolutionary development of IMT-2000, which refers to the enhancements of its technical capabilities, range of available services and breadth of applications that will be progressively introduced during its lifetime; and

b) Systems beyond IMT-2000, which are expected to be realized in the marketplace after the year 2010, and which could be widely deployed around the year 2015.

The complete ITU Vision encompasses both the “radio access network” and the “core network”. The scope of this ITU-R Recommendation is the radio access network, while the core network is addressed in a companion ITU-T Recommendation. The Vision for the future development of the IMT-2000 radio access network includes the emerging relationships with other radio access networks (existing and future), and all the capabilities required to deliver services securely to the users of IMT-2000 and systems beyond IMT-2000.

3 Related Recommendations

ITU-R F.1399 Vocabulary of terms for Wireless Access

ITU-R M.687-2 International Mobile Telecommunications-2000 (IMT-2000)

ITU-R M.816-1 Framework for services supported on International Mobile Telecommunications-2000 (IMT-2000)

ITU-R M.818 Satellite operation within International Mobile Telecommunications-2000 (IMT-2000)

ITU-R M.819	International Mobile Telecommunications-2000 (IMT-2000) for developing countries
ITU-R M.1034-1	Requirements for the Radio Interface(s) for International Mobile Telecommunications 2000 (IMT-2000)
ITU-R M.1035	Framework For The Radio Interface(s) And Radio Sub-System Functionality For International Mobile Telecommunications 2000 (IMT-2000)
ITU-R M.1182-1	Integration of terrestrial and satellite mobile communication systems
ITU-R M.1224 (IMT-2000)	Vocabulary of terms for International Mobile Telecommunications-2000
ITU-R M.1311	Framework for modularity and radio commonality within IMT-2000
ITU-R M.1450	Characteristics of broadband radio local area networks
ITU-R M.1457-2	Detailed specification of the radio interfaces of IMT-2000
ITU-T Q.LTVN	Long-term vision of network aspects for systems beyond IMT-2000.

4 Considerations

4.1 Market Trends

In defining the Vision for the future development of IMT-2000 and systems beyond IMT-2000, it is important to understand the market trends that will affect the development of such systems. In particular, the Vision should be informed by increasing user expectations and the growing demand for mobile services, as well as the evolving nature of the services and applications that may become available. The trends discussed below are thus an important underpinning of the Vision for the future development of IMT-2000 and systems beyond.

4.1.1 Growing Demand for Mobile Services

The number of mobile subscribers worldwide has increased from [300] million in 1997 to [800] million (13% of global population) in 2001 as shown in Figure 4-1. It is predicted that by 2010 there will be 1700 million terrestrial subscribers worldwide. A substantial portion of these additional subscribers are expected to be from outside the countries that have substantial penetration as of 2001.

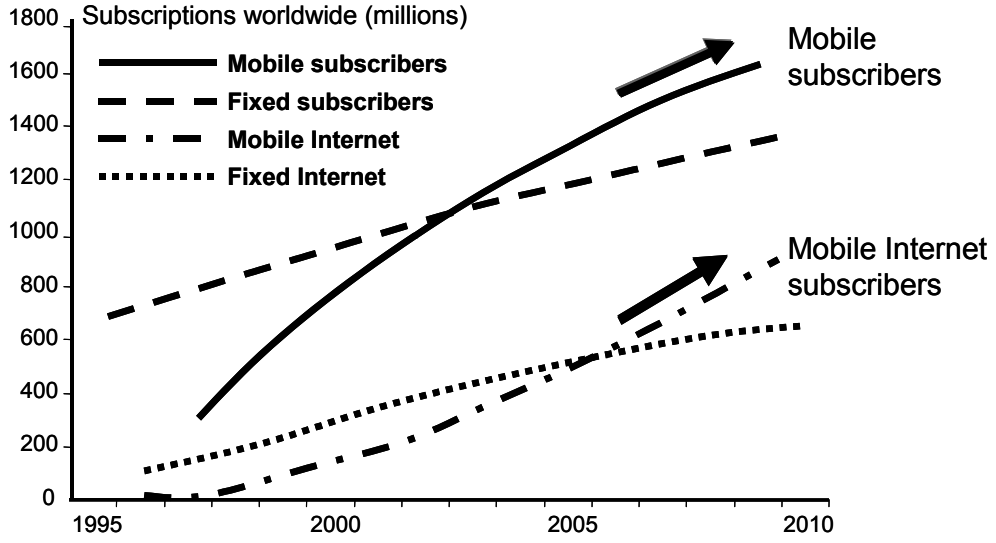


FIGURE 4-1: Global growth of mobile and fixed subscribers

It is the envisaged that, by 2020, potentially the whole population of the world could have access to advanced mobile communications devices, subject to, amongst other considerations, favourable cost structures being achieved. The number of portable handsets already exceeds and will continue to grow more rapidly than the number of fixed line devices (PCs, webphones, etc) connected to the Internet. Mobile terminals will be the major devices to access and exchange information. Already the number of mobile telephones exceeds the number of fixed line telephones.

User expectations are continually increasing with regard to the variety of services and applications. In particular, users will expect a dynamic, continuing stream of new applications, capabilities and services that are ubiquitous and available across a range of devices using a single subscription and a single identity (number or address). Versatile communication systems offering customized and ubiquitous services based on diverse individual needs will require flexibility in the technology in order to satisfy multiple demands simultaneously.

4.1.2 Evolving Services and Applications

The trend of 'digitalisation' is already well advanced. The majority of electronic and communications devices and delivery mechanisms (i.e. cellular, broadcast, fixed wireless access, wireless LANs, xDSL, satellite, etc) are either already digital or in the process of transitioning to digital.

Another trend is that multimedia services will dominate traffic flows. The majority of traffic is changing from speech-oriented to multimedia communications with a corresponding change in technology from predominantly circuit-switched to packet-switched delivery. This change from second-generation technology to IMT-2000 provides the user with the ability to receive more efficient multimedia services, including e-mail, file transfers, messaging and distribution services. These multimedia services can be symmetrical and asymmetrical, real-time and non real-time, and are expected to be highly bandwidth consuming resulting in higher data rate requirements for the future.

External market studies have predicted that in Europe in the year 2010 more than 90 million mobile subscribers will use mobile multimedia services, generating about 60 % of the traffic in terms of transmitted bits.

In Japan mobile web browsing service, which is one type of mobile multimedia service, have become popular around 2000. The number of mobile web browsing service users was 48.5 million (72 % of mobile subscribers) at the end of 2001 and is still growing.

Other communication relationships will also emerge, in addition to person to person, such as machine-to-machine, machine-to-person and person-to-machine.

To meet rising expectations, work has already begun on the convergence of telecommunication services such as digital broadcasting and commercial wireless services. The trend toward integration and convergence can be characterized by:

i) Connectivity (provision of a pipe, including intelligence in the network and the terminal).

ii) Content (information, including push-pull).

iii) Commerce (transactions).

These trends may be viewed as the integration and convergence of information technology, telecommunications, and content. This will result in new service delivery dynamics and a new paradigm in telecommunications where value added services, such as those which are location dependent, will provide enormous benefits to both the end users and the service providers.

4.2 Vision

Present mobile communication systems have evolved by adding more and more system capabilities and enhancements, and the user will see a continuous increase in capability. Systems beyond IMT-2000 will be realized by functional fusion of existing, enhanced and newly developed elements of cellular systems, nomadic wireless access systems and so forth, with high commonality and seamless interworking.

4.2.1 High Level Vision

The high level vision of the future development of IMT-2000 and systems beyond IMT-2000 is considered to be as follows:

- Future development of IMT-2000:

  There will be a steady and continuous evolution of IMT-2000, to support new applications, products and services. For example the capabilities of some of the IMT-2000 terrestrial radio interfaces are already being extended up to 10 Mb/s and it is anticipated that these will be extended even further up to approximately 30 Mb/s by around the year 2005. These data rates are under optimum signal and traffic conditions. This is discussed in more detail in Section 4.2.4.

- New capabilities of systems beyond IMT-2000:

  For systems beyond IMT-2000, there may be a requirement for a new wireless access technology for the terrestrial component, around the year 2010. This will complement the enhanced IMT-2000 systems and the other radio systems with which there is an inter-relationship. It is envisaged that these potential new radio interface(s) will support up to approximately 100 Mb/s for high mobility and up to approximately 1Gb/s for low mobility such as nomadic/local wireless access, by around the year 2010. This is discussed in more detail in Section 4.2.5.

  The data rate figures are targets for research and investigation on the basic necessary technologies to implement the vision. The future system specification and design will be based on the results of the research and investigations. Due to the high data rate requirements additional spectrum will be needed for these new capabilities of systems

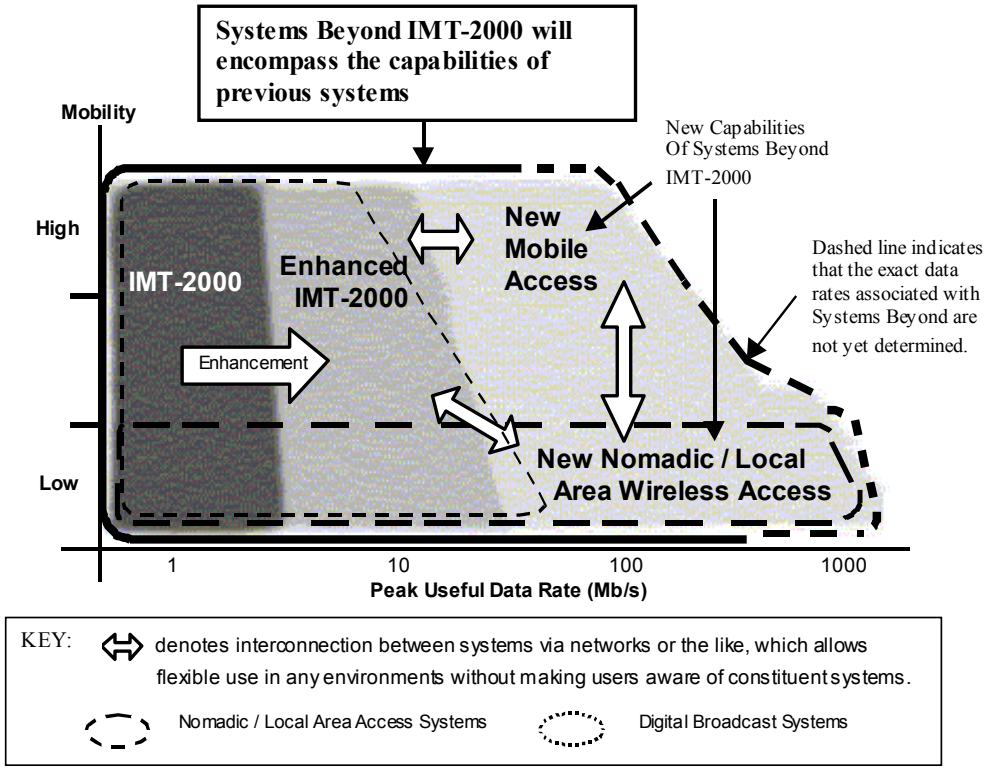
beyond IMT-2000. The data rate targets consider the advances in technology and these values are expected to be feasible from a technology perspective in the time frame of investigation and development of the new capabilities of systems beyond IMT-2000.

- Relationship of IMT-2000, Systems Beyond IMT-2000, and other access systems:

  In conjunction with the future development of IMT-2000 and Systems Beyond IMT-2000, there will be an increasing relationship between radio access and communications systems, for example wireless PANs, LANs, digital broadcast, and fixed wireless access. This is discussed in more detail in Section 4.2.6.

It is possible that upstream and downstream may have different maximum transmission speeds.

The vision for the future development of IMT-2000 and systems beyond IMT-2000 is depicted in Figure 4-2, which illustrates the various components described above and their relationships to each other.



Dark gray color indicates existing capabilities, medium gray color indicates enhancements to IMT-2000, and the lighter gray color indicates new capabilities of Systems Beyond IMT-2000.

The degree of mobility as used in this figure is described as follows: Low mobility covers pedestrian speed, and high mobility covers high speed on highways or fast trains (60 km/h to ~250 km/h, or more).

Illustration of Capabilities of IMT-2000 and Systems Beyond

Figure 4-2: Illustration of Capabilities of IMT-2000 and Systems Beyond

4.2.2 Perspectives on the Vision

The Vision for the future development of IMT-2000 and systems beyond IMT-2000 can be considered from multiple perspectives, including the user, manufacturers/application developers, network operators, and service and content providers. From the users' perspective, there will be a demand for a variety of services, content and applications whose capabilities will increase over time. Similarly, it is expected that services may be ubiquitously available through a variety of delivery mechanisms and service providers, using a wide variety of devices that will be developed to meet the various market requirements and these may resemble today's devices such as desktop and laptop PCs, mobile phones, digital television, and other computing and communication devices. These user demands will be addressed by a large community consisting of content providers, service providers, network operators, manufacturers, application and hardware developers.

The high-level objectives, as seen from the perspectives of the end user, content provider, service provider, network operator, and manufacturer/application developer can be summarized in the following table.

TABLE 4-1:

High-Level Objectives from Multiple Perspectives

PERSPECTIVE	HIGH LEVEL OBJECTIVES
END USER	Ubiquitous mobile access Easy access to applications and services Appropriate quality at reasonable cost Easily understandable user interface Long equipment and battery life Large choice of terminals Enhanced service capabilities User friendly billing capabilities;
CONTENT PROVIDER	Flexible billing capabilities; Ability to adapt content to user requirements depending on terminal, location and user preferences; [Access to a very large market through a single interface.] *[Editor's note: Check with SSG document]*
SERVICE	Fast, open service creation, validation and provisioning;

PROVIDER	QoS and security management; Automatic service adaptation as a function of available bit rate and type of terminal; Flexible billing capabilities;
NETWORK OPERATOR	Optimisation of resources (spectrum and equipment); QoS and security management; Ability to provide differentiated services; Flexible network configuration; Reduced cost of terminals and network equipmentbased on global economies of scale; Smooth transition from IMT2000 to systems beyond; Maximisation of sharing capabilities between IMT-2000 and systems beyond (sharing of mobile, USIM, network elements, radio sites); Single authentication (independent of the access network). Flexible billing capabilities; Access type selection optimising service delivery
MANUFACTURER / APPLICATION DEVELOPER	[Ability to realize] economies of scale; Access to a global market; Open physical and logical interfaces between modular and integrated subsystems; General purpose programmable platforms that enable fast and lost cost development through high-level programming environments.

[Editor's note: There are several square brackets in the above table, reflecting lack of time to verify concensus. Most of the line items have now been abbreviated, but need checking]

4.2.3 Coverage Objectives

An objective of IMT-2000, defined in ITU-R Recommendation M.687-2, is to make available to mobile users a wide range of telecommunication services, and to provide these services over a wide range of teledensity (number of users per square kilometre) and geographic coverage areas. This continues to be a priority for the future development of IMT-2000 and systems beyond IMT-2000. Teledensity and geographic coverage are related because many people who do not at present have

access to mobile communications live in parts of the world where the population density and/or income levels are low, especially in developing countries.

Global economies of scale will help to lower entry costs to serve the needs of the majority of people who do not presently have mobile or fixed line telephones. To achieve this goal, limited complexity of handsets is beneficial, in particular in the RF part.

Geographical coverage could be increased for the terrestrial component by also using lower frequency ranges than those today identified for IMT-2000, or by using the satellite component of IMT-2000, subject to market conditions and certain limitations, such as handset size, power consumption, indoor coverage. IMT-2000 services can best be provided at low cost to rural areas and to low income populations by using globally harmonized frequencies to achieve economies of scale.

To meet users' expectations, it is important that the service area of IMT-2000 networks is maintained for systems beyond IMT-2000, taking into account the effects of higher bit rate, operating frequency and advances in technology.

4.2.4 Future development of IMT-2000

A key feature of the high level vision for the future development of IMT-2000 is that there will be a steady and continuous evolution and enhancement of IMT-2000 capabilities by deployment and upgrading of IMT-2000 technologies over at least the next 10 years. This would then be followed by further operation for possibly a further 10 years or more. This evolution will promote the development of an expanding number of services and applications.

Similarity of services and applications across the different IMT-2000 technologies and frequency bands is beneficial to users, and a broadly similar user experience leads to a large-scale take up of products and services, common applications and content, and an ease and efficiency of use.

Terrestrial IMT-2000 systems are already being enhanced and, for instance, many will incorporate an "all IP" network and the wireless access will offer increased capabilities such as up to 10 Mb/s under favourable circumstances. These initial enhancements, which are already being standardised, will be followed by further enhancements, that could increase the peak aggregate useful data rate up to approximately 30 Mb/s under favourable circumstances by around 2005; however, some operators may need additional spectrum in addition to their existing spectrum.

The satellite component of IMT-2000 may further evolve to provide complementary services (e.g., broadcasting, multicasting).

From a radio access perspective, it is expected that the future development of IMT-2000 will build on and further develop the radio access systems and technologies already being developed and deployed. This evolution will enhance market stability and promote the development of an expanding number of services and applications.

4.2.5 New capabilities for Systems Beyond IMT-2000

The services that users will want, and the increasing number of users, will place increasing demands on the access network that would not be achieved by the enhancement of today's IMT-2000 radio access systems (in terms of peak bitrate to a user, aggregate throughput, and more flexibility to support many different types of service simultaneously). It is anticipated that there will be a requirement for a new radio access technology or technologies at some point in the future to satisfy these anticipated demand for such high bandwidth services.

Systems beyond IMT-2000 will support a wide range of symmetrical, asymmetrical, and unidirectional services. They will also provide management of differing qualities of service levels to

realise the underlying objective of efficient transport of packet-oriented services. There will be an increased penetration of nomadic and mobile wireless access multimedia services.

In the dynamic market environment of mobile communications, it is difficult to develop a detailed vision very far into the future. However, the technologies, applications and services associated with systems beyond IMT-2000 could well be radically different from the present, challenging the perceptions of what may be considered viable by today's standards and going beyond what can be achieved by the future enhancement of IMT-2000 working with other radio systems. New radio access interface(s) are envisaged to handle a wide range of supported data rates according to economic and service demands in multi-user and multi-cell environments' with target peak data rates of up to approximately 100 Mb/s for high mobility and up to approximately 1 Gb/s for low mobility such as nomadic/local wireless access.

These data rates are indicative only and are intended to provide guidance as targets for the research community for systems beyond IMT-2000, they should not be taken as the definitive requirements for systems beyond IMT-2000.

These data rates will be shared between all active users, who are connected to the same radio resource. The achievable (peak or sustained) throughput for any individual user depends on many parameters, including the number of active users, traffic characteristics, service parameters, deployment scenarios, spectrum available, and propagation and interference conditions. These data rates are the maximum value of the sum of the data rate for all of the active users on a radio resource; it is possible that the peak data rate needed in the upstream direction will be different from the downstream direction. The transport data rates may need to be higher due to overheads, such as signalling and coding . Depending on the services for which the technologie(s) will be used, continuous radio coverage may not be needed in order to meet the service requirements

This Recommendation provides a very high level view of the vision for the new capabilities envisaged for systems beyond IMT-2000, and the new radio interface(s) that might be needed to support them. Further ITU-R Recommendations will develop these concepts in more detail. Other new Recommendations will address spectrum requirements for systems beyond IMT-2000, which frequency bands might be suitable, and in what time frame such spectrum would be needed, with a view to accommodating the emerging broadband services and applications. It is expected that new spectrum requirements documented in these Recommendations will be addressed at a future World Radio Conference. This topic is included in item 2.16 of Resolution 801 (WRC 2000) as a preliminary agenda item for WRC-06.

4.2.6 Relationship of IMT-2000, Systems Beyond IMT-2000 and Other Access Systems

Wireless communications comprises a wide range of technologies; services and applications that have come into existence to meet the particular needs of different market sectors and user environments. Different systems can be broadly characterised by:

– content and services offered,
– frequency bands of operation,
– standards defining the systems,
– data rates supported,
– degree of mobility,
– regulatory requirements, and
– cost.

A similarity of services and applications across the different systems is beneficial to users, and this has stimulated the current trend towards convergence. However, this should not be at the expense of innovation. Furthermore, a broadly similar user experience across the different systems leads to a large-scale take up of products and services, common applications and content and an ease and efficiency of use. The access to a service or an application may be performed using one system or may be performed using systems simultaneously (e.g., a digital broadcast channel and a return channel using IMT-2000). There are also many emerging embedded applications needing machine-to-machine communications.

The increasing prevalence of IP-based applications is a key driver for this embryonic convergence and facilitates the establishment of relationships between previously separate wireless platforms. What form these relationships will take depends on what the market wants, but they might include, for example, hardware integration within a device, network inter-working, common access, authentication, accounting, common man-machine interfaces, portals, roaming and hand-over between systems.

An individual person, or machine, can from time to time be a user on one or more of these systems, either sequentially or simultaneously, depending on the task at hand.

The formation of these relationships is distinct from the development of each wireless access system, including IMT-2000; it will need to take into account the characteristics and future development of the systems, inter-related (or even interdependent) spectrum issues and the respective regulatory environments.

The relationships between and among systems and devices can be broadly described as follows:

– Level 1 comprises the Personal Area Network (PAN). This level consists of communications between terminal and peripheral devices. Level 1 devices move with the user and communicate directly with each other (e.g., communication between headset and mobile phone).

– Level 2 comprises direct communication between a user device and other devices (e.g., communication of a refrigerator, digital television, home gateway, etc.) in the immediate surroundings of the user. This communication runs over of a maximum of a few meters.

– Level 3 comprises the communication of the devices via the equipment of network operators. Examples are the communication between mobile phones, PANs and servers in the network.

These three levels are illustrated in Fig. 4-3.

Fig. 4-3: Levels of communications relationships between devices of Enhanced IMT-2000 and Systems beyond IMT-2000

It is important to note that different technologies, such as WLAN, short range connectivity systems, and IMT-2000, may be present in many devices operating across the various networks at any particular time. For example, a personal digital assistant (PDA) may contain multiple radio

interfaces enabling it to communicate with a mobile phone (Level 1); a home WLAN (Level 2); or a wide-area service provider, such as a commercial WLAN or conventional mobile service provider (Level 3).

From a service provision perspective, the Levels share some common characteristics. Wireless service provision will be characterized by global mobile access (terminal and personal mobility), high quality of services (full coverage, intelligible, no drop and no/lower call blocking and latency), and ergonomic access to personalised multimedia services for voice, data, message, video, world-wide web, location based services, etc. via one user terminal. This level consists of communications between an IMT-2000 terminal and peripheral devices. For example, one important element in realizing this vision of integrated services, given the emerging dominant role of IP based data traffic and applications, networks and ever-increasing Internet penetration where there is a high degree of asymmetry between uplink and downlink, is that suitable adaptive packet data transfer solutions be developed.

[End-to-end secured services are likely to be fully coordinated, via access control, authentication including use of biometric sensors and/or smart card and mutual authentication, data integrity and encryption. User added encryption features for higher levels of security may also be added.]

At some point in the future some operators will make steps to deploy a mix of technologies that could, at various stages in time and subject to market and regulatory considerations, incorporate satellite, WLAN, digital broadcast, cellular, and other access systems. This will require the seamless integration of these systems in order for the user to be able to receive a variety of content via a variety of delivery mechanisms depending upon the particular terminal capabilities and location. For example there will be a choice of WLAN component chips that could be included in mobile terminals.

Different radio access systems will be connected via a common, flexible and seamless core network. In this way, an individual user can be connected via a variety of different access systems to the networks and services he desires. The interworking between these different access systems in terms of horizontal and vertical handover and seamless service provision with service negotiation including mobility, security and QoS management will be a key requirement, which will be handled in the core network.

This “Optimally Connected Anywhere, Anytime” vision could be realised with a seamless network comprising a variety of interworking access systems connected to a common IP based core network, as seen in Figure 4-4. Due to the different application areas, cell ranges and radio environments the different access systems can be organized in a layered structure (according to Figure 4-5) similar to hierarchical cell structures in cellular mobile radio systems. This allows a scalable system to deploy the necessary system capacity and capability where needed.

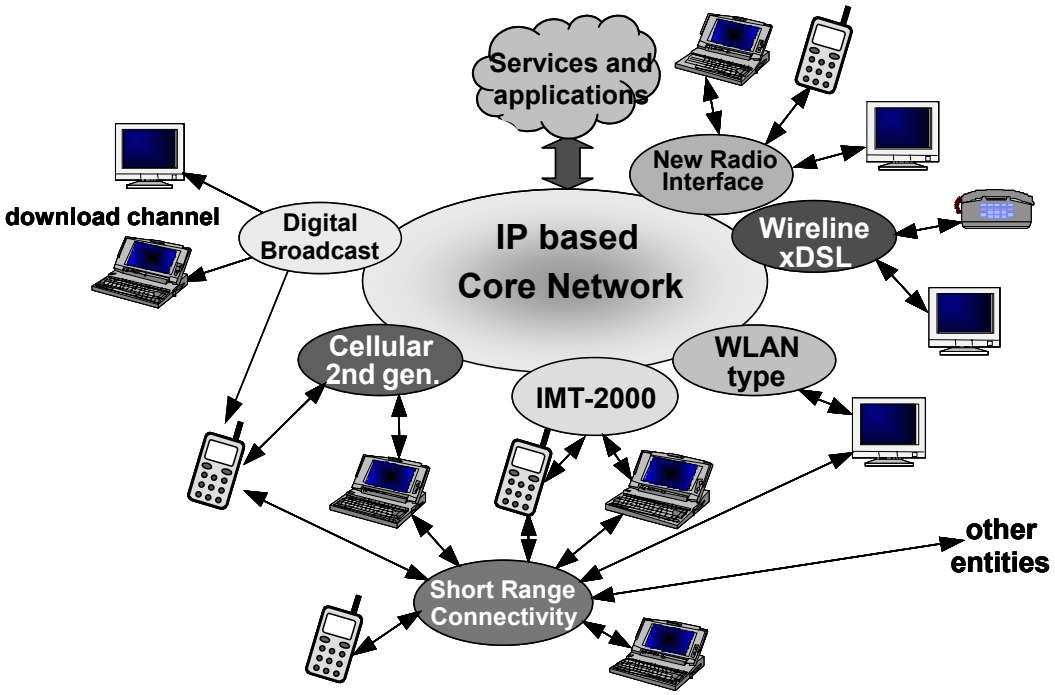


FIGURE 4-4: Seamless future network of Systems Beyond IMT-2000 including a variety of potential interworking access systems

Figure 4-5 presents an illustration of examples of the seamless interworking between different complementary access systems in a deployment area. Interworking between different access systems will be performed in terms of vertical handover or session continuation including service negotiation to adapt the application to the service capabilities of the candidate access systems (double-sided arrows). The different layers correspond to the:

- Distribution layer: This layer comprises digital broadcast type systems to distribute the same information to many users simultaneously through unidirectional links. Other duplex access systems can be used as a return channel.
- Cellular layer: The cellular layer may comprise several cell layers with different cell size and or different access systems.
- Hot spot layer: This layer may be used for very high data rate applications, very high traffic density and individual links, e.g., in very dense urban areas, campus areas, conference centers, and airports. Microcells of mobile networks and nomadic/local wireless access of systems beyond IMT-2000 are part of this layer.
- Personal network layer: Personal area networks will support short range direct communication between devices.
- Fixed layer: This layer includes any fixed access system .

This figure illustrates a flexible and scalable environment for the allocation of system capacity in a deployment area, where one or several systems may be deployed according to need.

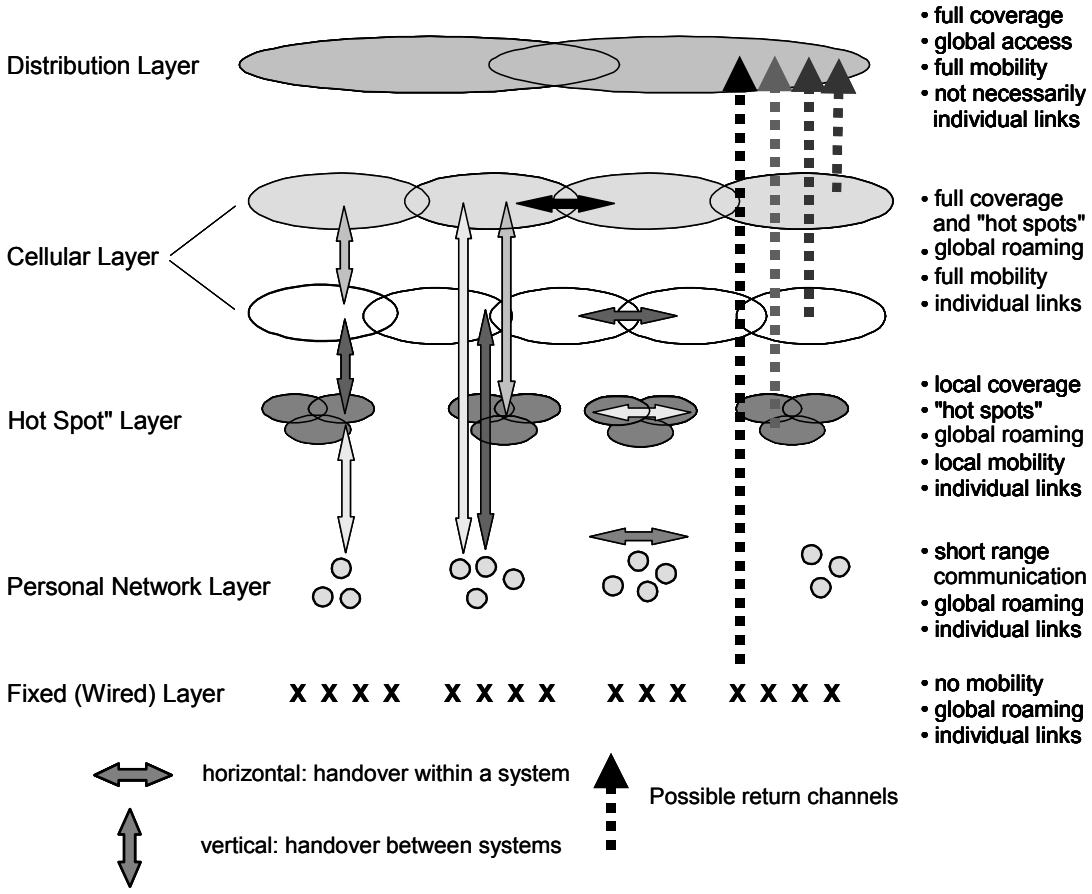


FIGURE 4-5: Illustration of complementary access systems

4.2.7 Timelines

One important aspect in planning for the future development of IMT-2000 and systems beyond IMT-2000 is the timeline associated with their realization. Timelines are dependent on a number of factors:

a) Market trends, requirements and user demands;

b) Technical capabilities and technology developments that lead to enhancements of the radio transmission technologies for IMT-2000;

c) Standards Development;

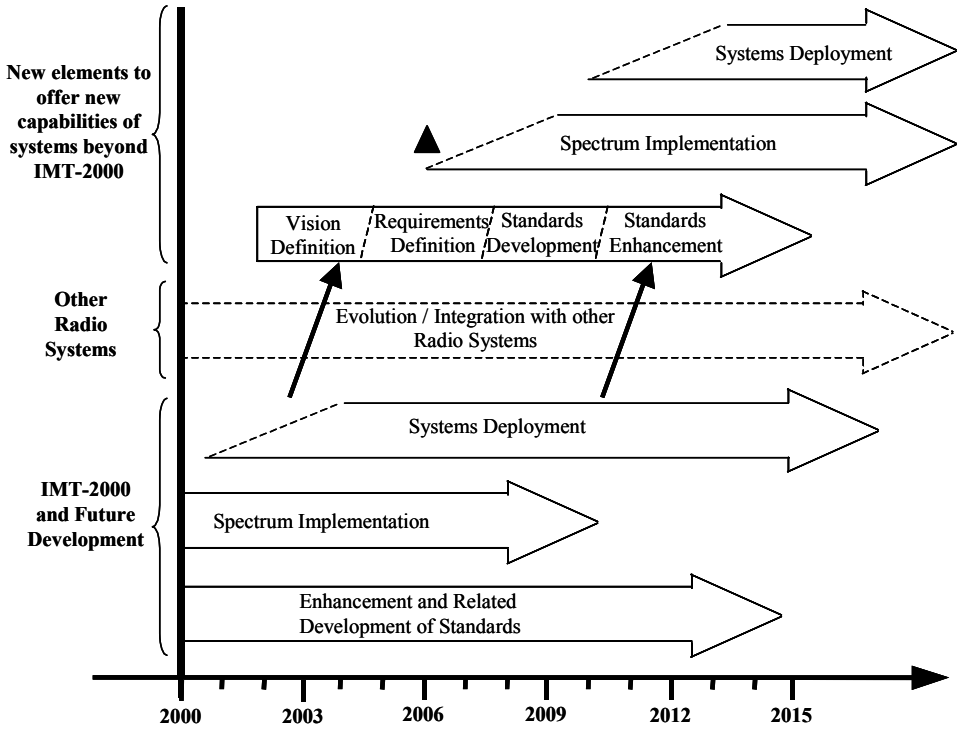
d) Spectrum availability, including allowing sufficient time to re-locate systems that may be using the proposed band;

e) System (mobile and infrastructure) development and deployment.

f) Regulatory considerations

All of these factors are interrelated. The first four have been and continue to be addressed within the ITU. System development and deployment, relates to the practical aspects of deploying new networks that include the desire to minimize additional infrastructure investment and to allow time for customer adoption of the capabilities of a major new system, such as IMT-2000.

The timelines for these different perspectives is depicted in Figure 4-6. When discussing the time phase for systems beyond IMT-2000, it is important to specify the perspective, (i.e., time at which the standards are completed, time at which spectrum must be available, or the time at which deployment starts).



The dotted lines indicate that the exact starting point of the particular subject can not yet be fixed.

▲ : Spectrum identification assuming that WRC03 approves WRC06 agenda and WRC06 identifies the spectrum

FIGURE 4-6: Phases and expected timelines
for future development of IMT-2000 and Systems Beyond

4.2.7.1 Short Term

The short-term (up to about 2010), it is envisaged that the future development of IMT-2000 will progress with the ongoing enhancement of the capabilities of the initial deployments, as demanded by the market and allowed by the status of technical developments. This phase to will be dominated by the growth in traffic within the existing IMT-2000 spectrum, and the development of IMT-2000 during this time will be distinguished by incremental or evolutionary changes to the existing IMT-2000 radio interface specifications (i.e. these changes can be reflected in revisions to existing IMT-2000 M-Series Recommendations). There could be significant progress towards harmonization of the radio interfaces and the introduction of IP-based core networks.

It is envisaged that the bands identified by the WRC-2000 will be made available for IMT-2000 within this time frame, subject to market demand and other considerations.

4.2.7.2 Longer term

The longer term (from around 2010) is associated with the introduction of potential new radio interface(s) with capabilities beyond those envisaged as being part of an "evolved" IMT-2000. It is envisaged that new interface(s) will add significant new capabilities (using much higher user data rates), and they may need to be supported by additional frequency bands. New technologies, however, may also significantly increase spectral efficiency and/or inter-working between frequency bands, which may mitigate the need for additional spectrum. It is envisaged that certain core capabilities will be common to both enhanced IMT-2000 and the systems beyond IMT-2000.

It is also envisaged that the new radio interface(s) of systems beyond IMT-2000 will be primarily and initially intended for use in new spectrum identified by WRC-06. A tentative date of 2010 is proposed for the purposes of planning within ITU-R. However, the timescale will depend on:

a) the market requirement and the technologies for systems beyond IMT-2000,

b) the availability of the spectrum that is identified, especially the possible need to relocate existing users of this spectrum.

4.3 Technology Trends

In defining the vision and objectives for the future development of IMT-2000 and systems beyond, the significant technology trends need to be considered. This section identifies the domains in which trends can be foreseen at the time of preparation of this Recommendation. Depending on their development, evolution, expected capabilities and cost structure, each of these technologies may or may not have an impact or be used for the systems beyond IMT-2000. It is expected that the research and development of systems beyond IMT-2000 will consider these technologies and provide guidance on the applicability or influence they might have on systems beyond IMT-2000. The technology trends will be more fully described in a separate Report.

System-related:

New or evolved architectures are foreseen, in particular related to the use of IP, and also offering increased intersystem mobility and interoperability capabilities.

Increase in security and reliability of mobile services is also foreseen.

Example key technologies:

Voice over IP; Optimisation of IP for mobile radio transmission; Fault-tolerant (high reliability) network architecture; Seamless mobility, (inter-system handover, roaming, optimal network selection); Mobile platform technology (seamless inter-system handover, roaming, optimal network selection; Security and privacy; Cryptography; Authentication and mobile electronic commerce; Billing; Intelligent data filtering.

Access network and radio interface:

Several new concepts and new physical radio access schemes may influence systems beyond IMT-2000. This includes, but is not limited to:

– New modulation schemes, multiple access schemes.

– Software defined radio.

– Adaptive radio interface.

– New antenna concepts and technologies.

Example key technologies:

Software defined radio; Novel access network architectures (e.g. high packet rate nodes); Mobile ad hoc networks; Routing algorithms; Multicast; Radio over fibre; Handover between different radio interfaces (vertical and horizontal); Dynamic QoS control; IP mobility control; Robust IP packet transmission; Distributed MAC; Error correction and channel coding; Adaptive and higher order modulation, and link adaptation; adaptive and MIMO antenna concepts (including SIMO and MISO); Multi-user and interference cancellation detection schemes; backhaul links (also known as entrance links).

Utilisation of spectrum:

New techniques designed to increase spectrum usage and spectrum efficiency are being studied. These studies may lead to increased frequency usage and/or to new ways to share the spectrum resource with other users or systems.

Example key technologies:

Hierarchical cell structures (including three dimensional); Adaptive and MIMO antennas; Adaptive dynamic channel assignment; Spectrum sharing (between different operators and systems);

Mobile Terminals:

Major evolutions are foreseen on the mobile terminals, with use of new components, new architectures, new hardware and software platforms, improved user interfaces and with increased performances.

Example key technologies:

Man machine interfaces (including "intelligent" mobile terminals); Integration of mobile terminals and IT devices; Mobile terminal platforms (OS, middleware and APIs); Autonomous subsystem architecture (separate communication and applications subsystems); Advances in display devices; Voice recognition; Wearable terminals; Software defined radio and multi-mode terminals; Advances in processing power of semiconductors (as described by Moore's Law); Improvements in RF devices (allowing higher operating frequencies and improved receiver sensitivity); RF MEMS (micro electro-mechanical systems); Battery technology (increased energy density).

Applications:

Applications accessed through IMT-2000 systems and systems beyond will evolve:

– to follow the general trends of telecommunication systems,

– to adapt to the capabilities of the mobile systems and optimise service delivery in radio environment.

Example key technologies:

Data coding and compression techniques; Dynamic variable-rate codecs; Mobile agents; Content description language; Streaming of speech and video; APIs (application programming interfaces) and middleware.

4.4 Spectrum Implications

A critical consideration in realizing the vision for the future development of IMT-2000 and systems beyond is the availability of adequate spectrum to support future services. When considering the requirements and potential frequency ranges to support these systems, it is useful to consider the timelines, services, technology trends and candidates technologies discussed above, recognizing

that these topics may be further developed in additional recommendations and reports. More specifically, in analysing the spectrum implications of the future development of IMT-2000 and systems beyond, many issues must be addressed, including, but not limited to:

– traffic projections and requirements;

– service and application requirements;

– spectrum efficiency;

– radio transmission characteristics (TDD/FDD, duplex direction, transmit/receive separation, modulation and access schemes, etc.);

– global roaming requirements and harmonized use of spectrum;

– technical solutions to facilitate global roaming;

– techniques of dynamic spectrum sharing;

– sharing and compatibility analysis;

– evolution of IMT-2000 systems.

This would determine the potential need for and identification of additional spectrum.

With the ongoing growth of user penetration, the anticipated growth of data applications and bandwidth need a further demand for new additional spectrum is expected. Evolving technology advances allow a more efficient use of spectrum. For the calculation of the expected additional spectrum a new calculation method will be developed. This method will take into account the advances in technology, traffic models and user demand. All effort will be made by the combination of techniques to use the spectrum as efficient as possible to limit the additional spectrum demand. The method must also consider the constraints associated with realizing these data rate targets, including potential availability of spectrum in suitable frequency ranges.

Figure 4.2 focuses on the capabilities IMT-2000 and systems beyond. Figure 4.5 describes the complementary access systems. This PDNR only considers the spectrum implications for the new capabilities for systems beyond IMT-2000 according to Figure 4.2.

The necessary calculation method and estimations on the expected spectrum demand will be presented in other Recommendations of ITU-R.

The spectrum demand is determined by the data rate targets, the modulation, coding etc. methods (physical layer), advanced antenna concepts, guard bands, frequency bands, deployment conditions, among others. The necessary steps in calculating this spectrum demand include:

- to develop a method for calculation of the spectrum demand,
- to encourage the necessary research and investigation for new technologies,
- the assessment of potential new technologies for efficient use of the spectrum and
- the investigation of new methods for reuse and sharing of spectrum.

4.4.1 Preferred frequency bands

It is expected that IMT-2000 and its enhancements will continue to operate in the bands identified by WARC-92 and WRC-2000. To fulfil the vision for systems beyond IMT-2000, it is envisaged that further spectrum may be needed, in addition to that identified for IMT-2000 at WARC-92 and WRC-2000. The new capabilities for high mobility and nomadic/local wireless access have different objectives for mobility and bit rate, for which different frequency ranges may be appropriate.

For high mobility capability, data rates higher than IMT-2000 would result in a smaller cell size (other things being equal). The cell size also decreases at higher frequencies. This would increase the number of base stations required and hence the deployment cost. This suggests that the preferable frequency bands to support the wide area mobility capability of systems beyond IMT-2000 would be reasonably close to the bands already identified for IMT-2000. Since it is becoming increasingly difficult to find suitable spectrum for new applications, especially if a wide bandwidth or paired spectrum is needed, it is necessary to find the spectrum at an early stage in order that it can be made available for use in a timely manner.

Internationally agreed frequency bands will encourage the adoption of systems beyond IMT-2000 by facilitating global roaming and reducing equipment cost through global economies of scale. Common spectrum is a preferred objective.

4.4.2 Bandwidth considerations

To fulfil the vision of systems beyond IMT-2000, sufficient spectrum should be available both for the launch of services and, later, to carry the predicted traffic for systems beyond IMT-2000.

The factors influencing the bandwidth needed for launch of service include:

- The RF bandwidth of a single carrier.
- Reuse factor
- Duplex technique (ranging from slightly greater than one for TDD to two for symmetrical FDD).
- The number of carriers an operator needs to operate an efficient network (taking into account technology trends, for example in hierarchical cell structures).
- The number of operators.
- An allowance for guardbands.
- whether the spectrum is segmented between network operators or ‘pooled’ and also whether it is shared with other radio services

The factors influencing the bandwidth needed to carry the predicted traffic include:

- The peak traffic demand.
- Duplex technique.
- The spectrum efficiency of the radio interface (including the reuse factor).
- Trunking efficiency.
- Technologies for spectrum reuse within a cell, such as adaptive antennas and MIMO.
- An allowance for guardbands.

It is likely that not all of the spectrum required in the longer term for systems beyond IMT-2000 will be available for the initial launch of service. It is therefore desirable that systems beyond IMT-2000 may be launched using less spectrum than expected to be needed later to support the predicted traffic.

[In addition to the implications of data rate requirements on needed spectrum, range and cluster size above factors, further issues have to be considered. Spectrum will be more encumbered, less available and fully utilized. This results in limited availability, prioritization fights and in few (if any) gaps in reasonable frequency ranges from the radio propagation point of view. Therefore, spectrum (as the radio natural resource) may not be used like as it is today, because the efficient use

of scarce frequency bands and the convergence of services may require the need for dynamic spectrum sharing. This has to be taken into account in the evolution to next generation enhanced IMT-2000 systems and systems beyond IMT-2000. Cost factors such as spectrum cost versus technology complexity, will influence the feasible calculation of requirements and the technology choice. [US Note: the following sentence is very unclear; no edit suggested because not sure of the point being conveyed.] Information thrust for ever increasing bandwidth on individual signals and in the aggregate has to be assessed carefully with respect to the availability of additional spectrum and the requirements on security and integrity of communications paramount. Therefore, "Multiples" may be the buzzword to support the requirements with respect to

- multiple radio bands
- multiple modes
- multiple services/missions/applications.]

5 Recommends

The ITU Radiocommunication Assembly recommends

5.1 High-level vision

- that enhanced IMT-2000 systems should support a steady and continuous evolution of new applications, products, and services through improvements in data rates and enhancements to the existing IMT-2000 radio interfaces,
- that the vision for systems beyond IMT-2000 should be realized by the functional fusion of existing, enhanced and newly developed elements of cellular systems, nomadic wireless access systems and so forth, with high commonality and seamless interworking,
- that the development of new radio interface(s) should recognise that any new wireless access technology for systems beyond IMT-2000 is likely to be used in conjunction with enhanced IMT-2000 wireless access technologies (as detailed in ITU-R M.1457) and other existing radio systems;
- that the potential new radio interface(s) of systems beyond IMT-2000 should support data rates higher than enhanced IMT-2000, with either an adaptive interface or multiple interfaces with maximum commonality,
- that the services offered over the wireless access technologies comprising IMT-2000 and systems beyond IMT-2000 should appear as seamless and as common as possible from the user's perspective, taking into account the limitations of particular wireless access technologies and requirements of the user, so that the user need not be aware of the underlying technology being used at a particular point in time or location.

5.2 Framework of future work

a) Review of market trends

– that once mobile multimedia data services have been widely deployed and sufficient market experience gained, the characteristics and trends information from such experience be considered in re-evaluating the potential market requirements for the future development of IMT-2000 and systems beyond IMT-2000;

– that reviews of market trends be undertaken as and when required and reflected in possible future revisions to this Recommendation;

b) Research

– that research, on a global basis, be undertaken to address the vision detailed in this recommendation and into a potential new wireless access technique(s) for the terrestrial component;

– that this research should contribute to progress the knowledge on the technologies described in the technology trend and candidate technologies section of this recommendation and on their potential applicability and impacts on IMT-2000 evolutions and on systems beyond IMT-2000.

– that a global cooperation of the various wireless research fora is encouraged;

– that work should be undertaken to enhance the interrelation between satellite and terrestrial mobile systems, particularly on seamless interworking between them in IP layer connection,

– that research on the specifications for the future development of IMT-2000 and systems beyond IMT-2000 consider how these systems may relate to other radio technologies and systems and how all systems will continue to evolve;

– that the goals for the capability of systems beyond IMT-2000 are up to approximately 100 Mbit/s for high mobility and up to approximately 1 Gbit/s for low mobility such as nomadic/local wireless access, around the year 2010. These goals are targets for research and investigation and may be further developed in other ITU Recommendations, and may be revised in the light of future studies.

– that new technologies and technology trends be studied for their possible contributions to the effective and efficient realization of the Vision for the future development of IMT-2000 and systems beyond IMT-2000;

c) Spectrum

– that work should be undertaken to further improve the efficient and effective use of spectrum for the future development of IMT-2000 and of systems beyond IMT-2000;

– that the need for additional spectrum for IMT-2000 and Systems Beyond IMT-2000, beyond that already identified in the Radio Regulations for IMT-2000, needs to be considered in time for WRC-06;

– that the market requirements are considered when determining future potential frequency ranges;

– that the technical requirements to facilitate the cost effective deployment of a new radio interface(s) to satisfy the new “mobile” and “nomadic” access capabilities are considered when determining potential frequency ranges;

– that globally common spectrum and harmonised frequency arrangements should be continue to be sought for spectrum needed for the future development of IMT-2000 and of systems beyond IMT-2000;

d) Standardisation

that detailed standardisation of the radio interface(s) should take into account the frequency band(s) in which it is intended to be used;

that global and open standardisation of the radio interface specifications should continue in the future to realise the benefits of mass market and ensure inter-operable equipment so that users, operators, manufacturers, etc. can continue to benefit from mobile communications;

– that the level and type of standardisation should be adapted to meet technical and market requirements at that time;

that standardisation should be performed in a timely manner prior to system deployment, should take account of the availability of spectrum, subject to market considerations

5.3 Focus areas for further study

- that research forums and other external organizations wishing to contribute to the future development of IMT-2000 and systems beyond IMT-2000, are encouraged to focus especially in the following key areas:

· Radio Interface

· Access Network related issues

· Spectrum related issues

· Traffic characteristics

· Market estimations

More detailed research topics are found in [hyperlink].

[Editor's note: This link needs insertion in due course]

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