RECOMMENDATION ITU-R M.1167*

Framework for the satellite component of International Mobile Telecommunications-2000 (IMT-2000)

(1995)

CONTENTS

		Page
1	Introduction	2
2	Scope	2
	2.1 Purpose	2
3	Structure of the Recommendation	3
4	Related documents	3
5	Abbreviations	3
6	Distinct features of the satellite component of IMT-2000	3
	6.1 Key features of the satellite component of IMT-2000	3
	6.2 Coverage and handover	4
	6.3 Satellite system configuration	5
	6.4 Mobile location	6
	6.4.1 Authorized use of location information	6
	6.5 Security aspects	6
7	Integrated satellite and terrestrial components	6
	7.1 Network integration	6
	7.2 Service integration	7
	7.3 Radio interface integration	7
	7.4 Roaming between the terrestrial and satellite components	7
8	Standardization/commonality of interfaces associated with the satellite component of IMT-2000	7
	8.1 Radio interfaces	9
	8.1.1 General considerations	9
	8.1.2 Satellite-PES/MES/SP (Interface A)	10
	8.2 Network interfaces	11
9	Services supported by the satellite component of IMT-2000	11
	9.1 General IMT-2000 considerations	12
	9.2 Satellite component considerations	12

* Radiocommunication Study Group 8 made editorial amendments to this Recommendation in 2004 in accordance with Resolution ITU-R 44.

1 Introduction

International Mobile Telecommunications-2000 (IMT-2000) are third generation mobile systems which are scheduled to start service around the year 2000 subject to market considerations. They will provide access, by means of one or more radio links, to a wide range of telecommunication services supported by the fixed telecommunication networks (e.g. PSTN/ISDN), and to other services which are specific to mobile users.

A range of mobile terminal types is encompassed, linking to terrestrial or satellite based networks, and the terminals may be designed for mobile or fixed use.

Key features of IMT-2000 are:

– high degree of commonality of design worldwide;

– compatibility of services within IMT-2000 and with the fixed networks;

– high quality;

– use of a small pocket-terminal with worldwide roaming capability.

IMT-2000 are defined by a set of interdependent ITU Recommendations of which this one is a member.

The integrated terrestrial and satellite components of IMT-2000 are complementary in terms of service provision. Together they cover the wide range of user densities, service types, and available service sets which comprise IMT-2000. Each component has particular advantages and constraints.

The terrestrial component provides, economically, high quality telecommunication services typically to areas of high to very high user densities. The satellite component provides users with quality telecommunication services primarily on a virtually global coverage basis, and is most economic outside those areas covered by the terrestrial component. Additionally to providing this global coverage, the satellite component may, in more densely populated areas, precede and encourage later coverage by the terrestrial component.

2 Scope

Recommendation ITU-R M.818 sets the overall requirements of the satellite component of IMT-2000. Recommendation ITU-R M.1035 describes the framework of the radio interfaces of IMT-2000 taking particular account of the terrestrial component.

This Recommendation together with Recommendation ITU-R M.1035 describes the technical and operational capabilities and features of the satellite component, particularly where they are distinct from those of the terrestrial component. It forms the framework for further development of the satellite component of the integrated overall systems of IMT-2000.

In particular, the Recommendation comments on the aspects of integration with the terrestrial component, operational considerations, network interfaces and radio interfaces.

2.1 Purpose

This Recommendation builds upon Recommendation ITU-R M.818 in particular, to provide input material firstly to the derived Recommendations on radio interface selection procedures for satellite system and subsequently to the key choices and specifications of IMT-2000 satellite component, as well as the guidelines for satellite system design.

3 Structure of the Recommendation

This framework Recommendation sets out a number of considerations in the form of outline discussions which are grouped together into sections on: distinct features of the satellite component (§ 6); integrated satellite and terrestrial components (§ 7); standardization/commonality of interfaces associated with the satellite component (§ 8); and services supported by the satellite component of IMT-2000 (§ 9). The considerations form a part of the overall Recommendation and the specific Recommendations, shown in bold and italics, follow the discussions within the relevant section.

4 Related documents

Recommendations ITU-R M.818, ITU-R M.819, ITU-R M.1035, ITU-R M.1036 and ITU-R M.1078

5 Abbreviations

CDMA: code division multiple access

DTMF: dual tone multi frequency

e.i.r.p.: equivalent isotropic radiated power

FDMA: frequency division multiple access

FSS: fixed-satellite service

GSO: geostationary orbit

HEO: highly inclined elliptical orbit

IN: intelligent network

ISL: inter-satellite link

LEO: low-Earth orbit

LES: land earth station

MEO: medium Earth orbit

MES: mobile earth station (See Note 1)

MS: mobile station (See Note 1)

MSS: mobile-satellite service

PES: personal earth station (See Note 1)

PS: personal station (See Note 1)

SP: satellite pager

TDMA: time division multiple access

UPT: universal personal telecommunication

NOTE 1 – It should be noted that in this Recommendation the expressions (mobile) station and (mobile) terminal are equivalent.

6 Distinct features of the satellite component of IMT-2000

6.1 Key features of the satellite component of IMT-2000

– The geographical coverage of any one satellite is likely to be much larger than that of any cluster of terrestrial base stations.

– Coverage is likely to be by means of a number of spot beams from any one satellite – each spot beam is likely to be larger than any terrestrial cell.
– Coverage by satellite can be regional, multiregional or global.
– Potential orbit constellations will fall into a number of categories, such as GSO, LEO, MEO, HEO; each with its own particular properties (e.g. propagation delay, Doppler shift etc.) and IMT-2000 design implications.
– Technical and/or economic considerations may constrain the distribution and the number LES (forming gateways to the fixed networks) which can be accommodated in a satellite system.
– The Radio Regulations provision No. 5.388 identifies frequencies on a worldwide basis for IMT-2000 of which some frequencies are additionally identified for the satellite part of the system. It should be noted that it may be desirable to dedicate the use of this band to the satellite component rather than share with the terrestrial component.
– The terrestrial and satellite components of IMT-2000 should be optimized taking the existence of the other component into account.
– The LESs will connect to the satellites using feeder links which operate in frequency bands outside those identified for mobile satellite and IMT-2000 operation. The feeder link frequencies may be used by other satellite systems and terrestrial systems, and appropriate sharing criteria need to be observed.
– ISLs if used, will operate outside the IMT-2000 band.
– When using the satellite component in indoor locations, it may be necessary to enhance performance by suitable orientation and location of the antenna.
– It is assumed that there will be more than one satellite system possibly utilizing different satellite constellations in operation and that they will be in competition. However, even with only one satellite system in operation, multiple service providers can provide competition in service provision to users.

6.2 Coverage and handover

For the terrestrial component of IMT-2000, geographical coverage is provided from base stations which communicate over relatively limited ranges giving service to users within that range; the coverage area thus formed is termed a cell. To achieve continuity of coverage a number of contiguous cells are provided and, for users in motion, the system automatically transfers calls in progress from one cell to another. This transfer involves functionality in both the mobile and in the base station together with its infrastructure. The transfer process is termed handover.

In the satellite component, continuity of coverage is provided by the contiguous footprints of (spot) beams from one or more satellites in a constellation. For non-geostationary satellites, these footprints will be in motion, and continuity of calls in progress, whether for mobile or stationary users, is achieved by handover between beams; again involving functionality in the mobile and in the satellite component.

The importance of handover depends upon the expected rate of handover occurrence. In a terrestrial network the rate of handover is mainly influenced by the rate at which a terminal crosses cell boundaries. However, handover due to user movement rarely happens in a satellite network since the size of a satellite cell (beam) is usually very wide compared with the moving range of a terminal during a call. In a non-geostationary satellite constellation, the satellite beams, or cells, will be in motion, necessitating a handover mechanism between beams and between satellites in order to achieve call continuity. Therefore, handover requirements may depend upon the choice of satellite constellation as well as satellite cell sizes.

Handover involving the satellite component of IMT-2000 may be initiated based on prediction of the satellite movements, estimates of signal strength or quality of service parameters (bit error ratio, delay, etc.), traffic conditions or user requests. This needs to be taken into account when designing the handover mechanisms and protocols for IMT-2000.

It should be noted that such handovers in the satellite component due to satellite movement may be performed locally between the terminal and the LES through appropriate air interface protocols, and using dedicated connections between LESs (or ISL connections between satellites), if required. Thus such handovers can be performed solely within the mobility management of the IMT-2000 satellite networks.

Six scenarios for handover involving the satellite component have been identified as indicated below:

a) on the same satellite, maintain the same feeder link, handover the service link;

b) on the same satellite, handover the feeder link, maintain the same service link;

c) on the same satellite, handover the feeder link, and handover the service link (combination of cases a) and b));

d) handover from satellite to satellite, handover feeder link, handover service link (satellite handover-trunk handover);

e) handover from the satellite component to terrestrial component (intercomponent handover);

f) handover from the terrestrial component to the satellite component (intercomponent handover).

For users of equipment which is able to access both the terrestrial and satellite components, there may be a perceived need to maintain continuity of calls in progress as the user crosses the boundary between the components (i.e. intercomponent handover). Such handovers are expected to be relatively rare and the actual implementation will be for the network operators to determine. Nonetheless, technical capability of the process involved should be further considered.

Spectrum availability or the economics of the satellite component may limit the number of IMT-2000 satellite systems. If each IMT-2000 satellite network provides virtually global coverage, there is no technical reason to provide handover between IMT-2000 satellite networks.

6.3 Satellite system configuration

There may be more than one type of satellite system within IMT-2000 each having a different internal configuration and different ownership. Each system will comprise of: a number of satellites with defined spacings and orbital parameters forming a constellation; radio (service) links from the satellites to the mobiles; radio (feeder) links from the satellite to the LESs (not in the IMT-2000 frequency bands); a number of LESs; a satellite operator’s control, routing, and monitoring system; and interfaces to other networks (fixed and mobile).

LES antennas and associated controllers may be grouped together, electrically or geographically. The LES, or LES grouping, interfaces to other networks through a gateway or switching entity, and the mobility management functions associated with the satellite system may be either within the gateway or shared between the satellite infrastructure and the interfacing network. In the first case the satellite component can be considered as a self contained mobile system capable of interfacing to any network regardless of the degree of intelligence in that network. In the second case the satellite component may couple with other intelligent networks (e.g. mobile or IMT-2000 terrestrial component networks).

Since the satellite component of IMT-2000 will have a limited number of LESs, then operation of the network will inherently involve international (terrestrial) connections, and access to the satellite component may also involve an international connection.

6.4 Mobile location

The satellite component can provide information on mobile terminal position at least equivalent to the cell or spot beam in which the terminal is operating. Information regarding the position of a mobile may be regarded as confidential to the system operator, although derived information for use by associated bodies (e.g. for billing purposes) will be made available as necessary.

6.4.1 Authorized use of location information

When there is a desire to use this information by a body authorized by the relevant regulator (e.g. for aiding the emergency services) then it should be recognized that the location area: may be very large and not well defined; may extend over several countries; and may be time dependent and system traffic dependent.

In addition it should be noted that, in the satellite case, the physical landing point (i.e. the location of the LES involved) for any call, including those to the emergency services, may be far removed from the location of the mobile, and quite possibly in a different country.

6.5 Security aspects

Security aspects are covered in Recommendation ITU-R M.1078. The following additional factors should be noted when this current Recommendation is applied for the satellite component of IMT-2000:

– time delay and data rate are not likely to affect the security process;

– ***confidentiality and lawful interception depend upon the satellite component architecture;***

– there may be a need for geographic position fixing.

7 Integrated satellite and terrestrial components

7.1 Network integration

Terrestrial and satellite components which are integrated at the network level provide the IMT-2000 user with global continuity of coverage. In order to be fully integrated it is necessary for the satellite component of IMT-2000 to support identical management services to the terrestrial component. Note that there may also be specific functions that are unique to the satellite component. In a fully integrated network, functional entities can be shared between satellite and terrestrial components. Where in the network these functional entities are implemented will depend upon network operators. Network integration, therefore, requires that functional entities and network protocols are standardized and capable of supporting either terrestrial or satellite components.

Common network hardware and software would result in commonality of equipment between satellite and terrestrial components and would:

– allow mobility management to be handled between satellite and terrestrial components, thus enabling handover;

– enable economies of scale to be realized more easily;

– enable reuse of network infrastructure between satellite and terrestrial components;

– allow for common interfaces between network operators and service providers.

7.2 Service integration

It will not be practical to offer all services in all environments since this will be dependent upon the mode of delivery and on commercial decisions of network operators and service providers.

In order to achieve service integration, services must be offered in the same way in the IMT-2000 satellite and terrestrial environments. The offered network capability must be comparable for both IMT-2000 components regardless of the environment. These comparable network capabilities will then form the basis for establishing network functionality to support roaming and handover, and also to seek the maximum commonality in designing radio interfaces to support that capability.

7.3 Radio interface integration

Based upon the above network capabilities, a common radio interface for the satellite and terrestrial components would be desirable. However, due to critical design constraints such as spectral and power efficiency, this may not be practical and different radio interfaces may be required in the satellite and terrestrial environments. IMT-2000 stations may require the ability to operate over a number of different radio interfaces. This will increase the complexity of the station.

The selection of the radio interface(s) is not critical in achieving such integration, as such integration is dependent upon network functions.

A high degree of commonality between IMT-2000 satellite and terrestrial component radio interfaces is desirable.

7.4 Roaming between the terrestrial and satellite components

The satellite component of IMT-2000 will play an essential role in providing global roaming capability. It is expected that the satellite and terrestrial components of IMT-2000 will complement each other in terms of radio coverage and service capability.

IMT-2000 should support roaming between the terrestrial and satellite components. ***An IMT-2000 user should not necessarily need to request the terminal to access the satellite or the terrestrial component.*** Roaming is subject to terminal capabilities and subscription agreements. ***The user preferences with respect to the use of the satellite or terrestrial component should be part of the subscription agreements.*** The user preferences may also include the action to be taken if the requested service is not available in the preferred or both components.

In order to facilitate roaming, it is important that the user can be reached by dialling a single number, regardless of whether the mobile terminal is accessing the terrestrial or the satellite component at the time.

The support of roaming should not seriously affect the operations or costs associated with either component.

8 Standardization/commonality of interfaces associated with the satellite component of IMT-2000

The design of IMT-2000 must recognize that, whilst achieving compatibility, commonality and inter-working, the terrestrial and satellite components may be considered to be independent of each other for operational resources and similarly independent of the fixed networks. Additionally IMT-2000 satellite systems may be designed to create satellite extensions to terrestrial networks, thus extending the area over which a network with IMT-2000 functionality can directly provide service.

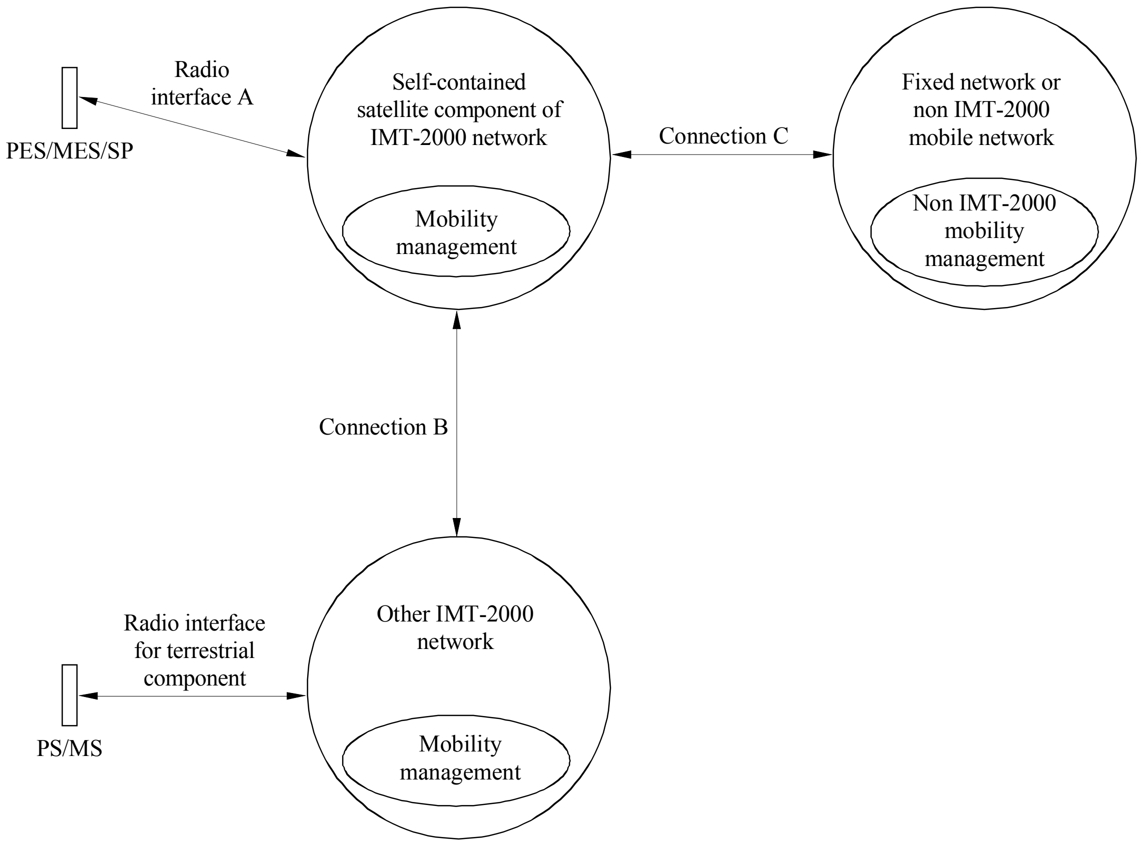
The following three deployment scenarios are envisaged for the satellite component of IMT-2000 as shown in Figs. 1a to 1c:

Scenario 1 – Self-contained satellite component (see Fig. 1a)

In this scenario a IMT-2000 satellite network will contain essentially all the required network functionalities described in Recommendation ITU-R M.817. It interfaces with fixed and non-IMT-2000 mobile networks, via the connection labelled (C). It will also interface with other IMT-2000 components (terrestrial and satellite) through the connection labelled (B). Certain IMT-2000 functional entities may be duplicated in IMT-2000 satellite and terrestrial networks, and the distribution of actual functions will need to be coordinated.

FIGURE 1a

Self-contained scenario



Scenario 2 – Integrated IMT-2000 network (see Fig. 1b)

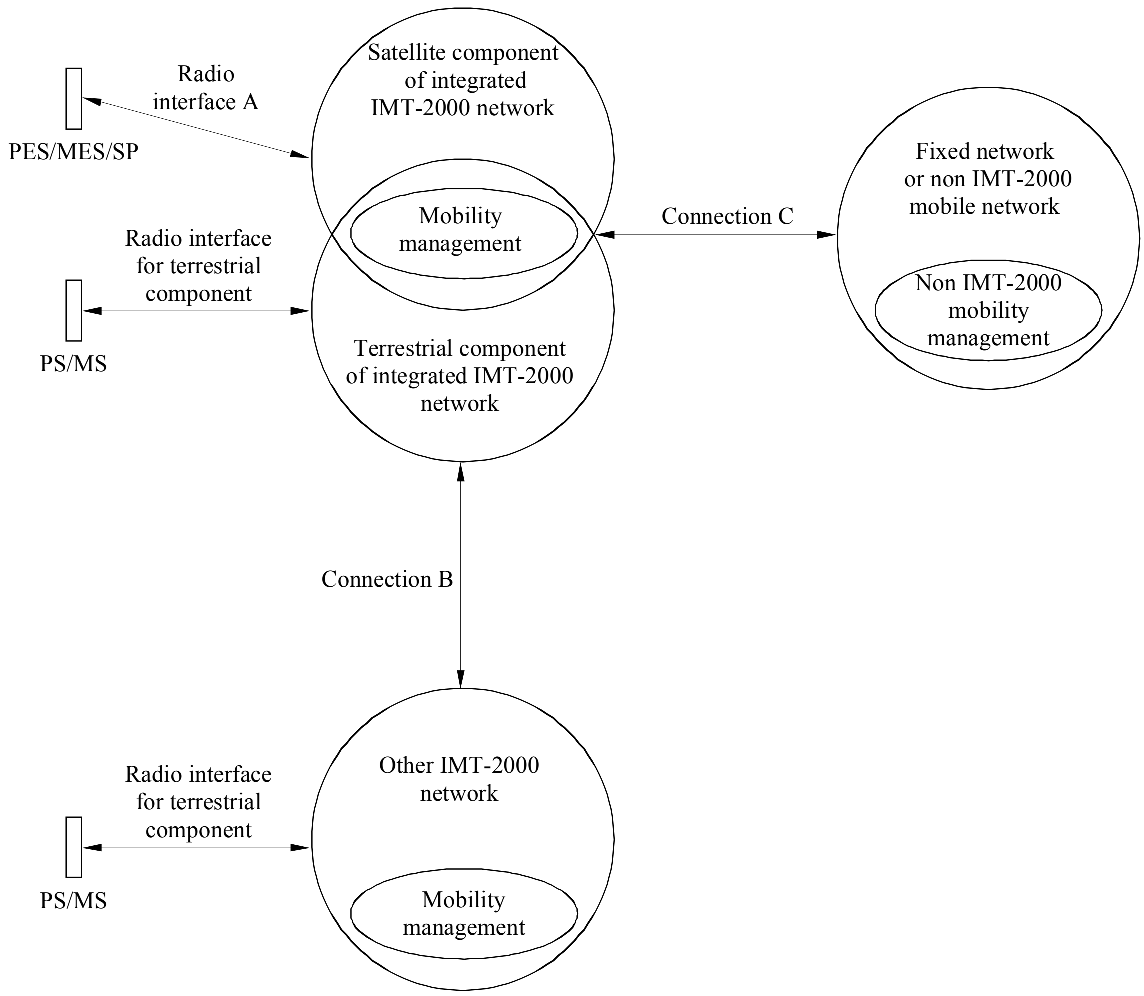
An integrated IMT-2000 network provides both terrestrial and satellite components. In this case there would be no duplication of IMT-2000 related functions. Network function can be used in common for both the components to the maximum extent possible. In this case the network operator is able to maximize commonality within the network.

Scenario 3 – Fixed network extension (see Fig. 1c)

In this scenario, some of the network functions that reside within the intelligent fixed network (e.g. IN based mobility management) will be utilized by the satellite (and/or terrestrial) component of IMT-2000 to minimize costs by reusing existing functionality. As it is a single integrated network, flexible distribution of functional entities will be possible (e.g. IN based mobility management).

FIGURE 1b

Integrated scenario



8.1 Radio interfaces

8.1.1 General considerations

It needs to be recognized that appropriate techniques need to be developed in order to ensure that mobile terminals do not cause interference by operating in a frequency band not authorized for that combination of mobile type and location.

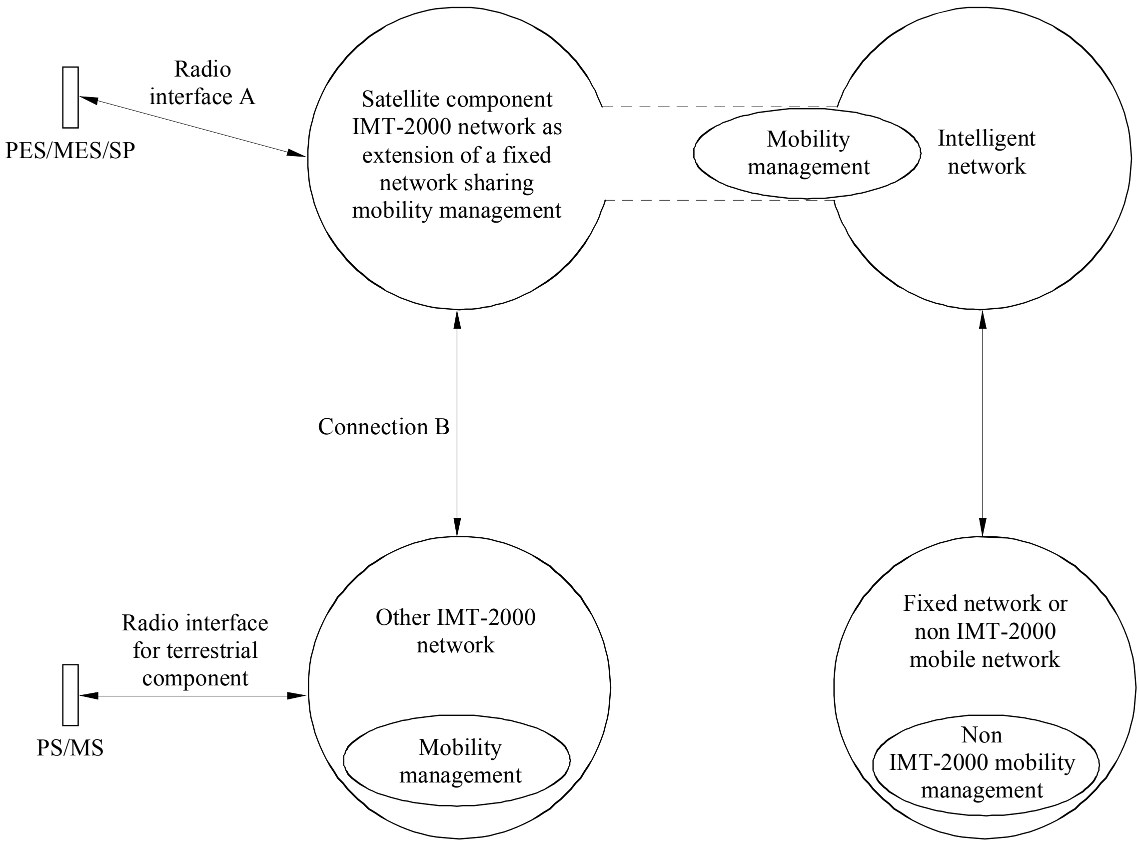
The satellite component will provide services to mobile users from a space segment which could involve a number of different satellite types, satellite constellations, and owners. The economics of worldwide satellite systems dictates that such systems will be designed and operated very close to the limits of what is possible for the services to be provided. It must be recognized that these factors could well impose tight constraints on the possible design of IMT-2000 radio interfaces for the satellite component.

For each of the IMT-2000 radio environments (satellite and terrestrial) a case can be considered for each radio interface to be designed and optimized in its own right. This may conflict with the overall goal of commonality and compatibility among interfaces. In the case of satellite systems, both the bandwidth requirement (kHz) and the information rate (bit/s) per channel can be directly related to overall system costs and a small departure from optimum design for this situation could impose an unacceptable cost penalty. ***The optimization of the design of the satellite radio interface is of paramount importance when considering commonality of radio interfaces.***

The radio interfaces between the satellites and the LESs (i.e. the feeder links) are not subject to IMT-2000 standardization.

FIGURE 1c

Fixed network extension scenario



8.1.2 Satellite-PES/MES/SP (Interface A)

As shown in Fig. 1 (a to c), this is ***the radio link between the satellite and the PES, MES or SP (the service link) and is the only radio interface within the satellite component which should be considered for IMT-2000 standardization***. The satellite may offer different radio access technologies to the PES, MES or SP operating in different radio environments.

The following features need to be taken into account when designing and selecting this interface for the satellite component:

a) Narrow spot satellite beams are critical to the introduction of hand-held satellite terminals for two reasons: firstly the high gain antennas (leading to increased e.i.r.p.s and receive sensitivities) facilitate the concept for handheld terminals and secondly multiple small spot beams allow improved frequency reuse to increase system capacity. The adoption of small spot beams is not necessarily limited to low or medium Earth orbits but complex beam forming networks and very large deployable satellite dish antennas would be required for a GSO or HEO spacecraft.

b) At present, any significant spectrum sharing between IMT-2000 satellite and terrestrial services appears not to be practicable, at least not in the same large geographical area.

c) Finely balanced system optimization will be essential to make a low cost satellite hand-held service viable. For this reason, modulation formats consistent with good S/N, and C/I performance will need to be selected and may not be able to be the same as the terrestrial component where different constraints apply.

d) Satellite spectrum will be very scarce compared to terrestrial spectrum (where microcellular networks can be used, for example, to increase capacity). All channel overheads will need to be reduced to an absolute minimum. Some functions that might be handled in higher terrestrial layers could, for example, be embodied more efficiently within the satellite physical layer.

e) Satellite signalling and broadcast channels will generally operate at higher powers or with more robust protection than traffic channels.

f) ***Radio access techniques must be tolerant of signal acquisition delays, variable propagation delays, Doppler shifts, and delay or Doppler jumps.***

g) ***Means should be provided for the radio interface to compensate for the Doppler frequency shift due to the satellite movement in both feeder and service links. Also, especially in case of the system using TDMA, means should be provided to adjust the slot timing so that the TDMA slots from different terminals will not overlap with each other in spite of the variable transmission delay.***

h) The speech coder should be designed such that the bit rate is optimized for satellite application. Commonality with terrestrial speech coders is desirable.

i) Radio multiple access techniques such as CDMA, FDMA and TDMA are all potential candidate solutions for the satellite component. Each offers particular advantages and disadvantages dependent on the service requirements and the orbital/system characteristics.

j) The shadowing caused by buildings etc. poses problems for both terrestrial and satellite components. It may be countered by several techniques such as link margin, coding, etc. For the satellite component, satellite diversity may also be considered.

8.2 Network interfaces

The IMT-2000 satellite component interfaces with other networks the same way as the IMT-2000 terrestrial components.

9 Services supported by the satellite component of IMT-2000

This section covers the considerations which are associated with the satellite component of IMT-2000.

9.1 General IMT-2000 considerations

Different services may be supported in different environments. The transmission rate may be different for the different types of mobile terminals. Even though high bit rates for the satellite component are possible, the majority of terminals and services should be targeted to low bit rates, less than 64 kbit/s.

The economics of satellite systems have to recognize the inherent constraints imposed by power and bandwidth limitations which means that the range and quality of services available to the users of the satellite component may differ from those available to terrestrial users.

The satellite component has the same quality objectives as the terrestrial component, however, there may be cases where this cannot be achieved.

An outline of the services for IMT-2000 is provided in Recommendation ITU-R M.816: "Framework for Services Supported on International Mobile Telecommunications-2000 (IMT-2000)"; ITU-T Recommendation F.115 describes operational and service provisions for IMT-2000. The provision of services for satellite IMT-2000 users has to take into account a number of factors which are particular to satellite communications. These derive from the nature of the radio channels involved in combination with the operational considerations of the economics of service provision to a wide range of user or traffic densities (users/km^2 or E/km^2).

9.2 Satellite component considerations

From a technical viewpoint, the services available to a user depend on the capabilities of the three major elements of the satellite component; i.e. the mobile terminal, the space segment, and the satellite infrastructure. IMT-2000 has an objective of ensuring that the system is designed in such a way that the form, nature, and number of services are not fixed and can be changed with time or circumstances. This will provide the desired service flexibility.

There will be limitations to the extent of this service flexibility; in the satellite component situation the satellites themselves will have a performance envelope which is fixed for the lifetime of the satellites or constellation. Non-processing, or "bent-pipe", satellites are likely to be the least inflexible in this respect. The overall limitation will take the form of an upper bound on the usable bit rate for a given error ratio performance.

In practice this overall constraint will be divided between the number of spot beams and radio channels deployed by the satellite. Thus each radio channel, which is taken to be defined by the radio interface specification, will have an upper limit to its bit rate. This in turn will limit the service capability of the interface; i.e. the number, form, and nature of the services which it can support.

The way in which this service capability is assigned to specific services depends on the services chosen for specific situations. Using the bit rates associated with each service there will be an iterative process involved in determining the service composition which each interface is capable of delivering. This is the complete service capability. This will take account of: footprint area, user density, radio link performance, and technical capabilities.

The actual services available in any one situation will depend on the radio link capability, together with the commercially based decisions of the network operator and service providers. For each situation however, the radio link must be capable of delivering at least the technical capability to provide voice and data IMT-2000 services.