

RECOMMENDATION ITU-R M.1034-1

**REQUIREMENTS FOR THE RADIO INTERFACE(S) FOR INTERNATIONAL
MOBILE TELECOMMUNICATIONS-2000 (IMT-2000)**

(Question ITU-R 39/8)

(1994-1997)

The ITU Radiocommunication Assembly,

recommends

1 that the requirements for the radio interface(s) of International Mobile Telecommunications-2000 (IMT-2000) include the following aspects.

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1 Introduction

International Mobile Telecommunications-2000 (IMT-2000) are third generation mobile systems (TGMS) 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. public switched telephone network (PSTN)/integrated services digital network (ISDN)), and to other services which are specific to mobile users.

A range of mobile terminal types is encompassed, linking to terrestrial and/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 on requirements for the radio interface(s) is a member.

This Recommendation forms part of the process of specifying the radio interface(s) of IMT-2000. IMT-2000 will operate in the worldwide bands specified by the World Administrative Radio Conference for Dealing with Frequency Allocations in Certain Parts of the Spectrum (Malaga-Torremolinos, 1992) (WARC-92) (1 885-2 025 MHz and 2 110-2 200 MHz, with the satellite component limited to 1 980-2 010 MHz and 2 170-2 200 MHz).

The subject matter of IMT-2000 is complex and its representation in the form of Recommendations is evolving. To maintain the pace of progress on the subject it is necessary to produce a sequence of Recommendations on a variety of aspects. The Recommendations strive to avoid apparent conflicts between themselves. Future Recommendations, or revisions, will be used to resolve any discrepancies.

2 Scope

The purpose of this Recommendation is to build on the IMT-2000 concepts contained in Recommendation ITU-R M.687 and to provide a high-level view of the constraints placed on the radio interface(s) particularly in terms of the system requirements, user requirements, and operational requirements. It takes account of the Recommendations on framework for services (Recommendation ITU-R M.816), adaptation to the needs of developing countries (Recommendation ITU-R M.819), satellite operation (Recommendation ITU-R M.818), network architecture (Recommendation ITU-R M.817), security principles (Recommendation ITU-R M.1078), and speech and voice band data performance requirements (Recommendation ITU-R M.1079) to produce recommendations on the requirements for the IMT-2000 radio subsystem from an overall system perspective.

3 Structure of the Recommendation

Section 4 contains a list of related Recommendations. In § 5, a list of definitions used throughout this Recommendation is given. Section 6 states the considerations that have been taken into account in the production of this Recommendation. In § 7, the IMT-2000 radio operating environments are defined and characterised. Section 8 gives radio propagation characteristics. In § 9, the service accessibility of IMT-2000 radio operation environments is discussed. In § 10, user requirements dealing with cost/complexity, security and handportable viability are described. Finally, in § 11 various operational requirements are discussed.

4 Related documents

The following ITU Recommendations contain information on IMT-2000 relating to this Recommendation:

- Recommendation ITU-R M.687: International Mobile Telecommunications-2000 (IMT-2000)
- Recommendation ITU-R M.816: Framework for services supported on International Mobile Telecommunications-2000 (IMT-2000)
- Recommendation ITU-R M.817: International Mobile Telecommunications-2000 (IMT-2000). *Network architectures*
- Recommendation ITU-R M.818: Satellite operation within International Mobile Telecommunications-2000 (IMT-2000)
- Recommendation ITU-R M.819: International Mobile Telecommunications-2000 (IMT-2000) for developing countries
- Recommendation ITU-R M.1035: Framework for the radio interface(s) and radio sub-system functionality for International Mobile Telecommunications-2000 (IMT-2000)
- Recommendation ITU-R M.1036: Spectrum considerations for implementation of International Mobile Telecommunications-2000 (IMT-2000) in the bands 1 885-2 025 MHz and 2 110-2 200 MHz
- ITU-T Recommendation F.115: Service objectives and principles for Future Public Land Mobile Telecommunications Systems
- Recommendation ITU-R M.1225: Guidelines for evaluation of radio transmission technologies for IMT-2000
- Recommendation ITU-R M.1078: Security principles for International Mobile Telecommunications-2000 (IMT-2000)
- Recommendation ITU-R M.1079: Speech and voiceband data performance requirements for International Mobile Telecommunications-2000 (IMT-2000)
- Recommendation ITU-R M.1224: Vocabulary of terms for International Mobile Telecommunications-2000 (IMT-2000)

5 Definitions

A partial list of definitions pertinent to this Recommendation is found in Annex 1.

6 Considerations

In the development of this Recommendation the following considerations have been taken into account:

- a) the relevant ITU-R and ITU-T Recommendations and ongoing studies;
- b) that satellite operation within IMT-2000 could facilitate the development of telecommunication services in developing countries;
- c) the need for a flexible system structure able to match network investment to the revenue growth, to adapt readily to environmental factors and to respond to new developments without restricting innovation;
- d) the need for mobile terminals (including those with satellite capability) to roam between mobile telecommunication networks in different countries;
- e) that IMT-2000 will be required to operate in a multitude of environments, each characterised by different propagation characteristics as well as different traffic density and mobility characteristics;
- f) that satellite operation within IMT-2000 holds the possibility of significantly enhancing the overall coverage and attractiveness of the services;
- g) the need for the quality of service of IMT-2000 to be comparable to that of the PSTN/ISDN;
- h) the increasing importance of the various types of non-voice telecommunication services;
- j) that mobile terminals of IMT-2000 may be used to access mobile satellite systems for use on land, ships and aircraft.

7 IMT-2000 radio operating environments

A range of radio operating environments are applicable to IMT-2000, and are defined in this section. These are characterised by a range of environment attributes as seen by the IMT-2000 radio sub-system.

The purpose of defining distinct IMT-2000 radio operating environments is to identify scenarios that, from a radio perspective, may impose different requirements on the radio interface(s). The purpose of identifying IMT-2000 radio operating environments is not to identify allowed scenarios for IMT-2000.

The distinct IMT-2000 radio operating environments identified will serve as a basis for the further IMT-2000 system design process in order to identify commonalities and trade-offs, with the aim to minimise the number of IMT-2000 radio interfaces and to maximise the commonality between them.

7.1 Characteristics of IMT-2000 radio operating environments

IMT-2000 radio operating environments are characterised by a range of attributes which in some way may impact on the IMT-2000 radio sub-system. These attributes include:

7.1.1 Network attributes

System application areas for IMT-2000 are characterised by the purpose of the system coverage. The IMT-2000 system application areas may vary significantly in terms of the type of IMT-2000 network used for the system application area. These various network types may in turn impose differing requirements on the radio interface(s). Some examples of IMT-2000 system application areas may include:

- public cellular applications,
- private business applications,
- residential cordless applications,

- fixed subscriber loop replacement,
- residential neighbourhood applications,
- mobile base station applications,
- paging applications.

IMT-2000 modes of delivery are characterised by the fundamental network implementation, but may not be seen by the users. Two distinct IMT-2000 modes of delivery are defined:

- terrestrial based infrastructure,
- satellite based infrastructure.

IMT-2000 modes of delivery are to a great extent independent of the system application areas above, but each mode of delivery may not be applicable in all system application areas.

7.1.2 Physical attributes

Propagation effects are determined by the physical location of the IMT-2000 base stations and the IMT-2000 mobile stations. Propagation effects in this respect may thus vary according to, for example:

- indoor and/or outdoor operation,
- outdoor operation in urban, suburban, rural, hilly or coastal areas,
- terrestrial or satellite operation,
- land, maritime, or aeronautical operation.

7.1.3 User attributes

Usage characteristics are given by the situation in which the IMT-2000 mobile user uses the services. These may vary according to, for example:

- usage at home, in the office or on the move,
- the expected traffic demand,
- the approximate service information rates to be provided over the IMT-2000 radio interface(s).

The relative speed between the IMT-2000 base stations and the IMT-2000 mobile stations may vary due to movement of either the IMT-2000 mobile stations or the IMT-2000 base stations. Broad categories for this relative speed include:

- stationary (0 km/h),
- pedestrian (up to 10 km/h),
- typical vehicular (up to 100 km/h),
- high speed vehicular (up to 500 km/h),
- aeronautical (up to 1 500 km/h),
- satellite (up to 27 000 km/h).

7.2 Identification of IMT-2000 radio operating environments

Following from the above, a very high number of different IMT-2000 radio operating environments could in principle be identified. The IMT-2000 radio operating environments identified in this section have, however, been reduced to those radio operating environments that are clearly and justifiably distinct in terms of the characteristics listed above, and that could in some way impose different requirements on the IMT-2000 radio sub-system.

The IMT-2000 radio operating environments and their modes of delivery are identified in Table 1.

These radio operating environments are described in greater detail below. In all cases the propagation ranges, mobile speeds, etc. represent typical values only, and are not meant to be restrictive. In all cases, the propagation path considered is between the mobile unit and its serving base station; that is, the second radio interface of a mobile base station or repeater lies outside the described environment. The expected service information rates, however, will be given by the weakest link in the chain.

TABLE 1

IMT-2000 operating environments and modes of delivery

Environment	Mode of delivery
Business indoor environment	Terrestrial
Neighbourhood indoor/outdoor environment	Terrestrial
Home environment	Terrestrial
Urban vehicular outdoor environment	Terrestrial
Urban pedestrian outdoor environment	Terrestrial
Rural outdoor environment	Terrestrial
Terrestrial aeronautical environment	Terrestrial
Fixed outdoor environment	Terrestrial
Local high bit rate environment	Terrestrial
Urban satellite environment	Satellite
Rural satellite environment	Satellite
Satellite fixed-mounted environment	Satellite
Indoor satellite environment	Satellite

Some considerations leading up to the choice of IMT-2000 radio operating environments identified above are given in Annex 2.

7.2.1 Business indoor environment

The business indoor environment encompasses indoor propagation over ranges up to around 100 m in an office environment, with zero to pedestrian mobile speeds (0-10 km/h). Very high traffic requirements are expected in this environment.

7.2.2 Neighbourhood indoor/outdoor environment

The neighbourhood indoor/outdoor environment encompasses outdoor and indoor propagation over ranges up to around 1 km in a residential area, with zero to pedestrian mobile speeds (0-10 km/h). Low traffic requirements are expected in this environment.

An example of such an environment is an environment where services are provided to one or more users in or near their residences through a base station located in the close vicinity of their residences.

7.2.3 Home environment

The home environment encompasses indoor and outdoor propagation over ranges up to around 100 m in and around the home, with zero to pedestrian mobile speeds (0-10 km/h). Very low traffic requirements are expected in this environment.

7.2.4 Urban vehicular outdoor environment

The urban vehicular outdoor environment encompasses outdoor propagation in urban areas, over ranges up to around 1-5 km, with zero to typical vehicular mobile speeds (0-100 km/h). Urban outdoor propagation is characterised by frequent shadowing of the signal and multipath mostly due to buildings, and base stations located on the ground at limited heights. High traffic requirements are expected in this environment.

7.2.5 Urban pedestrian outdoor environment

The urban pedestrian outdoor environment encompasses outdoor propagation in urban areas, over ranges up to around 100 m to 5 km, with zero to pedestrian mobile speeds (0-10 km/h). Urban outdoor propagation is characterised by frequent shadowing of the signal and multipath, mostly due to buildings, and base stations located on the ground at limited heights. High traffic requirements are expected in this environment.

7.2.6 Rural outdoor environment

The rural outdoor environment encompasses outdoor propagation in rural areas over ranges up to around 5-35 km, with zero to high speed vehicular mobile speeds (0-500 km/h). Rural outdoor propagation is characterised by shadowing of the signal and multipath mostly due to mountains and trees, and base stations located on the ground at limited heights. Medium traffic requirements are expected in this environment.

7.2.7 Terrestrial aeronautical environment

The terrestrial aeronautical environment encompasses outdoor propagation to users within airplanes over ranges up to around 500 km, with mobile stations moving at aeronautical speeds (0-1 500 km/h). Low traffic requirements are expected in this environment. It should be noted that this environment may also be treated as a special case of the rural outdoor environment.

7.2.8 Fixed outdoor environment

The fixed outdoor environment encompasses outdoor propagation in urban and/or rural areas over ranges up to around 1 to 100 km, with stationary mobile stations. Low traffic requirements are expected in this environment.

An example of such an environment is an environment where services are provided to a user using a fixed radio link as a part of the subscriber loop, i.e. a radio link between a fixed radio distribution point in the network and a radio end-point on the customer's premises which provides a network termination point into which a fixed or cordless apparatus may be connected.

The propagation in this fixed case is characterised by an optimised positioning of the mobile station, and possibly use of directive antennas, so that multipath and blocking possibly can be avoided to some extent, and/or that longer ranges can be achieved.

NOTE 1 – The propagation conditions for fixed terrestrial applications in urban and rural areas may be somewhat different. However, giving due weight to the relative importance of fixed applications with respect to mobile applications in IMT-2000, it is not justified to identify separate radio operating environments for these applications.

7.2.9 Local high bit rate environment

The local high bit rate environment encompasses indoor and/or outdoor propagation over ranges up to around 100 m with zero to pedestrian mobile speeds (0-10 km/h). Typically, such an environment would consist of a dedicated base station for very high bit rate services located at selected spots covering a small area. High traffic requirements are expected in this environment.

7.2.10 Urban satellite environment

The urban satellite environment encompasses outdoor propagation over ranges up to around 47 000 km in urban areas. Medium traffic requirements are expected in this environment.

The mobile earth stations may be moving with zero to typical vehicular speeds (0-100 km/h), and the space stations (satellites) may be moving with speeds (relative to ground) from practically zero to satellite speeds (0-27 000 km/h). The range and the relative speed in this operating environment depend on the satellite configuration.

Urban satellite propagation is characterised by frequent blocking of the signal and multipath mostly due to buildings, and space stations (satellites) located at varying elevations and positions. The varying elevations and positions for the IMT-2000 satellites depend on the satellite constellation.

7.2.11 Rural satellite environment

The rural satellite environment encompasses outdoor propagation over ranges up to around 47 000 km in rural areas. Low traffic requirements are expected in this environment.

The mobile earth stations may be moving with zero to aeronautical speeds (0-1 500 km/h), and the space stations (satellites) may be moving with speeds (relative to ground) from practically zero to satellite speeds (0-27 000 km/h). The range and the relative speed in this operating environment depend on the satellite configuration.

Rural satellite propagation is characterised by line-of-sight and occasional shadowing, and space stations (satellites) located at varying elevations and positions. The varying elevations and positions for the IMT-2000 satellites depend on the satellite constellation.

It should be noted that for the purposes of this Recommendation the rural satellite environment includes aeronautical and maritime. In these cases there may be significant differences to the rural land environment due to terminal speeds and propagation effects (e.g. multipath).

7.2.12 Satellite fixed-mounted environment

The satellite fixed-mounted environment encompasses outdoor propagation over ranges up to around 47 000 km with stationary (fixed) mobile stations. Low traffic requirements are expected in this environment.

The mobile earth stations are stationary, and the space stations (satellites) may be moving with speeds (relative to ground) from practically zero to satellite speed (0-27 000 km/h). The range and the relative speed in this operating environment depend on the satellite configuration.

The propagation in this fixed case is characterised by an optimised positioning of the mobile earth station, and possibly use of directive antennas, so that multipath and blocking possibly can be avoided to some extent. Depending on the satellite constellation, the base stations (satellites) may be located either in a fixed position or at varying elevations and positions.

7.2.13 Indoor satellite environment

The indoor satellite environment encompasses outdoor propagation with an additional indoor component added to it, over ranges up to around 47 000 km. The indoor satellite environment is a special and restrictive case, with a very limited set of application areas, mostly restricted to paging. Very low traffic requirements are expected in this environment.

The mobile earth stations may be moving with zero to pedestrian speeds (0-10 km/h), and the space stations (satellites) may be moving with speeds (relative to ground) from practically zero to satellite speeds (0-27 000 km/h). The range and the relative speed in this operating environment depend on the satellite configuration.

The propagation in this case is characterised by an outdoor component which may be caused by blocking of the signal and multipath due to mountains, trees or buildings, with an additional indoor component requiring an additional margin of the order of 10-15 dB. The space stations (satellites) are located at varying elevations and positions. The varying elevations and positions for the IMT-2000 satellites depend on the satellite constellation.

8 Radio propagation characteristics

Radio propagation characteristics need to be determined in order to develop the system design for IMT-2000. Radio propagation characteristics include:

- maximum transmission ranges,
- overall path loss prediction models,
- multipath delay spreads,
- slow fading statistics,
- fast fading statistics,
- maximum Doppler shifts.

Four different radio propagation environments have been identified: the indoor environment, the terrestrial outdoor environment, the outdoor to indoor environment and the satellite environment. Propagation models for these environments exist, or are being developed, and can be found in the P-Series of ITU-R Recommendations.

8.1 Indoor environments

The home, business and industrial indoor environments are characterised as follows:

Maximum transmission range: Typically below 100 m.

Overall path loss prediction models: Even though indoor propagation distances tend to be short, a line-of-sight (LOS) path between base and mobile stations can seldom be guaranteed due to the presence of walls, floors, furniture, etc. Therefore path losses are in general in excess of LOS path loss. This excess path loss is generally low in open industrial