RECOMMENDATION ITU-R M.1034

**REQUIREMENTS FOR THE RADIO INTERFACE(S) FOR FUTURE PUBLIC
LAND MOBILE TELECOMMUNICATION SYSTEMS (FPLMTS)**

(Question ITU-R 39/8)

(1994)

The ITU Radiocommunication Assembly,

recommends

that the requirements for the radio interface(s) of Future Public Land Mobile Telecommunication Systems (FPLMTS) include the following aspects:

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1. Introduction

Future Public Land Mobile Telecommunication Systems (FPLMTS) 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. PSTN/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 FPLMTS are:

– high degree of commonality of design worldwide,

– compatibility of services within FPLMTS and with the fixed networks,

– high quality,

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

FPLMTS 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 FPLMTS. FPLMTS 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 FPLMTS 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 FPLMTS 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 FPLMTS 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 FPLMTS radio operating environments are defined and characterised. Section 8 gives radio propagation characteristics. In § 9, the service accessibility of FPLMTS radio operation environments is discussed. Section 10 outlines service performance relative to voice and data issues. In § 11, user requirements dealing with cost/complexity, security and handportable viability are described. Finally, in § 12 various operational requirements are discussed.

4. Related documents

The following ITU documents contain information on FPLMTS relating to this Recommendation:

– Recommendation ITU-R M.687:   Future Public Land Mobile Telecommunication Systems (FPLMTS)

– Recommendation ITU-R M.816:   Framework for services supported on Future Public Land Mobile Telecommunication Systems (FPLMTS)

–	Recommendation ITU-R M.817:	Future Public Land Mobile Telecommunication Systems (FPLMTS). *Network architectures*
–	Recommendation ITU-R M.818:	Satellite operation within Future Public Land Mobile Telecommunication Systems (FPLMTS)
–	Recommendation ITU-R M.819:	Future Public Land Mobile Telecommunication Systems (FPLMTS) for developing countries
–	Recommendation ITU-R M.1035:	Framework for the radio interface(s) and radio sub-system functionality for Future Public Land Mobile Telecommunication Systems (FPLMTS)
–	Recommendation ITU-R M.1036:	Spectrum considerations for implementation of Future Public Land Mobile Telecommunication Systems (FPLMTS) in the bands 1 885-2 025 MHz and 2 110-2 200 MHz
–	Draft ITU-T Recommendation F.115:	Operational and service provisions for Future Public Land Mobile Telecommunication Systems (FPLMTS)
–	Preliminary draft Recommendation FPLMTS.RSEL:	Procedure for selection of radio transmission technologies for Future Public Land Mobile Telecommunication Systems (FPLMTS)
–	Recommendation ITU-R M.1078:	Security principles for Future Public Land Mobile Telecommunication Systems (FPLMTS)
–	Recommendation ITU-R M.1079:	Speech and voice band data performance requirements for Future Public Land Mobile Telecommunication Systems (FPLMTS)
–	Preliminary draft Recommendation FPLMTS.TMLG:	Future Public Land Mobile Telecommunication Systems (FPLMTS) terminology

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 FPLMTS 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 FPLMTS 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 FPLMTS holds the possibility of significantly enhancing the overall coverage and attractiveness of the services;

g)   the need for the quality of service of FPLMTS to be comparable to that of the PSTN/ISDN;

h)   the increasing importance of the various types of non-voice telecommunication services; and,

j)   that mobile terminals of FPLMTS may be used to access mobile satellite systems for use on land, ships and aircraft.

7.   FPLMTS radio operating environments

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

The purpose of defining distinct FPLMTS 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 FPLMTS radio operating environments is not to identify allowed scenarios for FPLMTS.

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

7.1   *Characteristics of FPLMTS radio operating environments*

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

7.1.1   *Network attributes*

System application areas for FPLMTS are characterised by the purpose of the system coverage. The FPLMTS system application areas may vary significantly in terms of the type of FPLMTS 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 FPLMTS 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.

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

–   terrestrial based infrastructure,

–   satellite based infrastructure.

FPLMTS 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 FPLMTS base stations and the FPLMTS 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 FPLMTS 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 FPLMTS radio interface(s).

The relative speed between the FPLMTS base stations and the FPLMTS mobile stations may vary due to movement of either the FPLMTS mobile stations or the FPLMTS 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/hr).

7.2   *Identification of FPLMTS radio operating environments*

Following from the above, a very high number of different FPLMTS radio operating environments could in principle be identified. The FPLMTS 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 FPLMTS radio sub-system.

The FPLMTS radio operating environments and their modes of delivery are identified in Table 1:

TABLE 1

FPLMTS 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

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.

Some considerations leading up to the choice of FPLMTS 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 FPLMTS, 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 FPLMTS 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 FPLMTS 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 FPLMTS 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 FPLMTS. 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 PN and PI 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 buildings, moderate in the home environment and stronger in the office environment. It can also be adequately modelled by means of wall and floor penetration losses. Leakage to surrounding outdoor or to neighbouring buildings is to be expected.

Multipath delay spreads: Typical indoor r.m.s. delay spreads range from several tens to several hundreds of nanoseconds. Worst case delay spreads occur typically in the absence of LOS path and/or when inter-building reflections are involved.

Slow fading characteristics: Obstructions of the LOS path give rise to substantial shadowing effects, particularly in the office environment.

Fast fading characteristics: Although fast fading is generally frequency selective, for narrow-band systems this fading can be regarded as flat. For high transmission bit rates (above 1 Mbit/s) the frequency selective nature must be considered.

Maximum Doppler shifts: Typically lower than 10 Hz since they are proportional to pedestrian speeds.

8.2   Terrestrial outdoor environments

Terrestrial mobile systems generally employ a cellular architecture. Typical environments include rural, residential or suburban, and urban environments. Such environments are characterised as follows:

Maximum transmission range: Typically from 100 m in urban microcells to 35 km in rural macrocells, and up to 100 km in fixed-mounted outdoor cells.

Overall path loss prediction models: The model developed by Okumura and Hata has found wide acceptance. However, for urban environments, where shadowing needs particular attention, the COST 231-Walfish-Ikegami model seems more appropriate. A more accurate path loss prediction can be achieved by taking edge diffraction and scattering into account. Rough path loss estimates can also be obtained using an inverse third to fourth power law.

Multipath delay spreads: Typical outdoor r.m.s. delay spreads range from 1 µs for rural and suburban areas to 2 µs for urban areas. However, longer and even much longer delay spreads occur when reflections from distant hills or distant high-rise buildings are involved.

Slow fading characteristics: Shadowing effects can be adequately modelled by a log-normal distribution. A standard deviation of 8 dB is often used by network designers.

Fast fading characteristics: Fast fading of the received signal envelope can be modelled by a Nakagami-m distribution in the general case, which degenerates to a Rayleigh distribution in the absence of specular paths. The Rice distribution also provides a very good fit. Fast fading is also generally frequency-selective in the outdoor environment.

Maximum Doppler shifts: Range from about 10 Hz for pedestrian users to about 1 kHz for high speed vehicular (e.g. train) users.

8.3   *Outdoor to indoor environments*

This environment reflects the influence of building penetration on the terrestrial outdoor environment.

Maximum transmission range: Excess building attenuation reduces the maximum achievable range, relative to the terrestrial outdoor environment.

Overall path loss prediction models: Terrestrial outdoor models can be used with an additional loss called building penetration loss and defined as the difference in median signal levels between that measured immediately outside the building at 1.5 m above ground and that immediately inside the building at some reference level on the floor of interest. Median values between 10 and 18 dB with a standard deviation of about 7.5 dB are reported in the literature. An overall decrease of 1.9 dB per floor with increasing height is also reported. Signal loss within the building also increases when distance to the exterior wall increases. Measurements indicate inverse distance power law exponents between 2 and 4. Typical car penetration losses between 8 and 10 dB have been measured at 1.9 GHz.

Multipath delay spreads: Since building attenuation tends to limit the maximum transmission range, large delay spreads are not expected.

Maximum Doppler shifts: Same as for the indoor environment with some paths showing higher Doppler shifts in the neighbourhood of freeways.

8.4   *Satellite environments*

Maximum transmission range: Varies from a minimum of approximately 700 km when using LEOs (low-Earth-orbit satellites) to about 36 000 km for GSOs (geostationary-orbit satellites) and 47 000 km for HEOs (highly-inclined elliptical-orbit satellites).

Overall path loss prediction models: The presence of a direct path between the satellite and the mobile user is generally a mandatory requirement. However, this direct path can suffer from additional attenuation from shadowing due to foliage, buildings and other man-made structures. The level of additional attenuation tends to increase when the path length through the obstacles increases. This occurs mainly when the elevation angle decreases. Data on foliage attenuation at 1.6 and 2.5 GHz can be found in the literature and can be appropriately scaled in frequency. Additional attenuation is also introduced by ionospheric and tropospheric disturbances. The former are essentially Faraday rotation and amplitude scintillation while the latter only appear for elevation angles below 5°.

It should be noted that propagation impairments apply differently to the land, maritime and aeronautical satellite environments.

Multipath delay spreads: r.m.s. delay spreads tend to be smaller than a few microseconds.

Slow fading characteristics: The lognormal distribution provides adequate fits for the amplitude variations of the direct path over a large area.

Fast fading characteristics: The overall received signal envelope statistics can be modelled by a Rice distribution.

Maximum Doppler shifts: When using GSOs, Doppler shifts are essentially determined by the satellite and user speeds, and ranges up to 2 kHz for land mobile and maritime, and up to 4 kHz for the aeronautical, satellite environments. When using LEOs, Doppler shifts are essentially determined by the satellite speed, and range up to several tens of kHz with Doppler accelerations up to 350 Hz/s.

9. Service accessibility in FPLMTS radio operating environments

FPLMTS will provide a wide range of services in a wide range of service and radio operating environments and to a wide range of mobile station types. However, the physical radio interface is a limiting factor, and not all services are practical for provision in all radio operating environments, nor would they be meaningful in all radio operating environments. It should be noted that the exact services to be provided in the various FPLMTS operating environments are national or operator-specific choices.

This section defines the service accessibility requirements for FPLMTS services across the various FPLMTS radio operating environments, based on limitations of the FPLMTS radio interface(s). The service accessibility requirements defined in this section thus serve as requirements for the more detailed further work on identifying the final set of FPLMTS radio interfaces.

9.1 Classification of FPLMTS services

FPLMTS services may be categorised in various ways, with various different parameters and attributes. The most relevant service parameters and attributes which may have an impact on the design of the FPLMTS radio interface(s) are the service information categories, including the user bit rates.

The following service information categories have been identified for FPLMTS:

1. Speech
2. Audio
3. Data
4. Text
5. Image
6. Video
7. ISDN bearers

Each of these service information categories has several sub-categories. For example, speech is normally associated with a two-way telephone conversation with standard telephone quality. However, high quality telephony is currently being standardised and should be a sub-category. In a similar manner, audio could be hi-fi or telephone quality, and for data, the information bit rate leads to several sub-categories. The image and video categories are also split into low- and high-resolution categories. Furthermore, each service information category includes a range of services.

9.2   *Classification of service accessibility*

The accessibility of a FPLMTS service may be categorised in several ways, with various different parameters and attributes, including:

a)   *Its cellular coverage*

The cellular coverage may depend on several factors like the system coverage and the radio coverage.

The system coverage may be:

–   global service area,

–   regional service area,

–   national service area,

–   limited service area.

The radio coverage may be:

–   contiguous coverage,

–   island coverage,

–   spot coverage.

b)   *Its support in operating environments*

The support of FPLMTS services in an operating environment refers to the technical capabilities of the radio interface(s) to support FPLMTS services in that operating environment, i.e. what that radio interface is primarily designed for. It should not restrict regulators or operators choosing appropriate services for the operating environments.

9.3   *Service accessibility requirements*

9.3.1   *System coverage*

The FPLMTS system coverage depends on national and operator specific choices, and on the eventual international compatibility. It is desirable to accomplish system coverage without placing significant design requirements on the FPLMTS radio interface(s).

9.3.2   *Radio coverage*

The radio coverage depends on national and operator specific choices, but may have some impact on the design on the FPLMTS radio interface(s) in terms of, for example, handover, roaming and location updating.

Radio coverage requirements are covered in Table 2 together with service information categories and operating environments, where the mapping is to service information categories rather than operating environments.

9.3.3   *Support in operating environments*

Provisional service accessibility requirements across FPLMTS operating environments for various FPLMTS service information categories are given in Table 2. Also, radio coverage requirements are covered in this table, mapped on to service information categories.

The eventual accessibility of FPLMTS services may depend on issues of a commercial or regulatory nature, e.g. on whether there is public or private access, whether or not there is competition in the service provision, etc. The service accessibility requirements given in Table 2 are, however, not intended to restrict the provision of FPLMTS services in any operating environments, but are only defined as a basis for the optimization of the design of the FPLMTS radio interface(s) and their characteristics.

The exact FPLMTS services or service categories of any kind to be provided in the various FPLMTS environments are to be decided by the FPLMTS service providers or operators.

10.   Service performance user requirements

This section includes requirements from the perspective of the end-user. Actual requirements for the radio interface(s) are contained in Recommendation ITU-R M.1079.

The detailed choice of FPLMTS services to be provided in any given area is a national or operator specific matter. However, the service capabilities for which the FPLMTS radio interface(s) shall be optimised are defined in this Recommendation.

The framework for services for FPLMTS is defined in Recommendation ITU-R M.816, and the operational and service provisions for FPLMTS are given in ITU-T Recommendation F.115. Further, the service accessibility requirements across FPLMTS radio operating environments are given in § 7 of this Recommendation.

10.1 Support of multiple FPLMTS services

The FPLMTS radio interface(s) shall support this range of services with the service accessibility requirements given in § 7 of this Recommendation, and with sufficient capabilities to set up communication with any appropriate combination of these defined services with their defined qualities of service.

10.2 Flexible service platform

The FPLMTS radio interface(s) shall be designed in a flexible manner so that new services can easily be implemented. The FPLMTS radio interface(s) shall support a flexible service creation and execution platform, allowing operator and user specific services to be easily created.

10.3 Variable user bit rates

The FPLMTS radio interface(s) shall support variable user bit rate services. In addition, mechanisms for flexible user bit rate allocation according to user or system demand shall be supported by the FPLMTS radio interface(s). This applies to any FPLMTS radio operating environment, irrespective of the multiple access scheme used.

10.4 Speech quality

Requirements for speech quality are found in Recommendation ITU-R M.1079.

Near-wireline quality speech service should be provided consistent with the characteristics of the wireless environment.

Spectrum allocation and capacity requirements will determine channel bandwidth and codec bit rates used to achieve desired voice quality.

10.5 Speech quality maintenance techniques

Speech quality maintenance techniques, which maintain a subjectively acceptable speech quality to the users in case of temporary radio channel outages, shall be facilitated by the design of the FPLMTS radio interface(s), irrespective of the FPLMTS radio operating environment.

10.6 Speech delay

Requirements for speech delay are found in Recommendation UIT-R M.1079.

With the widespread use of wireless systems in the public network, the overall transmission performance experienced by users will be largely influenced by the performance of wireless systems. The FPLMTS radio interface(s) should be optimised to minimise delays, which implies careful design of any RF frame structure and of processing for voice coding, modulation, demodulation and in the base station.

10.7 Voiceband data

Draft ITU-T Recommendation F.115 specifies the services to be supported by FPLMTS. Some of these services include voiceband data, which may have particular impact on the radio interface(s).

10.8   *Support of data services*

The FPLMTS radio interface(s) shall support packet-switched data services as well as circuit-switched data services, irrespective of the FPLMTS radio operating environment or multiple access scheme used.

10.9   *Data quality*

Requirements for data performance may, in the future, be found in draft ITU-T Recommendation G.174.

10.10   *Priority access and the emergency services*

The FPLMTS radio interface(s) shall support the requirements for such services as are contained in draft ITU-T Recommendation F.115.

10.11   *Simultaneous use of multiple services*

The FPLMTS radio interface(s) shall support the simultaneous use of several different FPLMTS services by a single FPLMTS terminal.

10.12   *Bearer channel bit-count integrity*

Bit-count integrity should be maintained across link transfers and periods of multipath fading. This is important for synchronous data services and many encryption techniques.

11.   User requirements

11.1   *Cost/complexity*

A low cost/complexity goal could be facilitated by a minimum number of discrete standards for FPLMTS. This could rapidly provide the greatest penetration and coverage area commensurate with optimal cost, complexity and use of spectral resources. Low cost/complexity is clearly important for a widely acceptable portable telephone service.

The FPLMTS radio interface(s) shall be designed in such a way that the total cost of a FPLMTS mobile station, when mature in technology and in the appropriate system application area, shall not be greater than the comparable mobile stations for the corresponding second generation systems. Preferably, the cost should be significantly lower.

11.2   *Widespread service*

Standardization of a minimum number of interfaces could be an essential requirement for widespread service to facilitate roaming to other service areas, other systems and other countries.

11.3   *Security*

Security encompasses the concepts of registration, authentication, privacy and fraud protection.

11.3.1   *Security constraints*

System oriented security requirements for FPLMTS are given in Recommendation ITU-R M.1078. The security requirements which impact on the FPLMTS radio interface(s) include mainly the requirement for possible encryption of the FPLMTS radio interface(s).

The detailed design of the FPLMTS radio interface(s) shall support encryption. This includes accommodation of the encryption and decryption functions in the FPLMTS radio sub-system. The FPLMTS radio interface(s) shall have the technical capabilities to maintain encryption when roaming and during handover, without decrease in quality of service or privacy for the FPLMTS users.

11.3.2 Maintenance of security on handover

Security must be maintained while the handover is taking place.

11.3.3 Security signalling under burst error conditions

The radio propagation environment can occasionally cause errors to occur in bursts; security signalling and application must work in spite of these burst errors.

11.3.4 Minimise additional call set-up delay

The time required to provide authentication must be considered in the development of the call set-up budget. Depending on the approach, call set-up delay will be dominated by the key computations and transmission of long key information in a burst-error environment or by the required time to perform a (distributed) database query. The FPLMTS radio interface(s) shall have minimal effect on call set-up delay.

11.4 Hand-portable viability

Hand-portable FPLMTS terminals are expected to be widely used. Some factors that determine hand-portable viability are size, weight, and operating time. The components that contribute to the size of the hand-portable terminal include: power supply (including battery), antenna, and microelectronics.

The following should be considered when assessing hand-portable viability:

– cost,

– effective radiated power,

– the power consumed by the required signal processing hardware,

– the possibility of exploitation of voice activity and/or power control to reduce average transmitted power,

– the impact of signal processing complexity on the size of the microelectronics,

– size and weight,

– ASIC and DSP implementation,

– antenna technology,

– battery technology,

– multi-mode considerations.

Power drain is an important concern because it affects the size of the battery for a specified operating time. Battery saving techniques for FPLMTS mobile stations shall be facilitated by the design of the FPLMTS radio interface(s), irrespective of the FPLMTS radio operating environment.

11.5 Dial tone

Although it is not desirable to provide dial tone across the air interface to conserve spectrum, it is desirable to provide an indication of network access similar to the PSTN (e.g. an indicator light or personal terminal generated tone).

11.6 Safety requirements

It is to be anticipated that, before FPLMTS services commence, internationally agreed conditions for limits on thermal health hazards will be established. However, the non-thermal health hazards are also under study especially where pulsed transmissions are investigated. FPLMTS equipment shall meet the requirements of the then current relevant international safety requirements and legislation.

In particular, in determining the radio link budget for the FPLMTS mobile station, the maximum power into the antenna and the antenna gain must be such that the user of the apparatus is not subjected to RF radiation in excess of recommended safety limits. This is of particular importance for hand-portable mobile stations where the antenna will be close to the head and eyes of the user.

The perceptions of the general public regarding issues of thermal and non-thermal health hazards are recognised, since they could have an impact on FPLMTS service commencement.

11.7   Electromagnetic compatibility

The FPLMTS radio interface(s) shall be in accordance with appropriate EMC regulations. In the design of the FPLMTS radio interface(s), EMC performance shall be evaluated.

12.   Operational requirements

The operational scenario for FPLMTS is very complex. This section defines requirements on the FPLMTS radio interface(s), considering this complex operational scenario. The section also defines functional and performance requirements of the FPLMTS radio interface(s) for the operation of the system.

The operational requirements in this section are to be used for the initial design of the FPLMTS radio interface(s), and are not to be seen as final system requirements for FPLMTS when put in operation. Further, there may be a range of additional more system-oriented operational requirements on FPLMTS not covered in this section, which only includes operational requirements on the radio interface(s) of FPLMTS. The operational requirements given in this section may constrain the physical FPLMTS radio interface(s) as well as the signalling mechanisms of the FPLMTS radio interface(s).

12.1   Scenario requirements

The operational scenario for FPLMTS includes international operation across various FPLMTS radio operating environments, operation across multiple FPLMTS operators and multiple types of FPLMTS operators, operation over a terrestrial component and a satellite component, and across different regulatory scenarios. Further, FPLMTS will support a range of different mobile station types and a variety of services with a range of bit rates. This section gives scenario requirements on the FPLMTS radio interface(s).

12.1.1   Support of multiple radio operating environments

The radio operating environments for FPLMTS are defined in § 7 of this Recommendation. This includes a terrestrial and a satellite mode of delivery. The FPLMTS radio interface(s) shall support all of these radio operating environments.

12.1.2   Support of multiple FPLMTS operators

The FPLMTS radio interface(s) shall support various types of FPLMTS operators, and service by more than one FPLMTS operator of the same type in any given area.

The FPLMTS types of operators are generally regulatory and national matters. However, from a technical perspective, the FPLMTS radio interface(s) shall at least support the following types of FPLMTS operators:

a)   *Public FPLMTS operators*

Uniquely defined public operators, with wide-area networks generally available to any roaming user. These operators would typically be limited in numbers, and may need some form of coordination.

b)   *Private FPLMTS operators*

Defined private operators, with local area networks generally available only to closed user groups. These operators would typically be private companies offering services to their own employees. They could in principle be unlimited in numbers, and would typically be uncoordinated.

c)   *Residential FPLMTS operators*

These are residential users defined by a user identity rather than an operator identity, but may be regarded as residential FPLMTS operators. These operators would generally provide service only to one or a few residential users associated with a main residential user (the residential FPLMTS operator).

The FPLMTS radio interface(s) shall also support logically different terrestrial FPLMTS operators and satellite FPLMTS operators.

12.1.3 Support of multiple equipment vendors

The FPLMTS radio interface(s) shall support the possibility of using different equipment vendors for the user equipment market as well as the fixed infrastructure market.

12.1.4 Support of multiple FPLMTS mobile station types

The detailed design of FPLMTS mobile stations is a matter for FPLMTS mobile station manufacturers. However, some mobile station issues still need to be categorised from a system perspective, and some FPLMTS mobile station types are therefore defined in Recommendation ITU-R M.687.

These include FPLMTS mobile stations with different output power classes, mobile stations with different service access configurations or different access capabilities, and even mobile base stations. The FPLMTS radio interface(s) shall support this range of FPLMTS mobile station types.

12.2 Functional requirements

This section gives functional requirements of the FPLMTS radio interface(s). These are all subject to service capabilities chosen for implementation in the FPLMTS mobile station by the FPLMTS mobile station manufacturers, and the FPLMTS network operator's choice of network and services in a given geographical area. If the relevant service capabilities are implemented in the networks and in the mobile stations, however, these requirements shall apply.

12.2.1 Structural complexity

12.2.1.1 System complexity

There may be significant advantages in maximising the commonality between the radio interfaces for different FPLMTS radio operating environments and system application areas. Such advantages include economy of scale, greater markets and thus lower costs, greater competition and thus lower prices, and better service availability for mobile users.

The FPLMTS radio interface shall be designed with the aim of minimising the structural complexity of the total FPLMTS radio sub-system. There may be more than one FPLMTS radio interface. However, the number of different FPLMTS radio interfaces shall be minimised, and the commonality between the different FPLMTS radio interfaces shall be maximised.

12.2.1.2 Mobile station complexity

The FPLMTS radio interface(s) shall facilitate easy manufacturing of FPLMTS mobile stations which support all FPLMTS radio operating environments, including the satellite as well as the terrestrial mode of delivery and whether public, private or residential FPLMTS networks.

12.2.2 Roaming

12.2.2.1 General support

The standardised FPLMTS radio interface(s) shall have the capability to support roaming from any FPLMTS radio operating environment to any FPLMTS radio operating environment, irrespective of the physical radio interfaces for these. This includes also roaming capabilities between different types of FPLMTS operators, whether public, private or residential, or whether terrestrial or satellite.

The support of this feature in FPLMTS mobile stations will depend on the service capabilities of the mobile station, which are up to mobile station manufacturers, and on administrative inter-operator agreements on the network side, which may also imply subscription restrictions.

In order to be able to adapt to changes of operational environments and to provide technical roaming capabilities between different FPLMTS radio operating environments and between different types of FPLMTS operators, the FPLMTS radio interface(s) shall have the capability to identify networks and their structure, and for the FPLMTS mobile stations to detect and understand this scenario.

12.2.2.2 Physical radio interface compatibility

Irrespective of the eventual choice(s) of physical radio interface(s) in the various FPLMTS radio operating environments, the design of the physical FPLMTS radio interface(s) shall facilitate roaming capabilities between all FPLMTS radio operating environments, whether satellite or terrestrial mode of delivery.

12.2.3 *Handover*

The services provided to a FPLMTS user shall in principle be unchanged by handover and the qualities of service provided to a FPLMTS user shall in principle be maintained or improved.

12.2.3.1 *General support*

The standardised FPLMTS radio interface(s) shall, for a given service, have the capability to support handover from any FPLMTS radio operating environment to any FPLMTS radio operating environment, irrespective of the physical radio interfaces for these. This includes also a handover capability between different types of FPLMTS operators, whether public, private or residential, or whether terrestrial or satellite.

The support of this feature in the mobile stations will depend on the service capabilities of the mobile station, which are up to mobile station manufacturers, on the network implementation of a service in a geographical area, and on administrative inter-operator agreements, which may also imply subscription restrictions.

12.2.3.2 *Physical radio interface compatibility*

Irrespective of the eventual choice(s) of physical radio interface(s) in the various FPLMTS radio operating environments, the design of the physical FPLMTS radio interface(s) shall facilitate handover capabilities between all FPLMTS radio operating environments, whether satellite or terrestrial mode of delivery.

12.2.3.3 *Types of handover*

The FPLMTS radio interface(s) shall support handover within a cell (intra-cell handover) as well as handover between cells (inter-cell handover).

The FPLMTS radio interface(s) shall also support multi-bearer handovers and radio originated as well as network originated handovers, as applicable to the FPLMTS network types.

12.2.3.4 *Seamless handover*

In FPLMTS, the goal is to have an end-to-end quality of service which is comparable to that of the fixed networks. The FPLMTS radio interface(s) shall be designed to the greatest extent practicable such that the execution of handover is unnoticeable to the end users (seamless handover), irrespective of FPLMTS radio operating environments.

Every effort shall be made to accommodate this requirement of maintaining the quality of service during handover, including the possible momentary use of more than one radio channel. However, the design of the handover procedures over the FPLMTS radio interface(s) shall be such that execution of handover does not significantly decrease the system capacity.

12.2.3.5 *Signalling load of handover*

The FPLMTS radio interface(s) shall be designed such that the signalling procedure required to execute handover is as short (quick) as possible. This is necessary in order to accommodate very small cells, or to accommodate high-speed mobile stations at cell boundaries. FPLMTS radio interface(s) shall be designed such that the signalling load of handover shall be kept to a minimum.

12.2.4 *Need for inter-working*

FPLMTS will support a variety of services with a range of bit rates, including a range of data services. FPLMTS will thus provide access to various circuit-switched and packet-switched data networks.

The FPLMTS radio interface(s) shall be designed in such a way that the need for specific inter-working functions in order to inter-work with various fixed networks, in particular data networks, is minimised.

12.2.5 *Radio network deployment*

Recommendation ITU-R M.819 gives requirements on FPLMTS for the support of developing countries. For additional requirements on the FPLMTS radio interface(s) related to FPLMTS system deployment, see also that Recommendation.

12.2.5.1 Cell size flexibility

The FPLMTS radio interface(s) shall support a range of cell sizes. The detailed definitions of these FPLMTS cell types are given in Recommendation ITU-R M.1035.

The FPLMTS radio interface(s) shall be designed in such a way that several of these cell types can be used simultaneously in the same geographical area (e.g. as umbrella cells). The FPLMTS radio interface(s) shall also support the use of several cells of the same type in the same geographical area (e.g. from different network operators).

12.2.5.2 Cell location flexibility

The FPLMTS radio interface(s) shall be flexible with respect to the exact location of cell sites, such that significant system or capacity impairments due to non-ideal site locations are not risked.

12.2.5.3 Use of repeaters

The FPLMTS radio interface(s) shall support the use of repeaters, in order to extend the radio coverage in a simple manner, e.g. in rural areas where the users are either too far away or too obstructed by terrain to communicate directly with a given base station.

A number of repeaters (possibly up to 10) may have to be connected in tandem in specific cases. This may require extraordinary mechanisms, and lower end-to-end quality of service. The radio channel performance requirements defined in Recommendation ITU-R M.1079 apply to a single radio link.

12.2.5.4 Multi-operator aspects

The FPLMTS radio interface(s) shall facilitate the coexistence of multiple FPLMTS operators in the same geographical area. This may impose restrictions on each operator's individual freedom in network planning.

12.2.5.5 Synchronization

Time synchronization between different FPLMTS networks should not be a mandatory requirement.

12.2.5.6 Low capacity roll-out flexibility

The FPLMTS radio interface(s) shall facilitate minimum network installations in areas where little capacity is needed (e.g. in rural areas). Further, this low capacity roll-out shall facilitate band sharing with other (non-FPLMTS) services.

12.2.6 Radio network management

12.2.6.1 Frequency planning and coordination

The FPLMTS radio interface(s) shall require a minimum of frequency planning and necessary inter-network coordination for operation of a single FPLMTS operator's network.

12.2.6.2 Cell configuration and management

The FPLMTS radio interface(s) shall be designed in such a way that a minimum of operations in order to configure or reconfigure cells is required. It shall be simple to:

–   take single channels out of service,

–   install new channels in the cell,

–   temporarily take the whole cell out of service,

–   change the frequencies/channels in the cell,

–   carry out tests of the cell,

–   carry out maintenance on some channels in the cell, while leaving others in service,

–   etc.

12.2.6.3 Traffic adaptability

The FPLMTS radio interface(s) shall support simple mechanisms to adapt to varying traffic needs, irrespective of FPLMTS radio operating environment.

12.2.6.4 *Capacity/quality control*

In specific cases, a FPLMTS operator may wish to increase the capacity of his network temporarily, e.g. during peak traffic hours or during special events.

The FPLMTS radio interface(s) shall support simple mechanisms to adapt and control the capacity and quality of service according to varying traffic needs, irrespective of the FPLMTS radio operating environment.

12.2.6.5 *Channel allocation flexibility*

The FPLMTS radio interface(s) shall be designed in such a way that the allocation of channels within and between cells allows flexibility for handling varying services with a range of different, and possibly varying, bit rates in a spectrum efficient manner. This applies to all FPLMTS radio operating environments.

12.2.7 *Radio network evolution*

12.2.7.1 *Cell expansions*

The FPLMTS radio interface(s) shall require a minimum of planning and operations in order to install new cells.

12.2.7.2 *Use of capacity improvement techniques*

The FPLMTS radio interface(s) shall facilitate the implementation and use of appropriate capacity improvement techniques, if applicable, in the various FPLMTS radio operating environments.

It is desirable that the appropriate capacity improvement techniques can be implemented in the initial radio interface(s) or be easily added to an existing FPLMTS radio interface.

It is desirable that the FPLMTS radio interface(s) does not depend on the implementation of these techniques, but that they are capacity improvement options. It is desirable that they do not significantly add complexity or cost to the infrastructure or mobile stations.

12.2.7.3 *Implementation of new services*

The FPLMTS radio interface(s) shall be designed in a flexible manner so that new services can easily be implemented at later dates.

In addition, the FPLMTS radio interface(s) shall be designed in such a way that a given service, and a given quality of service, can later be implemented in a more efficient manner (e.g. in a more spectrum efficient manner requiring lower channel bit rates).

12.2.7.4 *Phased implementations and backwards compatibility*

The FPLMTS radio interface(s) shall be designed in a flexible manner so that FPLMTS can be implemented in phases with increased functionality. The FPLMTS radio interface(s) shall allow the maximum possible backwards compatibility to earlier phases, when new phases are implemented, and with minimal impact on earlier-phase mobile stations.

12.2.8 *Spectrum usage and management*

12.2.8.1 *Frequency sharing with other services*

Depending on national frequency allocations, FPLMTS may have to coexist and share the FPLMTS identified frequency band with other (non-FPLMTS) services. The detailed frequencies for band sharing may vary from country to country.

The FPLMTS radio interface(s) shall support such band sharing with maximum flexibility. See also Recommendation ITU-R M.1036.

12.2.8.2 Efficient spectrum sharing between FPLMTS operators

In FPLMTS, there may be several competing operators in a given geographical area. In addition, there may be several different types of FPLMTS operators operating in the same geographical area.

The FPLMTS radio interface(s) shall support efficient and flexible spectrum sharing between different FPLMTS operators. See also Recommendation ITU-R M.1036.

12.2.8.3 Power/interference control

The FPLMTS radio interface(s) shall support mechanisms for minimising the power (and interference) transmitted by the FPLMTS mobile stations and base stations at any time, irrespective of the FPLMTS radio operating environment.

12.2.9 Radio range and cell sizes

More detailed descriptions of the FPLMTS cell types are given in Recommendation ITU-R M.1035. These cell types may have various sizes depending on the needs of the FPLMTS operators in different geographical areas.

The requirements on FPLMTS radio interfaces from the various cell types may be generalised as follows:

– the cell types are generally related to the operating environments, but not uniquely;

– for indoor operating environments, a wide range of cell sizes should be supported. However, an optimised indoor radio interface, if any, should be optimised for small to very small cells;

– for outdoor operating environments, all types of cells should be supported. However, an optimised terrestrial outdoor radio interface, if any, should be optimised for moderate to large size cells;

– for satellite environments, very large cells should obviously be supported.

For the most restrictive FPLMTS operating environments, the FPLMTS radio interface shall support cell sizes as small as 10 m in radius.

It should also be possible to accommodate terrestrial cells with coverage over very long ranges.

12.2.10 Diversity techniques

The design of the FPLMTS radio interface(s) shall facilitate the use of appropriate diversity techniques for improved quality or capacity, as appropriate to the FPLMTS radio operating environment.

However, the FPLMTS radio interface(s) shall, if possible, not depend on such techniques if they significantly add complexity or cost to the infrastructure or mobile stations.

12.2.11 Operational flexibility

The FPLMTS radio interface(s) shall be designed in such a way that operational flexibility is maximised. Operational flexibility may include modification of operational data in the mobile station via the radio interface. Implementation of this requirement in mobile stations is subject to the capabilities of the mobile stations.

12.2.12 Risk

12.2.12.1 Development and implementation risk

The FPLMTS radio interface(s) shall be designed in such a way that the risk in development and implementation of the radio interface technology is kept at an acceptable level. This applies in particular to the implementation of the technology in FPLMTS mobile stations with a high degree of integration.

12.2.12.2 Operational risk

The FPLMTS radio interface(s) shall be designed in such a way that the impact of malfunctions in the fixed infrastructure create the minimum loss of service for the FPLMTS users handled by that base station or any neighbouring base stations. The impact of faulty FPLMTS mobile stations or any other interfering equipment should also be minimised. Situations to consider in this respect include:

– loss of inter-base station synchronization, if any,

– loss of a base station carrier,

– interference from other services in the same band, if any,

– interference from services in adjacent bands,

– interference from uncoordinated FPLMTS operators,

– faulty mobile stations transmitting with full power,

– etc.

12.3   ***Performance requirements***

System oriented performance requirements for FPLMTS are given in Recommendation ITU-R M.1079. These requirements are related to end-to-end quality of service issues, and include subjective quality related issues, objective digital error ratios, as well as timing and delay constraints, reliability figures and service access probabilities. The FPLMTS radio interface(s) shall support these requirements, whether in the physical radio interface performance or in the signalling protocols to achieve service.

The performance requirements given in this section are performance requirements with direct impact on the design of the FPLMTS radio interface(s), and may not have any direct relation to end-to-end quality of service issues. There may, however, be an indirect relation in some cases.

12.3.1   ***Resistance to multipath effects***

Given the physical environments for a FPLMTS network, the network must be able to cope with a certain amount of multipath effects. The FPLMTS radio interface(s) shall generally support operation in the presence of the multipath effects experienced in the various FPLMTS radio operating environments defined in § 7 of this Recommendation. The radio propagation characteristics in these environments are detailed in § 8.

12.3.2   ***Support of moving vehicles***

The FPLMTS radio operating environments are defined in § 7. The FPLMTS radio interface(s) shall support operation at appropriate vehicle speeds for each FPLMTS radio operating environment. These include vehicle speeds ranging from 0 to 500 km/h for terrestrial applications and to 1 500 km/h for aeronautical applications.

12.3.3   ***Radio channel performance***

Radio channel performance requirements are given in Recommendation ITU-R M.1079, based on a set of end-to-end quality of service objectives for the FPLMTS defined services. Each FPLMTS service is defined with one or several end-to-end quality of service objectives, and the various radio channels to be defined are given performance requirements based on these.

The radio channel performance parameters can be specified as acceptable bit/frame error ratios (FERs/BERs) for given service qualities and given service access probabilities.

The radio channel performance for the FPLMTS radio interface(s) is no means for comparison. It is fixed at the radio channel performance levels given in Recommendation ITU-R M.1079, and the design of the FPLMTS radio interface(s) shall meet these requirements.

12.3.4 *Spectrum efficiency*

The spectrum efficiency of a FPLMTS radio network is a measure of the maximum number of active FPLMTS users that can be accommodated per area and spectrum, or per volume and spectrum in multi-floor buildings, for a given quality, cell size, propagation environment cost and design effort.

The spectrum efficiency of a FPLMTS radio interface shall be determined using the minimum cell size for the appropriate FPLMTS radio operating environment as the basis for the cell area. For non-voice services, an equivalent unit of traffic intensity must be calculated. The spectrum efficiency shall be based on fixed radio channel performances given in Recommendation ITU-R M.1079.

When evaluating spectrum efficiency, the effect of non-FPLMTS services in the same and adjacent frequency bands, and any guard bands resulting from these, shall be taken into consideration. Overhead such as control and signalling channels shall also be included in analysis of spectral efficiency.

12.3.5 *Operational reliability*

The FPLMTS radio interface(s) shall be designed in such a way that the operational reliability, including, for example, the mean time between failure (MTBF) for FPLMTS radio infrastructure in mature operation, can be at least as good as the reliability for corresponding second generation mobile systems, at reasonable cost.

In addition, the FPLMTS radio interface(s) shall be designed in such a way that the mean time to repair (MTTR) for FPLMTS radio infrastructure in mature operation, can be at least as good as the reliability for corresponding second generation mobile systems, at reasonable cost.

ANNEX 1

Definitions

The terms used in this Recommendation are consistent with definitions to be contained in a future Recommendation on FPLMTS terminology. However, there are some additional terms that need definition. These terms are as follows:

– **base station**: the *base station* (BS) is the common name for all the radio equipment located at one and the same place used for serving one or several *cells*;

– ***base station area**: the area covered by all the *cells* served by a *base station*;

– ***cell**: the radio coverage area of a satellite spot beam or a *base station*, or of a sub-system (e.g. sector antenna) of that *base station* corresponding to a specific logical identification on the radio path, whichever is smaller;

– ***handover**: the action of switching a call in progress from one cell to another or between radio channels in the same cell;

– ***mobile station**: the *mobile station* (MS) is the interface equipment used to access FPLMTS services. It includes the *mobile termination*, as well as the terminal functions required to provide services to the user, e.g. terminal equipment and terminal adaptors;

– ***mobile termination**: the *mobile termination* (MT) is the part of the *mobile station* which terminates the radio path at the mobile side and adapts the capabilities of the radio path to the capabilities of the terminal equipment;

– ***pocket-sized station**: a mobile station that can comfortably be carried around by a person due to light weight and small size, and which has relatively low power consumption;

– ***portable station**: a mobile station that is portable but cannot comfortably be carried around by a person due to weight and/or size, or having relatively high power consumption;

– ***vehicle-mounted station**: a *mobile station* which is mounted and operated in a vehicle and where the antenna is mounted on the outside of the vehicle;

– ***fixed-mounted station**: a station which is fixed-mounted and which is not intended to be operated while in motion. In all other respects, however, it behaves in the system like a mobile station;

–   ****service area**: the area within which a *mobile station* can access the FPLMTS services. A *service area* may consist of several FPLMTS networks. One *service area* may consist of one country, be a part of a country or comprise several countries;

–   ****global service area**: world-wide *service area*;

–   ****regional service area**: a *service area* that covers several countries and/or ocean regions of comparable size;

–   ****national service area**: a *service area* consisting of a single country;

–   ****limited service area**: a *service area* which is limited to a part of a country;

–   ****paging**: the act of seeking a *mobile station* when an incoming call has been placed to it;

–   ****radio interface**: the FPLMTS radio interface is the means of realising the wireless electromagnetic interconnection between a FPLMTS mobile station (or mobile earth station) and a FPLMTS base station (or space station);

–   **cell layer**: all *cells* of the same category with similar radio characteristics and sharing the same radio resources;

–   **end-user**: the user of the FPLMTS terminal used to access the FPLMTS services;

–   **(radio) power control**: dynamic adjustment of the output power to minimise the total interference in the system, while maintaining sufficient quality of any connection;

–   **spot coverage**: single cell;

–   **island coverage**: collection of cells which may range in coverage from a neighbourhood to a major urban area;

–   **contiguous coverage**: coverage provided everywhere in the intended *service area*.

Note 1 – Candidates to be moved to the future Recommendation on FPLMTS terminology are marked with asterisks (*).

ANNEX 2

Considerations for FPLMTS radio operating environments

The considerations leading up to the distinct FPLMTS radio operating environments identified in § 7.2 include:

–   concerning FPLMTS mobile base stations (e.g. a base station located in a moving vehicle), these have two radio interfaces which each may be in a different radio operating environment. The total radio operating environment will have physical characteristics (propagation and relative speed) given by the radio interface communicating directly with the mobile station. However, the expected service information rates for the total operating environment will be given by the capabilities of the weakest link in the chain;

–   the use of repeaters for FPLMTS may have a similar impact on the total FPLMTS radio environment as the FPLMTS mobile base stations. However, for repeaters the situation is even more complicated, and repeaters cannot be identified as one or a few separate FPLMTS radio operating environments. However, the impact of the use of repeaters on the service capabilities of the radio interface should be taken into consideration by the FPLMTS operators when planning their networks;

–   the urban environment is separated into pedestrian and vehicular applications, as the expected service information rates, in addition to the mobile speeds, may differ somewhat for pedestrian and vehicular urban environments. For rural environments, however, although the differences between pedestrian and vehicular applications are the same in principle, it is not considered necessary to split this environment into two separate ones;

–   the rural outdoor environment is intended to cover speeds up to those for high-speed trains. Increasing the required speed for this environment to also cover aircraft could be considered. This may, however, not be justified, and may better be treated as a special case if terrestrial based aeronautical coverage is required.

ANNEX 3

**Provisional service accessibility design constraints on FPLMTS interface(s)
across FPLMTS radio operating environments**

This Annex includes provisional service accessibility design constraints on FPLMTS radio interfaces across FPLMTS radio operating environments. The design constraints are pending alignment with FPLMTS service/system Recommendations (e.g. Recommendation ITU-R M.816, draft ITU-T Recommendation F.115, Recommendation ITU-R M.1079, etc.).

TABLE 2

Service Accessibility Design Constraints on FPLMTS Radio Interface(s) across FPLMTS Radio Operating Environments

Service information category	Typical source bit rate (kbit/s)	Cellular coverage: Typical radio coverage	Radio operating environment												
			(1) Bus. ind.	(2) Nei. i/o.	(3) Home ind.	(4) Urban veh.	(5) Urban ped.	(6) Rural out.	(7) Terr. aero	(8) Fixed out.	(9) Local h/r.	(10) Urban sat.	(11) Rural sat.	(12) Fixed sat.	(13) Ind. sat.
Speech Telephone 7 kHz	 8-32 48-64	 Contiguous Island	 yes yes	 yes yes	 yes yes	 yes –	 yes yes	 yes –	 yes –	 yes yes	 – –	 yes –	 yes –	 yes yes	 – –
Audio Telephone-Q Hi-Fi	 8-32 48-64	 Contiguous Island	 yes yes	 yes yes	 yes yes	 yes –	 yes –	 yes –	 yes –	 yes yes	 – –	 yes –	 yes –	 yes yes	 – –
Data Low Medium High Very high	 < 10 10-64 64-2 048 2 000-20 000	 Contiguous Contiguous Island / Spot Spot	 yes yes yes –	 yes yes yes –	 yes yes yes –	 yes yes yes –	 yes yes – –	 yes yes yes –	 yes yes yes –	 yes yes yes –	 – – yes yes	 yes yes – –	 yes yes – –	 yes yes yes –	 yes – – –
Text	20	Contiguous	yes	yes	yes	yes	yes	yes	yes	yes	–	yes	yes	yes	yes
Image Fax Hi-Q colour	 2.4-64 50-500	 Contiguous Contiguous / Island	 yes yes	 yes yes	 yes yes	 yes yes	 – –	 yes yes	 yes –	 yes yes	 – –	 yes –	 yes –	 yes yes	 – –
Video	 8-64 1 500-20 000	 Contiguous Spot	 yes –	 yes –	 yes –	 yes –	 yes –	 yes –	 – –	 yes –	 – yes	 yes –	 yes –	 yes –	 – –
ISDN bearers B + D 2B + D > 2B + D	 80 144 144-2 048	 Contiguous Contiguous Island / Spot	 yes yes yes	 yes yes yes	 yes yes yes	 yes yes yes	 yes yes –	 yes yes yes	 yes yes –	 yes yes yes	 – – yes	 yes yes –	 yes yes –	 yes yes yes	 – – –

Radio operating environments:

(1)   Bus. ind.:   business indoor environment

(2)   Nei. i/o.:   neighbourhood indoor/outdoor environment

(3)   Home ind.:   home indoor environment

(4)   Urban veh.:   urban vehicular outdoor environment

(5)   Urban ped.:   urban pedestrian outdoor environment

(6)   Rural out.:   rural outdoor environment

(7)   Terr. aero: terrestrial aeronautical environment

(8)   Fixed out.:   fixed outdoor environment

(9)   Local h/r.:   local high bit rate environment

(10)   Urban sat.:   urban satellite environment

(11)   Rural sat.:   rural satellite environment

(12)   Fixed sat.:   satellite fixed-mounted environment

(13)   Ind. sat.:   indoor satellite environment

Notes to Table 2

Note 1 – Very high bit rate service information categories like TV and very high bit rate data services are included in the table for possible future applications. Such service information categories are not foreseen for phase 1 of FPLMTS, and may require specialised base stations and infrastructure if included in the future.

Note 2 – It should be noted that the service information categories in Table 2 represent types of user information and not defined services.

Note 3 – It should be noted that paging services are covered by Table 2 (e.g. under "data" and/or "text").

Note 4 – There may be a possible need to identify a separate service information sub-category covering data with very low bit rates (e.g. 300 bit/s). This would typically apply to indoor satellite applications.

Note 5 – Satellite aeronautical and maritime radio operating environments are currently assumed to be included in the various satellite environments.

Note 6 – Due to their specific technical characteristics, some mobile satellite systems currently use lower rate speech and audio coders than those identified in the table above.

Note 7 – A "yes" entry for a particular radio operating environment implies that either all, or a subset, of the typical source bit rates indicated will be supported.

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