

RECOMMENDATION 687

FUTURE PUBLIC LAND MOBILE TELECOMMUNICATION SYSTEMS
(FPLMTS)

(Question 39/8)

(1990)

The CCIR,

CONSIDERING

- (a) Recommendation No. 205 of the WARC MOB-87;
- (b) that the cost of radio and Very Large Scale Integration (VLSI) technology is continually decreasing, thus making competitive, in a number of cases, the alternative option of a radio approach for accessing voice and non-voice telecommunication services;
- (c) that different future systems are under study;
- (d) that system compatibility is necessary for international operation, and that commonality is desirable in any event to ensure that the overall systems cost per mobile user is significantly less than it is with present systems;
- (e) 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;
- (f) the possible need for common channels or frequency bands to allow regional and/or world-wide operation, particularly with the increasing use of personal (hand-held, portable) terminals;
- (g) that the use of internationally agreed frequency bands also facilitates the planning of national networks and reduces the risk of harmful interference with other radio services;
- (h) the increasing importance of the various types of non-voice telecommunication services;
- (j) the relevant CCITT Recommendations and on-going studies;
- (k) that mobile terminals of the FPLMTS may be used to access mobile satellite systems for use on land, ships and aircraft;
- (l) the allocation of radio spectrum in the 1.5-1.6 GHz band by the WARC MOB-87 to the land mobile-satellite service;
- (m) that there is a need for mobile terminals to roam between public land mobile telecommunication networks in different countries;
- (n) that a standardized radio interface would facilitate the roaming of mobile units between networks;
- (o) that users may want to be able to use the same terminals and procedures as in the fixed network ISDN to access similar telecommunication services in FPLMTS;
- (p) Questions 77/8 and 38/9,

UNANIMOUSLY RECOMMENDS

that future public land mobile telecommunication systems intended for regional and/or world-wide use should conform to the following objectives and characteristics:

1. Objectives

1.1 General objectives

FPLMTS aim to achieve the following primary general objectives:

- 1.1.1 to make available voice and non-voice telecommunication services to users who are on the move or whose location may change (mobile users);
- 1.1.2 to provide these services over a wide range of user densities and geographic coverage areas;
- 1.1.3 to make efficient and economical use of the radio spectrum consistent with providing service at an acceptable cost;

- 1.1.4 to provide, as far as practical, a service of high quality and integrity, comparable to the fixed network;
- 1.1.5 to accommodate a variety of mobile terminals ranging from those which are small enough to be easily carried on the person (personal pocket radio) to those which are mounted in a vehicle;
- 1.1.6 to provide a framework for the continuing extension of mobile network services, and access to services and facilities of the fixed network (PSTN/ISDN) subject to the constraints of radio transmission, spectrum matters and system economics;
- 1.1.7 to admit the connection of mobile users to other mobile users or fixed users, using the fixed network (PSTN/ISDN) or other telecommunication networks as appropriate;
- 1.1.8 to permit the use of the FPLMTS for the purpose of providing its services to fixed users under conditions approved by the appropriate national or regional authority, either permanently or temporarily, either in rural or urban areas;
- 1.1.9 to admit the provision of service by more than one network in any area of coverage;
- 1.1.10 to allow mobile and fixed network users to use the services irrespective of location (i.e. national and international roaming);
- 1.1.11 to provide an open architecture which will permit the easy introduction of technology advancements, as well as different applications;
- 1.1.12 to allow the coexistence with, and interconnection with, mobile systems which use direct satellite links taking into consideration CCITT Recommendation E.171;
- 1.1.13 to provide a modular structure which will allow the system to start from as small and simple a configuration as possible and grow as needed, both in size and complexity within practical limits.

1.2 *Technical objectives*

FPLMTS aim to achieve the following primary technical objectives:

- 1.2.1 to support integrated communication and signalling;
- 1.2.2 to establish signalling interface standards in terms of the Open System Interconnection (OSI) model.

FPLMTS aim to achieve the following secondary technical objectives:

- 1.2.3 to provide for additional levels of security (for voice and data services) compared to that contained in § 1.1.4. In addition, to allow for the provision of end-to-end encryption for voice and data services;
- 1.2.4 to provide service flexibility which permits the optional integration of services such as mobile telephone, dispatch, paging and data communication, or any combination thereof;
- 1.2.5 to support terminal interfaces which allow the alternative use of terminal equipment in the fixed ISDN network;
- 1.2.6 to support equipment and component design that can withstand typical rural conditions (rough roads, dusty environment, extreme temperatures and humidity, etc.);
- 1.2.7 to accommodate the use of repeaters for covering long distances between terminals and base stations, providing this does not constrain the specification of the radio interfaces;
- 1.2.8 to allow the connection of PABXs or small rural exchanges to mobile stations.

1.3 *Operational objectives*

FPLMTS aim to achieve the following primary operational objectives:

- 1.3.1 to provide for the required user authentication and billing functions;
- 1.3.2 to provide for unique user identification and PSTN/ISDN numbers in accordance with appropriate CCITT Recommendations;
- 1.3.3 to provide for a unique equipment identification scheme;
- 1.3.4 to enable each mobile user to request particular services, and initiate and receive calls, as desired.

FPLMTS aim to achieve the following secondary operational objectives:

- 1.3.5 to provide an indication to the paying party of added call charges e.g. due to roaming;

1.3.6 to allow the system to be configured for special conditions where mobility between cells, or even within a cell is not required; or where a high traffic per user is required;

1.3.7 to take account of the communications requirements for road traffic management and control systems;

1.3.8 to allow for extension of the cell size in rural or remote areas, providing this does not constrain the specification of the radio interfaces.

2. Services

2.1 General

2.1.1 FPLMTS should offer the services available in the PSTN/ISDN and other public networks, as far as possible, bearing in mind the differences in the characteristics of the fixed network and mobile radio environment;

2.1.2 FPLMTS may also offer additional services, taking into account the special nature of mobile communications;

2.1.3 FPLMTS should be designed in such a way that the calling user does not have to know the location of the mobile;

2.1.4 it should be possible for stations in FPLMTS to be used in the maritime and aeronautical environment, to the extent permitted by national or international regulatory authorities;

2.1.5 it should be possible for FPLMTS to be used as a temporary or permanent substitute to fixed networks where fixed network facilities are limited or not available, or more generally where reasons of convenience or economics make this desirable. The system should then be capable of adaptation to these conditions (i.e. higher traffic per user, no mobility between cells or even within a cell);

2.1.6 FPLMTS should be designed to allow international operational operation and automatic roaming of mobile subscribers and stations. (The degree to which the roaming facility between networks or countries shall be automatic is not yet decided);

2.1.7 FPLMTS should be designed so that under favourable circumstances services requiring high information rates can be provided;

2.1.8 FPLMTS should be capable of providing service to a variety of mobile terminal ranging from those which are small enough to be easily carried on the person to those which are mounted in a vehicle.

2.2 Bearer services

Lower bit rate channels (or sub-rate channels) are recommended for the FPLMTS equivalent of the ISDN B-channel and the D-channel.

2.2.1 Circuit-mode bearer services

In accordance with the appropriate CCITT Recommendations, subject to FPLMTS limitations.

2.2.2 Packet-mode bearer services

In accordance with the appropriate CCITT Recommendations, subject to FPLMTS limitations.

2.3 Teleservices

FPLMTS should support the teleservices listed below:

2.3.1 Telephony

In accordance with the appropriate CCITT Recommendations, subject to FPLMTS limitations.

2.3.2 Text

In accordance with the appropriate CCITT Recommendations, subject to FPLMTS limitations.

2.3.3 *Paging*

FPLMTS should be able to provide paging services, integrated with telephony and data services to the extent permitted by individual administrations.

Mobile satellites may offer wide area paging beyond the range of terrestrial systems.

2.3.4 *Videotex*

In accordance with the appropriate CCITT Recommendations, subject to FPLMTS limitations.

2.3.5 *Facsimile*

In accordance with the appropriate CCITT Recommendations, subject to FPLMTS limitations.

2.3.6 *Data*

FPLMTS should provide synchronous and asynchronous data services which are offered on the PSTN, subject to the provision of additional error control facilities for the radio channel.

2.3.7 *Short messages*

FPLMTS should allow the exchange of messages of limited length between a storage system connected to the fixed network and a station.

2.4 *Supplementary services*

In accordance with the appropriate CCITT Recommendations, subject to FPLMTS limitations.

2.4.1 *Point-to-multipoint*

FPLMTS should provide this service for dispatch, group calling, closed user groups and other applications, to the extent permitted by individual administrations.

2.4.2 *Separation of answering from alerting*

FPLMTS should provide the capability for the user to answer on a network other than that on which he/she had been alerted.

2.4.3 *Charging service*

FPLMTS should allow the capability of providing the paying party with the option of terminating a call to a roaming mobile if there is an extra charge.

FPLMTS should offer the subscriber a supplementary service of having calls forwarded at his expense.

2.4.4 *Location*

FPLMTS should be able to provide, in special situations, location information only to the extent permitted by competent authorities.

3. **Frequency band considerations**

3.1 *General considerations*

Considerations on spectrum should take into account the estimated traffic, the available and foreseeable techniques, the propagation characteristics and time scale for meeting the users needs to the greatest possible extent.

Considerations on frequency matters should take into account the fact that to the end of the 20th century and after, the traffic generated by public mobile systems will continue to expand, as well as the number and diversity of services.

3.2 *Traffic considerations*

Any estimation of the traffic should take into consideration that in the future, non-voice traffic will constitute an increasing proportion of the total traffic and that traffic will be generated outdoors as well as indoors by mobile and personal stations.

3.3 *Spectrum requirements*

To comply with FPLMTS service requirements, namely the concept of regional and/or world-wide roaming, inclusion at least partly of world-wide common frequency allocations should be considered as the first choice to enable universal access particularly for personal stations.

A sufficient allocation of spectrum should be made available for use around 1998 to fulfill the potential needs of FPLMTS around that date and beyond.

3.4 *Technical and functional compatibility/commonality*

Frequency commonality should allow for the desired level of operational compatibility on the system(s). In principle, a complete commonality of one frequency band on a world-wide basis would be desirable, but reasonable commonality could also be obtained through a common signalling band and sufficient overlap of the traffic bands to ensure compatibility.

In order to facilitate the use of mobile satellite links with FPLMTS, the allocation of adjacent satellite and terrestrial bands should be considered.

3.5 *Choice of a frequency band*

The cost and power efficiency of the RF technology available, the resulting consequences on FPLMTS hardware and on battery operating durations for portable and personal stations as well as the impact on cell structure, should be considered when choosing frequency bands.

Overall propagation and RF technology factors indicate that the use of a band below 3 GHz would be suitable for FPLMTS.

3.6 *State of techniques*

Estimation of spectrum needs should take into account the design of a system carrying traffic with high spectrum efficiency. To that effect speech and data transmissions should include good quality codecs associated with channel coding, modulation and equalization, multiple access techniques and adaptive techniques.

Traffic management techniques such as queuing should also be considered since they may be very effective in smoothing the offered traffic load, and hence substantially increase spectrum utilization efficiency, particularly when services with differing characteristics including significant non-voice traffic are integrated into a common radio system.

3.7 *Estimation of spectrum needs*

In an estimation of spectrum needs for voice services the total required bandwidth should range from approximately 160 MHz down to approximately 110 MHz according to possible technical solutions.

In an evaluation of spectrum needs for non-voice services the total bandwidth should amount to 65 MHz. The total bandwidth therefore ranges from approximately 230 MHz (conservative projection of future technology) down to approximately 180 MHz (optimistic projection of future technology).

This estimation should also take into account that in a number of countries an allocation of 50 MHz of spectrum below 1 GHz is used for existing cellular mobile systems. If these existing systems remain in service, the traffic they carry should be subtracted from the FPLMTS traffic assumptions. The need for new spectrum should range therefore from approximately 180 MHz (conservative projection) down to approximately 130-150 MHz (optimistic projection, depending on technology employed by existing systems below 1 GHz).

3.8 *Studies to be undertaken*

Studies should be undertaken so that spectrum could become available and sharing criteria determined with a view to satisfying the potential evolving needs of FPLMTS around 1998 and beyond.

Such studies should take into account the possibility for FPLMTS to be an advanced system where control of the equipment will allow it to be adapted to various situations in particular by using dynamic power control and frequency agility (the ability to operate over a given frequency range).

4. *Technical characteristics*

In order to provide for regional and/or world-wide station compatibility, uniformity of main characteristics including architecture, channel structure, control procedures, access techniques, modulation methods and data rates, should be applied.

4.1 System architecture

FPLMTS should provide universal personal telecommunication services and should perform service origination and termination regardless of user location within the FPLMTS or PSTN/ISDN.

The FPLMTS could be a part of the PSTN/ISDN or separate telecommunication networks. Therefore the Mobile Services Switching Centre (MSC) may be separate or integrated into the PSTN/ISDN. If more than one MSC is required to service a high traffic density location area, they should be able to work together to provide such service. In addition, the switching architecture should allow for handovers as frequent as may be necessary, without significant transmission impairments.

Figure 1 illustrates the functional interfaces within FPLMTS and between FPLMTS and the PSTN/ISDN. These interfaces are intended to illustrate how the functions of the FPLMTS may be partitioned and do not imply an actual scenario for their implementation.

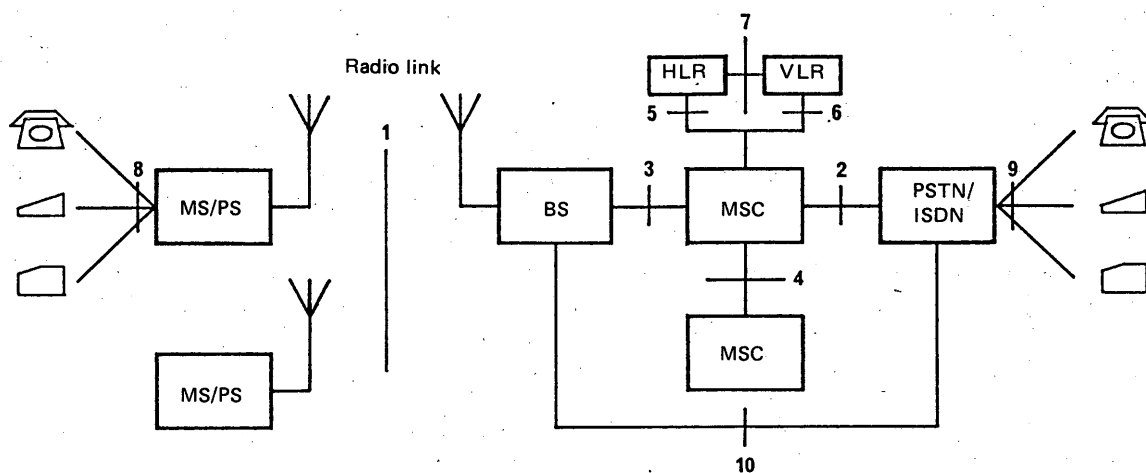


FIGURE 1 - Major functional components and interfaces of the FPLMTS

MS : mobile station
 PS : personal station
 BS : base station
 MSC : mobile services switching centre
 HLR : home location register
 VLR : visitor location register
 1-10 : interfaces

FIGURE 1, p.

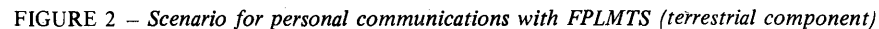
Furthermore, each functional interface may represent a family of more specific interfaces. A possible scenario for the evolution and implementation of personal communications within FPLMTS is given in Figs. 2 and 3. In these figures, the family of radio interfaces is:

- R1: the radio interface between a mobile station (MS) and the base station (BS);
- R2: the radio interface between a personal station (PS) and the personal base station (CS);
- R3: the radio interface between the satellite and the Mobile Earth Station (MES). FPLMTS may also allow for the automatic routing of traffic between terrestrial and mobile satellite systems;
- R4: an additional radio interface used for alerting (e.g. paging) in the case of a call which is terminated at an FPLMTS terminal.

In Fig. 2, R1 could be the same as R2 in some implementations. The generic radio link interface 1 of Fig. 1 could correspond to the sequence of interfaces mentioned above. It should be noted that this is not a complete list of all the interfaces.

Taking into account the characteristics of areas where FPLMTS is introduced, the system structure should be optimized according to the geographical coverage areas and traffic conditions. Therefore, more than one radio interface should be allowed for in the design of systems.

The radio interface should be designed to allow different applications to use the same interface where this can be shown to be technically and economically feasible. If the same radio interface cannot be used for all applications then the individual interfaces should have maximum commonality to allow interworking with the minimum of extra complexity.



- (1) Access to and the scope of the location registration functions will vary with system evolution and network operator requirements. This is reflected in network interfaces A and B.
- (2) In some implementation scenarios R1 may equal R2.

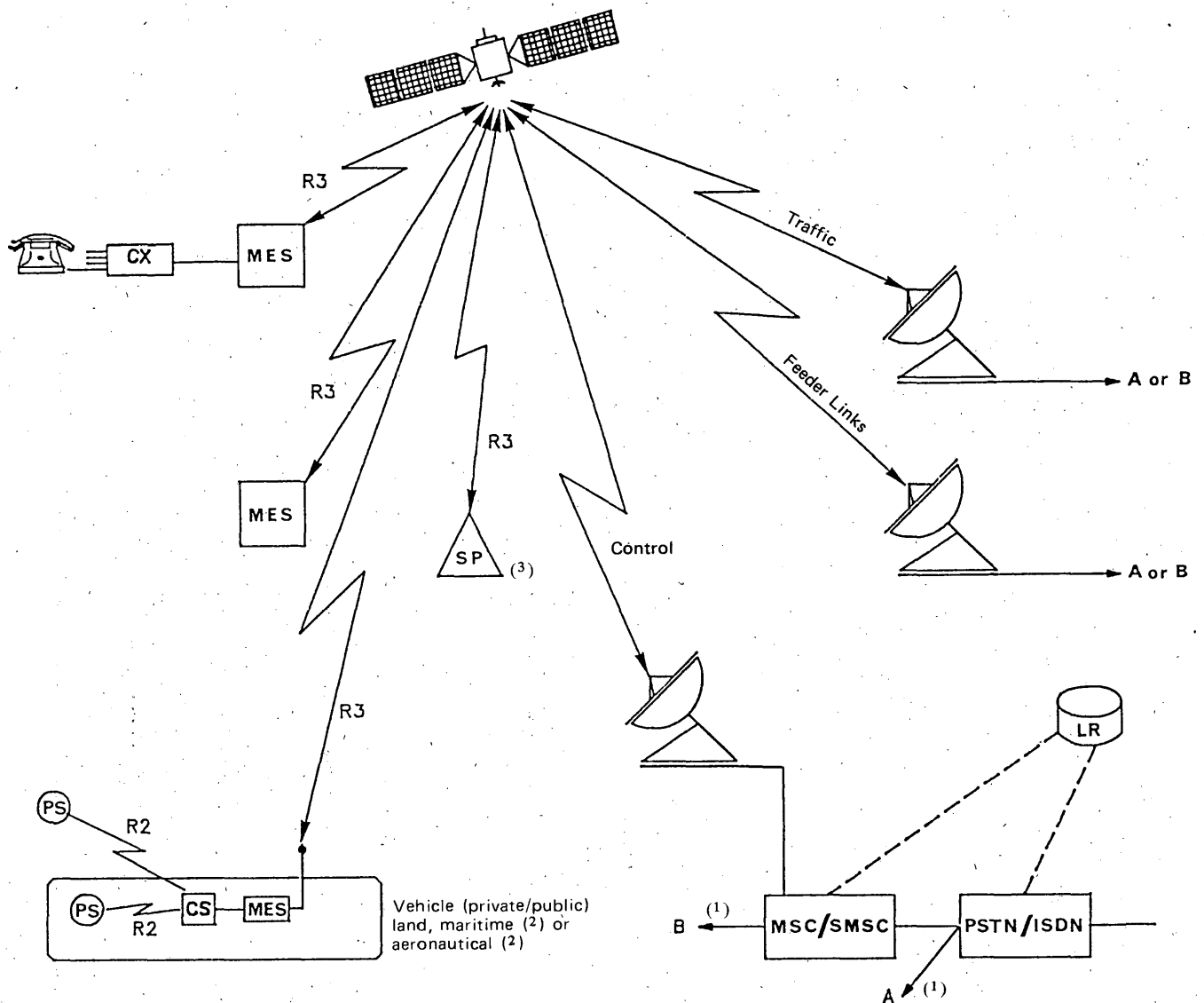


FIGURE 3 – Scenario for personal communications with FPLMTS (satellite component)

R1-R3: radio interfaces
 PS : personal station (R2)
 CS : personal base station (cell site for PSs)
 MES : mobile earth station
 SP : satellite pager (R3)
 MSC : mobile services switching centre
 SMSC : satellite mobile services switching centre
 LR : location register
 CX : small rural exchange, etc.

 : telephone

(1) Access to and the scope of the location registration functions will vary with system evolution and network operator requirements. This is reflected in network interfaces A and B.

(2) Terrestrial based systems have different radio interface requirements from R3 which need to be considered.

(3) Can be co-located/integrated with the PS.

4.1.1 *Radio coverage of the service area*

The aims of FPLMTS should be:

- 4.1.1.1 to accommodate the possibility of more than one base station in a service area;
- 4.1.1.2 to allow handover from one channel to another between cells, and in the same cell, if necessary;
- 4.1.1.3 to allow for implementation of small cell sizes taking account of the need for rapid handover for moving users;
- 4.1.1.4 to allow the re-use of the same channel assignment simultaneously by more than one cell and for more than one communication;
- 4.1.1.5 to be able to start with the fewest cells necessary to meet user demands and grow as necessary, with the possibility of increasing the availability of equipment for interconnection to the different system interfaces;
- 4.1.1.6 to provide for adequate coverage to include portable units outdoors and in both single-storey and multi-storey buildings;
- 4.1.1.7 to minimize the complexity of any radio network planning taking into consideration radio propagation variations in different environments and locations.

4.1.2 *Structure of signalling functions of Mobile Stations/Personal Stations (MS/PS)*

Among the logical signalling functions, either integrated or separated, the following should be provided by FPLMTS:

- call control,
- FPLMTS call control adaptation,
- mobility management,
- channel and RF transmission management.

4.1.3 *Personnal Telecommunication Number (PTN) Service*

A PTN service to enable call connection, billing etc., on a user basis should be considered.

4.2 *Quality of service*

FPLMTS should provide a level of service quality comparable to the PSTN/ISDN within the limitations set by the radio channel. Determination of the quality of telecommunication service should include consideration of the following:

- transmission quality:
 - S/N and S/I ;
 - service area reliability;
- blocking probability;
- cut off probability, such as cut off probability due to handover blocking;
- channel assignment strategies and call control thresholds;
- handover;
- initial connection delay;
- system reliability.

4.3 *Security*

FPLMTS should provide a level of security comparable to that of the PSTN/ISDN. If required, additional levels of encryption of user information could be offered. Any such facility should not have a significant influence on the costs of those parts of the system used by mobile subscribers who do not require such a facility.

It should be possible for the users themselves to provide end-to-end encryption, subject to the technical limitations of the network.

Protection should be provided to prevent unauthorized access to the system (authentication).

Location information regarding mobile units should be subject to special safeguards (see also § 2.4.4 and 5.3).

4.4 *Radio transmission considerations*

In order to improve performance, systems may adapt such parameters as channel bit rate, bandwidth, frequency/time/coding arrangements, diversity techniques and multipath equalization, to actual propagation, interference and traffic conditions, subject to cost and power consumption considerations.

4.4.1 *Multiple access techniques*

Voice and data services will be a basic part of FPLMTS and a flexible multiple access scheme is desirable to handle the wide range of traffic densities and services offered.

4.4.2 *Modulation techniques*

When considered with frequency re-use factors, the modulation techniques should achieve efficient use of the spectrum. Technologies having transmission efficiencies greater than 1 bit/Hz should be used for FPLMTS.

4.4.3 *Channel coding*

In order to maximize spectrum efficiency and transmission quality, channel coding should be utilized.

4.4.4 *Source coding*

For speech, a transmission rate of 16 kbit/s or below is desirable. When choosing the speech transmission bit rate for mobile channels, consideration should be given to methods such as linear predictive coding, adaptive quantization and adaptive prediction as well as other factors affecting quality and spectrum efficiency.

4.5 *Network aspects*

4.5.1 *The identification plan*

In accordance with the appropriate CCITT Recommendations.

4.5.2 *The numbering plan*

In accordance with the appropriate CCITT Recommendations. In addition, the Personal Telecommunication Number (PTN) plan should be based on appropriate CCITT Recommendations.

4.5.3 *Routing and billing rates*

System design should permit different charging and billing rates to be used in different networks.

4.5.4 *Interconnection signalling system*

CCITT Signalling System No. 7 should be used for the interconnection signalling system in FPLMTS.

5. **Operational characteristics**

5.1 *Call handling*

The following system functions which should take in account of the efficient use of the radio channel should apply to FPLMTS

- channel assignment and set-up control procedures;
- channel release at the completion and/or dropping of the call.

5.2 *Supervision*

FPLMTS should perform those functions necessary to supervise channel status and to maintain the necessary quality.

5.3 *Location registration*

In accordance with CCIR Recommendation 624 and CCITT Recommendations Q.1003 and Q.1004.

5.4 *Network interworking*

FPLMTS should interwork with PSTN and ISDN in accordance with CCITT Recommendations Q.1031 and Q.1032.

FPLMTS should provide the user with ISDN service transparency (within FPLMTS limitations). For details on FPLMTS compatibility with ISDN refer to Tables I and II.

TABLE I – ISDN-FPLMTS compatibility (general)

ISDN	FPLMTS (general)
<p>Digital</p> <p>Basic access (integrated voice and data) made up of $2B + D$ where $B = 64$ kbit/s (Bearer channel) and $D = 16$ kbit/s (Signalling channel).</p> <p>Consider B and D channels as information content building blocks.</p> <p>Error performance (64 kbit/s) is stated in CCITT Recommendation G.821. This will be acceptable for data transmission (therefore very acceptable for speech).</p> <p>Bearer services at 64 kbit/s can be used to support voice and data services.</p>	<p>Digital at interface between FPLMTS and ISDN network (as a minimum) (interface 2 of § 4.1.2, Fig. 1).</p> <p>B channel functionality (flexible bit rate). For voice (at $2B + D$ baseband) 32 kbit/s, more likely 16 kbit/s or lower; based on spectrum and coding efficiency trade-offs.</p> <p>Compatible with ISDN D channel standards. D channel functionality may be spread over a number of radio channels depending on the multiple access techniques used.</p> <p>For FPLMTS, I (information) and C (control) will be used in place of B (bearer) and D (signalling) respectively, to signify the above differences within otherwise similar structures.</p> <p>Voice quality will be a function of the coding and channel error ratio.</p> <p>Source and channel coding may be optimized for speech. Acceptable error performance for data traffic on mobile radio channels is a subject for further study.</p> <p>Extension of this capability to the mobile station would require provision of up to 64 kbit/s through the FPLMTS.</p> <p>Information on true user data rates to and from ISDN would make the provision of compatibility between FPLMTS and ISDN more efficient in spectrum usage.</p>

TABLE II – ISDN-FPLMTS compatibility (specific)

ISDN	FPLMTS (specific)	
	Mobile station/ personal station	Mobile PABX/ mobile concentrator
<p>Basic access ($2B + D$) 144 kbit/s</p> <p>Primary access 1536 kbit/s ($23B + D$) or 1920 kbit/s ($30B + D$)</p>	<p>$2I + C$, $I + C$, C to $2B + D$ (Note 1)</p>	<p>$mI + nC$ (Note 2)</p>

Note 1 – Full extent of ISDN basic access at 144 kbit/s ($2B + D$) could be provided by FPLMTS at the expense of reduced FPLMTS service availability due to the increased RF resource required to support such mobile use.

Note 2 – The exact values for m and n are subject for further study.