REPORT 1155

ADAPTATION OF MOBILE RADIOCOMMUNICATION TECHNOLOGY TO THE NEEDS OF DEVELOPING COUNTRIES

(Question 77/8)

(1990)

1. INTRODUCTION AND SUMMARY

Interim Working Party 8/13 was set up in 1985 by Decision 69 to study Future Public Land Mobile Telecommunication Systems (FPLMTS). It considered interalia that advances and cost reduction in radio and VLSI technologies could make the radio approach a competitive alternative for voice and non-voice telecommunication services, with special emphasis on personal communications, a concept of great interest to developed countries.

Recognizing the disparity that exists in telecommunication infrastructures in the world, this Report points out the potential of cellular technology (and its evolution into FPLMTS technologies) to help developing countries bridge the gap.

Also in 1985, the desire of developing countries in the Americas Region, through the plan-committee for Latin America, to take advantage of cellular technology to satisfy their own needs, including its use in fixed applications, led to Questions 77/8 and 38/9.

Report 1153 and Recommendation .687 include some of the aspects raised by these Questions with the idea that future wireless systems - FPLMTS - can serve the needs of developing as well as developed countries.

The objective of this Report is to emphasize the needs and interests of developing countries by promoting the application of FPLMTS for fixed services. It should furthermore be stressed that the use of FPLMTS for such applications is also attractive to developed countries.

Key objectives for FPLMTS are identified that could benefit developing countries: fixed service; standardization as a possible means of reducing costs; flexibility to start from a small, simple configuration and grow as needed as well as to accommodate special needs; commonality with remote areas of developed countries; large cells and repeaters.

2. THE TELECOMMUNICATIONS GAP

The role of telecommunications in the development process as a means to increase productivity and efficiency as a substitute for or complement to transportation and to save energy, etc. [ITU, a, b, c, 1988] is today more important than ever, but the gap between developed and developing countries is wider than ever. This has been clearly indicated by the Independent Commission for World Wide Telecommunications Development set up by the ITU in 1983, in its report [ITU, d, 1984]:

- 75% of the world's telephones are concentrated in 9 countries.
- 75% of the world's population live in countries with less than 10 telephones for every hundred persons.
- 50% of the world's population live in countries with less than one telephone for every hundred persons.

Faced with this reality one can only agree with the Commission's conclusion: "Neither in the name of common humanity nor on grounds of common interest is such a disparity acceptable."

The main reason for this situation is the limited financial resources available to a developing country to satisfy all its needs and the resulting allotment of resources to telecommunications which is not sufficient to close the gap as much — and as fast — as is required.

3. THE POTENTIAL OF FPLMTS TECHNOLOGIES

Present cellular technology and its evolution into the FPLMTS technologies by the end of the century, offer great potential to help developing countries bridge the gap in a more effective way [India, 1987]. Some of the aspects that make FPLMTS an attractive alternative to traditional wireline systems for telecommunications services are:

- Capability for rapid provision of service in new areas.
- Growth capacity and flexibility.
- Cost reductions resulting from technology improvements, modular design and mass usage of FPLMTS.
- Capability for covering wide geographical areas.

A number of developing countries are currently planning to use cellular technology to solve some of their problems such as lack of service in rural and remote areas or lack of capacity to satisfy demand promptly in urban areas.

4. OBJECTIVES AND ISSUES

Objectives have been set in Report 1153 for FPLMTS related to quality, mobility, flexibility, efficiency, connectivity, adaptability, security, identification, suggestions for charging (billing), etc.

The relative importance that each objective has to a developing country depends, on the one hand, on its stage of development and national goals, and on the other, whether effective cost savings will result from not implementing a specific feature in a particular situation.

Nevertheless, it is important to point out the features and characteristics that stand out as very important to developing countries, and deserve special notice: fixed service requirements, standardization and flexibility.

4.1 FIXED SERVICE

A very important objective defined for FPLMTS, from the point of view of developing countries, is that they can be used for the provision of service to fixed users either in rural or urban areas.

Two main factors that cause a radio solution to be considered are:

High installation and maintenance costs associated with rural wireline networks due to long distances, difficult terrain and climatic conditions.

The high and often difficult-to-foresee growth that limits the ability to plan the outside plant network properly in urban areas.

It is therefore of great importance for situations where wireline facilities are not available, that an FPLMTS can be used as a temporary or permanent substitute for the wireline network.

This objective requires FPLMTS to meet certain conditions and characteristics:

It should, to the maximum extent possible, support equipment and component design that can withstand rural conditions typically found in developing countries, such as rough roads, dusty environment, extreme temperatures or high humidity, while at the same time providing long equipment lifetime with minimum maintenance. It is, however, not intended that the basic FPLMTS equipment satisfies all the needs of the fixed service, while at the same time catering to the FPLMTS. Rather, the basic FPLMTS structure and technology should permit adaptation to fixed service requirements.

It should take into account the effect on reliability and availability of special propagation conditions such as, in mountainous terrains, areas of high rain precipitation or dense forests.

It should allow for large cell sizes.

Since the service to be provided is an extension of the national and international network, it should be possible to integrate it into the network without any, or with only very minor limitations. The objective that FPLMTS should provide a service with quality, integrity and security comparable to that provided in the fixed network is therefore very important to developing countries.

In some developing countries, the service provided by an FPLMTS may well be the only telecommunications pathway, and is likely to act as a lifeline, particularly for the provision of storm and flood warnings or similar public service activities. Service can also be provided to tourist areas, sports events and for other special needs.

The possibility of accessing both terrestrial and satellite systems, through the use of the same band or adjacent bands, could be important to countries with large, thinly populated rural areas. One possible application would be to link rural and remote base stations.

The use of an open architecture is of considerable importance for FPLMTS usage for fixed services as this would permit the administration in developing countries to choose the equipment based on performance needs.

CCIR Reports 380 and 1057 describe methods of providing fixed rural telecommunications and may be referred to for further information.

4.2 STANDARDIZATION

Report 1153 includes a discussion of a common radio interface standard from the point of view of personal communications. The advantage of such a standard in providing for regional and/or world wide roaming of mobile and personal stations as well as the coordination of spectrum allocations and planning are recognized. However, the limitations of a common standard in providing sufficient flexibility to meet diverse national or regional objectives, including the delay inherent in the standards process, are also noted.

From the point of view of some developing countries, standardization of the many interfaces associated with FPLMTS, including the radio interface, may offer important advantages:

a) Reduction of costs of networks and terminals: Economies of scale resulting from the mass production of equipment generally lead to lower costs. Significant cost differentials, however, may not exist between FPLMTS equipment manufactured to regional standards as opposed to world-wide standards due to the large regional markets that exist.

In any case, lower cost equipment could lead to its use on a wider basis in developing countries.

b) Increased equipment availability may facilitate the procurement process which could stimulate the introduction of FPLMTS in developing countries. Some developing countries may have an interest in the local manufacture of certain products unique to their markets for FPLMTS and may benefit from the flexibility provided by minimal standards. The use of standard elements within the system, such as speech codecs, RF components, etc., could contribute to the reduction of overall system costs.

4.3 FLEXIBILITY

Great importance has been given to an open, flexible architecture able to match network investment to revenue growth, adapt readily to environmental factors, different applications and new developments.

Of special importance to developing countries is to define the simplest possible system (e.g. speech alone), both from the point of view of hardware (terminals, base stations) and software. This may reduce cost and simplify maintenance. Of further special interest is the capability of the system to start from a small (e.g. stand-alone base station) and simple "stripped-down" (e.g. no roaming between cells or within a cell) configuration and grow as needed, both in size and complexity; thus enabling very low subscriber densities and low traffic rates to be catered for. This option, could allow a subset of the system's full service capability to be provided with minimum initial investment.

The use of a modular structure to permit simple configurations and future growth is of particular importance in developing countries.

Furthermore, there are special needs for fixed services such as: repeaters for covering long distances between terminals and base stations; PABX's, concentrators or small rural exchanges with wireless trunks; and different types of terminal equipment (2 or 4 wire terminals, coin boxes, etc.). The interface No. 8, defined in Figure 1 of Recommendation 687 and Report 1153 may be suitable to link MS to a PABX. This means, among other things, that the system should be able to be configured for situations of high traffic per terminal.

A graphical representation of what an FPLMTS is expected to achieve, accommodating both portable and fixed needs, is included in Report 1153, Figures 3 and 4.

5. SERVICES

The services that are proposed in Report 1153 for FPLMTS surpass the immediate needs of a number of developing countries. Furthermore, there are great differences in the stage of development and needs between developing countries.

The following services have been identified as more important to the developing countries:

- Voice
- Point to multipoint
- Short messages
- Paging
- Facsimile
- Text
- Data

The most immediate and largest requirement will be centered around voice communications.

Also, the FPLMTS should have sufficient charging (billing) flexibility to adapt to different charging schemes and be capable of being configured for special conditions where mobility between cells, or even within a cell, is not required.

6. COMMON CHARACTERISTICS WITH RURAL AND REMOTE AREAS OF DEVELOPED COUNTRIES.

The possibility of using mobile technologies for fixed applications is not only attractive and important to developing countries but also to some developed countries, especially those with extensive territories, difficult terrain and thinly populated areas.

Developed countries that must provide service to areas with such conditions face some of the same difficulties as developing countries.

7. LARGE CELLS AND THE NEED FOR REPEATERS

7.1 Large cells: area of radio coverage

Three aspects in particular distinguish the fixed service from FPLMTS:

- the cells tend to be large; the distance to be covered is often greater than is possible in one cell, while the number of subscribers is very low in all cells,
- the radio paths are fixed and well-defined, and
- the average traffic intensity per subscriber is typically 3 to 4 times higher than in the mobile service.

7.2 The need for repeaters

In a cellular mobile system, the cell centres are normally connected to a switching system by point-to-point microwave, cable, or fibre. In the fixed service, the total number of subscribers generally makes these means of connecting cells expensive. A means of employing a repeater to provide service to groups of subscribers well beyond line-of-sight has proven to be cost effective in today's point-to-multipoint communications systems. Without adversely affecting the mobile application the possibility of a repeater should be included in the basic structure of the FPLMTS.

Repeaters carrying multiple voice channels are inherently easier to design and build in a TDMA system than in an FDMA or CDMA system. The complexity and usefulness of the repeater depends on how many circuits the TDMA system employs on a radio carrier. The lower the number of circuits per RF carrier, the more difficult it is to design and build a repeater that can repeat all the circuits in a cell since more than one RF carrier may be needed to provide the desired number of circuits.

Another factor when implementing a repeater is the allowable radio path delay that arises from the longer distances and the processing delay in the repeaters themselves. It should be noted that a number of repeaters in series may be used to cover large distances or cope with mountainous terrain. The FPLMTS design should allow for such delays, perhaps on an optional basis.

8. ANTENNAS AND ANTENNA POLARIZATION

8.1 Antennas

Antennas used for fixed services, being stationary, can be directional and so have high gain.

Fixed service subscriber stations would use a single directional antenna to optimize the link to the base station which is normally either an omni or sectoral type. Mounting arrangements are kept as simple as possible (low height; existing structures) at the subscriber end whilst the base station should use an antenna mounted as high as possible to provide wide coverage. An additional difference for the fixed service is that connections between the transceiver and the antenna can sometimes be about 30 m in length, and is accomplished by coaxial cable feeders.

8.2 Polarization

Generally mobile services have used vertical polarization. Fixed service uses also permit horizontal polarization to be used where it is advantageous.

At a repeater location the discrimination obtainable between horizontal and vertical polarization can be very effectively used.

9. NEED FOR FURTHER STUDIES

The adaptation of mobile radiocommunications technology to the needs of the developing countries and the fixed service use of that technology requires ongoing analysis and inputs from all parties involved: the developing countries themselves, the developed countries with special interest in this issue, and the producers of technology and systems.

The areas which have been identified for further investigation are indicated in Report 1153.

Developing countries are particularly interested in:

- Propagation aspects
- Software and equipment simplification
- Rugged, simple to maintain terminal units for a wide range of environmental conditions
- Use of different types of terminals
- Use of concentrators, PABXs and Rural exchanges
- Services
- Flexibility and modularity
- Interference questions
- Evolution scenarios for FPLMTS
- Use of repeaters

Large cells
Reliability and availability
Performance objectives

Annex 1 to this report provides some preliminary considerations for performance objectives for circuit quality in the fixed service whilst Annex 2 provides some specific information regarding possible fixed service applications in India.

10. CONCLUSIONS

The ITU's Independent Commission for World-wide Telecommunications Development pointed out that industrialized and developing countries alike should join their efforts in improving and expanding telecommunications networks world-wide, fully exploiting the benefits of new technologies.

FPLMTS could be an effective means to help developing countries bridge the telecommunications gap by accelerating the expansion process of their networks and integrating their rural areas in to the national social and economic development process.

The objectives and architecture of FPLMTS noted in Report 1153 accommodate this need ans requirements for the fixed service are summarized in Table I.

This report is intended to focus greater attention on this matter and encourage more analysis towards the unified Recommendation for FPLMTS.

<u>References</u>

India, 1987: "A phone in every Village", Telecommunications Research Center, Department of Telecommunications, India, 1987

ITU a: ITU Publication, "Contributing telecom to the earnings/savings of foreign exchange in developing countries", April 1988

ITU b: ITU Publication, "Benefits of telecom to the transportation sector of developing countries", March 1988

ITU c: ITU Publication, "Telecom and the National Economy", May 1988

ITU d: "The Missing Link", Report of Independent Commission for World- Wide Telecommunications Development, ITU, 1984

TABLE 1 - REQUIREMENTS FOR THE FIXED SERVICE

ITEM	REQUIREMENT FOR FIXED SERVICE
1. VOICE ENCODING - BIT RATE - CIRCUIT NOISE - VOICE QUALITY	- FPLMTS SHOULD OFFER PERFORMANCE COMPARABLE TO THAT ACHEIVED IN THE FIXED NETWORK
2. RADIO COVERAGE - REPEATERS	- FPLMTS ARCHITECTURE SHOULD PERMIT THE POSSIBILITY OF REPEATERS. IF TDMA IS USED, REPEATER DESIGN IS SIMPLIFIED.
3. DESIGN LIFE	15 to 20 Years required for permanent fixed service applications
4. RELIABILITY	MTBF for subscriber stations and base stations should be very high to achieve an acceptable maintenance cost.
5. ENVIRONMENT	Some equipment may be exposed to the outdoor. environment. It will have to withstand rain, snow, dust, sand, corrosion, insects, and a wide temperature and humidity range.
6. POWER CONSUMPTION	As low as possible for solar and other sources.
7. ANTENNAS	Directional at subscriber stations (in some cases base stations) for optimized radio path design using both vertical and horizontal polarization.

NOTE: It is important that items 1 and 2 above be taken into account in the basic design of the FPLMTS. Some of the areas where the fixed service application requires special design are listed in items 3 through 7.

Annex 1
Preliminary performance objectives for circuit quality for the fixed service

The following preliminary considerations on circuit quality were put forward by one administration.

1. VOICE ENCODING SCHEME

The voice encoding scheme determines the ultimate quality of voice communications. Lower bit rate encoding, while conserving spectrum, can introduce performance degradations and limitations when compared with 64 kbit/s PCM. It is reasonable to expect that substantial improvements in low bit rate encoding will be made over the next 10 years.

The driving force for low bit rate voice encoding in the FPLMTS is the need for a way to use the spectrum more efficiently in heavily congested urban areas, whereas when used in the fixed service, especially in remote areas, such congestion is not likely and use of higher encoding bit rates for such applications may be a desirable approach.

2. VOICE QUALITY

Voice quality when the FPLMTS is applied to the fixed service should be as close as possible to present day voice quality in fixed networks. The FPLMTS coding scheme should not significantly limit overall voice quality and intelligibility, reduce the possible number of tandem serial encodings in the network, nor cause overall network delay requirements to exceed established limits. As it will be an integral part of the fixed telecommunication network, the fixed service application of FPLMTS should not compromise the network's overall performance.

3. CIRCUIT NOISE

Levels of circuit noise that permit full integration with the national and international network without degradation beyond limits established for such connections by CCITT recommendations are necessary.

Idle noise levels – the noise not exceeded for about 99% of the time – of about 100 pWp are easily achieved with radio systems using 64 kbit/s PCM employing low cost, mass produced, encoding devices. A performance requirement of a similar order is desirable when FPLMTS are applied to the fixed service.

Annex 2
Some specific information relating to possible FPLMTS applications in the fixed service in India

1 TRAFFIC ESTIMATES FOR FIXED SERVICE APPLICATION IN INDIA

1.1 Introduction

Provision of telephone facilities in rural areas has gained momentum in recent years, and a number of low cost solutions are evolving for rural communications. Presently, the traffic generated by the Village Telephones (VTs) in India is quite low because the number of villages having a telephone facility is also very low (6.5%). The economic condition of the villagers and lack of tariff subsidies are other main reasons for the low traffic generated by the VTs. As the number of villages provided with a telephone facility increases, and also if tariff subsidies are provided, the traffic will grow substantially.

1.2 Available Data

No detailed studies have been done on the traffic growth patterns so far, mainly because the number of villages having telephones is very low. The only study that has been carried out was by NCAER (National Council of Applied Economic Research) on Long Distance Public Telephones (LDPTs) in 20 selected Telecom districts. Further details of the traffic information and the VT program are given in the publication, "A Phone in Every Village" by B.S. Murty, Dept. of Telecommunications Government of India.

2. SOME SPECIFIC POTENTIAL REQUIREMENTS FOR THE FPLMTS IN THE FIXED SERVICE IN INDIA

2.1 Incoming Calls to VTs

There are a few problems in handling incoming calls to the VTs. If the call is long distance, it is not possible to hold the calling party until the called subscriber arrives at the VT location to answer. In such a case, where the VT is primarily a community phone, the particular person (PP) has to be sent a message that he is required to answer the telephone. It may take a few minutes for a messenger to locate the PP. The calling party can then make a repeat call, say after 15 minutes, when the PP has reached the VT. Alternatively, he can initiate a call if the calling party's identity is known and if the PP is willing to pay for the call. In most cases the PP may only wish to receive the call but be unwilling to call back and pay.

To facilitate such "re-calling", it is suggested that the software be flexible enough to permit delaying the commencement of billing to the calling party for the first 15 seconds so that this period can be used to leave a message regarding the identity of the PP. It is expected that the administration will consider such changes bringing relevant regulatory measures so that the volume of rural communications increases. There can be some scope for misuse of this facility for the passing of quick, short messages without paying, and this needs to be observed and remedies worked out.

It is expected that such implementation will be supported by PTN (Personal Telecommunication Number) service defined in FPLMTS. Also, low-cost hard- wired voice mail systems can be introduced to provide additional service to the villagers.

2.2 Quasi-stationary applications

There are a few cases which would provide fixed applications on a "quasi-stationary" basis. The concept is that any vehicle or person moving on some assigned tasks can carry a phone to the village or villages and allow the public to use the phone. Even though the vehicle is itself mobile, the phone is used and communications are carried out, only when the phone is stationary. The constraints of limited antenna gain and limited height are overcome in this mode since the antenna can be directed. In this case it is a general mobile used as a special mobile which puts the phone to use only when the vehicle is not moving. It is also not necessary to permanently fix the phone in the vehicle.

At present, only 6.5% villages have public phones while 93.5% of villages remain to be provided with telephones. To provide such a large number of villages with telephones will take some time. Therefore the quasi-stationary mode of operation described above will immediately improve the situation because one phone can be used in four to five villages at different times of the day.

3. LARGE CELL CONCEPTS FOR FIXED APPLICATIONS IN INDIA

3.1 General

To provide telephone facilities under the "a phone in every village" scheme, a number of low cost solutions are being developed and deployed in the villages. Presently, a very small percentage of villages are provided with telephones and even in these, the traffic generated is very low. Increasing the number of villages having telephones will increase the traffic; but at the same time, because of the economic conditions of the villagers, tariff subsidies need to be provided for rural communication. In addition a number of anomalies exist in the tariffs being charged for rural telephone subscribers as compared to urban telephone subscribers. Such anomalies need to be removed not only for promoting rural communication but in the interests of attaining the objectives of the

ITU Independent Commission for World-wide Telecommunications Development.

In an urban area, a telephone subscriber has access to 0.5 million to 1.0 million subscribers spread over a large geographical area, typically 40 km radius. For example in Bombay, nearly 0.7 million subscribers can be accessed over a 40-45 km belt at the cost of a local call. Also, there is no limit on the local call duration.

By contrast, a village subscriber, for all practical purposes, can be considered to not use a local call facility at all, because within a village, the number of telephones is very low and local switching activity is insignificant. So, each outgoing call from a village telephone will be a long-distance call which will also be metered.

3.2 FPLMTS coverage and its influence on the Unit Fee Zone (UFZ)

For fixed applications of FPLMTS, the coverage areas could be divided into three categories:

Category A consists of urban areas in which the mean traffic will be up to 25 calls/day/telephone and perhaps as high as 25 to 50 calls/day in special cases.

Category B consists of suburban areas in which the traffic will be 5 to 25 calls/day/telephone.

Category C consists of rural areas where the traffic will be 1 to 5 calls/day/telephone.

With the introduction of FPLMTS in a fixed mode and their coverage of urban and rural areas, it is expected that some of the anomalies mentioned above, will be overcome. The concept of UFZ needs to be redefined to fix the tariff so that the UFZ covers a large enough area with a group of villages and nearby towns. This region forms a "logical" area and all calls within the UFZ can be considered as local calls.

The FPLMTS can influence a new definition of UFZ as covered by the multiple cells connected to the main exchange (Mobile Switching Centre, MSC). Such a new definition can simplify the billing task. In addition, it will extend the "logical" area benefit to the village phones. A call originating from one UFZ and terminating in another UFZ is considered as a long-distance call. A time limit can also be put on the call duration for local calls.

This new definition of the UFZ concept will remove the anomalies between urban and rural subscribers because a village subscriber can then have ready access to the nearby villages and the nearest town.

A preliminary examination of one area in India indicates that cell radii of from 15 to 25 km will be typical.

REPORT 778-2

WIRELESS COMMUNICATION SYSTEMS FOR PERSONS WITH IMPAIRED HEARING

(Question 49/8)

(1978-1982-1990)

1. Introduction

Many forms of hearing impairment cannot be satisfactorily improved by the provision of amplification only. Difficulties such as distortion in the residual hearing, loss of binaural directivity, emphasis of environmental noise and room reverberation lead to the use of systems incorporating the placement of the microphone near to the speaker rather than to the listener.

2. Transmission systems

A number of means have been used to transfer the speech signals from the microphone to the listener's hearing device. The means include infra-red radiation, the magnetic induction field internal to current loops, VHF radio and the external induction field of a radiating antenna.

The use of infra-red radiation is of particular interest as it does not occupy allocated radio spectrum.

The radio induction field system is of particular interest as its realization leads to the following advantages:

- efficient use of the radio spectrum;
- ease of incorporation, with an acoustic hearing aid, into a single device;
- simulation of normal conditions of hearing;
- satisfactory use within the school, home, industrial or external environment.

On the other hand, VHF systems are employed to take advantage of the following:

- large coverage areas;
- relative immunity to natural and man-made noise.

3. System concepts

3.1 *Radio induction field system*

The mobile-to-mobile induction-field hearing assistance system exploits the FM capture effect to permit co-channel operation with selection by proximity. This pattern of selection closely parallels that used in ordinary conversation.

When an induction-field wireless hearing aid receiver is operated in the vicinity of two co-channel transmitters using a medium deviation FM transmission, the rapid change in field strength together with the FM capture effect ensures that there is a rapid changeover in reception from the more distant transmitter to the nearer transmitter with little subsequent breakthrough of consequence. For example, for a frequency deviation of 12 kHz and 75 µs receiver de-emphasis, as reported for the Australian system in Annex I, it can be shown that, at a field strength ratio of 8 : 1, the maximum breakthrough from the more distant transmitter is 34 dB (unweighted). Within the region of inverse cubic decay of the induction field, the unwanted transmitter need only be at twice the distance of the wanted one to achieve this result. The field decay rate is illustrated in Fig. 1.