RECOMMENDATION ITU-R M.819-2

INTERNATIONAL MOBILE TELECOMMUNICATIONS-2000 (IMT-2000) FOR DEVELOPING COUNTRIES

(Question ITU-R 77/8)

(1992-1994-1997)

Summary

This Recommendation describes the objectives to be met by IMT-2000 to meet the needs of developing countries. The potential of mobile radio technologies, including IMT-2000, to help developing countries “bridge the gap” between their communication capabilities and those in developed countries is given in Annex 1.

The ITU Radiocommunication Assembly,

considering

a) that in developing countries there is an urgent need to provide an economical, reliable and high quality telecommunications infrastructure;

b) that there is a need to provide mobile and fixed services in urban, rural and remote regions;

c) that the relative simplicity of installation and maintenance of radio based telecommunications systems could be of great benefit to developing countries;

d) that there is a need for a flexible, modular system which can be readily expanded in terms of types of service and number of users;

e) that there is a need for rugged equipment to operate reliably in harsh environments and where electric power sources are limited or unavailable;

f) that, giving due regard to propagation conditions and other factors, the telecommunications services provided must be reliable and comparable to those of the fixed network;

g) that users (fixed, mobile) should be able to communicate with any other user whether access is via satellite, mobile or fixed radio links;

h) Recommendation ITU-R M.687 and the relevant ITU-T Recommendations and ongoing studies;

j) that it is important to examine the application of IMT-2000 with regard to developing countries’ needs at an early stage in the development of IMT-2000 so that those needs can ultimately be met;

k) that telecommunication networks in some developing countries are mainly analogue, often use mechanical switching and that this is likely to continue for a number of years,

recommends

that the relevant aspect of IMT-2000, as defined in Recommendation ITU-R M.687, be specified as far as practicable in a manner which allows it to be used to meet the needs of developing countries with the following objectives:

1 that IMT-2000 provide, in both urban and rural areas, economical services of high quality and integrity comparable to those of the fixed network. The systems must be capable of serving a wide range of user densities and coverage areas as well as remote regions;

2 that IMT-2000 be capable of providing services to both mobile and fixed users, including voice, point-to-multipoint, short messages, paging, facsimile, text and data services;

3 that to allow a system to be introduced with minimum initial investment, IMT-2000 design should be modular (easily expandable) permitting flexible growth in terms of number of users, coverage areas and types of services;

4 that IMT-2000 take account of the need to match, efficiently and economically, spectrum usage to local conditions where there are only a few users and where severe propagation conditions are encountered;

5 that IMT-2000 hardware be capable of being optimized for local conditions e.g. to take account of heavy usage, operation in a variety of environments including extremes of heat and cold, high humidity, dust, corrosive atmospheres and other environmental hazards, recognizing the need to achieve long equipment lifetimes, high MTBF and low maintenance that permit a reasonable justification of the required investment;

6 that appropriate means such as repeaters, etc., be incorporated to provide service economically to more distant users, beyond line-of-sight of a base station. Similarly, it should be possible to serve remote regions by suitable means such as satellites, etc.;

7 that IMT-2000 provide an open architecture which will permit the easy introduction of new technology and different applications and will allow choice of equipment based on performance need including the ability to provide voice channels employing higher encoding rates such as 64 kbit/s and 32 kbit/s;

8 that IMT-2000 provide user friendly (simple and easy) operation to initiate and receive calls, both national and international;

9 that equipment is designed to take into account the need for low power consumption and the need to operate from a range of power sources;

10 that IMT-2000 have the capability of providing an effective alternative to wired local loops in urban areas;

11 that regional IMT-2000 be connected to existing analogue/digital networks at suitable points and in some cases at a single point.

NOTE 1 – Information on mobile radiocommunication technology for developing countries is given in Annex 1.

ANNEX 1

Mobile radiocommunication technology for developing countries

1 Introduction and summary

Recognizing the disparity that exists in the telecommunication infrastructures in the world, this Annex points out the potential of cellular technology (and its evolution into IMT-2000 technologies) to help developing countries bridge the gap.

Report ITU-R M.1153 and Recommendation ITU-R M.687 include some of the relevant aspects with the idea that future systems – IMT-2000 – can serve the needs of developing as well as developed countries.

IMT-2000 have been conceived primarily for mobile telecommunications which of course is of interest to developing as well as developed countries. The objective of this Annex is to emphasize the needs and interests of developing countries by promoting the application of IMT-2000 for fixed services. It should furthermore be stressed that the use of IMT-2000 for such applications is also attractive to developed countries.

Key objectives for IMT-2000 that could benefit developing countries are:

	Section reference
– Fixed service	§ 4.1
– Standardization as a means of reducing costs	§ 4.2
– Flexibility to start from a small, simple, configuration and grow as needed	§ 4.3
– Accommodation of special needs	§ 5
– Commonality with remote areas of developed countries	§ 6
– Large cells, repeaters, use of satellites	§ 7

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., 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 Worldwide Telecommunications Development set up by the ITU in 1983.

In addition the limited financial resources available to developing countries lead to the allotment to telecommunications of resources insufficient to close the "telecommunications gap" either as much or as quickly as required.

3 The potential and benefits of IMT-2000 technologies

Present cellular technology and its evolution into the IMT-2000 technologies by the end of the century, offer great potential to help developing countries bridge the gap in a more effective way.

IMT-2000 is a radio-based approach and so offers all the advantages of wireless network access. Figure 1 provides an illustration of some of the possible uses of IMT-2000 radio interfaces for wireless network access in the fixed service. The actual definition of IMT-2000 radio interfaces is dealt with in the appropriate IMT-2000 Recommendation.

With IMT-2000 a scheme can be established which enables a simple start-up with the provision of basic telephone services that can evolve, as required, to higher user information rates in the local loop and to a full mobility service. This is particularly appropriate when development capital is scarce as it may be the only way to keep modernization affordable.

The global acceptance of IMT-2000 should enable mass production for the global market and multiple applications. This, together with global competition should lead to low cost products.

Some of the aspects that make IMT-2000 an attractive alternative to traditional wireline systems for telecommunications services are:

– capability for rapid provision of voice and non-voice services in new areas;

– growth capacity and flexibility;

– cost reductions resulting from technology improvements, modular design and mass usage of IMT-2000;

– capability for covering wide geographical areas.

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* *Note from the Director, Radiocommunication Bureau* – The statements made in this section are based on the following ITU publications:

– "Contributing Telecom to the earnings/savings of foreign exchange in developing countries", April 1988.

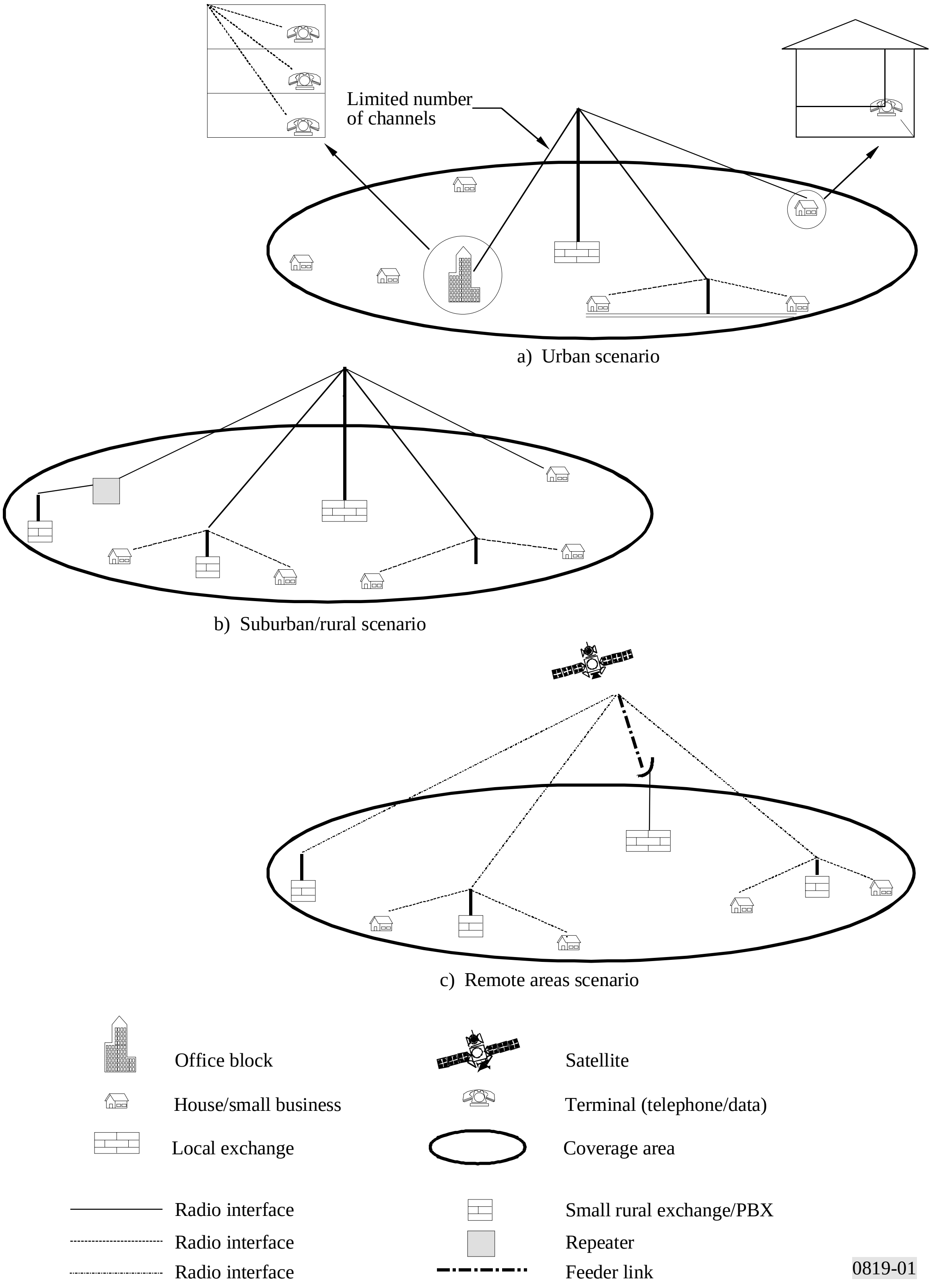
– "Benefits of Telecom to the transportation sector of developing countries", March 1988.

– "Telecom and the National Economy", May 1988.

– "The Missing Link". Report of Independent Commission for Worldwide Telecommunications Development, ITU, 1984.

FIGURE 1

Some possible uses of IMT-2000 radio interfaces for network wireless access in the fixed service



Additional attractive aspects of a wireless approach include:

– *economics:* wireless access provides point-to-multipoint radio links (base stations to user terminals) which can offer an economical alternative and significant simplification when compared to wireline access (local subscriber loops);

– *maintenance:* wireless access has the potential to alleviate some of the maintenance problems associated with wires such as accidental cuts, weather conditions, theft, etc.;

– *investment and amortization:* wireline access networks are usually installed with capacity to meet future demands over a period of 10-15 years due to the sheer inconvenience and the economics of piecemeal deployment. "Buried capital" cannot earn revenue until much later. Wireless access systems can be deployed and re-provisioned at short intervals. Capital investment is only required on a step-by-step basis, and this can provide additional safeguards against uncertainties in the forecasting of service requirements.

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 Recommendation ITU-R M.687 for IMT-2000 which are 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 that deserve special notice. They are fixed service requirements, standardization and flexibility.

4.1 Fixed service

A very important objective defined for IMT-2000, 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 IMT-2000 can be used as a temporary or permanent substitute for the wireline network.

This objective requires IMT-2000 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 and high humidity, while at the same time providing long equipment life-time with minimum maintenance. It is, however, not intended that the basic IMT-2000 equipment satisfies all the needs of the fixed service, while at the same time catering to the IMT-2000. Rather, the basic IMT-2000 structure and technology should permit fixed service requirements to be met;

– 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 IMT-2000 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 IMT-2000 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 IMT-2000 usage for fixed services as this would permit the administration in developing countries to choose the equipment based on performance needs.

Recommendations ITU-R F.755 and ITU-R F.756 describe methods of providing fixed rural telecommunications and may be referred to for further information.

4.2 Standardization

Report ITU-R M.1153 includes a discussion of a common radio interface standard from the point of view of personal communications. The advantages of such a standard in providing for regional and/or worldwide roaming of mobile and personal stations as well as the coordination of spectrum allocations and planning are recognized.

From the point of view of some developing countries, standardization of the many interfaces associated with IMT-2000, including the radio interfaces, may offer important advantages:

– reduction of costs of networks and terminals: economies of scale resulting from the mass production of equipment generally leads to lower costs.

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

– increased equipment availability may facilitate the procurement process which could stimulate the introduction of IMT-2000 in developing countries. Some developing countries may have an interest in the local manufacture of certain products unique to their markets for IMT-2000 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 which is able to match network investment to revenue growth, and can adapt readily to environmental factors, different applications and new developments.

For developing countries, fixed wireless access (FWA) is a potentially large IMT-2000 application. FWA is a fixed radio application and therefore the corresponding environment is less stringent than that of other IMT-2000 mobile environments. As a result, system complexity can be substantially reduced since mobility management is no longer required. Also the requirements on coding and diversity schemes to combat severe shadowing, fading and delay spread can be minimized due to the fixed operating environments. Hence, system flexibility is very important to be able to apply IMT-2000 to the FWA environments in a cost effective manner.

Of special importance to developing countries is the requirement 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 costs 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; PABXs, concentrators or small rural exchanges with wireless trunks, and different types of terminal equipment (2- or 4-wire terminals, coin boxes, etc.). This means that, among other things, the system should be able to be configured for situations of high traffic per terminal.

A description of what IMT-2000 is expected to achieve, accommodating both portable and fixed needs, is included in Report ITU-R M.1153.

5 Services

The services that are proposed in Report ITU-R M.1153 and Recommendation ITU-R M.816 for IMT-2000 surpass the immediate needs of a number of developing countries. Furthermore, there are great differences between developing countries in the stages of their development and needs.

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

– voice,
– point-to-multipoint,
– short messages,
– paging,
– facsimile,
– text,
– data.

When used in the fixed service IMT-2000 should provide services equivalent to those available to subscribers by metallic lines. Specifically these services are:

– 2-wire individual subscriber telephone service with the capability of carrying data including facsimile and other Telematic services up to a data rate of 9.6 kbit/s;
– 4-wire service with and without EM signalling;
– appropriate ISDN services.

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

Also, the IMT-2000 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, and populated areas in difficult terrain.

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

7 Large cells, the need for repeaters, the use of satellites

Large areas with low subscriber densities may be served by terrestrial or satellite systems.

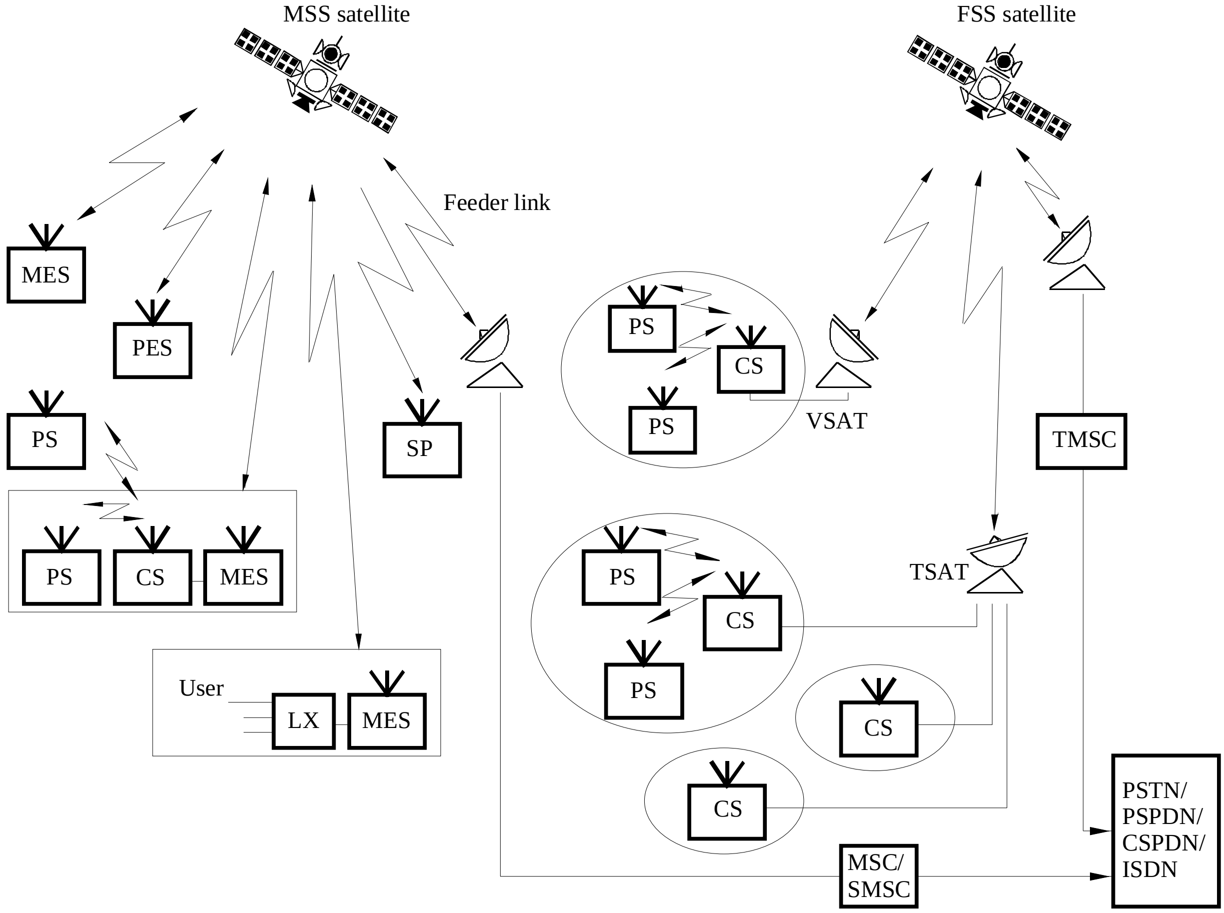
7.1 Possibilities offered by satellites

Satellite systems have very wide coverage and may be one of the solutions to the problem of covering large areas economically and serving widely scattered or remote subscribers in the regions where installation of a terrestrial infrastructure is not economically or physically feasible, either in developing or developed countries. The satellite system can be provided either as a stand-alone network or as an extension of an existing terrestrial network.

Figure 2 shows some possible configuration of IMT-2000 using satellite components and connection with the fixed-satellite service (FSS).

FIGURE 2

IMT-2000 network configuration involving mobile-satellite service (MSS)/FSS satellites



CS:	cell station
CSPDN:	circuit switched public data network
ISDN:	integrated services digital network
LX:	local exchange
MES:	mobile earth station
MSC:	mobile switching centre
PES:	personal earth station
PS:	personal station
PSPDN:	packet switched public data network
PSTN:	public switched telephone network
SMSC:	satellite mobile switching centre
SP:	satellite pager
TMSC:	terrestrial mobile switching centre
TSAT:	T-1 VSAT
VSAT:	very small aperture terminal
:	terrestrial cellular network

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Some service providers in developed countries are seeking solutions to the provision of IMT-2000 services without regard to the transmission mode throughout their geographic service areas with terminal costs and user charges comparable to those provided terrestrially. It is proposed to achieve this by having a terminal which is capable of both satellite and terrestrial operation. The service would be provided by terrestrial means in the areas where justified by the traffic density and by satellite in the other areas. The envisaged satellite systems will be capable of providing services to most locations in the world.

Should such a system be implemented, then the opportunity exists for countries to provide fixed and mobile telecommunications throughout their territories without the need for initial infrastructure investment. The provision of services by satellite will create a terminal base in the country which will be able to use the terrestrial infrastructure as and when it is installed.

7.2 Large cells in terrestrial systems

Three aspects in particular are important for the fixed service application of IMT-2000:

– 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;

– the average traffic level per subscriber is typically 3 to 4 times higher than in the mobile service.

7.2.1 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. The use of 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 using a repeater should be included in the basic structure of the IMT-2000.

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 IMT-2000 design should allow for such delays, perhaps on an optional basis.

7.2.2 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 (normally either an omni or sectoral type). Mounting arrangements should be 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 connection between the transceiver and the antenna can sometimes be about 30 m in length, and accomplished by coaxial cable feeders.

7.2.3 Polarization

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

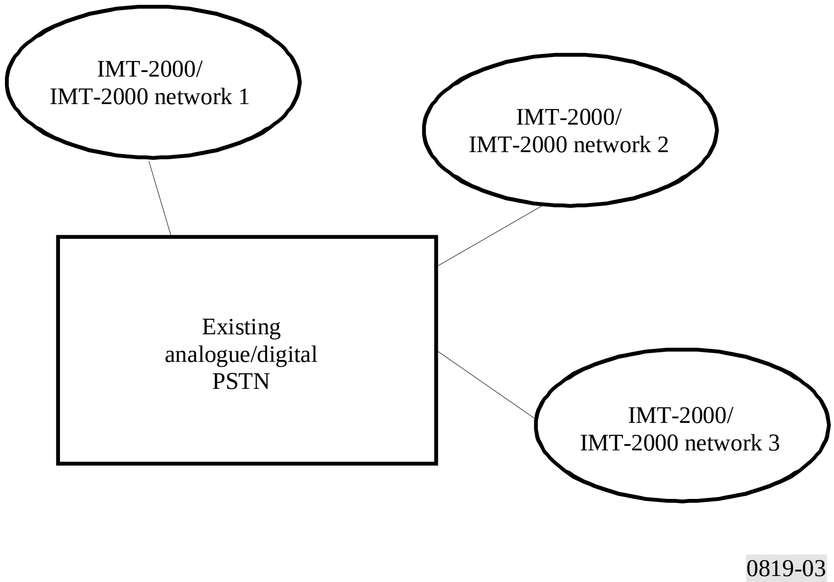
At a repeater location the discrimination obtainable between horizontal and vertical polarization can be very effectively used.

8 Interconnection of isolated/regional/national IMT-2000 networks

The typical situation is illustrated in Fig. 3 where a number of IMT-2000 networks exist and have to be connected via an existing analogue/digital PSTN.

FIGURE 3

Interconnection of IMT-2000 networks

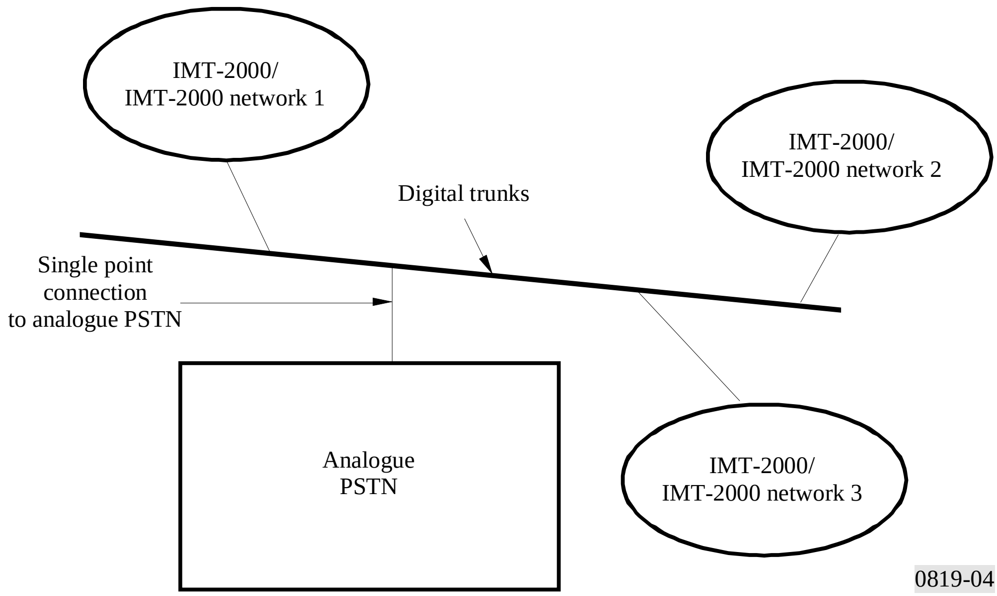


Depending on the capabilities of the PSTN not all the services provided by the IMT-2000 may be available through this network.

In some cases it may be appropriate to connect the IMT-2000 networks into the PSTN at a number of points while in other cases – for example where the PSTN is analogue, using mechanical exchanges – connection at a single point is desirable since it permits all the IMT-2000 networks to benefit amongst themselves from all IMT-2000 services. This latter scenario is illustrated in Fig. 4 in the case where existing digital trunk routes exist to interconnect the IMT-2000 regions.

FIGURE 4

Interconnection of IMT-2000 networks to an analogue PSTN at one point



In cases where no trunk routes are available, they will have to be constructed using such standard techniques as optical fibre, cable, point-to-point radio, point-to-multipoint radio, satellite, etc., as may be appropriate in the circumstances. For example, the interconnection of IMT-2000 networks may be appropriate via satellite or terrestrial radio depending on difficulties of terrain (e.g. deserts, dense forests, mountain ranges, large water bodies) and the distances between the networks/communities.

9 Need for further studies

The requirement for using mobile radiocommunications technology to meet the needs of the developing countries and the fixed service use of that technology requires on-going 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 ITU-R M.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 IMT-2000,
– use of repeaters,
– large cells,
– reliability and availability,
– performance objectives,
– and reduce cost compared to cellular specifications.

Section 10 provides some preliminary considerations for performance objectives for circuit quality in the fixed service, whilst Table 1 provides a list of applications.

TABLE 1

Requirements for the fixed services

Characteristic	Requirement for fixed service
1. Voice encoding – Bit rate – Circuit noise – Voice quality	IMT-2000 should offer performance comparable to that achieved in the fixed network
2. Radio coverage – Repeaters	IMT-2000 architecture should permit the possibility of repeaters
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 in any combination
6. Power consumption	As low as possible for solar and other sources
7. Antennas	Directional at subscriber stations (also, in some cases, base stations) for optimized radio path design using both vertical and horizontal polarization

NOTE 1 – It is important that items 1 and 2 above be taken into account in the basic design of the IMT-2000. Some of the areas where the fixed service application requires special design are listed in items 3 to 7.

10 Preliminary performance objectives for circuit quality for the fixed service

The following preliminary considerations on circuit quality have been put forward.

10.1 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 ten years.

The driving force for low bit rate voice encoding in IMT-2000 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 frequency congestion is unlikely to occur and the use of higher encoding bit rates for such applications may be a desirable approach.

10.2 Voice quality

Voice quality when IMT-2000 are used for the fixed service should be as close as possible to present day voice quality in fixed networks. The IMT-2000 coding scheme should not significantly limit overall voice quality and intelligibility, nor 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 IMT-2000 should not compromise the networks overall performance.

10.3 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 ITU-T 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 IMT-2000 are applied to the fixed service.

10.4 Error performance

As a guideline for error performance the objectives for local grade circuits as specified in Recommendation ITU-R F.697 should be used.

10.5 Grade of service

Giving due regard to economic considerations, IMT-2000 should be able to offer a grade of service normally better than 1%.

11 Conclusions

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

IMT-2000 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 to the national social and economic development process.