RECOMMENDATION ITU-R F.757-2*

BASIC SYSTEM REQUIREMENTS AND PERFORMANCE OBJECTIVES FOR FIXED WIRELESS ACCESS USING MOBILE-DERIVED TECHNOLOGIES OFFERING BASIC TELEPHONY SERVICES

(Question ITU-R 140/9)

(1992-1997-1999)

The ITU Radiocommunication Assembly,

considering

a) that mobile radiocommunication systems offering basic telephony services are already in wide use;

b) that such systems are implemented both with analogue and digital technologies;

c) that in some cases it may be desirable, for reasons of convenience and economy, to apply systems derived from mobile technologies for use as FWA (see Annex 1, § 6 for list of acronyms) in both rural and urban areas;

d) that there is a need for fixed applications using mobile-derived technologies that provide an equivalent access function to metallic lines;

e) that when used in fixed applications the radio links provided may form part of an international connection;

f) that the introduction of FWA systems derived from digital mobile technologies will make it possible to offer various types of service including the local grade portion of an ISDN;

g) that FWA applications using mobile-derived technologies may also operate in bands allocated to the fixed service,

recommends

1 that systems using mobile-derived technologies in fixed applications provide services also available by metallic lines. These services include:

– individual customer telephone service;

– pay-phone service of various kinds;

– 4-wire service with and without receive and send "E AND M" signalling;

– the capability to carry voice-band data signals including facsimile and other telematic services up to a data rate of 9.6 kbit/s;

2 that digital systems using mobile-derived technologies in fixed applications should provide the same ISDN access as digital mobile systems;

3 that, since such systems used as FWA may form part of an international connection, the relevant G-Series ITU-T Recommendations should be met;

4 that, a service quality comparable to that already provided to fixed end-users in urban areas should be offered, e.g. a grade of service better than 1% and should be calculated employing ITU-T Recommendations E.506, E.541 and Supplement No. 1 to the E-series Recommendations. Giving due regard to economical considerations, the grade of service (lost call probability) offered by such a system to an end-user should not normally be worse than 5%;

5 that the error performance and availability objectives of digital systems should generally be in accordance with Recommendations ITU-R F.697 and ITU-R F.1400;

---

* This Recommendation should be brought to the attention of Radiocommunication Study Group 8 (Working Party 8A) and the Telecommunication Development Study Group 2.

6 that analogue systems should be designed to provide voice circuits with a noise level less than 1 000 pWp (before companding improvement is taken into account) in the unfaded condition, concerning which further information including availability consideration is provided in Annex 1;

7 that Annex 1 should be referred to for the application of mobile-derived technologies as FWA.

ANNEX 1

Applications of mobile radiocommunication technologies for use as FWA offering basic telephony services

1 Introduction

Mobile radiocommunication systems are already in wide use. The technology for such systems is expanding rapidly.

It is technically feasible, and in some cases it may be desirable for reasons of convenience and economy, to apply mobile-derived radiocommunication systems for use as FWA. This Annex describes basic system requirements for such applications. In general most applications deal with the connection of end-users to the telephone exchange and thereby into the switched network.

For brevity, the application of mobile radiocommunication technologies for use as FWA will be called simply “mobile-derived FWA”.

2 General considerations

The service to be provided forms a permanent, integral part of the national telephone network and as such can be part of an international connection.

A number of administrations have already implemented such systems, for the provision of basic telephony services in rural areas. It is important, therefore, to establish the basic system requirements (e.g., performance objectives, frequency bands, implementation process and maintenance aspects) which permit such integration as effectively as possible without degrading overall network performance.

The general goal in rural and remote areas is to establish an overall quality of service equal to that achieved by wireline systems in well served urban areas. A minimum objective towards this goal is to achieve service quality at least comparable to that offered in these urban areas, as proposed in the ITU-T (ex-CCITT) Handbook on Rural Telecommunications (Geneva, 1985) and in Recommendation ITU-R F.756.

In some cases, it may be effective to use mobile-derived FWA systems not only in rural areas but also in urban areas e.g. where the cable infrastructure is temporarily inadequate. The radio system has the advantage that it can be deployed rapidly compared with cable systems. Also it may be another attractive feature that the facilities can be easily converted for mobile use after the cable systems become available.

2.1 Basic approach

There are two basic approaches for mobile-derived FWA. One is to establish an entirely new mobile-derived FWA system, optimized for and dedicated to fixed use, and the other approach is to make minimum changes to the existing or planned mobile systems for adaptation to fixed use.

The former approach may be justified in some cases from the viewpoint of economic considerations. However, it should be taken into account that in many cases it may be desirable that a system can accommodate both mobile and fixed end-users. The latter approach seems preferable for these cases. It is therefore desirable that future mobile systems should include in their design considerations the possible application of the systems for FWA to satisfy its own performance criteria set by the mobile environment, and may well limit the performance achievable by the fixed station. For example, one administration operates mobile systems with a carrier to interference ratio of 18 dB at the edges of the cell. This provides an acceptable level of performance for a mobile system, but could result in unacceptable performance in the fixed service where the radio link is intended to be part of the telephone network and radio is used instead of wire or cable only for convenience and economy. Another factor is that mobile systems are normally optimized for low end-user traffic, 0.02 E, whereas fixed end-user traffic normally averages between 0.05 and 0.09 E.

2.2 Frequency bands

Frequency spectrum is a limited natural resource. Therefore, the frequency bands suitable for mobile communication should be primarily used for the mobile services. For this reason, the application of mobile-derived systems for FWA may be justified mainly in rural areas where the demand for mobile communication is small and the provision of telecommunication services by means of wireline facilities is too costly. See also draft new Recommendation ITU-R F.1401 (Frequency bands for fixed wireless access systems and the identification methodology).

If mobile systems are adapted for use as FWA, frequency bands should be the same as those for mobile systems.

Frequency bands commonly used for mobile radio are, for example, in the 400 MHz and 800/900 MHz bands. Any of these bands are, in principle, suitable for the provision of a fixed service; however, the interference environment in any area where it is proposed to operate must now satisfy criteria for the fixed service as opposed to the mobile service.

2.3 Operational aspects

As a matter of principle, all kinds of telecommunication services offered through wireline facilities could be made available through mobile-derived FWA systems. Most of the services are already provided by mobile systems. Among the services which are not usually provided by mobile systems is the pilot number service (multiple lines) which is essential for key telephones and private branch exchanges.

Some features of mobile systems are not necessary for mobile-derived FWA. Among them are roaming and hand-off capabilities. In addition, certain sub-systems of mobile systems may require modifications for adaptation to the FWA. Most important are the numbering plan and charging sub-system. In particular, in cases where a system accommodates both mobile and mobile-derived FWA end-users, the numbering and charging sub-systems should be capable of handling the two categories of end-users, unless the regulation permits a common sub-system to be applicable to both mobile and mobile-derived FWA end-users.

One of the solutions for numbering and charging when mobile systems are introduced into an existing PSTN might be to adopt service control points with common channel signalling.

In providing telecommunications services, consideration must be given to the likely location of the end-user station. While it is possible to locate the end-user terminal at the customer’s premises, this is not necessarily the best location for the radio antenna. In hilly terrain, houses are most often built in valleys or where some shielding is provided from the weather. This must be taken into account in the system design by, for example, adapting mobile equipment to feed a 650 Ω loop (including the telephone set) when used in the fixed service.

In some rural areas, the commercial alternating current power is either unavailable or is less reliable than that in urban or suburban areas. Substantial attention must be given to provide reliable power sources for the end-user units in rural areas. To equip a backup battery is one alternative.

2.4 Traffic capacity – grade of service

The grade of service or lost call probability is frequently designed to be of the order of 1%, but it is seldom as high as 5%, while some administrations set requirements in the range 0.1% to 0.5%, in order not to degrade the national network beyond the ITU-T recommended objective of 1%. Care must be taken to allow for appropriate growth in the number of end-users and the higher loss probability figures should, therefore, be avoided, since they will generally result in severe customer dissatisfaction. These probabilities are calculated in the usual manner, employing ITU-T Recommendations E.506, E.541, and Supplement No. 1 to the E-Series Recommendations, as well as Recommendation ITU-R F.756. Factors to consider include:

– the number of radio channels required,

– the number of end-users to be served, and

– the traffic intensity per end-user.

Average traffic intensities of 0.05 to 0.09 E per end-user have been used frequently for rural end-users. The loss probability for up to 6 RF channels is shown in graphical form in the ITU-T (ex-CCITT) Handbook on Rural Telecommunications (Geneva, 1985), page 84, Fig. 7-4(III).

3 Requirements for analogue systems

3.1 General

A full description of the voice channel would involve the specification of all voice channel parameters:

– circuit noise,

– frequency response,

– envelope delay,

– impulse noise,

– gain stability,

as well as impedance, return loss, balance, etc., at the interface.

Whilst all the above are important, only the circuit noise is discussed here, the other requirements being the subject of further study.

3.2 Mobile radio noise performance

Mobile radio traditionally does not specify the noise level of a connection in absolute terms. Channel performance as a whole is specified in terms of MOSs which describe the level of satisfaction expressed by a group of listeners to a given circuit, as described in ITU-T Recommendations P.75, P.76, P.78, and P.79. FWA applications, on the other hand, deal with absolute values of circuit parameters, such as noise level, frequency response, etc. Hypothetical reference connections to allocate noise allowances to various parts of a circuit have not yet been established for mobile systems.

Analogue mobile radios employ FM modulation and companding. In a mobile environment the performance is normally limited by the rapid fading associated with the movement of the end-user. In a fixed environment the radio path is, by definition, comparatively stable and subject only to fading and may be designed in accordance with established principles. In particular, directional antennas are used by the end-user station which increase system gain and help to reduce the effects of interference. Based on reported figures, a steady state (unfaded, high received signal level, no interference), noise level in the range 1 000 to 10 000 pWp is typical of mobile radio.

Companding in accordance with ITU-T Recommendation G.162 is normally employed and subjective improvements of the order of 10 to 20 dB have been reported, reducing the steady state circuit noise to 100-1 000 pWp subjective equivalent. However, ITU-T Recommendation G.162 provides guidance on the use of compandors and recommends that only a 10 dB “advantage” (improvement in subjective noise level) should be assumed for planning purposes and cautions on the possible effects of compandors used in series in the network.

3.3 Local grade portion noise performance requirements

Various performance figures for the noise contribution in the local grade portion have been put forward for analogue systems. For example, ITU-T Recommendation G.103, which provides recommendations for hypothetical reference connections, allows 100 to 500 pWp for the connection to the local exchange. In as much as the rural connection can be part of an international connection, these figures are applicable to the end-user to exchange connection in a rural area. This is essential if the objective of providing urban quality service is to be achieved. This would not be inconsistent with Recommendation ITU-R F.395 which, for example, establishes a noise power limit of 350 pWp for a 50 km link and 500 pWp for a 100 km link. These distances are typical for rural end-user connections via radio. The ITU-T Handbook on Rural Telecommunications makes reference to ITU-T Recommendation G.103 for guidance but suggests "realistic" figures such as 4 000 to 10 000 pW0p and discusses figures of 1 000 pW0p used by some administrations. Recommendation ITU-R F.754 which deals with trunk connections in rural areas, uses a figure of 1 000 pWp derived from ITU-T Recommendation G.123 (Circuit noise in the national network). However, the ITU-T Handbook on Rural Telecommunications (Geneva, 1985) also cautions (on page 28) that, in the most complex reference connection, any appreciable increase of receiving end noise will degrade the system and result in user dissatisfaction. It also discusses the importance of maintaining a proper balance between noise and loss. It is clear that the ITU-R and ITU-T do not envisage high levels of noise for rural connections where it can be reasonably and economically avoided.

Narrow-band FM systems such as certain mobile systems, while offering performance that may well be acceptable in a number of applications, are limited by the residual noise inherent in these systems. They are designed for an environment where the residual equipment noise is negligible in relation to the noise caused by interference and multipath fading. Wideband techniques, such as TDMA systems discussed in Recommendation ITU-R F.756 can offer low noise performance (typically 100 to 200 pWp) owing to, in the case of digital systems, the use of standard A and μ-law PCM voice encoding as specified in ITU-T Recommendation G.165.

3.4 Service requirements

The basic service requirement is typically a 2-wire connection. However, in practice, a variety of additional services is also required. For example, in rural and remote areas, the provision of a pay-phone service is a necessity, while telex, facsimile, 4-wire with "E AND M" signalling and a variety of data services represent a wide range of additional telecommunications services which may need to be provided by radio to end-users.

3.5 Availability

When used in the fixed service, the design of the analogue radio path should conventionally permit an overall availability to an individual end-user of not less than 99.9% for both propagation and equipment effects (NOTE – When an analogue system carries digital data traffic, availability may be required to be in line with Recommendation ITU-R F.697). This may achieve a quality of service comparable to that in urban areas served by wireline systems. Some links are often designed with a higher availability when the administration considers it necessary to have the objective comparable to that for digital FWA (see § 4.3).

4 Requirements for digital systems

4.1 General

Today's widespread use of digital mobile technologies has provided cost-effective radio equipment for FWA. Such systems have the following features:

– high system availability and good speech quality,

– shorter installation time,

– low initial cost in rural and suburban areas,

– easy maintenance and management of facilities,

– flexible access network construction to respond to changing demand,

– immunity against disasters.

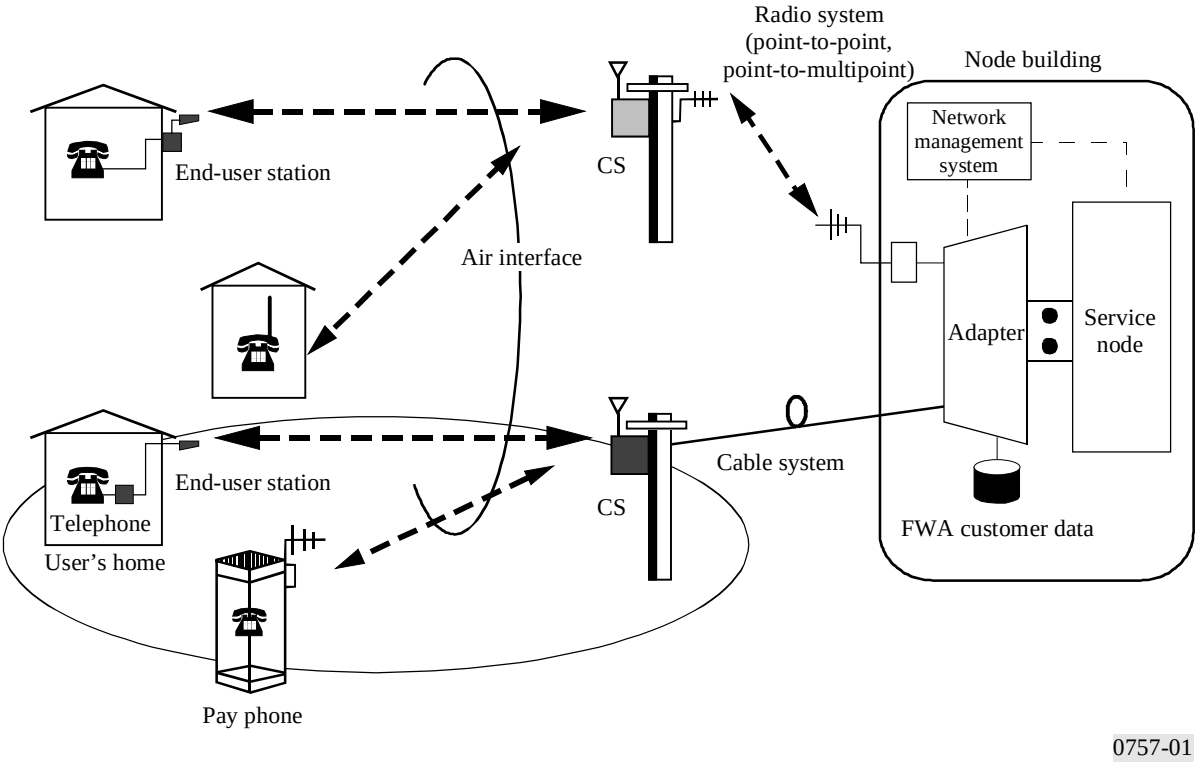
Making use of the above advantages, digital mobile-derived FWA systems have been extensively introduced in many countries. Services provided by mobile-derived FWA systems include 2-wire telephone, public telephone, facsimile and data transmission using modems (up to 9.6 kbit/s). Future provision of ISDN (2B + D) connection is taken into account.

4.2 System configuration

System configuration of a FWA system is shown in Fig. 1. The major components of the system are ADPs, CSs and end-user stations or SSs. Cables or radio systems are used for connections between ADPs and CSs. ADPs are positioned between the SN and the CSs. ADPs function to implement concentration, authentication and so on.

FIGURE 1

FWA system using mobile technologies



Examples of interface between ADPs and CSs may be E1/T1 or those based on Recommendations ITU-T G.964/G.965. CSs are installed outdoors in such locations as at the top of poles. One CS can contain several radio units, each one having a number of message channels depending on the technology used. As a result one CS will provide message channels up to about several tens as well as one control channel. Service area radius of such FWA systems ranges from 0.1 to several tens of kilometres.

Main parameters of reported FWA applications using mobile-derived technologies are given in Table 1.

4.3 Performance and availability requirements

As specified in *recommends* 5 in this Recommendation the error performance and availability objectives of digital FWA systems should generally be in accordance with Recommendations ITU-R F.697 and ITU-R F.1400. Since these Recommendations do not discriminate mobile-derived FWA systems from systems designed purely for fixed use, it is required for mobile-derived FWA systems to meet the objectives in these Recommendations. In particular, to realize the availability objectives in Recommendation ITU-R F.1400, i.e. 99.99% for medium quality applications and 99.999% for high quality applications, the MTTR should be sufficiently short in both urban and rural environments.

TABLE 1

Main parameters of reported FWA applications using digital mobile technologies

	D-AMPS-FWA 450/900	CT2-FWA	IS-95-CDMA-FWA	GSM-FWA 900/1 800	CDMA/TDMA-FWA	PHS-FWA	DECT-FWA	PACS-FWA	PDC-FWA 800/1 500
Frequency band (MHz)	440-450/869-894 485-495/824-849	864.1-868.1	869-894 824-849	935-960/ 1 805-1 880 890-915/ 1 710-1 785	1 850-1 990	1 893.5-1 919.6	1 880-1 900	1 930-1 990 1 850-1 910	810-828/1 429-1 453 940-958/1 477-1 501
Access	TDMA (FDD)	FDMA (FDD)	CDMA (FDD)	TDMA (FDD)	CDMA/TDMA (TDD)	TDMA (TDD)	TDMA (TDD)	TDMA (FDD)	TDMA (FDD)
Service area radius (km)	Several tens	0.1 to 2	Up to 62.5	0.1 to 30/0.1 to 20	0.4 to 11	5	5	(1)	Up to 50
Voice coding scheme	IS-54 IS-136	ADPCM	QCELP 13.2 kbit/s	HR 5.6 kbit/s FR, EFR 13 kbit/s	J-STD-17 IS-661	ADPCM	ADPCM	ADPCM	VSELP 6.7 kbit/s PSI-CELP 3.45 kbit/s
Number of channels	(1)	40	20	124/374	28	348	120	300	216/288
Network interface(2)	T1/E1(2)	$n \times$ E1	T1/E1	E1	T1/E1	G964/G965 GR303/PSTN	E1	T1/E1	G964, G965 PSTN (analogue 2-wire)

(1) To be provided later.

(2) E1 = 2 Mbit/s; T1 = 1.5 Mbit/s.

ADPCM: Adaptative differential pulse code modulation

CDMA/TDMA-FWA: Composite code division multiple access/time division multiple access FWA

CT2-FWA: Cordless telephone 2 FWA

D-AMPS-FWA: Digital advanced mobile telephone system FWA

DECT-FWA: Digital enhanced cordless telecommunications FWA

FDD: Frequency division duplex

FDMA: Frequency division multiple access

GSM-FWA: Global system for mobility FWA

IS-95-CDMA-FWA: Interim Standard-95 code division multiple access FWA

PACS-FWA: Personal access communications system FWA

PDC-FWA: Personal digital cellular FWA

PHS-FWA: Personal handyphone system FWA

PSI-CELP: Peripheral subsystem interface-code excited linear prediction

PSTN: Public switched telephone network

QCELP: Quadrature code excited linear prediction

T1/E1: Primary rate transmission system

TDD: Time division duplex

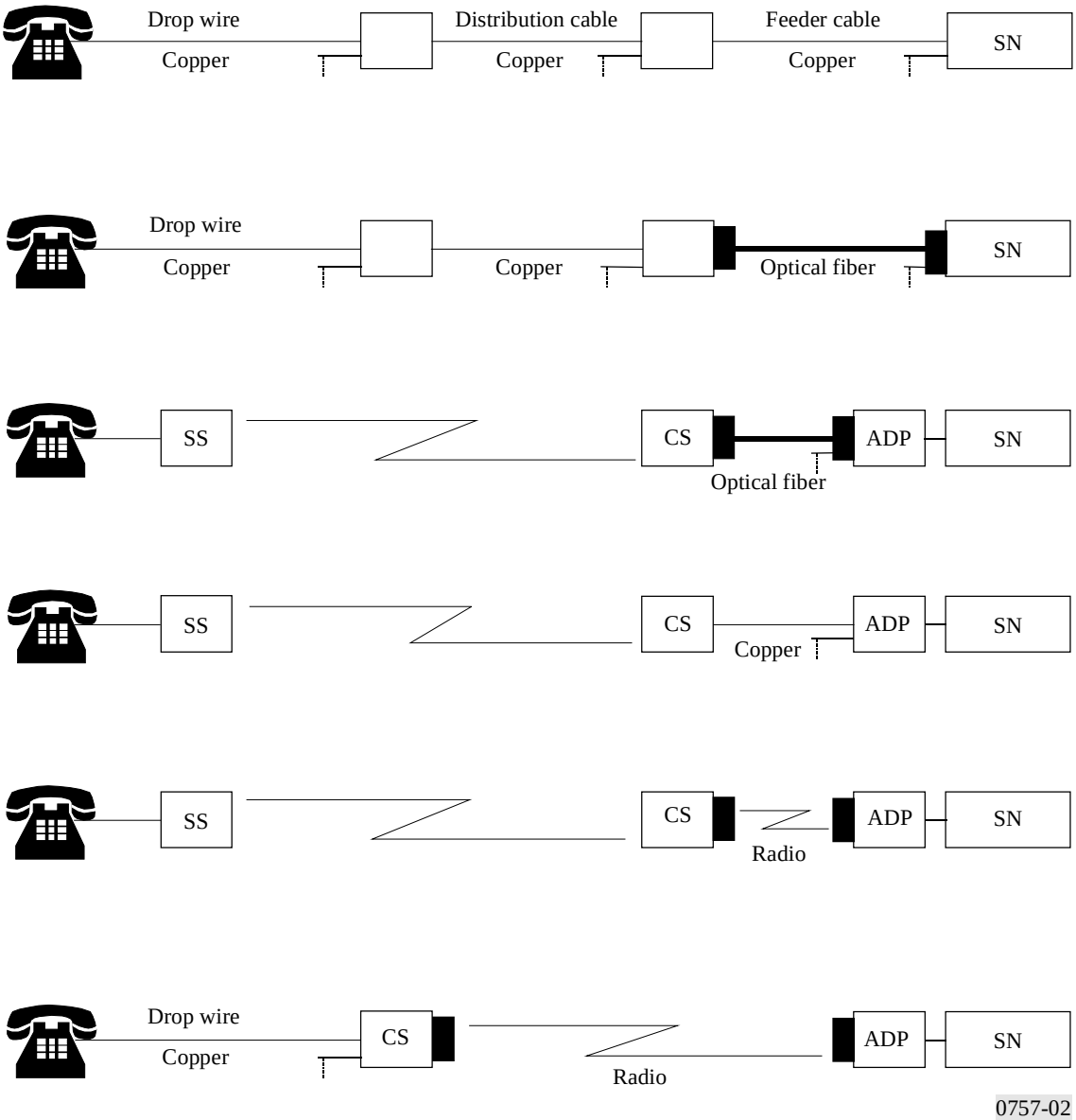
VSELP: Vector sum excited linear prediction

4.4 Implementation process

There are many possible ways to implement access facilities that include mobile-derived FWA systems, as shown in Fig. 2. In the figure, typical wireless access system consists of ADP, CS, and SS (or end-user station). For example, in a large area accommodated by one SN, there will be a number of small sub-areas at different distances from the SN, having different numbers, densities, and growth-rates of end-users. Therefore, the most important question facing network operators is how to select the optimal (i.e. lowest-cost and highest-efficiency) implementation, given the conditions in each of the sub-areas in question.

FIGURE 2

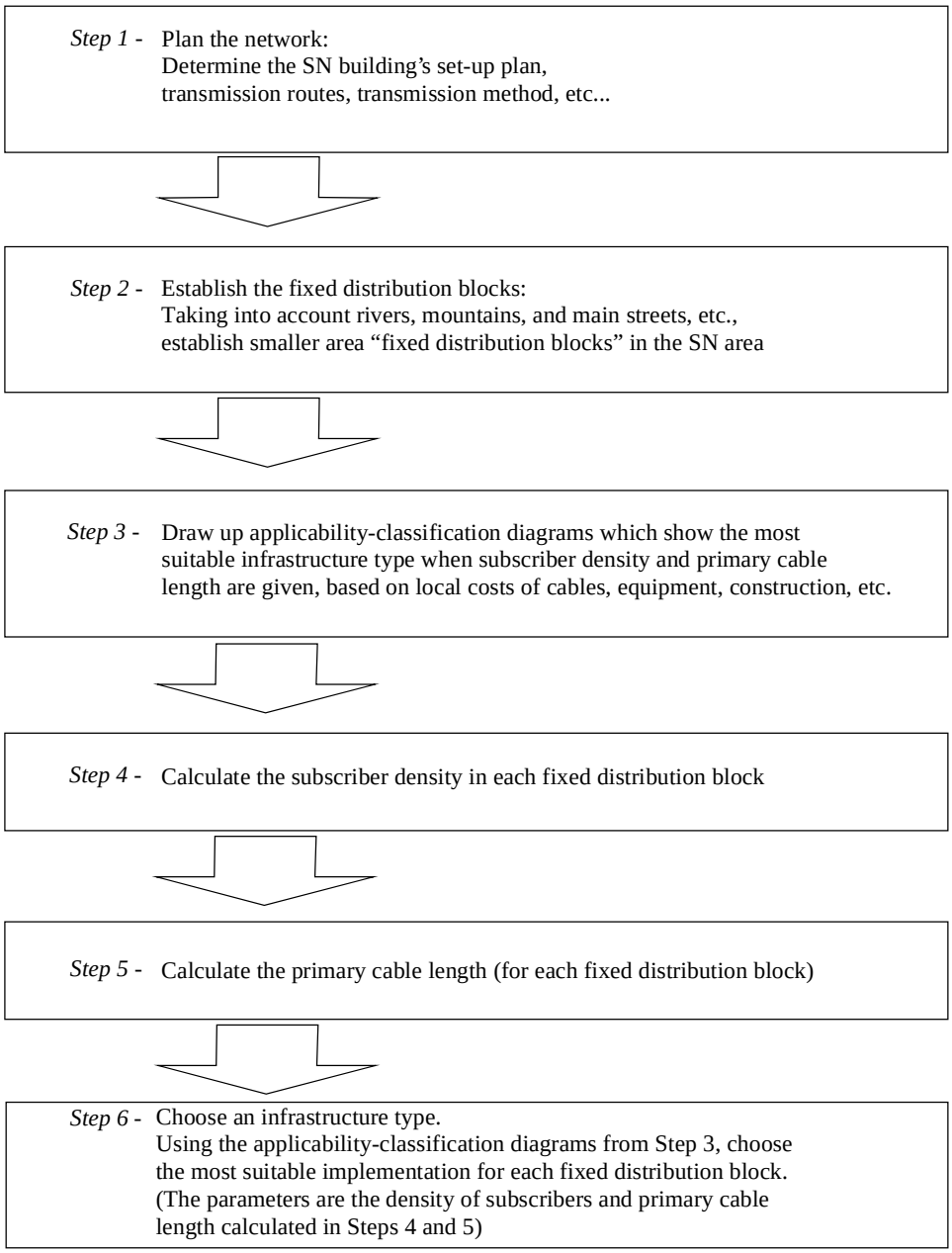
The access facility forms



An outline of choosing the most suitable facility is described in Fig. 3.

FIGURE 3

Choosing the appropriate mobile-derived FWA systems



4.5 Operation and maintenance aspects

Operators can control and manage several mobile-derived FWA systems from one operations centre. There are two choices of management architectures (tree or ring) for the system. They have different characteristics in terms of cost, reliability etc. and one can switch from one architecture to the other when expanding the system, equipment, or centre.

In terms of functions, there are three systems that constitute the NMS implement functions. The functions of each system is shown below:

– network operation and maintenance system for operations centre;

– facility engineering and management support system for local offices;

– service order system for customer service centre.

Each operations centre holds backup data (for customers, the system, traffic, etc.) fully mirroring one or more other operations centres, to provide protection in case of accidents. If one centre fails, data can be restored from another site or control can be switched to another site for continuous operations.

Relational DBMS provides fast and flexible searching of data, easy collection of statistics, and high-performance transaction processing for large quantities of data. It also supports various forms of data storage, such as floppy disk, magneto-optical disk, etc. Operators can easily manipulate the NMS, determine the current system status, and take appropriate measures using graphical user interface.

5 Conclusion

Mobile-derived FWA systems are capable of making telecommunication services available to end-users in rural areas and, in particular, to end-users in the developing countries.

Optimized fixed systems can offer, as should be expected, a higher level of performance and service features than might be achieved by the use of mobile radio. The level of performance offered by FWA systems may be acceptable, in some cases, to an administration that requires a basic telephone service for a few widely scattered end-users, especially if the service can be provided very economically within an existing mobile cell. An administration, however, should consider that the performance which can be achieved may degrade national or international connections beyond acceptable national or ITU-T objectives. As is always the case, a full evaluation of suitable radio techniques must be made which will include the consideration of ITU-T and ITU-R Recommendations, comparisons of achievable versus required performance, cost, the lifetime of the equipment, maintenance, reliability, suitability for the local physical environment, services offered, etc.

In view of the apparent growing use of FWA using mobile-derived technologies, it would be highly desirable if administrations could provide information on the effects they have noted on overall network performance.

6 List of acronyms

ADP	Adapter
CS	Cell station
DBMS	Data base management system
FM	Frequency modulation
FWA	Fixed wireless access
GOS	Grade of service
ISDN	Integrated services digital network
ITU-T	ITU Telecommunication Standardization Sector
MOS	Mean opinion scores
MTTR	Mean time to repair
NMS	Network management system
PLMN	Public land mobile network
PCM	Pulse code modulation
SN	Service node
SS	Subscriber station (end-user station)
TDMA	Time division multiple access

7 References

7.1 ITU-R Recommendations

– Recommendation ITU-R F.395: (Volume IX, Part 1 (Düsseldorf, 1990)) — Noise in the radio portion of circuits to be established over real radio-relay links for FDM telephony

– Recommendation ITU-R F.697: — Error performance and availability objectives for the local-grade portion at each end of an integrated services digital netwok connection at a bit rate below the primary rate utilizing digital radio-relay systems

– Recommendation ITU-R F.754: — Radio-relay systems in bands 8 and 9 for the provision of telephone trunk connections in rural areas

– Recommendation ITU-R F.756: — TDMA point-to-multipoint systems used as radio concentrators

– Recommendation ITU-R F.1399: — Vocabulary of terms for wireless access

– Recommendation ITU-R F.1400: — Performance and availability requirements and objectives for fixed wireless access to public switched telephone network

7.2 ITU-T Recommendations

– ITU-T Recommendation E.506: — Forecasting international traffic

– ITU-T Recommendation E.541: — Overall grade of service for international connections (subscriber-to-subscriber)

– ITU-T Recommendation G.103: — Hypothetical reference connections

– ITU-T Recommendation G.123: — Circuit noise in national networks

– ITU-T Recommendation G.162: — Characteristics of compandors for telephony

– ITU-T Recommendation G.165: — Echo cancellers

– ITU-T Recommendation G.173: — Transmission planning of speech in digital public land mobile networks

– ITU-T Recommendation G.964: — V-Interfaces at the digital local exchange (LE) – V5.1-Interface (based on 2 048 kbit/s) for the support of access network (AN)

– Recommendation ITU-T G.965: — V-Interfaces at the digital local exchange (LE) – V5.2 interface (based on 2 048 kbit/s) for the support of access network (AN)

– Recommendation ITU-T P.75: — Standard conditioning method for handsets with carbon microphones

– Recommendation ITU-T P.76: — Determination of loudness ratings; fundamental principles

– Recommendation ITU-T P.78: — Subjective testing method for determination of loudness ratings in accordance with Recommendation P.76

– Recommendation ITU-T P.79: — Calculation of loudness ratings for telephone sets

7.3 Other publications of ITU

ITU-T (ex-CCITT) Handbook on Rural Telecommunications (1985).