RECOMMENDATION ITU-R F.1103-1*

Basic requirements and technologies for fixed wireless access systems operating in bands below 3 GHz for the provision of wireless subscriber connections in rural areas

(Question ITU-R 125/9)

(1994-2007)

Scope

This Recommendation provides basic requirements and technologies for fixed wireless access (FWA) systems operating in bands below 3 GHz for use for wireless connections in rural areas. The requirements include service aspects as well as performance/availability objectives. The Annexes describe technical and operational information specifically required for FWA applications used in rural areas.

Vocabulary

RCS Radio Concentrator System

A wireless system in which the radio resource (e.g. a time slot in the time domain or a frequency channel in the frequency domain) is commonly used by more than one subscriber by applying a multiple access technique.

Abbreviations

ADPCM Adaptive differential pulse code modulation

CDMA Code division multiple access

E&M Electrical & magnetic

FDD Frequency division duplexing

PCM Pulse-code modulation

P-MP Point-to-multipoint

P-P Point-to-point

TDD Time division duplexing

TDMA Time division multiple access

TF Time frame

TS Time slot

* This Recommendation should be brought to the attention of ITU-D Study Group 2 (Q.10).

The ITU Radiocommunication Assembly,

considering

a) that there is an urgent need for the provision of economic telecommunication subscriber connections in rural areas, especially in developing countries;

b) that the equipment for such links should be simple and reliable for reduction of establishment costs, and for ease of maintenance and operation;

c) that in the provision of such links, the calling rate allows the use of such methods as fixed wireless access (FWA) systems using point-to-multipoint (P-MP) applications;

d) that FWA systems operating in bands below 3 GHz are suitable for the provision of such links and it is necessary to provide technical information on these systems for the system designers;

e) that in rural areas it is often difficult to implement metallic lines or other cable systems economically, however various telecommunication services provided by metallic lines or other cable systems should, as far as possible, be available also in rural areas;

f) that Recommendation ITU-R F.1490 specifies generic requirements for FWA systems;

g) that Recommendation ITU-R F.757 provides basic system requirements and performance objectives for FWA systems using mobile-derived technologies offering telephony and data communication services,

recommends

1 that FWA systems used for rural subscriber links should provide services also available by metallic lines. These services may include:

– 2-wire individual telephone service;

– payphone service of various kinds;

– 4-wire service with and without E&M signalling;

– the capability to carry voiceband data including facsimile and other telematic services up to a bit rate of at least 9.6 kbit/s;

2 that, in many cases, the above FWA systems should:

– carry data at rates up to and including 64 kbit/s;

– provide, integrated services digital network (ISDN) basic rate access, 2B+D;

3 that giving due regard to economical considerations:

3.1 the grade of service (lost call probability) offered by such a system to a subscriber should not normally be worse than 1% and should be calculated employing ITU-T E-series Recommendations (e.g. E.506 and E.541) (see Note 1);

3.2 the error performance and availability objectives should be in accordance with Recommendations ITU-R F.697 and ITU-R F.1400;

4 that for the effective use of frequency spectrum, radio concentrators and other digital multiple access techniques are preferred and for detailed technical information on TDMA P-MP systems Annex 1 be referred to (see Note 2);

5 that for equipment general characteristics and operational environments, information contained in Annex 2 be referred to as a guide for administrations and system designers;

6 that voice encoding methods employed in digital systems be such that the integration of the system into the switched network is straightforward and introduces as few limitations as possible.

Recommended encoding methods are 64 kbit/s PCM and 32 kbit/s ADPCM in accordance with ITU-T Recommendations G.711 and G.726, respectively.

NOTE 1 – Some administrations may adopt other values for the grade of service, e.g. as much as 5%, depending on local conditions.

NOTE 2 – Other technologies such as CDMA and orthogonal frequency division multiplex (OFDM) can be found in the Fixed Wireless Access Handbook (Volume 1 of the Land Mobile Handbook).

References

ITU-R Recommendations

Recommendation ITU-R F.382 – Radio-frequency channel arrangements for fixed wireless systems operating in the 2 and 4 GHz bands

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

Recommendation ITU-R F.701 – Radio-frequency channel arrangements for point-to-multipoint radio systems operating in frequency bands in the range 1.350 to 2.690 GHz (1.5, 1.8, 2.0, 2.2, 2.4 and 2.6 GHz)

Recommendation ITU-R F.746 – Radio-frequency arrangements for fixed service systems

Recommendation ITU-R F.757 – Basic system requirements and performance objectives for fixed wireless access using mobile-derived technologies offering telephony and data communication services

Recommendation ITU-R F.1242 – Radio-frequency channel arrangements for digital radio systems operating in the range 1 350 MHz to 1 530 MHz

Recommendation ITU-R F.1243 – Radio-frequency channel arrangements for digital radio systems operating in the range 2 290-2 670 MHz

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

Recommendation ITU-R F.1401 – Considerations for the identification of possible frequency bands for fixed wireless access and related sharing studies

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.711: Pulse code modulation (PCM) of voice frequencies

ITU-T Recommendation G.726: 40, 32, 24, 16 kbit/s Adaptive Differential Pulse Code Modulation (ADPCM)

Annex 1

General characteristics of fixed wireless access systems using TDMA techniques

1 Introduction

This Annex provides information on P-MP FWA systems using TDMA. Such systems can also generally operate in a non-concentrating mode such as for pre-assigned low capacity data links.

These systems are now widely used to provide a subscriber voice data service primarily in rural/suburban areas and less frequently in urban locations.

2 General description

The basic purpose of these systems is to provide a radio link that will extend services to rural subscribers where cable systems are more costly or severely restricted by terrain or to protect environments. As far as practicable these services should provide a transmission quality and range of facilities that are normally provided to subscribers in urban areas.

Multiple access systems give subscribers access to several circuits, the number n of which is smaller than the number N of subscribers ($n < N$). As this is a concentrator system, a certain grade of service in respect of attempts to set up calls must be accepted. The grade of service depends on the number n of circuits, the number N of subscribers and the traffic that is originated.

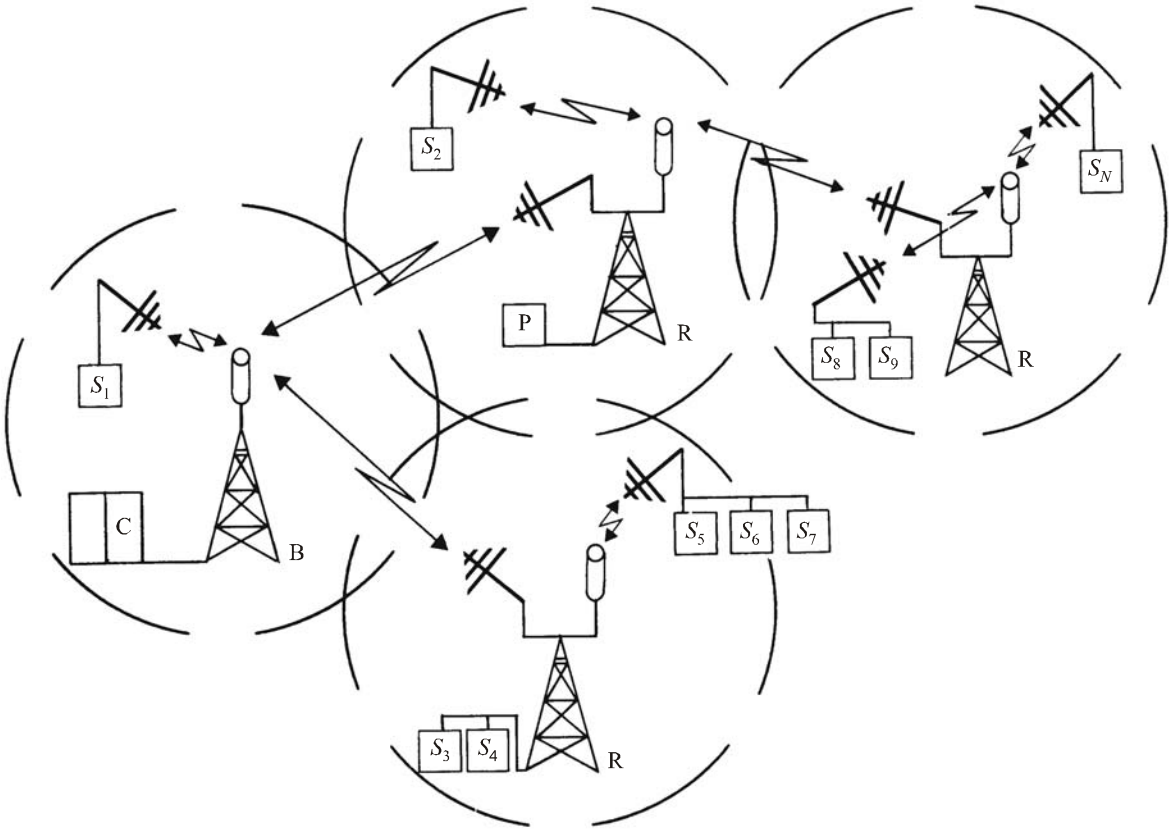
A TDMA radio concentrator system (TDMA-RCS) consists of a single transmitter-receiver unit at the central station and at each subscriber station. The transmitted signal consists of n time slots multiplexed in time, with each capable of providing a telephone channel. Any subscriber station has access to any of the n time slots which are allocated on a demand basis by the central station.

It is possible to introduce repeater stations to extend the service from the exchange to far-distant subscribers. Repeater stations consist of two transmitter-receiver units connected back-to-back through appropriate equipment. Repeaters may serve local subscribers and operate as two-way RF translators that retransmit the signal into the adjacent radio zones (see Fig. 1), thereby eliminating the need for interconnecting links between cells.

In one possible implementation using repeater stations with local switching, the signalling information, the routing requirements, and information on the operational status of the multiple access network are conveyed over supervisory channels which are continuously monitored and, if necessary, updated at all stations. Unutilized subscriber channels or time slots are allocated on demand on a drop and insert basis to the individual subscribers via the local switches and the supervisory channels are updated with information on new connections and disconnections. The same channel or time slot can be reused several times along the network due to the local switch facility. No central switch is required. A central station is provided as a gateway to the public network.

FIGURE 1

A possible configuration for a TDMA radio concentrator system for rural subscribers



: telephone exchange
S_i : subscriber interface
R : repeater station
B : central station
P : public telephone
C : switching unit

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3 Principles of operation

All TDMA P-MP systems use the same transmission principle. Data or digitally encoded speech signals are transmitted from the central station in a time division multiplex (TDM) format, using bit or byte interleaving. Alternatively, the information for the various outlying (subscriber or remote) stations is transmitted sequentially. In the reverse direction, each outlying station is allocated a time slot within which it transmits its information. Great care must be taken to ensure that the bursts of data arrive at the central station sequentially. This is generally achieved by careful design of the control system and by the provision of absolute delay equalization. Such equalization is either preset or dynamically adjusted depending on the design objectives for the system. When propagation time variations are short in relation to the baud period of the system, preset equalization is generally adequate. Figures 2 and 3 show a typical system schematic and TDMA frame arrangement, respectively.

In general, the connection of P-MP systems to the network is effected at the central station and it is preferable that the P-MP system appears to be transparent to the network without any constraints imposed by the use of TDMA. Furthermore, the use of a conventional interface allows the central station to be placed at some distance from the connection point to the network, as the link to this point can be made by conventional radio or cable systems.

Normally, the regenerated signal received at each outlying station is used to provide timing information for the outlying station. Synchronization information for the burst mode transmissions is obtained from the supervisory bits received from the central station. Hence each burst contains preamble information and consequently bursts with long frame periods are desirable for efficient use of the system. However, this approach can lead to overall delays that are unacceptable in a public switched network, consequently the relationship between transmission efficiency and permitted system delay must be carefully considered.

FIGURE 2

A typical configuration of a P-MP TDMA fixed wireless system

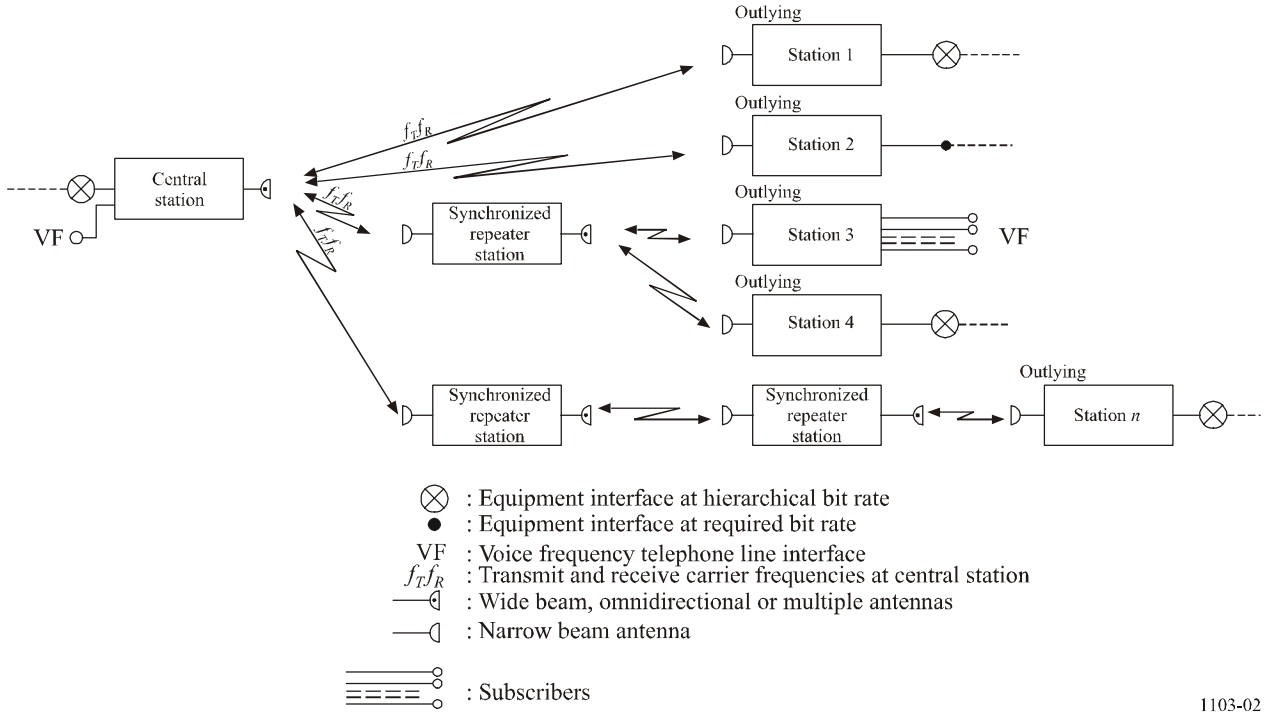
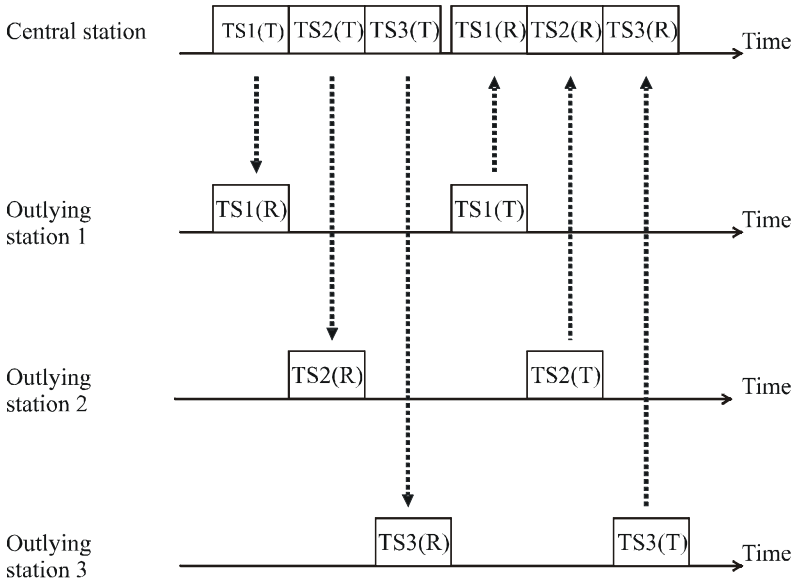
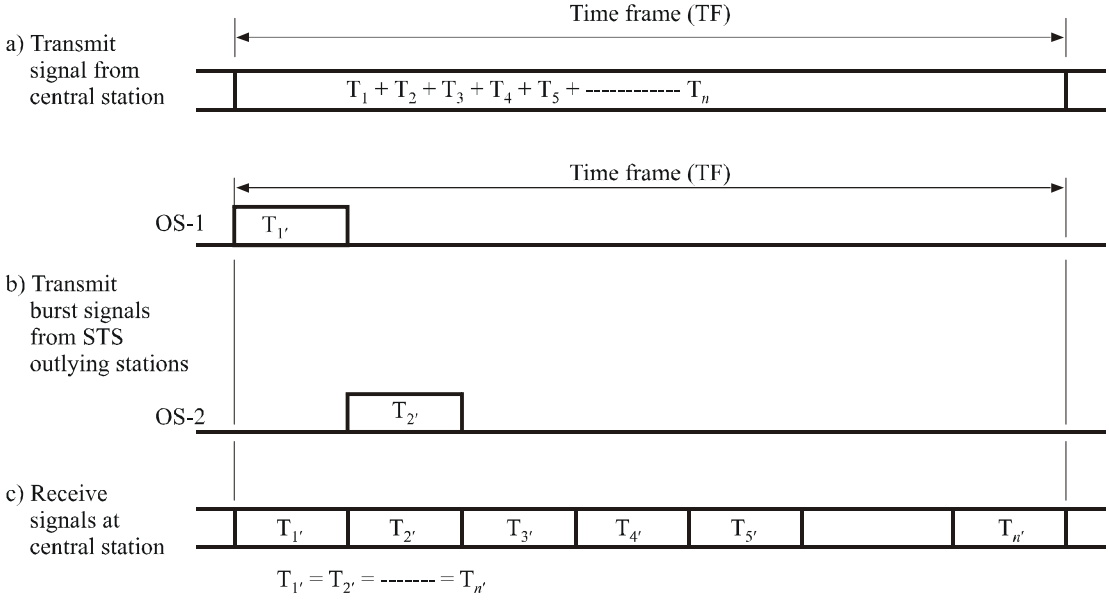


FIGURE 3

TS arrangement in a TDMA system using TDD and FDD



a) TDD system



b) FDD system

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Annex 2

Supplementary information on technical and operational aspects of FWA systems used in rural areas

1 General

It is necessary to reduce to a minimum the cost of establishing the infrastructure required for systems used in rural areas. This infrastructure includes, in particular:

– the provision of adequate access roads;

– the provision of housing for the equipment, and if necessary, maintenance facilities such as accommodation for maintenance personnel;

– the provision of accommodation for power supplies, together with fuel tanks, if necessary;

– the provision of antenna supports, etc.

In existing fixed wireless systems, the cost for this infrastructure has often occupied a very high proportion of the expenditure.

It may be noted, that in certain cases (when crossing marshy land, deserts, mountainous regions or foreign territory) the use of trans-horizon radio-relay systems working in a relatively low frequency band may be advantageous, since this will avoid the provision of stations remote from important centres of population without necessitating a large installation. In these cases solid-state components might not be suitable for the transmitter power-amplifier.

While it is generally difficult to forecast the long-term requirements of traffic demands for trunk links or access links in rural areas, the choice of system capacity is an economic optimum based on such forecasts. An initial installation of equipment will be uneconomic if its final capacity exceeds future requirements. On the other hand, replacement of an initially installed smaller system, when its capacity becomes inadequate, should only be necessary after several years' growth. A higher capacity system will then be justified, and the initial equipment can be recovered for use on another light-traffic link. Moreover, considering the broadband demand in the future, scalable systems are desirable.

2 Frequency band consideration

It is outside the scope of this Recommendation to identify any preferred frequency bands below 3 GHz for FWA systems used in rural areas. The information in Table 1 of Recommendation ITU-R F.746 would be useful for system designers for their consideration on the choice of the frequency band as well as the RF channel arrangements.

Also, Recommendation ITU-R F.1401 provides considerations for the identification of possible frequency bands for FWA and related sharing studies.

3 Antennas

The antennas at the subscriber stations should be sturdy and with a small surface area exposed to the wind. When considering the difficulties of access to remote sites, the need for reliability is paramount. Yagi antennas, if well constructed, are a good solution at frequencies up to about 1.5 GHz. At higher frequencies, other types of antenna such as a helix or a dipole array with a reflector may be used, depending on the gain required and the frequency used. Horn antennas have

proved to be a good compromise between gain, reliability and cost at frequencies at or above 1.5 GHz.

The use of the same antenna for transmission and reception is generally more economical for FDD systems, but in such cases a larger frequency separation must be adopted to avoid blocking the receiver (e.g. 3% to 5% of the mean frequency). However, technical difficulties might arise from the adoption of too large a frequency separation because of the bandwidth limitation of some antennas. For TDD systems, the same antenna is used for both transmission and reception so that it can apply the simpler and more economical antenna configuration.

In a multiple access system, the antenna(s) at the central station (where all the subscribers in the service area are concentrated) should be chosen so that their radiation characteristics are as closely matched as possible to the geographical area to be covered or distribution of subscriber stations.

Repeater stations have two antennas. The most common configuration would be a directional antenna directed towards the central station and an omnidirectional or possibly a wide-beam antenna to serve local subscriber stations, and if necessary, for linking with other repeaters.

The use of directional antennas at the subscriber station provides for more efficient use of the available radio spectrum by minimizing mutual interference.

4 Power supply

In general, dynamic sources of energy (generator sets) should not be used owing to the amount of maintenance required.

Solar energy is particularly attractive, although its use may restricted by the climatic conditions prevailing in certain areas.

For a TDMA system, power saving is achieved because the transmitter is switched on only for the duration of the active time slots. Additional power savings can be achieved if the receiver is switched off when idle, although this would require the use of working cycles compatible with the signalling philosophy adopted.

5 Installation

The radio equipment may be placed in a cabinet either at the top of the support structure carrying the antennas, which reduces cable losses, but makes installation and maintenance more difficult, or at the foot of the support structure so as to facilitate these functions. If the cabinet contains both radio and line interface equipment, then installation at the foot of the support is the only practical solution. In general, the equipment should be small, lightweight, robust and easy to install even in hostile environments.

Equipment for outdoor installation should operate reliably over a wide temperature range or high humidity. Dust-proof construction is also required in areas such as desert. Alternatively, the equipment may have to be installed in shelters.

The above information is applicable to the installation of equipment at the subscriber locations or at the repeater site. However, the infrastructure required for the radio equipment of the central station may be greater since the base equipment is more bulky, the power consumption higher, etc.

6 Maintenance

Since it may often be difficult to obtain access to equipment providing service in rural areas, the equipment should be as reliable as, or more reliable than, cable systems. Some administrations have used systems that have been found to have a mean time between failures of more than 10 years for subscriber stations.

In addition, since the technical skills available to maintain the equipment in remote locations may be limited, design should be such that field maintenance can be carried out by card or complete unit replacement. Field adjustment should be minimized, if not eliminated.

The operation system to monitor and test the network elements is greatly useful for maintenance.