RECOMMENDATION ITU-R M.1040

PUBLIC MOBILE TELECOMMUNICATION SERVICE WITH AIRCRAFT USING THE BANDS 1 670-1 675 MHz AND 1 800-1 805 MHz

(Question ITU-R 74/8)

(1994)

The ITU Radiocommunication Assembly,

considering

a) that user demand has been expressed for an automated airborne voice/data public correspondence system which should be capable of providing adequate capacity in all regions of operation;

b) that public mobile telecommunication services, i.e. services for aeronautical public correspondence via radio stations connected to the public-switched telephone network are (or will be) in operation in a certain number of countries;

c) that the bands 1 670-1 675 MHz and 1 800-1 805 MHz are intended for use, on a worldwide basis, by administrations wishing to implement aeronautical public correspondence (see No. 740A of the Radio Regulations (RR));

d) that it is essential that such systems be fully compatible with other systems utilized on board aircraft, especially those which provide safety services;

e) that worldwide system compatibility/inter-operability is desirable in order to maximize the possibilities of operational utilization of the systems,

recommends

1. that the system characteristics of a worldwide public mobile telecommunication service with aircraft should be those indicated in Annex 1 to this Recommendation;

2. that due consideration must be given to the necessity for the Terrestrial Flight Telecommunication System (TFTS) to be fully compatible with other systems on board aircraft, especially those which provide safety services. This may require operational tests to be conducted prior to placing TFTSs into operation to confirm that interference-free operation is possible.

ANNEX 1

1. Introduction

A public mobile telecommunication service with aircraft will be provided by a digital cellular system known as the Terrestrial Flight Telecommunication System (TFTS).

The TFTS system complies also with the standards of the Airlines Electronic Engineering Committee (AEEC) and the European Airlines Electronics Committee (EAEC) for the airborne equipment.

This system enables the efficient use of the frequency spectrum, provides comprehensive service area coverage based on a cellular network, facilitates maximum call continuity and gives access to at least 4 voice, data or facsimile circuits from each aircraft terminal, while keeping the weight, power and heat generation of on-board equipment to a minimum.

2. Services

2.1 General

The TFTS provides the following types of communications:

– air-to-ground telephony including dual tone multi-frequency (DTMF) procedures;

– facsimile, data and paging;

– additional services as ground-to-air calls by means of paging.

The non-speech services can operate at user data rates up to 4.8 kbit/s.

The TFTS system allows the passengers on board to communicate during all phases of the flight (provided the ground network ensures the coverage).

The charging is made by means of credit cards.

2.2 Access

The system provides digital, automatic, full duplex and high quality communications with direct-dial access to the existing public telephone or data networks including Integrated Services Digital Networks (ISDN).

It imposes no limitations in call destination other than those existing in the fixed networks.

The dialling procedure is the same as for international direct dialling (ITU-T Recommendation E.164). (That is, beginning by the country code.)

The design of the system ensures that no modification of the national PSTNs/ISDNs will be required (i.e. the public network beyond the ground station termination).

The system uses the same air-to-ground radio interface over the entire system coverage area. The selection of a ground station to be used by a given aircraft is based on criteria of system efficiency, and not based on the preferential use of a ground station.

The system provides the capability for handover between ground stations of all types.

3. Technical description

A summary of the TFTS main technical parameters is given in Table 1.

3.1 Frequency plan

In accordance with RR No. 740A, the following frequency bands are identified for the direction indicated:

1 670-1 675 MHz for ground-to-air transmissions;

1 800-1 805 MHz for air-to-ground transmissions.

3.2 Type of access and frame structure

The system uses time division multiplex (TDM) combined with frequency division multiplex (FDM) for the ground-to-air link and time division multiple access (TDMA) for the air-to-ground link.

The gross bit rate on each carrier is of 44.2 kbit/s allowing for four to sixteen traffic channels on the same carrier.

The system is intended to transmit speech using 9.6 kbit/s voice codecs. However, provision is made for other access types for data and lower bit rate speech codecs.

The frame structure is designed in such a way that it permits the simultaneous use of codecs of different rates.

TABLE 1

TFTS – Main parameters

1.	Frequency	
1.1	Ground transmit band	1 670-1 675 MHz
1.2	Airborne transmit band	1 800-1 805 MHz
2.	Channelling	
2.1	Ground transmit channel "*n*"	1 670 + *n*/33 MHz
2.2	Airborne transmit channel "*n*"	1 800 + *n*/33 MHz
2.3	Number of channels (*n* = 1-164)	
2.4	Channel width	30.30 kHz
2.5	Frequency tolerance	2 parts in 10^{-7}
3.	En-route ground station (typical example)	
3.1	Spacing between adjacent GS	380 km
3.2	Coverage of one station	125 000 km^2
3.3	Range criterion for handover	240 km
4.	Operational heights	
4.1	En-route stations	15- 43 kft
4.2	Intermediate stations	0-15 kft
4.3	Airport stations	0 ft
5.	Speech coding	
5.1	Output codec rate	9.6 kbit/s
5.2	Codec frame duration	20 ms
6.	Power output - e.i.r.p.	
6.1	En-route stations	–1 to 19 dBW
6.2	Intermediate stations	–11 to 9 dBW
6.3	Airport stations	–11 to 9 dBW
6.4	Airborne stations (1 dB antenna gain)	–69 to 11 dBW
7.	Modulation	
7.1	Method: π/4 shifted differential QPSK (π/4 DQPSK)	
7.2	3 dB bandwidth of Tx spectrum	22.1 kHz
7.3	Bit rate	44.2 kbit/s
8.	Signal structure	
8.1	Bit time	22.62 µs
8.2	Slot length	208 bits
8.3	Slot time	4.706 ms
8.4	Frame length	17 slots
8.5	Frame duration	80 ms
8.6	Number of traffic bits/slot	192 bits

The frames are constituted of 17 timeslots of 4.706 ms, giving a total duration of 80 ms. Sixteen timeslots are used for traffic (4 per 9.6 kbit/s traffic channel), and one for control. The frames are organized in superframes of 20 frames.

The traffic channels contained in a frame of a specific carrier in a ground station (GS) can be allocated to several different aircraft.

The aircraft station (AS) periodically scans the GS carriers and extracts control information by means of a dedicated scanning receiver. This permits the AS to select the optimum GS and carrier when initiating or handing over a call.

3.3 Modulation characteristics

The carrier is modulated at a rate of 44.2 kbit/s using a π/4 shifted differential quadrature phase shift keying modulation (π/4 DQPSK).

The in-band RF spectrum mask is presented in Table 2.

TABLE 2

TFTS – In-band RF spectrum mask

Frequency (kHz)	Level (dB)
± 11.31	+1
± 14.05	–20
± 15.6	–43
± 30.0	–45
± 60.0	–49
± 120.0	–65
± 5 000.0	–65

Note 1 – The output in-band spectrum shall fall within the mask defined by joining with straight lines the points listed in Table 2. Frequency shall be measured from the nominal value and amplitude from the level at the nominal frequency.

3.4 Ground station and aircraft characteristics

3.4.1 Ground stations

There are three types of ground stations in the TFTS network:

– *En-route GS*

The en-route (ER) GSs are used when aircraft are at cruising altitude, i.e. at heights between 15 and 43 kft. It is envisaged that the ER/GSs are to be installed within the coverage area spaced at approximately 380 km intervals in a nearly hexagonal pattern.

The range covered by ER/GSs is approximately 240 km (nominal value). The adjacent cells overlap each other in order to facilitate handover.

In the horizontal plane, the ER/GSs have an e.i.r.p. in the range +29 to +49 dBm per channel which is manually adjustable.

– *Intermediate GS*

The intermediate (INT) GSs are used when aircraft are taking off or landing, i.e. at heights between 0 and 15 kft and for ranges up to about 50 km. INT/GSs are to be located in the vicinity of airports.

In the horizontal plane, the INT/GSs have an e.i.r.p. in the range +19 to +39 dBm per channel which is manually adjustable.

– *Airport GS*

The airport (AP) GSs are used when aircrafts are on the ground. AP/GSs are to be located in the airport area or the vicinity can be co-sited with the INT/GS. The range covered by an airport GS is about 5 km.

In the horizontal plane, the AP/GSs have an e.i.r.p. in the range +19 to +39 dBm per channel which is manually adjustable.

3.4.2 GS organization and siting

Ground stations are connected to a ground switching centre controller (GSC) which provides the interface with the fixed networks and manages the GS communications. A group of ground stations linked to the same GSC constitutes a ground station system (GSS).

3.4.3 Aircraft stations (AS)

The AS is capable of transmitting with a maximum e.i.r.p. of +41 dBm in the horizontal plane. The AS periodically adjusts its RF transmitted power under control of the GS.

3.4.4 Doppler shift

The TFTS system makes no correction for the Doppler shift as it is small (1.8 kHz max) in proportion to the channel spacing.

3.5 Antenna characteristics

The airborne antenna is near torroidal with a gain of more than 0 dBi and not exceeding 2.5 dBi in the horizontal plane.

The ER/GS and INT/GS antennas are omnidirectional in the azimuth plane and have an 8 dBi minimum gain near 0° elevation angle.

No pattern is defined for AP/GS antennas, as these could be directive or have some special radiation pattern according to their location.

The polarization is vertical.

3.6 Link budget

A typical link budget for a ground-to-air transmission between an aircraft in limit of a cell (240 km) and an en-route ground station is presented in Table 3.

TABLE 3

TFTS – Typical air-to-ground link budget

a)	
Aircraft Tx output	+44 dBm
Diplexer and cable losses	–4 dB
AS antenna gain	+1 dBi
Path loss (240 km)	–144 dB
GS antenna gain	+8 dBi
Rx loss at GS	–4 dB
Net signal received power (LNA input)	–99 dBm
b)	
Noise per hertz (at $T = 290$ K)	–174 dBm
Bit rate (44.2 kbit/s)	+46.4 dBm
Rx noise figure	+3 dB
E_b/N_0 for BER 10^{-3}	+11 dB
Required Rx sensitivity	–113.6 dBm
Margin	+14.6 dB

4. Implementation of the ground network in Europe

The TFTS standard specifying this system has been developed by the European Telecommunications Standards Institute (ETSI) for the radio link and the ground network parts.

In Europe, a continuous coverage will be provided for aircraft flying at altitudes between 15 kft and 43 kft.

The en-route ground stations giving this coverage are located in such a way that they also ensure a lower altitude coverage in the vicinity of the main European airports, therefore limiting the need to install intermediate ground stations.

The frequency plan is established in such a manner that GSs operating on the same radio channels are spaced by at least 900 km (distance of visibility at the altitude of 43 kft), and that GSs operating on adjacent channels (separated by 30.3 kHz) are spaced by at least 700 km.

The ground stations operate with radio channels spaced by 60.6 kHz in order to reduce interference problems for aircraft within the same cell.