RECOMMENDATION ITU-R S.1001*

Use of systems in the fixed-satellite service in the event of natural disasters and similar emergencies for warning and relief operations

(1993)

The ITU Radiocommunication Assembly,

considering

a) that reliable and rapid deployment of telecommunication equipment is essential for relief operations in the event of natural disasters and similar emergencies;

b) that inherent to natural disaster events is the unpredictability of the site location thus implying the need for prompt on-site transportation of the telecommunication equipment;

c) that satellite transmission using transportable earth stations is invaluable and at times is the only viable solution to provide emergency telecommunication services for warning and relief operations;

d) that the World Radio Conference (Geneva, 1979) has adopted Recommendation No. 1;

e) that the telecommunication equipment might perform a variety of functions including, but not limited to, voice communication, field reporting, data collection and in some instances video transmission primarily for aerial site survey,

recommends

1 that when planning the use of systems in the fixed-satellite service for warning and relief operations in the event of natural disasters and similar emergencies, the material in Annex 1 should be taken into consideration;

2 that the following Notes should be regarded as part of this Recommendation:

NOTE 1 – The logistics of the transportation, installation and operation of the telecommunication equipment requires careful consideration in order to maximize the system performance in terms of reliability and deployment rapidity.

NOTE 2 – Although the use of transportable earth stations for disaster management makes it impractical to undertake detailed prior coordination and interference assessment, attention should be paid to these aspects when using shared frequency bands.

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* Radiocommunication Study Group 4 made editorial amendments to this Recommendation in 2001 in accordance with Resolution ITU-R 44 (RA-2000).

ANNEX 1

The use of small earth stations for relief operation in the event of natural disasters and similar emergencies

1 Introduction

In the event of natural disasters, epidemics and famines, etc., the most urgent need is for a reliable communication link for use in relief operations. To set up these communications using the fixed-satellite service (FSS), it is desirable that a transportable earth station, with access to an existing satellite system, should be available for transportation to, and installation at, the disaster area.

To establish such a communication service, any satellite system compatible with the technical characteristics of the transportable earth station can be used.

2 Basic considerations

2.1 Required services and associated channel capability

The communication link for the relief operation connects the disaster area with designated relief centres, and its basic transmission capability would be composed of telephony circuits (including teletype and facsimile) and an engineering service channel.

In addition, because a real time aerial site survey of the disrupted area is also considered to be highly desirable in order to better coordinate relief operations (priority evaluation), in some instances a one-way 2.048 Mbit/s, video-compressed channel could also be needed. Furthermore, a network of unattended platforms for continuous monitoring of main environmental data (1.2 kbit/s average throughput) on specific risk parameters could be usefully integrated in the emergency communications network covering the whole concerned territory, in order to help in the timely location of the disaster area.

2.2 Circuit quality

The quality of circuits for emergency relief operations need not necessarily be of the high quality recommended by the ITU for the FSS. An equivalent weighted signal-to-noise ratio of about 30 dB for a voice channel would appear to provide acceptable voice intelligibility for this purpose.

2.3 Selection of frequency band

For relief operation the use of the 6/4 GHz band is desirable. Where suitable satellites are available, it is preferable that relief operations should be conducted in bands which are not generally shared with terrestrial facilities. Bands such as 14/12 GHz and 30/20 GHz may be suitable in some circumstances.

2.4 Associated earth station

The transportable earth terminal could operate with any suitable existing earth station provided it is suitably equipped. Suitable earth stations would need to be identified so that they may be provided, in advance, with the additional equipment.

3 Preferred modulation methods

The choice of the form of modulation best suited to a system using a transportable earth station must take account of the power-limited condition of the downlink together with the need for flexibility of access to the satellite system.

A station of this type might employ frequency division multiplex FM, or single-channel-per-carrier (SCPC), CFM, PCM/PSK, delta-modulated PSK and low rate encoding LRE/PSK.

The single-channel-per-carrier PCM/PSK is in operation already, and is provided on a global basis. Companded single-channel FM, delta modulation (DM/PSK) and LRE/PSK systems are more effective in a power-limited environment. System efficiency may be further improved by use of forward error-correction coding techniques.

Examples of the required satellite e.i.r.p., the earth station e.i.r.p. and the bandwidth required for most of these modulation methods in the 6/4 GHz band are shown in Table 1. However it should be emphasized that this Table does not reflect all the advanced techniques available at the moment.

TABLE 1

Examples of transmission system parameters in 6/4 GHz band

G/*T* ratio dB(K^{-1}) (diameter)	Type of modulation	Bandwidth per carrier (kHz)	Satellite e.i.r.p. per carrier (dBW)	Earth station e.i.r.p. per carrier (dBW)	Earth station transmit power per carrier (W)	Circuit quality (clear-sky condition)
17.5 (2.5 m)	FDM-FM (for 6 ch)	250	14	57.5	45	*S*/*N* 30 dB
	SCPC 64 kbit/s PCM-QPSK	45	11	54.5	22	Bit error ratio: 10^{-4}
	SCPC 32 kbit/s ΔM-BPSK	45	5	48.5	5.6	Bit error ratio: 10^{-3}
	SCPC companded FM	30	1	44.5	2.2	*S*/*N* 22 dB (without compandor)
23.5 (5 m)	FDM-FM (for 6 ch)	250	8	57.5	11	*S*/*N* 30 dB
	SCPC 64 kbit/s PCM-QPSK	45	5	54.5	5.6	Bit error ratio: 10^{-4}
	SCPC 32 kbit/s ΔM-BPSK	45	–1	48.5	1.4	Bit error ratio: 10^{-3}
	SCPC companded FM	30	–5	44.5	0.6	*S*/*N* 22 dB (without compandor)

NOTE 1 – In the FDM-FM and SCPC companded FM systems, the use of a threshold extension demodulator is assumed.

NOTE 2 – Values of satellite e.i.r.p. and earth station e.i.r.p. are for a small earth station with antenna elevation of 10° excluding any margin. Earth stations with which the small earth station is communicating have a *G*/*T* of 40.7 dB(K^{-1}).

NOTE 3 – Satellite transponder characteristics are similar to those of the Intelsat-V global beam transponder and the transponder gain is assumed such that the difference between earth station e.i.r.p. and the corresponding satellite e.i.r.p. is 65 dB.

NOTE 4 – In addition to FDM-FM, time division multiplexing techniques should also be considered for multichannel applications.

NOTE 5 – Other SCPC encoding techniques such as LRE/PSK at 16 kbit/s should also be considered for use in these applications.

4 Characteristics of the transportable earth station

4.1 System *G*/*T* ratio

In the 4 GHz band, it will be reasonable to consider a system *G*/*T* in the range of 17.5 to 23.5 dB(K^{-1}) as an objective. Assuming a low noise amplifier with a noise temperature of about 50 K (uncooled FET) and an antenna elevation angle of 10°, these values correspond to antenna diameters in the range 2.5 m to 5 m approximately.

In the 11 to 13 GHz bands, typical receiver noise temperatures range from 100 K to 150 K (FET amplifier). With antennas having diameters around 3 m, *G*/*T* in the order of 23 dB(K^{-1}) could be achieved.

In the 20 GHz band, it will be reasonable to consider a system *G*/*T* in the range of 14.5 to 24.5 dB(K^{-1}) as an objective. Assuming an FET amplifier of noise temperature of about 750 K, these values correspond to antenna diameters in the range of 1 m to 3 m approximately.

4.2 Earth station e.i.r.p.

The earth-station e.i.r.p. depends on the type of modulation, the transmitting channel capacity, and the satellite characteristics.

However, in case of multi-carrier operation, such as the SCPC transmission, the maximum output power of the transmitter must take account of a back-off level to reduce intermodulation noise to an acceptable level. Table 1 shows typical e.i.r.p. required for the transportable earth station.

5 Configuration of the transportable earth station

The earth station may be divided into the following major subsystems:

– antenna,

– power amplifier,

– low noise receiver,

– ground communication equipment,

– control and monitoring equipment,

– terminal equipment, including teleprinters, facsimile and telephones,

– support facilities.

5.1 Weight and size

All the equipment, including shelters, should be capable of being packaged into units of weight which can be handled by a few persons. Furthermore, the total volume and weight should not be in excess of that which could be accommodated in the luggage compartment of a passenger jet aircraft such as a Boeing B707 (allowable weight 7 000 kg) or a Douglas DC8-62 (allowable weight 10 000 kg). This is readily attainable with present-day technology.

5.2 Antenna

One of the major requirements for the antenna is ease of erection and transportation. For this purpose, the antenna reflector could consist of several panels made of light material such as fibre reinforced plastic or aluminium alloy. The use of an antenna of a diameter from 2.5 to 5 m is foreseen for use in the 6/4 GHz band. However, for other frequency bands, antenna construction requirements are eased because smaller antenna sizes can be used.

The main antenna reflector may be illuminated by a front-fed horn or a feed which includes a sub-reflector. The latter type may have a slight advantage in G/T performance, since the curvature of both the sub-reflector and main reflector can be optimized, but ease of erection and alignment may take precedence over G/T considerations.

A manual or automatic pointing system may be provided commensurate with weight and power consumption, by monitoring a carrier signal from the satellite, having a steerable range of approximately $\pm 5°$.

5.3 Power amplifier

Air-cooled klystron and TWT (helix-type) amplifiers are both suitable for this application, but from the point of view of efficiency and ease of maintenance, the former is preferred.

Although the instantaneous transmission bandwidth is small, the output amplifier may need to have the capability of being tunable over a wider bandwidth, e.g. 500 MHz, since the available satellite channel may be anywhere within this bandwidth.

For power requirements less than 15 W, a solid state power amplifier (FET) would also be suitable.

In the 30 GHz band, IMPATT, TWT and klystron amplifiers are suitable for this application.

5.4 Low-noise receiver

Because the low-noise receiver must be small, light and be capable of easy handling with little maintenance, an uncooled low noise amplifier is the most desirable.

A temperature of 50 K has been realized and even lower temperatures are expected in the future in the 4 GHz band. An FET amplifier is more suitable from the point of view of size, weight and power consumption than a parametric amplifier. A noise temperature of 50 K in the 4 GHz band and 150 K in the 12 GHz band has been realized by FET amplifiers. In the 20 GHz band, an FET amplifier with a noise temperature of 300 K or less at room temperature has been realized.

6 Examples of transportable earth station realizations and system implementation

6.1 Small transportable earth stations

In the 6/4 GHz band, a number of transportable earth stations are operating now with various antenna diameters. In the 14/12 GHz band, most of the transportable stations have antennas with around 3 m diameters.

6.1.1 An example of a small transportable earth station for operation at 6/4 GHz

An air-transportable earth station, which may also be carried by an 8-ton truck, has been manufactured using the principles outlined in § 5 and satisfactory performance has been achieved.

The station has a 3 m diameter antenna, a peak e.i.r.p. of about 67 dBW and a G/T of about 18 dB(K^{-1}). The total weight is 7.0 tons and the power requirement, including air conditioning, is 12.5 kVA. The reflector is in one piece and the total setting up time for the system is about 1 hour using three persons. The station uses FDM-FM and provides 132 two-way channels using a shaped beam transponder similar to the Japanese CS-3 (Communication Satellite-3) transponder with a channel signal-to-noise ratio of about 43 dB*.

6.1.2 Examples of air transportable and vehicle equipped small earth stations in the 14/12 GHz band

Various types of small earth station equipment have been developed for the use of new satellite communication systems in the 14/12 GHz band in Japan. For implementing small earth stations, efforts have been made to decrease the size and to improve transportability so as to ease their use for general applications. This allows the occasional or temporary use of these earth stations for relief operation elsewhere in the country or even worldwide. Such temporary earth stations are installed either in a vehicle or use portable containers with a small antenna. It is thus possible to use them in an emergency.

The vehicle equipped earth station in which all the necessary equipment is installed in the vehicle, e.g. a four-wheel drive van, permits operation within 10 min of arrival including all necessary actions such as antenna direction adjustments.

A portable earth station is disassembled prior to transportation and reassembled at the site within approximately 15 to 30 min. The size and weight of the equipment generally allow it to be carried by hand by one or two persons, and the containers are within the limit of the IATA checked luggage regulations. Total weight of this type of earth station including power generator and antenna assembly is reported to be as low as 150 kg, but 200 kg is more usual. It is also possible to carry the equipment by helicopters.

Examples of small transportable earth stations for use with Japanese communication satellites in the 14/12 GHz band are shown in Table 2.

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* *Note from the Director, Radiocommunication Bureau* – The information contained in the second paragraph of § 6.1.1 of this Recommendation has been updated based on the proposal from the Japanese Administration which was received after the approval under former ex-CCIR Resolution 97 (Düsseldorf, 1990).

TABLE 2

Example of small transportable earth stations for the 14/12 GHz band

Example No.	1	2	3	4	5	6
Type of transportation	Vehicle equipped			Air transportable		
Antenna diameter (m)	2.6 × 2.4	1.8	1.2	1.8	1.4	1.2
e.i.r.p. (dBW)	72	70	62.5	70	64.9	62.5
RF bandwidth (MHz)	24-27	20-30	30	20-30	30	30
Total weight	6.4 tons	6.0 tons	2.5 tons	275 kg	250 kg	200 kg
Package: – Total dimensions (m) – Total number – Max. weight (kg)	 – – –	 – – –	 – – –	 <2 10 45	 <2 13 34	 <2 8 20
Capacity of engine generator (kVA)	7.5	10	5	3	0.9-1.3	1.0
Required number of persons	1-2	1-2	1-2	2-3	2-3	1-2

6.1.3 Examples of small transportable earth stations for operation at 30/20 GHz

Two types of 30/20 GHz small transportable earth stations, which can be transported by a truck or a helicopter, have been manufactured and operated satisfactorily in Japan.

Examples of small transportable earth stations for operation at 30/20 GHz are shown in Table 3.

6.2 Example of an emergency network and associated earth stations in the 14/12.5 GHz band

An emergency satellite network has been designed and implemented in Italy for operation in the 14/12.5 GHz frequency band via a EUTELSAT transponder. This dedicated network, which is based on the use of wholly digital techniques, provides emergency voice and data circuits and a time shared compressed video channel for relief operations and environmental data collection. The network architecture is based on a dual sub-networking star configuration, for the two services and makes use of a TDM-BPSK and an FDMA-TDMA-BPSK dynamic transmission scheme, respectively for the outbound and inbound channels. The ground segment is composed of: a master common hub station for the two star networks, which is a fixed-earth station having a 9 m antenna and a 80 W transmitter; a small number of transportable earth stations, having antennas of 2.2 m and 110 W transmitters; a number of fixed data transmission platforms with 1.8 m dishes and 2 W solid state power amplifier transmitters. These platforms have a receive capability (G/T of 19 dB/K), in order to be remotely controlled by the master station, and their average transmit throughput is 1.2 kbit/s.

The transportable earth stations are mounted on a lorry, but if necessary, can also be loaded in a cargo helicopter for fast transportation. They have a G/T of 22.5 dB(K^{-1}) and are equipped with two sets of equipment each containing one 16 kbit/s (vocoder) voice channel and one facsimile channel at 2.5 kbit/s. These earth stations which are also able to transmit a compressed video channel at 2.048 Mbit/s in SCPC-BPSK, are remotely controlled by the master station. The major features of this *ad hoc* emergency network are summarized in Table 4.

TABLE 3

Examples of small transportable earth stations

Operating frequency (GHz)	Total weight (tons)	Power requirement (kVA)	Antenna		Maximum e.i.r.p. (dBW)	G/T dB(K^{-1}))	Type of modulation	Total setting-up time (h)	Normal location of earth station
			Diameter (m)	Type					
30/20	5.8	12	2.7	Cassegrain	76	27	FM (colour TV 1 channel) (1) or FDM-FM (132 telephone channels)	1	On a truck
	2	9	3	Cassegrain (2)	79.8	27.9	FM (colour TV 1 channel) (1) and ADPCM-BPSK-SCPC (3 telephone channels)	1	On the ground
	1	1 (3)	2	Cassegrain	56.3	20.4	ADM-QPSK-SCPC (1 telephone channel)	1.5	On the ground
	0.7	3	1	Cassegrain	59.9	15.2	FM-SCPC (1 telephone channel) or DM-QPSK-SCPC (1 telephone channel)	1	On a truck

(1) One-way.

(2) The reflector is divided into three sections.

(3) Excluding power for air conditioning.

TABLE 4

Example of an emergency satellite communication network operating at 14/12.5 GHz

Station designation	Antenna diameter (m)	G/T (dB(K^{-1}))	Trans-mitter power (W)	Primary power requirement (kVA)	Transmission scheme		Service capability
Master	9.0	34.0	80	15.0	Tx	512 kbit/s-TDM/BPSK (+ FEC 1/2)	12 × 16 kbit/s (vocoder) voice channels
					Rx	"*n*" × 64 kbit/s-FDMA/TDMA/BPSK (+ FEC 1/2) and 2.048 Mbit/s-SCPC/QPSK (+ FEC 1/2)	12 × 2.4 kbit/s facsimile channels 1 × 2.048 Mbit/s video channel
Peripherals (transpor-table)	2.2	22.5	110	2.0	Tx	64 kbit/s-TDMA/BPSK (+ FEC 1/2) and 2.048 Mbit/s-SCPC/QPSK (+ FEC 1/2)	2 × 16 kbit/s (vocoder) voice channels 2 × 2.4 kbit/s facsimile channels
					Rx	512 kbit/s-TDM/BPSK (+ FEC 1/2)	1 × 2.048 Mbit/s video channel
Unattended platforms	1.8	19.0	2	0.15	Tx	64 kbit/s-TDMA/BPSK (+ FEC 1/2)	1 × 1.2 kbit/s data transmission channel
					Rx	512 kbit/s-TDM/BPSK (+ FEC 1/2)	