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

S Series

Fixed-satellite service

International Telecommunication Union

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REPORT ITU-R S.2151

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

(2009)

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1 Introduction

This Report describes how fixed-satellite service (FSS) systems can provide disaster relief radiocommunications.

When developing a new FSS system in preparation to respond to natural disasters, the technical characteristics of the satellite(s) to be accessed should be considered in the design of such FSS system. In § 2 of this Report, the summary of system design and examples of characteristics of systems using small aperture earth stations are provided. Additionally, since FSS systems are inherently suitable for data delivery, they are expected to be utilized for warning operations. In § 3 of this Report, the outline of an earthquake early warning system is provided as an example of warning operations using FSS system.

FSS systems operate in general on frequency bands as identified in Recommendation ITU-R S.1001.

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

2.1 Introduction

In the event of natural disasters, epidemics and famines, etc., there is an urgent need for a reliable telecommunication link for use in relief operations. Satellite appears as the most appropriate means to quickly set up a telecommunication link with remote facilities. The main requirements of such a satellite system are discussed here. Assuming the system is to operate in the FSS, it is desirable that a small earth station, such as a fixed VSAT, a vehicle-mounted earth station or a transportable earth station, with access to an existing satellite system, should be available for transportation to, and installation at, the disaster area. It is also desirable that the system relies on widespread standards so that:

– equipment is readily available;
– interoperability is ensured;
– reliability is ensured.

This § 2 provides material that may be useful in planning the use of systems in the FSS in the event of natural disasters and similar emergencies for warning and relief operations.

2.2 Basic considerations

2.2.1 Required services

The basic telecommunication architecture for relief operations should be composed of a link connecting the disaster area with designated relief centres, and its basic telecommunication services should comprise at least telephony, any kind of data (IP, datagrams, facsimile, ...), video. For such transmission, digital transmission technologies are employed in most cases.

2.2.2 Channel and physical layer requirements

In digital transmissions, one means to measure the performance of the coded channel is the bit error probability (BEP). The recommended objective BEP in the FSS provided in Recommendation ITU-R S.1062 is 10^{-6} for 99.8% of time in the worst month. This BEP results both from the signal-to-noise and interference ratio (SNIR), which is the performance of the channel, and from the coding. Appropriate coding can compensate, to a certain extent, for poor channel quality but lowers the useful bit rate.

The particular conditions of transmission in the place of a disaster in case of both warning and relief operation (e.g. climate of site, nature of mission, …), which might degrade the channel quality, should be taken into account by reinforcing coding. The ideal would be to have adaptive coding, i.e. a system able to get back information from the channel and to respond by adapting the coding rate.

2.2.3 Network requirements

For relief operations, due to the essential requirement of having small antennas, it is preferable to operate the network in the 14/12 GHz band or even in the 30/20 GHz band. Although the bands such as 6/4 GHz require larger antennas, they are also suitable depending on conditions of transmission and coverage of satellite resources. In order to avoid interference, it should be taken into account that some bands are shared with terrestrial services.

The network should offer suitable quality of service. In case the network is shared with customers having non-urgent needs, the emergency operations should have absolute priority which means a "pre-emption" class of service. A fully private network, with reserved frequency bands and facilities, could be desirable.

When the number of operational earth stations is large, a network control based on demand assignment multiple access (DAMA) may be necessary.

2.2.4 Associated earth station

For (a) small earth station(s) on site, a vehicle-mounted earth station or a transportable earth station should be considered. The material provided in § 2.3 to § 2.6 may be useful for sizing of such earth stations.

For the smooth operation of earth stations in the event of a disaster, regular training for potential operators and preparatory maintenance of the equipment is essential. Particularly, special attention should be given to the inclusion of autonomous battery or power systems.

2.3 Required earth station e.i.r.p. levels and satellite resources

In § 2, required earth station e.i.r.p. levels and satellite resources are studied by link budget calculations based on the assumption that a small earth station (a fixed VSAT, a vehicle-mounted earth station or a transportable earth station) operating in the disaster area communicates with a hub earth station equipped with a larger antenna.

The choice of system parameters should be based on considerations listed in § 2.3 for the 6/4 GHz band, the 14/12 GHz and the 30/20 GHz band. The system parameters are listed in Table 1a) to 1f).

QPSK with rate 1/2 convolutional code, 3/4 convolutional code, 1/2 convolutional code + 188/204 Reed Solomon outer code and 1/2 turbo code are typical digital modulation and FEC methods commonly used for FSS satellite links. It is worth stressing that the combination of a convolutional code as the inner code with a Reed-Solomon code as the outer code is now rendered obsolete by turbo coding or low density parity check (LDPC) coding which performs better in general; the former coding scheme is surviving as a past legacy.

The antenna diameter of a small earth station (vehicle-mounted or transportable) is assumed to be 2.5 m or 5 m for the 6/4 GHz band and 1.2 m or 3 m for the 14/12 GHz band and 1.2 m or 2.4 m for the 30/20 GHz band in this example of the link budget calculation. For 14/12 GHz and 30/20 GHz stations, smaller diameter antennas may be used if appropriate measures, such as satellites with greater G/T or spread spectrum techniques are used to allow reduction of the off-axis emissions to acceptable levels.

In the 4 GHz band, a typical G/T of an earth station is 17.5 dB/K and 23.5 dB/K for the 2.5 m and 5 m antenna, respectively. In the 12 GHz band, a typical G/T of an earth station is 20.8 dB/K and 28.8 dB/K for the 1.2 m and 3 m antenna, respectively. In the 20 GHz band, a typical G/T of an earth station is 25.1 dB/K and 31.1 dB/K for the 1.2 m and 2.4 m antenna, respectively. The noise temperature of low noise amplifier is assumed to be 60 K, 100 K and 140 K for the 4 GHz band, the 12 GHz band and the 20 GHz band, respectively. Although small aperture antennas such as 45 cm, 75 cm, etc. can be used, Radio Regulations (RR) including the off-axis limitation should be considered when using those antennas. The use of small antennas may not allow meeting the off-axis emission criteria, therefore, the earth station transmit power should be reduced in order to avoid the interference to adjacent satellites and other services.

It should be noted that values of satellite e.i.r.p. and earth station e.i.r.p. are for a small earth station with antenna elevation 10° and 2 dB of the total margin.

In Table 1f), typical satellite parameters for global beams in the 6/4 GHz band, spot beams in the 14/12 GHz band and the 30/20 GHz band are provided. The “transponder gain #a” and “transponder gain #b” in Table 1f), are defined as shown in Fig. 1.

TABLE 1

Typical satellite, earth station, carrier parameter for calculation

a) Distance to GSO satellite

Elevation (degrees)	10
Distance (km)	40 600

b) Path loss (EL = 10°)

Frequency (GHz)	6/4		14/12		30/20	
	4.0	6.2	12.25	14.25	20.0	30.0
Wavelength (m)	0.08	0.05	0.02	0.02	0.02	0.01
Path loss (dB)	196.7	200.5	206.4	207.7	210.6	214.2

c) Transmission channel parameter

Modulation FEC	**QPSK 1/2 Conv.(1)**	**QPSK 3/4 Conv.(1)**	**QPSK 1/2 Conv.(1)**	**QPSK 1/2 turbo coding**	**8-PSK 2/3**
BER	10^{-6}	10^{-6}	10^{-6}	10^{-6}	10^{-6}
Required E_b/N_0 (dB)	6.1	7.6	4.4	3.1	9.0
FEC rate	0.5	0.75	0.5	0.5	0.67
Outer code rate	1.0	1.0	188/204	1.0	1.0
Number of bits in a symbol	2	2	2	2	3
Required C/N (dB)	6.1	9.4	4.0	3.1	12.0

(1) Constraint length $k = 7$.

TABLE 1 (*end*)

d) Earth station antenna gain and *G*/*T*

Frequency band (GHz)	6/4				14/12				30/20			
Antenna diameter	2.5 m		5.0 m		1.2 m		3.0 m		1.2 m		2.4 m	
Frequency (GHz)	4.0	6.2	4.0	6.2	12.25	14.25	12.25	14.25	20.0	30.0	20.0	30.0
Efficiency	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6
Antenna gain (dBi) peak	38.2	42.0	44.2	48.0	41.5	42.8	49.5	50.8	45.8	49.3	51.8	55.3
G/*T* (dB/K)	17.5		23.5		20.8		28.8		25.1		31.1	

e) HUB earth station antenna gain and *G*/*T*

Frequency (GHz)	6/4		14/12		30/20	
	4.0	6.2	12.25	14.25	20.0	30.0
Antenna gain (dBi)	55.7	59.5	57.9	59.5	58.0	61.8
HUB earth station *G*/*T* (dB/K)	35.0		35.0		35.0	
HUB earth station antenna size (m)	18 m		7.6 m		4.7 m	

f) The satellite transponder gain

Satellite (GHz)	6/4	14/12	30/20
Frequency band (GHz)	6/4	14/12	30/20
Wavelength (m)	0.05	0.02	0.01
Beam type	GLOBAL	SPOT	Multi
Satellite receive *G*/*T* (dB/K)	−13.0	2.5	11.0
Transponder saturation e.i.r.p. for single carrier (dBW)	29.0	45.8	54.5
SFD (dB(W/m^2))	−78.0	−83.0	−98.4
IBO-OBO (dB)	1.8	0.9	5.0
Gs (dB)	37.3	44.5	51.0
Transponder gain #a (dB)	146.1	174.2	200.2
Transponder gain #b (dB)	−55.3	−33.5	−14.0

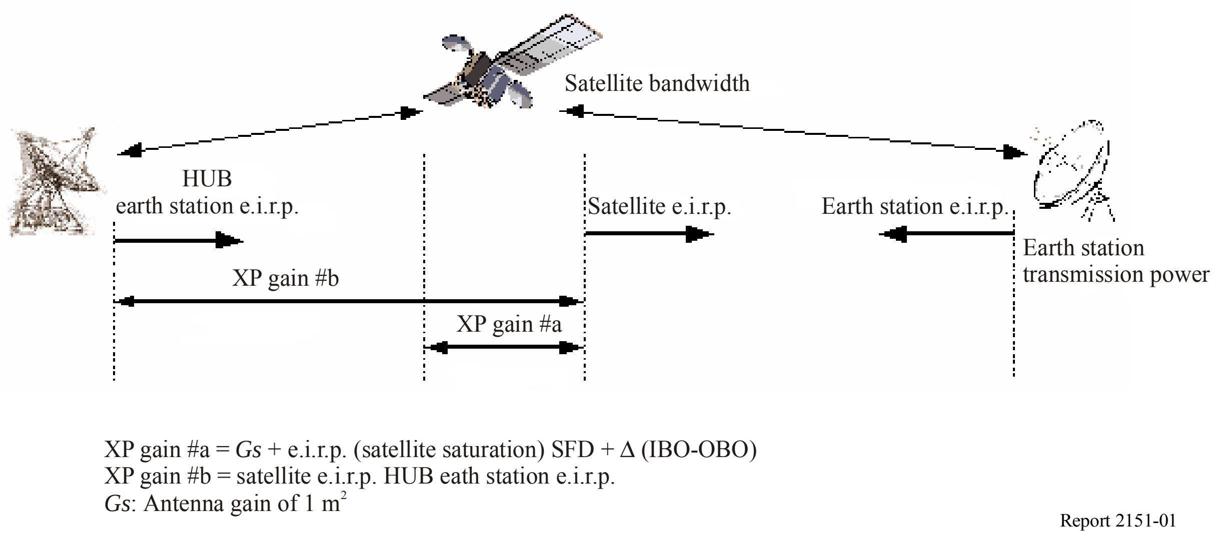
SFD: Saturation flux-density.

IBO: Input back-off.

OBO: Output back-off.

FIGURE 1

Definition of transponder gain (XP gain)



As a result of link budget calculation of the outbound (hub-to-VSAT) and inbound (VSAT-to-hub) direction, Tables 2a), 2b) and 2c) provide examples of required earth station e.i.r.p. levels and satellite resources including the required satellite e.i.r.p., the earth station e.i.r.p. and the bandwidth required for typical digital modulation and FEC methods in the 6/4 GHz band, the 14/12 GHz and the 30/20 GHz band.

TABLE 2a

Examples of the required earth station e.i.r.p. levels and satellite resources in 6/4 GHz band

IR(1)	Modulation/FEC	QPSK 1/2 Conv.(2)		QPSK 3/4 Conv.(2)		QPSK 1/2 Conv.(2)+RS		QPSK 1/2 TC	
	Antenna diameter	2.5 m	5.0 m	2.5 m	5.0 m	2.5 m	5.0 m	2.5 m	5.0 m
64 kbit/s	Allocated satellite bandwidth (kHz)	90	90	60	60	90	90	60	60
	Satellite e.i.r.p. (dBW)	6.8	0.9	8.3	2.4	6.8	0.9	8.3	2.4
	Earth station e.i.r.p. (dBW)	46.2	46.2	47.7	47.7	46.2	46.2	47.7	47.7
	Earth station transmit power (W)	3.1	0.8	4.4	1.1	3.1	0.8	4.4	1.1
1 Mbit/s	Allocated satellite bandwidth (kHz)	1 434	1 434	956	956	1 434	1 434	956	956
	Satellite e.i.r.p. (dBW)	18.8	12.9	20.3	14.4	18.8	12.9	20.3	14.4
	Earth station e.i.r.p. (dBW)	58.2	58.2	59.7	59.7	58.2	58.2	59.7	59.7
	Earth station transmit power (W)	50.3	12.6	71.1	17.8	50.3	12.6	71.1	17.8
6 Mbit/s	Allocated satellite bandwidth (kHz)	8 602	8 602	5 734	5 734	8 602	8 602	5 734	5 734
	Satellite e.i.r.p. (dBW)	26.6	20.7	28.1	22.2	26.6	20.7	28.1	22.2
	Earth station e.i.r.p. (dBW)	66.0	66.0	67.5	67.5	66.0	66.0	67.5	67.5
	Earth station transmit power (W)	302.1	75.5	426.7	106.7	302.1	75.5	426.7	106.7

(1) IR: Information rate.

(2) Constraint length $K = 7$.

TABLE 2b

Examples of the required earth station e.i.r.p. levels and satellite resources in 14/12 GHz band

IR(1)	Modulation/FEC	QPSK 1/2 Conv.(2)		QPSK 3/4 Conv.(2)		QPSK 1/2 Conv.(2)+RS		QPSK 1/2 TC	
	Antenna diameter	1.2 m	3.0 m	1.2 m	3.0 m	1.2 m	3.0 m	1.2 m	3.0 m
64 kbit/s	Allocated satellite bandwidth (kHz)	90	90	60	60	97	97	90	90
	Satellite e.i.r.p. (dBW)	14.7	7.4	16.2	8.9	13.0	5.7	11.7	4.4
	Earth station e.i.r.p. (dBW)	35.6	35.6	37.1	37.1	33.9	33.9	32.6	32.6
	Earth station transmit power (W)	0.3	0.1	0.5	0.1	0.2	0.04	0.2	0.03
1 Mbit/s	Allocated satellite bandwidth (kHz)	1 434	1 434	956	956	1 556	1 556	1 434	1 434
	Satellite e.i.r.p. (dBW)	26.7	19.4	28.2	20.9	25.0	17.7	23.7	16.4
	Earth station e.i.r.p. (dBW)	47.7	47.7	49.2	49.2	46.0	46.0	44.7	44.7
	Earth station transmit power (W)	5.3	0.9	7.5	1.2	3.6	0.6	2.7	0.4
6 Mbit/s	Allocated satellite bandwidth (kHz)	8 602	8 602	5 734	5 734	9 334	9 334	8 602	8 602
	Satellite e.i.r.p. (dBW)	34.5	27.2	36.0	28.7	32.8	25.5	31.5	24.2
	Earth station e.i.r.p. (dBW)	55.4	55.4	56.9	56.9	53.7	53.7	52.4	52.4
	Earth station transmit power (W)	32.0	5.1	45.1	7.2	21.6	3.5	16.0	2.6

(1) IR: Information rate.

(2) Constraint length $K = 7$.

TABLE 2c

Examples of the required earth station e.i.r.p. levels and satellite resources in 30/20 GHz band

IR(1)	Modulation/FEC	QPSK 1/2 Conv.(2)		QPSK 3/4 Conv.(2)		QPSK 1/2 Conv.(2)+RS		QPSK 1/2 TC	
	Antenna diameter	1.2 m	2.4 m	1.2 m	2.4 m	1.2 m	2.4 m	1.2 m	2.4 m
64 kbit/s	Allocated satellite bandwidth (kHz)	90	90	60	60	97	97	90	90
	Satellite e.i.r.p. (dBW)	25.8	25.5	27.3	27.0	24.1	23.8	22.8	22.5
	Earth station e.i.r.p. (dBW)	30.7	30.7	32.2	32.2	29.0	29.0	27.7	27.7
	Earth station transmit power (W)	0.024	0.006	0.035	0.009	0.017	0.004	0.012	0.003
1 Mbit/s	Allocated satellite bandwidth (kHz)	1 434	1 434	956	956	1 556	1 556	1 434	1 434
	Satellite e.i.r.p. (dBW)	37.9	37.6	39.4	39.1	36.2	35.9	34.9	34.6
	Earth station e.i.r.p. (dBW)	42.8	42.8	44.3	44.3	41.1	41.1	39.8	39.8
	Earth station transmit power (W)	0.4	0.1	0.6	0.1	0.3	0.1	0.2	0.05
6 Mbit/s	Allocated satellite bandwidth (kHz)	8 602	8 602	5 734	5 734	9 334	9 334	8 602	8 602
	Satellite e.i.r.p. (dBW)	45.6	45.4	47.1	46.9	43.9	43.7	42.6	42.4
	Earth station e.i.r.p. (dBW)	50.6	50.6	52.1	52.1	48.9	48.9	47.6	47.6
	Earth station transmit power (W)	2.3	0.6	3.3	0.8	1.6	0.4	1.2	0.3

(1) IR: Information rate.

(2) Constraint length $K = 7$.

As the required bandwidth shows for one direction, twice the listed value is needed for both directions. The required satellite e.i.r.p. shows the one for the downlink of outbound direction which is usually under a power limited situation at satellites. The required earth station e.i.r.p. and transmit power shows the one for the uplink of inbound direction which is usually under a power limited situation at earth stations.

Rain attenuation is not included in the above calculations. Depending on local conditions, provision for rain margin may be needed. The interference or intermodulation is not taken into account. Therefore, additional margin is needed. (See Recommendation ITU-R P.618 for the rain attenuation for local climate and Recommendation ITU-R S.1432 for the various interference criteria.)

2.3.1 Example of link budget calculation

For illustrative purpose, details of the link budget calculation of Table 2a (in case of 6 Mbit/s of 6/4 GHz band with QPSK 1/2 Conv., 2.5 m antenna) are shown in Table 3a.

A mark of (2) in Table 3a are the values listed in Table 2a as results of calculation.

TABLE 3a

The link budget calculation of Table 2a
(6 Mbit/s of 6/4 GHz band with QPSK 1/2 Conv., 2.5 m antenna)

Item	Unit	Value
A. Transmission channel parameter		
Modulation		QPSK 1/2 Conv.(1)
BER		10^{-6}
Required E_b/N_0 (dB)	dB	6.1
Required C/N (dB)	dB	6.1
B. Satellite main parameter		
SFD (beam edge)	dB(W/m^2)	−78.0
G/T (beam edge)	dB/K	−13.0
Transponder saturation e.i.r.p. for single carrier (beam edge) (dBW)	dBW	29.0
IBO	dB	−5.4
OBO	dB	−4.5
Δ(IBO-OBO)	dB	0.9
Gain of 1 square metre	dB	37.3
TP gain (#a)	dB	145.2
C. Transmission carrier parameter		
Information rate	kbit/s	6 144.0
FEC rate		0.5
RS (Reed Solomon) rate		1.0
Transmission rate	kbit/s	12 288.0
Noise bandwidth	kHz	6 144.0
Allocated bandwidth(2)	kHz	8 601.6(2)

TABLE 3a (*end*)

Item	Unit	Value	
D. Earth station main parameter			
G/*T*	dB/K	17.5 (2.5 m earth station)	35.0 (HUB earth station)
E. Link budget calculation			
		Outbound (HUB ≥ 2.5 m earth station)	**Inbound (2.5 m earth station ≥ HUB)**
1. Uplink C/N (HUB E/S -> satellite)			
HUB/earth station e.i.r.p.	dBW	81.9	66.0(2)
Free space loss (6 GHz)	dB	200.5	200.5
Satellite *G*/*T* (beam edge)	dB/K	−13.0	−13.0
C/*N* (a)	dB	29.1	13.21
2. IM (intermodulation) of earth station			
C/*N* (b)	dB	99.0	99.0
3. IM (intermodulation) of satellite			
C/*N* (c)	dB	99.0	99.0
4. Downlink C/N (satellite -> E/S)			
Satellite EIRP (beam edge)	dBW	26.6(2)	10.7
Pattern advantage etc.	dB	0.0	0.0
Free space loss (4 GHz)	dB	196.7	196.7
Earth station *G*/*T*	dB/K	17.5	35.0
C/*N* (d)	dB	8.1	9.7
5. Co-channel interference			
C/*N* (e)	dB	99.0	99.0
Total *C*/*N*（*C*/*N* (a) ~ *C*/*N* (e))	dB	8.1	8.1
Margin	dB	2.0	2.0
Total *C*/*N*	dB	6.1	6.1
Transponder gain (#b)	dB	−55.3	
Feed loss	dB		0.8
Antenna gain of earth station (2.5 m)	dBi		42.0
Required earth station transmit power	W		302.1(2)

(1) Constraint length $K = 7$

2.4 Configuration of the transportable earth station

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

– antenna,
– power amplifier,
– low noise receiver,
– ground radiocommunication equipment,
– control and monitoring equipment,
– terminal equipment, including facsimile and telephones,
– support facilities.

This section should be referred to as a guideline of actual characteristics of the system and small earth stations such as transmission capability, weight/size and performance of the subsystem.

2.4.1 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. This is readily attainable with present-day technology. The allowable size and weight specifications of the various aircraft should be consulted during the design of satellite terminals for disaster relief telecommunications.

2.4.2 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 m 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 ±5°.

2.4.3 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 tuneable over a wider bandwidth, e.g. 500 MHz, since the available satellite channel may be anywhere within this bandwidth.

For power requirements less than 100 W, a solid state power amplifier (FET) would also be suitable.

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

2.4.4 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. A 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.

2.5 Examples of transportable earth station realizations and system implementation

2.5.1 Small transportable earth stations

In the 14/12 GHz and 30/20 GHz bands, most of the transportable stations have antennas with around 1.2 m diameters.

2.5.1.1 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 radiocommunication systems in the 14/12 GHz band. 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 International Air Transport Association (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 4.

TABLE 4

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

Example No.	1	2	3	4[(1)]	5	6
Type of transportation	Vehicle equipped					
Antenna diameter (m)	2.6 × 2.4	1.8	1.2	1.8	0.9	1.5 × 1.35
e.i.r.p. (dBW)	72	70	62.5	65.1-71.2 (95-400 W)[(2)]	54-64 (20-200 W)[(2)]	72 (400 W)[(2)]
RF bandwidth (MHz)	24-27	20-30	30	1.4-60 Mbit/s	64 kbit/s- 60 Mbit/s	1.4-60 Mbit/s
Total weight	6.4 tons	6.0 tons	2.5 tons	250 kg[(3)]	70 kg[(4)]	210 kg
Package: – Total dimensions (m) – Total number – Max. weight (kg)	 – – –	 – – –	 – – –	 2.62 × 1.95 × 0.88 – < 345 kg	 1.2 × 1.1 × 0.4 m 1 –	 2.37 × 1.53 × 0.45 1 –
Capacity of engine generator or power consumption	7.5 kVA	10 kVA	5 kVA	~ 4 100 W	~ 4 100 W	~ 4 100 W
Required number of persons	1-2	1-2	1-2	1	1	1

Example No.	7	8	9	10	11	12	13	14	15
Type of transportation	Air transportable								
Antenna diameter (m)	1.8	1.4	1.2	0.75	0.9	0.9 × 0.66	1	0.9	0.9 × 0.66
e.i.r.p. (dBW)	70	64.9	62.5	42.5	44.0	51.7	55	66	51.7
RF bandwidth (MHz)	20-30	30	30	Up to 0.5	Up to 0.5	2	6	64 k ~ 60 Mbit/s	64 k ~ 4 Mbit/s
Total weight (kg)	275	250	200	131	141	100	110	130	39
Package: – Total dimensions (m) – Total number – Max. weight (kg)	 < 2 10 45	 < 2 13 34	 < 2 8 20	 1 5 37	 1.2 5 37	 – – –	 – – –	 1 × 0.6 × 1.2 3[(5)] < 43 kg	 70 × 47 × 31 (cm) 1 39 kg
Capacity of engine generator or power consumption	3 kVA	0.9-1.3 kVA	1.0 kVA	< 370 W	< 370 W	< 2 kVA	< 2 kVA	~ 4 100 W	750 W
Required number of persons	2-3	2-3	1-2	1-2	1-2	2	3	1	1

(1) Flyaway.

(2) The amplifier size is selectable for the purpose.

(3) Total weight dose not include the weight of the car.

(4) Without amplifier.

(5) There are three packages; the sizes are 72 × 60 × 26 (cm), 51 × 29 × 40 (cm) and 100 × 60 × 40 (cm) respectively.

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

Several 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 5.

TABLE 5

Examples of small transportable earth stations for the 30/20 GHz band

Operating frequency (GHz)	Total weight (tons)	Power require-ment (kVA)	Antenna		Maxi-mum e.i.r.p. (dBW)	*G*/*T* (dB/K)	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
	3.5(4)	< 8.5	1.4	Offset Cassegrain	68	20	Digital-TV (3 voice channels are multiplexed)(1) or 1 voice channel	> 1	On a van/SUV
	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.

(4) Include vehicle.

2.5.2 Example of an emergency network and associated earth stations

2.5.2.1 Example of an emergency network in Italy using the 14/12 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 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 6.

TABLE 6

Example of an emergency satellite radiocommunication network operating at 14/12 GHz

Station designation	Antenna diameter (m)	*G*/*T* (dB/K)	Trans-mitter power (W)	Primary power requireme nt (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 (transportable)	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)	

2.5.2.2 Example of an emergency network in Japan using the 14/12 GHz band

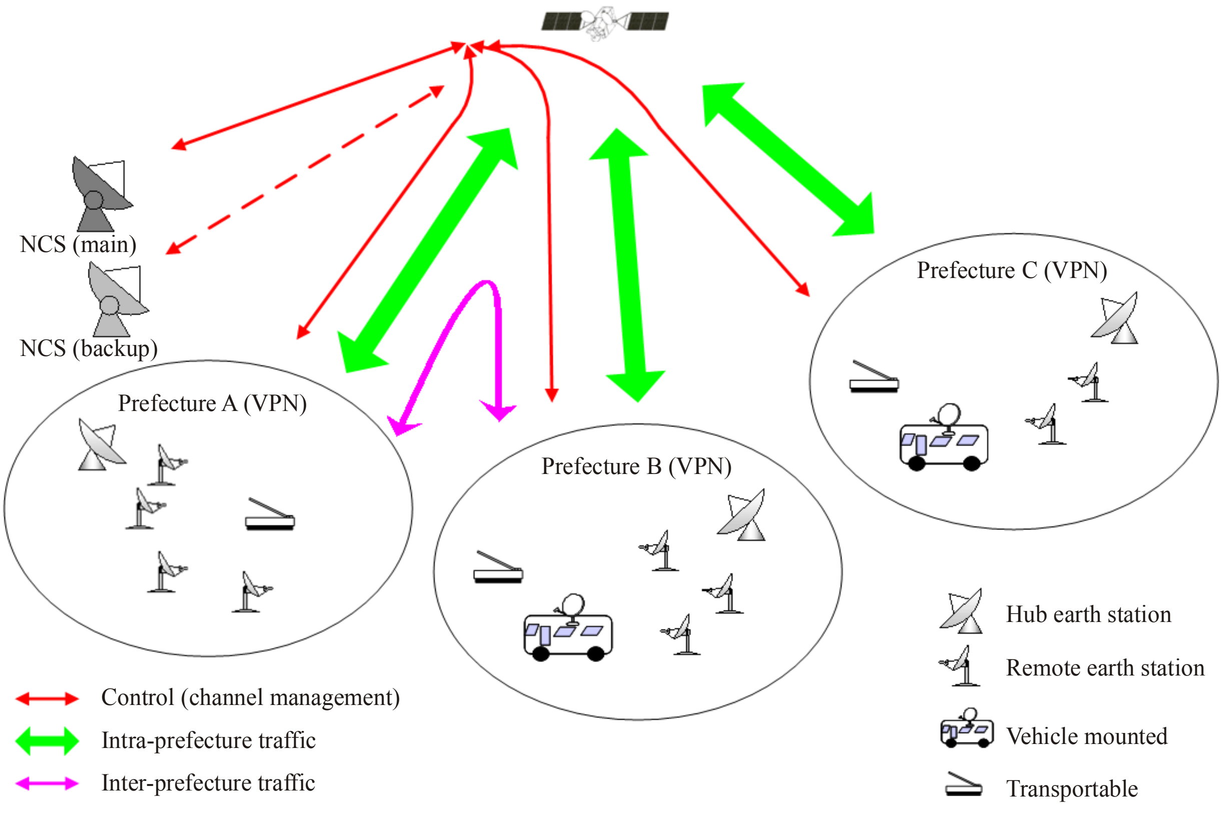
In Japan, there is a satellite network operating in the 14/12.5 GHz frequency band mainly for the purpose of emergency radiocommunications that accommodates more than 4 700 earth stations including VSATs located at municipal offices and fire departments, transportable earth stations and vehicle-mounted earth stations. The network provides voice, facsimile, announcement (simplex), video transmission and high-speed IP data transmission.

As shown in Fig. 2, the network is based on DAMA, so that satellite channels can be efficiently shared by as many as 5 000 earth stations. An earth station asks the network coordination station (NCS) for the assignment of traffic channels such as voice, facsimile and IP transmission prior to its radiocommunication with other earth stations. Note that there are two NCSs, main and backup, in the network.

The network is designed to have a multi-star topology where each prefecture (note that Japan consists of 47 prefectures) configures an independent sub-network so that the principal office of the prefecture can be the hub of emergency radiocommunications in the case of an event. By virtue of the closed-group network, the satellite resources can be controlled by the NCS depending on urgency of events. For instance, the NCS can provide priorities for radiocommunications originated from a particular prefecture where an emergency event occurs over routine radiocommunications in other prefectures. The network also provides inter-prefecture radiocommunications if any.

FIGURE 2

Configuration of the emergency network



The summary of channel parameters is listed in Table 7. There are six types of channels consisting of SCPC (voice/data/fax), announcement, IP data transmission, digital video, satellite data broadcast and common signalling channel (CSC). SCPC channels (32 kbit/s ADPCM) and IP data transmission channels (32 kbit/s-8 Mbit/s variable rate) are assigned to earth stations on a demand basis by the NCS. The bandwidth of an IP data transmission channel is requested from an earth station based on its instantaneous throughput of IP data traffic and assigned by the NCS. Thus, the NCS manages the satellite resource efficiently by accommodating traffic channels with variable bandwidth by a novel channel management algorithm. An earth station designated to high-speed TCP/IP transmission is equipped with a 2-segment splitting TCP gateway to enhance the TCP throughput (see Recommendation ITU-R S.1711).

In order to help telecommunications from/to an area damaged by disasters, the development of smaller user earth stations with high performance is under way. Typical parameters of such earth stations are listed in Table 8. There are two types of vehicle-mounted earth stations. Type-A earth station is designed to transmit full motion picture based on MPEG-2 (i.e. 6 Mbit/s) and provide a voice circuit simultaneously available during video transmission. The earth station is to be mounted on a relatively large vehicle such as “Wagon” type. On the other hand, a type-B earth station is designed to transmit a low rate limited-motion picture by MPEG-4/IP (i.e. 1 Mbit/s) with a voice circuit switchable with video transmission. The earth station is to be mounted on a smaller vehicle such as “Land-cruiser” type. Similar to type-B vehicle-mounted earth stations, the transportable earth station is designed to transmit a low rate limited-motion picture by MPEG-4/IP with a voice circuit switchable with video transmission. Its video transmission rate is only 256 kbit/s.

TABLE 7

Summary of channel parameters of the satellite network

Parameters	SCPC (voice, fax, data)	Announcement	IP data transmission	Digital video transmission	Satellite data broadcast	CSC
Direction	2-way	2-way	2-way	1-way	1-way	2-way
Multiple access(1)	DA-FDMA	PA-TDMA/ FDMA	DA-FDMA	DA-FDMA	DA-FDMA	RA-TDMA/ FDMA
Modulation	QPSK(2)	QPSK(3)	QPSK	QPSK	QPSK	QPSK(3)
Information rate	32 kbit/s	32 kbit/s	32k-8 Mbit/s(4)	7.3 Mbit/s	6.1 Mbit/s	32 kbit/s
FEC	1/2 FEC	1/2 FEC	1/2 FEC (5)	3/4 FEC+RS	3/4 FEC+RS	1/2 FEC
Ciphering	N/A	N/A	(IPSec)(6)	(MULTI2)(6)	MISTY	N/A
Encoding	32k ADPCM	32k ADPCM	N/A	MPEG2	N/A	N/A

(1) The following are acronyms of multiple access schemes:

DA-FDMA: Demand assignment – frequency division multiple access

PA-TDMA: Permanent assignment – time division multiple access

RA-TDMA: Random access – time division multiple access.

(2) The burst channel is employed because of voice activation.

(3) The burst channel is employed in the uplink direction.

(4) Asymmetric type variable rate with IP.

(5) 3/4 FEC + RS is employed for channels over 3 Mbit/s.

(6) Optional.

TABLE 8

Parameters of the vehicle-mounted and transportable earth station

Parameters	Vehicle-mounted earth station		Transportable earth station
	Type-A	Type-B	
Description	– Full-motion pictures based on MPEG-2 – Simultaneous voice circuit	– IP-based low-rate motion picture based on MPEG-4 – Voice circuit switchable with the video circuit	– IP-based low-rate motion picture based on MPEG-4 – Voice circuit switchable with the video circuit
Antenna diameter	1.5 m (offset parabola)	75 cm (offset parabola)	1 m (Flat array)
Output power	70 W (SSPA)	15 W (SSPA)	15 W (SSPA)
Number of channels and transmission rate	Video: 1 channel (6 Mbit/s, MPEG2) Voice/IP: 1 channel	Video: 1 channel (1 Mbit/s, IP) Voice/IP: 1 channel	Video: 1 channel (256 kbit/s, IP) Voice/IP: 1 channel
Type of vehicle	Wagon type	Land-cruiser type	N/A

2.5.2.3 Example of an emergency network in South-East Asia using the 14/12 GHz band

An agency in South-East Asia has set up an end-to-end broadband VSAT system to improve the broadband telecommunication between its offices and enhance the e-risk management policy.

The satellite network interconnects the headquarters (redounded) with: 13 national offices, 25 county offices, 72 villages and 12 emergency vehicles. Based on IP, it offers all the common services of an intranet such as access to web and FTP servers, electronic messaging and content distribution in multicast, e.g. streaming. In addition, it offers broadband applications relevant for crisis management (e-risks services suite): videoconferencing, collaborative working and voice-over-IP.

In normal situations, the system carries up to 8 Mbit/s:

– 2 Mbit/s shared by all voice radiocommunications;

– 3 Mbit/s for central data exchanges;

– 3 Mbit/s for data shared by other data exchanges.

In crisis situations, the system carries up to 21 Mbit/s:

– 12 Mbit/s for two video streams;

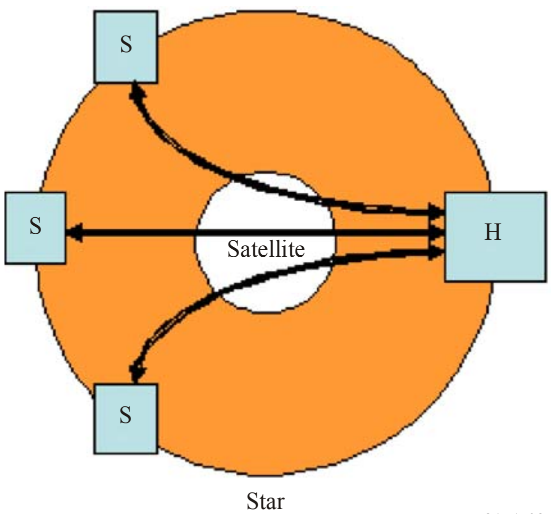
– 9 Mbit/s for up to 16 videoconference terminals.

It is based on a DVB-RCS star satellite network. DVB-RCS stands for digital video broadcasting-return channel via satellite. This technology corresponds to the ETSI standard (EN 301 790) and enables access to multimedia services by satellite by the means of a small dish. It is cited in the Recommendation ITU-R S.1709 – Technical characteristics of air interfaces for global broadband satellite systems.

The topology chosen is the star topology (as opposed to the mesh one) with a hub installed at the headquarters and satellite terminals installed at the remote sites listed above.

FIGURE 3

Star topology



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This topology is the best suited to services such as videoconferencing since they are by nature point-to-multipoint with a multipoint control unit located at the hub. This one also enables access to the Internet by means of a broadband access server. It shall be located abroad from the place of the disaster, and therefore there is less constraint on the facilities; for example, the antenna can be as large as necessary.

The network operates in 14/12 GHz band (the 14 GHz band for the uplinks; the 12 GHz band for the downlinks). 14/12 GHz band antennas are smaller and lighter, which eases the use and the transportation of material. The terminals are state-of-the-art with a diameter ranging from 0.6 m to 1.2 m; the diameter is chosen so as to optimize the trade-off between the signal-to-noise ratio and the ease of transportation. The RF subsystem of remote terminals is specified in the norm as the outdoor unit.

The forward link is compliant with the DVB-S standard implying QPSK modulation and a combination of a Reed-Solomon (188, 204) code as the outer code and a convolutional 1/2 code as the inner code. The protocol stack for the forward link is IP/MPE/MPEG2-TS/DVB-S[1].

The return link relies on QPSK modulation and a 2/3 turbo code. The protocol stack for the return link is IP/AAL5/ATM/DVB-RCS.

The satellite access technology on the return link is fixed multifrequency time division multiple access (fixed MF-TDMA). Fixed MF-TDMA allows a group of satellite terminals to communicate with the hub using a set of carrier frequencies of equal bandwidth while the time is divided into slots of equal duration. The network control centre at the hub will allocate to each active satellite terminal series of bursts, each defined by a frequency, a bandwidth, a start time and a duration.

The satellite network supports quality of service thanks to standard features at the MAC level: the so-called capacity categories; but the architectures enables the definition of a QoS policy at higher levels such as DiffServ or InterServ based policies (DiffServ is generally preferred).

Satellites terminals can be controlled from the hub, they can be configured, faults can be detected and software can be downloaded.

3 An example describing use of FSS system for warning operations in the event of natural disasters and similar emergencies

3.1 Earthquake Early Warning System

In Japan, people have suffered from huge earthquakes since early times (see Fig. 4) and the demands on the protection of life and property and mitigation of damage to the functioning of society have been increased.

To respond to this demands, an observation network has been deployed all over Japan to seize P-wave by seismographs closely deployed to the epicentre and transmit the P-wave information to the meteorological centers responsible for processing such information (see Fig. 5).

The Japan Meteorological Agency (JMA) analyses this data and obtains the focus and magnitude of the earthquake and, based on these analyses, it estimates the expected arrival time and seismic intensity of the principal motion at each location. The advance announcement of these estimations is called the “Earthquake Early Warning” (EEW).

JMA currently uses this process to predict possibility of tsunami events and to provide early warning to the communities that may be impacted by such events.

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[1] MPE stands for MultiProtocol Encapsulation.

FIGURE 4

Major earthquakes occurred around Japan (1996-2008 May)

(Obtained from the JMA website)

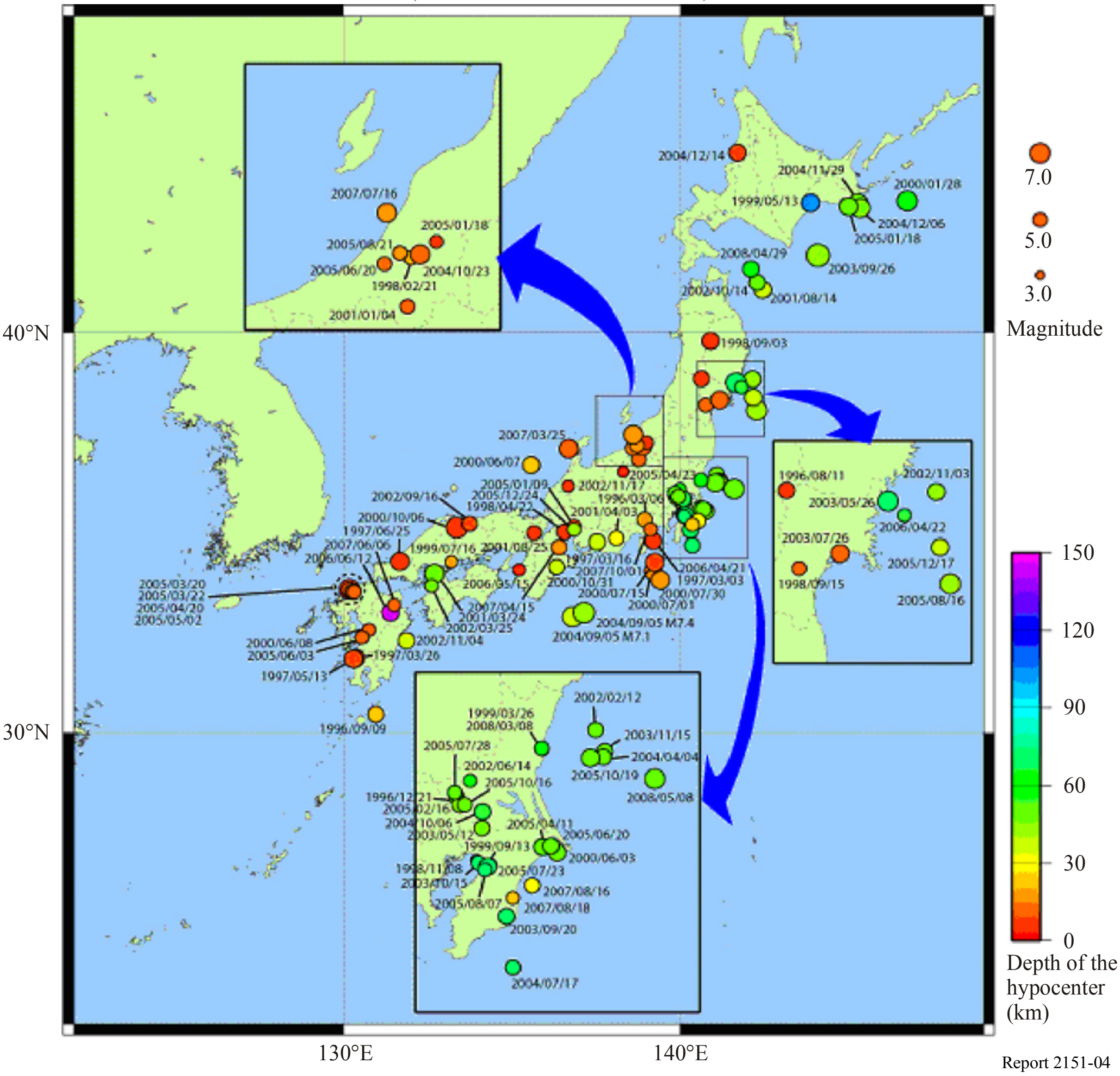

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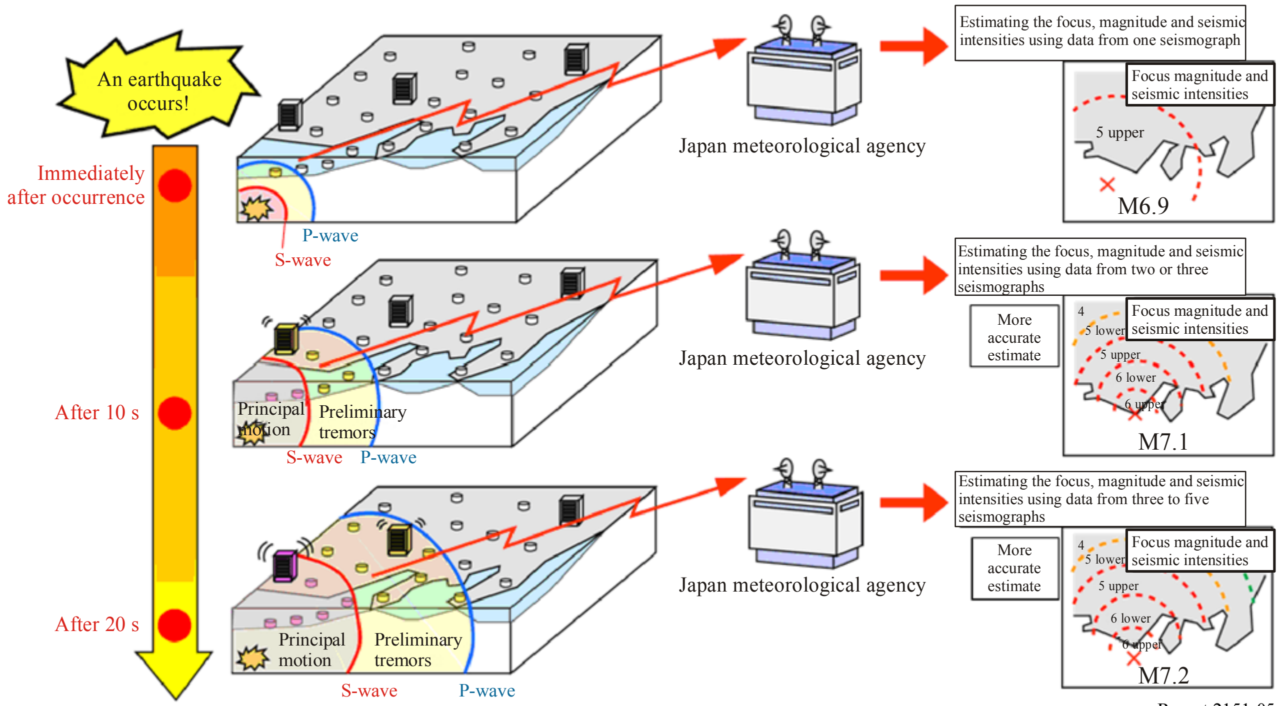
FIGURE 5

Mechanism of the EEW

(Obtained from the JMA website)



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3.2 Satellite delivery

In Japan, the EEW mentioned above is disseminated by various means, including FSS systems. In this section, advantages and system architecture of the EEW satellite delivery service are explained.

3.2.1 Advantage of the satellite network

Since a satellite network is inherently robust against natural disasters, information transmitted through satellite networks can be received securely and reliably even though the receiving site is close to the hypocentre. Unlike terrestrial-based networks, a satellite network is not likely to be congested or impaired in the event of natural disasters and similar emergencies.

Additionally, it is also an advantage of the satellite network that new receiver stations can be implemented with minimal difficulty anywhere within the coverage area of the satellite concerned.

3.2.2 Example of the system for satellite delivery

The outline of the EEW satellite delivery system is shown in Fig. 6, where the EEW sent by JMA is delivered via a satellite system to receiving terminals. The EEW information is also delivered through other telecommunications service systems.

The block diagram of the system is shown in Fig. 7. The EEW provided by JMA is delivered in a safe (from interception) and reliable (high-link performance) manner.

The IP multicast technology employed in this system allows customers and/or system integrators to customize user subsystems to meet their requirement. Additionally, the attached software enables receiving terminals to display necessary information concisely. Figures 8 and 9 show the system diagram of the receiving subsystem and screen display of the attached software, respectively.

FIGURE 6

Outline of the EEW satellite delivery system

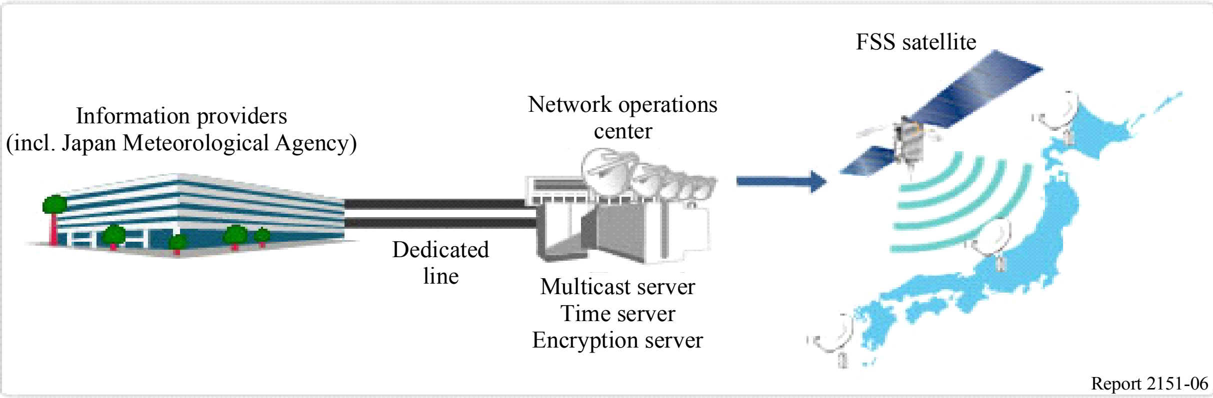


FIGURE 7

Block diagram of the EEW satellite delivery system

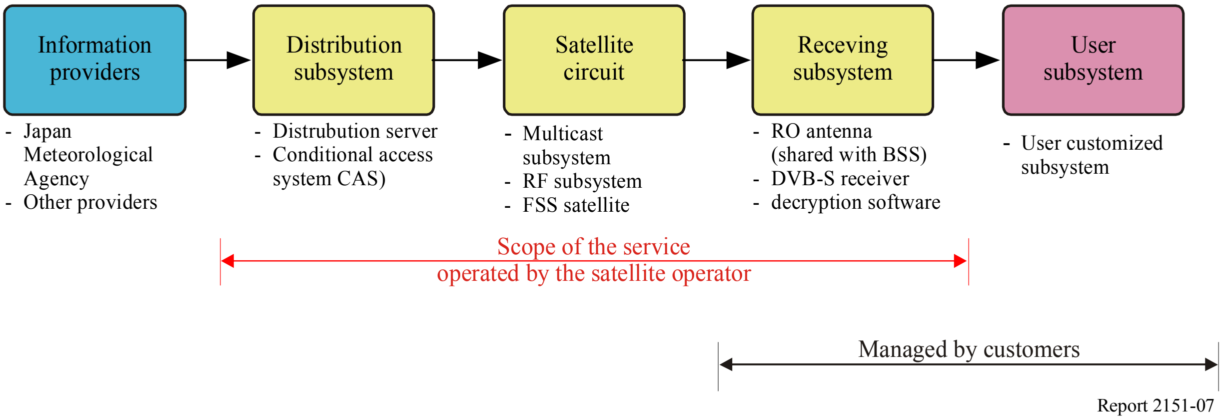


FIGURE 8

Receiving subsystem

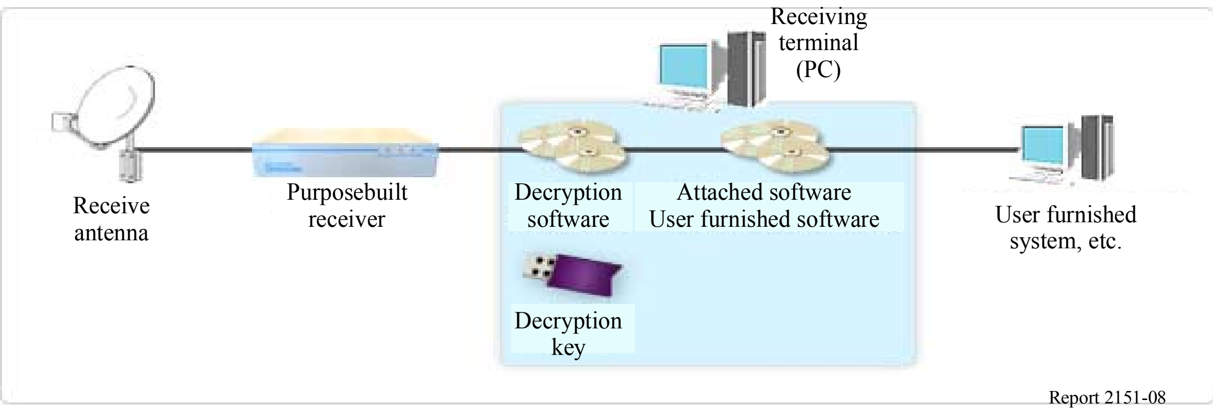
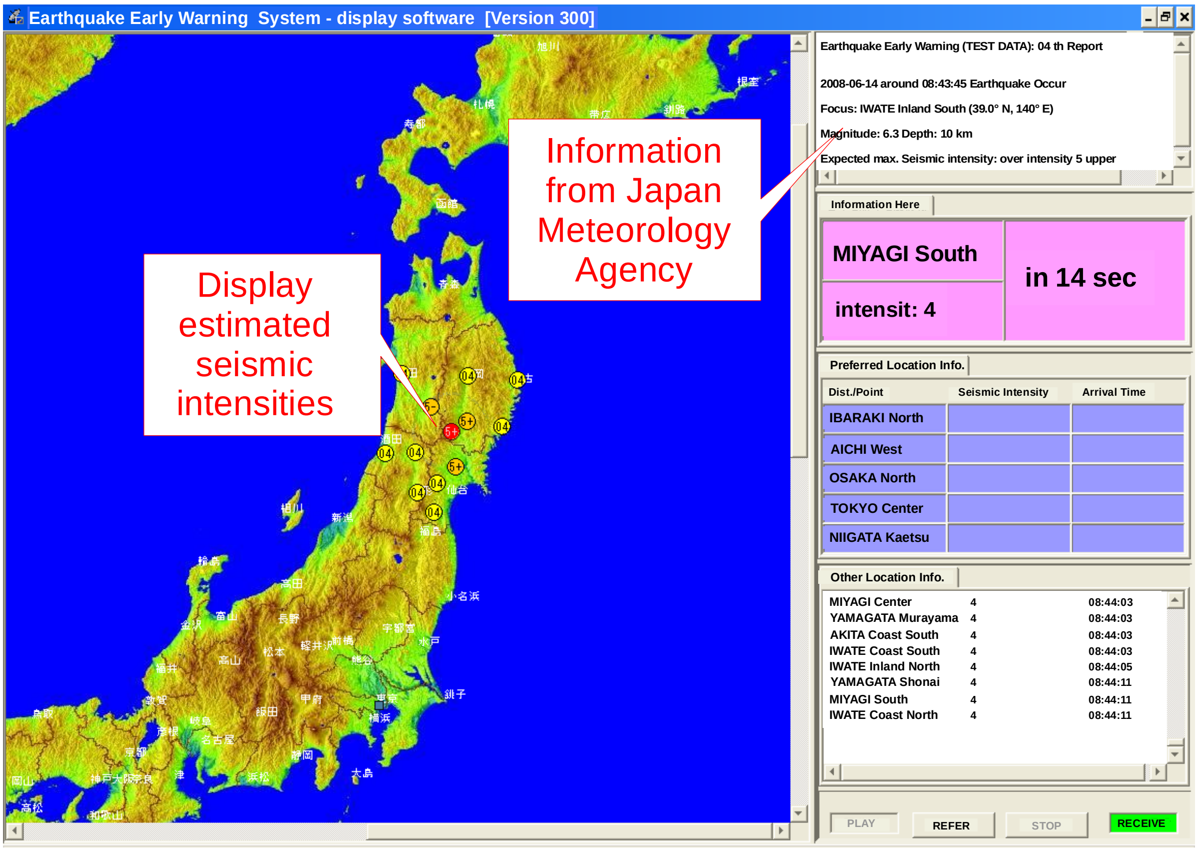


FIGURE 9

Example of screen display of the attached software



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3.3 Case examples of the EEW satellite delivery service

In the EEW satellite delivery receiving system, a number of functions such as contact output, audio playback, sending e-mail and so on can be customized to facilitate in-building announcements, radio warning devices, factory control equipment and video camcorder. These functions accommodate various entities such as railway companies, CATV operators, plants, schools, building management enterprises, elevator manufacturer and hospitals (see Fig. 10).

3.4 Further development of the satellite delivery system

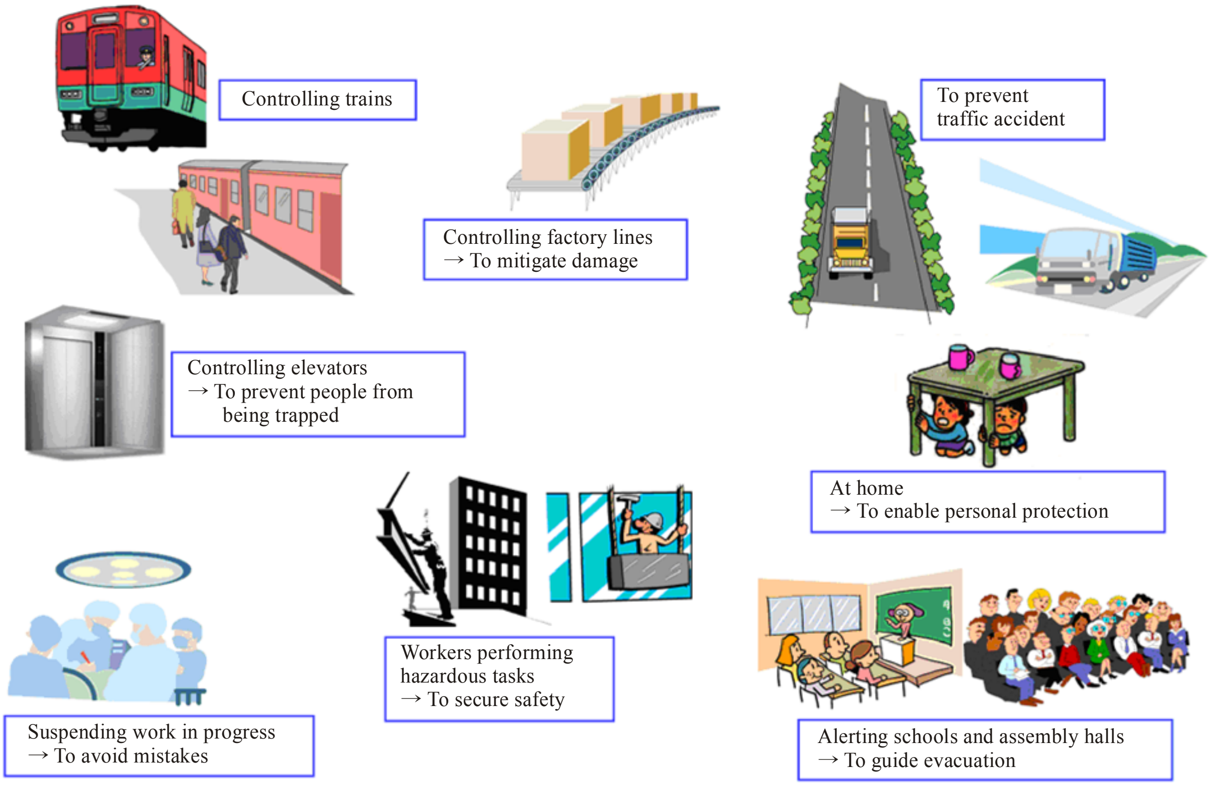
In Japan, prompt announcement and forecast of lightning strike and precipitation are also delivered through FSS networks.

An entity deployed a lightning observation network all over Japan to observe and record the location of lightening strikes, their time and lightning current magnitude and so on. This entity provides prompt announcement and forecast of lightning strike and precipitation.

FIGURE 10

Examples of utilization of the EEW

(Obtained from the JMA website)



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4 Conclusions

This Report will be updated regularly.

Other examples of emergency networks associated with FSS are available in the draft new Report on Guidelines for Implementation of Satellite Telecommunications for Disaster Management in Developing Countries (see ITU-D Document 2/245).