RECOMMENDATION ITU-R S.1587-2

Technical characteristics of earth stations on board vessels communicating with FSS satellites in the frequency bands 5 925-6 425 MHz and 14-14.5 GHz which are allocated to the fixed-satellite service

(Question ITU-R 254/4)

(2002-2003-2007)

The ITU Radiocommunication Assembly,

considering

a) that the World Radiocommunication Conference (Geneva, 2003) (WRC-03) agreed Resolution 902 (WRC-03) concerned with earth stations on board vessels (ESVs);

b) that ESVs may operate under Radio Regulations (RR) No. 4.4 in the fixed-satellite service (FSS) in part of the frequency band 5 925-6 425 MHz;

c) that ESVs may operate under RR No. 4.4 in the FSS in part of the frequency band 14-14.5 GHz;

d) that there is a requirement to protect existing and planned geostationary (GSO) FSS systems;

e) that to ensure efficient use of the spectrum and to facilitate sharing ESVs must operate with certain constraints as called for in Resolution 902 (WRC-03),

recognizing

a) that ESVs may operate in FSS networks under RR No. 4.4 and shall not claim protection from, nor cause interference to services having allocations in the band, until their status is modified by a competent radiocommunication conference,

noting

a) that Resolution 902 (WRC-03) gives regulatory and operational provisions and technical limitations for ESVs transmitting in the bands 5 925-6 425 MHz and 14-14.5 GHz,

recommends

1 that the characteristics in Annex 1 are examples for ESVs communicating with FSS satellites in the frequency band 5 925-6 425 MHz and may be used in frequency sharing studies involving ESVs;

2 that the characteristics of Annex 2 are examples for ESVs which operate in part of the frequency band 14-14.5 GHz shared with the terrestrial services and also characteristics for ESVs which operate in parts of this band which are not shared with the terrestrial services and may be used in frequency sharing studies.

Annex 1

Technical characteristics of ESVs operating in the frequency band 5 925-6 425 MHz which is allocated to the FSS

1 Introduction

At present, ESVs are in operation in all ITU Regions on a variety of sea-going vessels and mobile platforms, utilizing existing FSS space segment in the band 5 925-6 425 MHz on an experimental basis. The broadband signal capacity, ubiquitous coverage, dependable operation, resistance to weather-related interruptions and ready availability afforded by existing FSS networks in the 5 925-6 425 MHz band make them desirable for ESV operations.

This Annex provides a description of existing and planned earth stations on vessels that operate in the band 5 925-6 425 MHz in FSS networks.

2 Description of deployed ESV systems and their operations

2.1 Description of ESV systems

ESV operations utilizing 5 925-6 425 MHz FSS frequencies are now employed in all ITU Regions on a variety of large vessels such as passenger ships, seismic research and petroleum exploration ships, and naval vessels. (The size, weight and expense associated with ESV systems in the 5 925-6 425 MHz band dictate that only the largest vessels are candidates for such facilities.) In addition, movable oil and gas drilling platforms employ ESVs for the exchange of high-speed data essential to their operations. An ESV utilizes an extremely reliable stabilized platform and proven very small aperture terminal (VSAT) technology. Each ESV installation on board vessels is individually controlled by a land earth station (hub).

The equipment comprising an earth station installed on board a vessel can be subdivided into three subsystems:

– antenna subsystem;

– RF subsystem; and

– digital/modem subsystem.

The antenna subsystem is mounted above decks and it possesses characteristics unique to maritime applications. The digital/modem subsystem is located below decks while the RF subsystem is installed above decks with the antenna subsystem. The components used for the digital/modem and the RF subsystems are conventional pieces of equipment used for land earth stations.

2.2 Antenna subsystem

The antenna subsystem consists of a stabilized platform and an antenna. These components are mounted above decks and are covered by a rigid radome composed of composite foam/fibreglass. In an illustrative system, the antenna is a steerable 2.4 m aluminium axis-symmetrical parabola with either a circular or a linear polarized prime focus feed. The antenna gain towards the horizon ranges from 4 to 7 dBi. The G/T is 16.5 dB/K or greater. The antenna centreline is a fixed value, such as 26 m above mean sea level. The antenna operating characteristics meet Recommendations ITU-R S.524, ITU-R S.580, ITU-R S.731 and ITU-R S.732.

The antenna subsystem must be designed such that it is able to compensate for the motion of the vessel. The pointing accuracy shall be better than ±0.2° peak. It is noted that in order to meet antenna performance recommendations with current antenna designs, antenna size must be 2.4 m or more.

The stabilized platform uses a microprocessor-based antenna control unit. It stabilizes the earth station on a mobile seaborne platform to maintain signal lock and maintains the pointing accuracy within ±0.2° peak. The unit adjusts for the relative position of the mobile platform and the movements caused by wind and waves.

2.3 RF subsystem

The RF subsystem consists of standard transmitters and receivers, and conventional up- and down-converters certified for performance with satellites. The up- and down-converters are mounted above decks with the antenna in the rigid radome.

2.4 Digital/modem subsystem

The digital/modem subsystem, which is located below decks in the radio room, consists of an antenna control unit, and other conventional, readily available electronic equipment designed to work in accordance with the above-specified operational parameters.

2.5 Terminating capability

– In order to adequately safeguard against inadvertent interference with stations in the terrestrial service, the technical design of ESVs must include automatic features capable of either limiting or terminating operations when certain conditions are met. Those operating conditions are discussed in § 3.

– The system is set up to terminate transmissions instantaneously in the event antenna system losses pointing lock on the satellite.

2.6 Description of ESV hub function

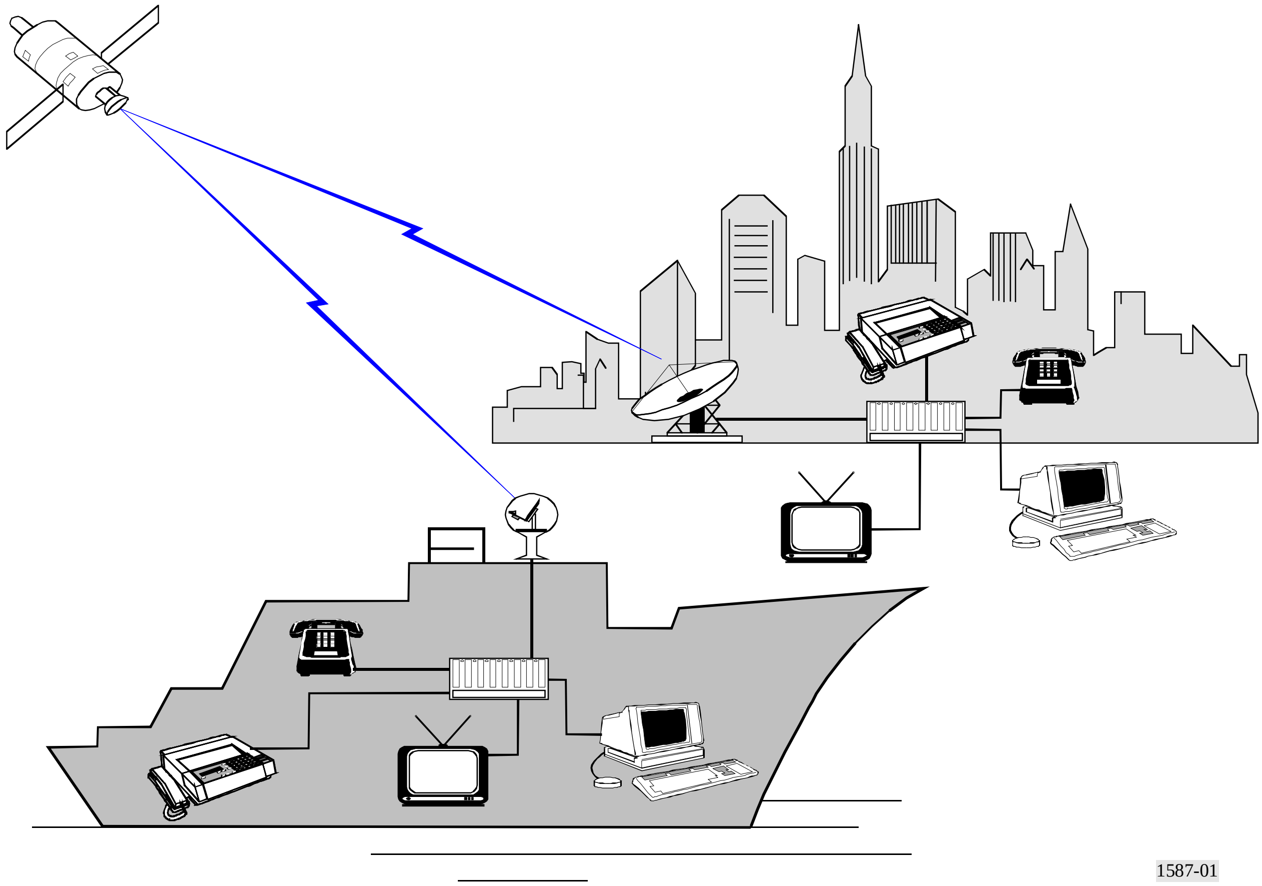
Figure 1 illustrates the operating relationship of a typical ESV and its HUB. The system is a closed user group network with the ships communicating only through the hub earth station, without a direct connection to the public switched telephone network. The hub operator is responsible for requests to discontinue service on a ship for any given reason. Control of the ship’s transmission by the hub is maintained 24 hours a day, seven days a week.

3 Operational characteristics of typical ESVs operating in the 5 925-6 425 MHz frequency band

Because these earth stations are rather large they are deployed on heavy, deep draft ships. ESVs have the capability to operate 24 hours per day while in port, in transit in the deep-water channel to and from port, and while on the high seas. When in port these vessels are assigned to predetermined piers that can facilitate large tonnage vessels. While transiting between the port facility and the open seas, these ships must maintain adequate speed, usually a minimum of 5 knots, for effective steerage, and stay in the deep-water channel. Antennas, which are sea stabilized, have their main beams directed toward the satellite in geostationary orbit.

FIGURE 1

Operating relationship of a typical ESV and its HUB



The ESV transmitter is to be inhibited when any of the following conditions occur:

– the antenna subsystem loses lock on the satellite and/or the ability to maintain tracking accuracy; e.g. during heavy wave conditions when pointing accuracy is lost;

– the ESV e.i.r.p. towards the horizon exceeds the recommended value;

– when the ESV is within certain predefined geographical boundaries where the use of ESVs is prohibited.

3.1 In general: three distinct operational phases

For purposes of studying the interference potential between ESVs and the terrestrial service, there are three distinct phases of operation:

Phase 1: operations in open sea;

Phase 2: operations while at a specific, fixed location, such as when a ship is docked in port;

Phase 3: operations in-motion in the sea lanes and port channels near shore when a ship approaches or departs from a port.

3.2 ESV operations in open sea

When ESVs operate in open sea, they should be sufficiently far from terrestrial services and FSS stations that they do not represent a source of potential interference to those stations, nor are they concerned with interference from terrestrial 4 GHz transmitters. It would be desirable and practical from an operational perspective to select a fixed distance from shore where it may be safely presumed that ESVs may operate without the need to coordinate with terrestrial service stations.

3.3 ESV operations in stationary mode

Vessels equipped with ESVs that are stationary in port can be coordinated, employing applicable procedures and technical parameters set forth in Recommendations ITU-R SM.1448 (coordination area) and ITU-R SF.1006 (interference potential). ESV-equipped vessels are inevitably large, with all of their operations confined as a matter of necessity to specified port channels (the path into and out of a port, generally surrounded by land), sea lanes (the limits marked just outside a port beyond the port channels indicating where a ship may safely operate while approaching or departing from a port), and piers. For purposes of coordination, the entire area of the identified pier in which an ESV-equipped ship is located can be specified with precision, analysed and coordinated for interference. The ESV-equipped vessels usually dock at the same piers on every trip, so it is possible to coordinate operations at the pertinent piers using existing coordination procedures.

3.4 ESV operations in motion

While ESV-equipped vessels are under way in the channel or within the sea-lane limits, they are constantly in motion, travelling at speeds ranging from 5 to 15 knots. The large vessels which employ ESVs require identified piers, defined port channels, and specified sea-lanes. These port channels and sea lanes are clearly physically demarcated in every case so that they may be observed and followed by large vessels, and they are also set forth on maps and charts. Large vessels typically spend some time docked at identified piers, and periodically go to sea. Multiple vessels that are equipped with earth stations may operate at the same port, but each ship of a given type operates with the same parameters as others of its type, including pier locations and limits of the path travelled in and out of the port (i.e. the port channel and limits of the sea lanes). These in-motion ESV operations near shore present a potential for interference to terrestrial fixed station receivers in the 6 GHz band, and also potential for interference from terrestrial transmitters in the 4 GHz band to the ESV receiver.

4 ESV technical characteristics

The technical characteristics of four earth station terminals operating in the band 5 925-6 425 MHz are presented in Table 1. The systems represented are currently in use by ESV operators. Table 2 presents a system that could potentially operate and be used in sharing studies in the 5 925-6 425 MHz band. Below is some additional information on typical ESVs:

– The modem is variable rate with various types of error rate coding;

– GPS interface;

– Service available in all ITU Regions;

– Meets or exceeds IESS-601 standard for INTELSAT;

– Typical emission designator is 80K00G7W;

– Typical height above mean sea level is 26 m.

TABLE 1

Parameter	**System 1**			**System 2**	
Transmit tuning range (MHz)	5 925-6 425				
Emission type (modulation)	QPSK				
Data rate	19.2 kbit/s	128 kbit/s	Typical data circuits	1.544 Mbit/s	
Occupied bandwidth	23 kHz	153.6 kHz	1/2 rate FEC	2.346 MHz	
Transmit power (dBW)	1	9.5		23	
Transmit power/bandwidth (dB(W/1 MHz))	1	9.5		19	
Feeder loss (dB)	1	1		2	
Transmitter power density at antenna input (dB(W/1 MHz))	0	8.8		17	
Antenna main beam gain (dBi)	41.7	41.7	Includes Radome loss	42	
Transmit e.i.r.p. density (dB(W/1 MHz)	41.7	50.2		59	
Receiver tuning range (MHz)	3 700-4 200				
Receiver IF bandwidth (MHz)	70 ± 20			2.346	Occupied bandwidth
Antenna type	Prime focus			3-axis stabilized parabolic	Ring focus
Antenna size (m)	2.4		With Radome	2.74	
Polarization	Circular			Circular	Left-hand circular or right-hand circular
Beamwidth (degrees)	1.4		Transmit	1.4	Transmit
Beam positioning (degrees)	0.2			360 azimuth 10-90 elevation	Operation prevented below 10 elevation
Antenna first side lobe gain (dBi)	20.1			28	At 2.5°
Tracking stability (degrees)	0.2 peak			0.2 peak	0.2 peak
Number of terminals	Around 40			Around 50	
Geographic area where deployed	Global		All ocean regions	Global	All ocean regions

Parameter	**System 3**				**System 4**		
Transmit tuning range (MHz)	5 925-6 425						
Emission type (modulation)	QPSK						
Data rate	19.2 kbit/s	$n \times 64$ kbit/s	2 Mbit/s		128 kbit/s	2 048 kbit/s	And other data rates within this range
Occupied bandwidth	33 kHz	$n \times 73$ kHz	2.3 MHz		107.5 kHz	1 720.3 kHz	For 3/4 FEC
Transmit power (dBW)	1.8	10 log n + 4.7 for $n \leq 10$	19.6	20 W SSPA ≤ 512 kbit/s < 140 W TWTA	7.6	19.2	For maximum feeder loss
Transmit power/bandwidth (dB(W/1 MHz))	1.8	10 log n –19.3 for $n \leq 10$	16		7.2	16.9	

TABLE 1 (*end*)

Parameter	**System 3**				**System 4**		
Feeder loss (dB)	1	1	1		1.5-3.5		
Transmitter power at antenna input (dB(W/1 MHz))	0.8	10 log *n* −20.3 for $n \leq 10$	15		3.7	13.4	
Antenna main beam gain (dBi)	41.2	41.2	41.2		41.5		
Transmit e.i.r.p. density (dB(W/1 MHz))	42.0	10 log *n* + 20.9 for $n \leq 10$	56.2		45.2	54.9	For 128 kbit/s carrier, assumes single carriers in 1 MHz bandwidth
Receiver tuning range (MHz)	3 700-4 200						
Receiver IF bandwidth (MHz)					70 ± 20		
Antenna type	Prime focus				Prime focus, 2 axis stabilized		
Antenna size (m)	2.4				2.4		
Polarization	Circular				Circular		
Beamwidth (degrees)	1.4			Transmit	1.5		Transmit
Beam positioning (degrees)	360 azimuth, limited elevation				360 azimuth, limited elevation		
Antenna first side lobe gain (dBi)					28		
Tracking stability (degrees)	0.2 peak				0.2 peak		
Number of terminals	43				Around 50		Planned
Geographic area where deployed	Atlantic Ocean and South China Sea				Global		All ocean regions

SSPA: solid state power amplifier.

TWTA: travelling wave tube amplifier.

TABLE 2

Parameter	System 5		
Transmit tuning range (MHz)	5 925-6 425		
Emission type (modulation)	QPSK/CDMA		
Data rate (kbps)	38.4	76.8	128
CDMA spreading factor	127	127	127
Occupied bandwidth (MHz)	9.14	18.29	30.48
Transmit power (dBW)	–1.2	3.3	4.8
Transmit power/bandwidth (dB(W/1 MHz))	–10.8	–9.3	–10
Feeder loss (dB)	0.5		
Transmitter power at antenna input (dB(W/1 MHz))	–11.3	–9.8	–10.5
Antenna main beam gain (dBi)	35.7		
Transmit e.i.r.p. density (dB(W/1 MHz))	24.4	25.9	25.2
Receiver tuning range (MHz)	3 700-4 200		
Receiver IF bandwidth (MHz)	950-1 450		
Antenna type	Parabolic		
Antenna size (m)	1.2		
Polarization	Circular		
Beamwidth (degrees)	2.9		
Beam positioning (degrees)	360 azimuth, limited elevation		
Antenna first side lobe gain (dBi)	22.7		
Tracking stability (degrees)	0.2 peak		
Geographic area where deployed	Global		

SSPA: solid state power amplifier.

TWTA: travelling wave tube amplifier.

NOTE 1 – Further study is needed to convert the 1 MHz reference bandwidth for the 14 GHz band and 6 GHz band to 40 kHz and 4 kHz respectively.

Annex 2

Technical characteristics of ESVs communicating with FSS satellites in the frequency band 14-14.5 GHz which is allocated to the FSS

Description of example 12/14 GHz ESV systems

The ESVs comprise three elements:

– the antenna subsystem,

– the RF subsystem,

– modem subsystem.

The latter is normally installed below the deck while the antenna and the RF subsystems are mounted above decks and meet all maritime specifications for such equipment. The components used for modem and RF equipment are conventional pieces of equipment used for land earth stations.

1 Antenna subsystem

The antenna subsystem consists of a stabilized platform and a reflector antenna. These systems are mounted above decks and are covered by a rigid radome composed of composite foam/fibreglass. The diameter used in the shared bands of the antenna normally is from 0.6 m to 1.5 m. Off-set type of antennas are used as well as axis-symmetrical parabolas normally with linear feeds. The antenna horizon gain ranges from 0 to −10 dBi. The *G*/*T* is normally 17 dB(K^{-1}) or greater. The antenna operating characteristics meet Recommendations ITU-R S.524, ITU-R S.580, ITU-R S.731, and ITU-R S.732.

2 RF subsystem

The RF subsystem consists of standard transmitters and receivers, and conventional up- and down-converters certified for performance with satellites. The up- and down-converters are mounted above decks with the antenna in the rigid radome. The actual transmitting ESV psd number will depend on several parameters like:

– The location of the vessel with respect to the service area of the satellite beam.
– The antenna size of the ESV (transmitting antenna gain).
– The location of the receiving earth station with respect to the service area of the satellite beam.
– The antenna size of the receiving earth station (receiving *G*/*T*).
– The operational gain step of the satellite transponder, etc.

3 Modem subsystem

The modem subsystem, which is located below decks in the radio room, consists of an antenna control unit and other conventional, readily available electronic equipment designed to work in accordance with the above specified operational parameters.

4 ESV technical characteristics

Technical characteristics of earth station terminals operating in the band 14-14.5 GHz are presented in Table 3.

TABLE 3

Parameter	System 1			System 2			System 3			System 4	
Transmit tuning range (MHz)	14 000-14 500						14 000-14 500			14 000-14 500	
Emission type (modulation)	QPSK						8-PSK	QPSK	8-PSK	O-QPSK/ CRMA	
Data rate (kbit/s)	19.2	$n \times 64$	Typical data circuits	128	1 024	And other data rates within this range	12 288	7 667	35	16-1 024 kbit/s	
Occupied bandwidth (kHz)	16.4	$n \times 54.6$ $n \leq 3$	3/4 rate FEC	107.5	860.2	3/4 rate FEC	7 372.8	6 660	44.1	6.75-36 MHz (depending on transponder width)	
Transmit power (dBW)	–11.5	$-6.4 + 10 \log(n)$ $n \leq 3$		2.5	13.5	For maximum feeder loss	20	26.5	6.6	12.0 (max.)	9.0 (max.)
Transmit power/bandwidth (dB(W/1 MHz))	–11.5	$-6.4 + 10 \log(n)$ $n \leq 3$		2.5	13.5	Assumes single carrier in 1 MHz bandwidth	12.1	19.1	6.6	–3.1 (max.)	–6.1 (max.)
Feeder loss (dB)	2	2		1.5-3.5			2.2	2.3		0.5	
Transmitter power at antenna input (dB(W/1 MHz))	–13.5	$-8.4 + 10 \log(n)$ $n \leq 3$		1.0	10.0		9.9	16.8	4.3	–3.6 (max.)	–6.6 (max.)
Antenna main beam gain (dBi)	43.3			43.4			38.5	38.6		43.0	37.0
Transmit e.i.r.p. density (dB(W/1 MHz))	29.8	$34.9 + 10 \log(n)$ $n \leq 3$		44.4	53.4		48.4	55.4	42.9	39.4 in a 36 MHz transponder	
Receiver tuning range (MHz)	10 950-12 750						12 250-12 650			10 700-12 750	
Receiver IF bandwidth (MHz)	70 ± 20			70 ± 20						36	
Antenna type	Offset fed reflector antenna		3 axis stabilized	Offset fed reflector 3 axis stabilized			Offset fed Gregorian reflector antenna			"Backfire" centre-fed reflector	
Antenna size (m)	1.2			1.2			0.75			1.2	0.6
Polarization	Dual linear			Dual linear			Dual linear			Dual linear	
Beamwidth (degrees)	1.2		Transmit	1.2		Transmit	1.9 (Transmit)			1.2	2.4
Beam positioning (degrees)											
Antenna first side lobe gain (dBi)											
Tracking stability (degrees)	± 0.2 peak			± 0.2 peak			0.5 peak (0.3 r.m.s.)			±0.2 peak	
Number of terminals											
Geographic area where deployed	All ocean regions			All ocean regions			All ocean regions			All ocean regions	

NOTE 1 – Further study is needed to convert the 1 MHz reference bandwidth for the 14 GHz band and 6 GHz band to 40 kHz and 4 kHz respectively.