RECOMMENDATION ITU-R SF.1650-1

The minimum distance from the baseline beyond which in-motion earth stations located on board vessels would not cause unacceptable interference to the terrestrial service in the bands 5 925-6 425 MHz and 14-14.5 GHz[*,**]

(Questions ITU-R 226/9 and ITU-R 251/4)

(2003-2005)

Scope

This Recommendation provides the offshore distance beyond which earth stations on board vessels (ESVs) will not interfere with fixed service systems. The Annex provides the assumptions and methodology used in determining these distances in the frequency bands 5 925-6 425 MHz and 14-14.5 GHz.

The ITU Radiocommunication Assembly,

considering

a) that the technology exists which permits the use of FSS networks by earth stations on board vessels (ESVs) in the bands 5 925-6 425 MHz and 14-14.5 GHz (Earth-to-space);

b) that ESVs have the potential to cause unacceptable interference to FS systems in these bands;

c) that ESV operations require considerably less than the full bandwidth in this FSS allocation and only a portion of the visible GSO arc;

d) that in order to ensure the protection and future growth of the FS, the ESV must operate with certain operational constraints;

e) that a minimum distance from the low-water mark as officially recognized by the coastal State could be determined beyond which the ESV will not cause unacceptable interference to the FS in these bands;

f) that the minimum distance in *considering* e) may be based on administrative and technical considerations,

noting

a) that some administrations have been operating ESVs for several years under No. 4.4 of the Radio Regulations (RR),

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[*] With respect to the impact to other terrestrial services other than the fixed service (FS), this will be the subject of further study.

[**] The Administrations of Saudi Arabia, Djibouti, Egypt, United Arab Emirates, Jordan, Kuwait, Morocco, Mauritania, Syrian Arab Republic, Tunisia and Yemen objected to the approval of this Recommendation for the reasons that can be found in the Radiocommunication Assembly (Geneva, 2003) (RA-03) Report to the WRC-03.
The Administrations of Germany, Australia, Canada and Israel reserve their opinion on this Recommendation for the reasons that can be found in the RA-03 Report to the WRC-03. The Administrations of Gabon and Senegal reserve their opinion on this Recommendation.

recommends

1 that, in the band 5 925-6 425 MHz, the minimum distance from the low-water mark as officially recognized by the coastal State, beyond which in-motion ESVs would not cause unacceptable interference to the terrestrial services is 300 km for an antenna of 2.4 m diameter (based on the parameters of Table 1);

2 that, in the band 14-14.5 GHz, the minimum distance from the low-water mark as officially recognized by the coastal State, beyond which in-motion ESVs would not cause unacceptable interference to the terrestrial services is 125 km for an antenna of 1.2 m diameter in bands shared with the terrestrial services (based on the parameters of Table 2).

NOTE 1 – The purpose of this Recommendation is to protect terrestrial services to which the frequency bands are allocated. As for the protection of the space services in the same frequency bands the matter is dealt with in Recommendation ITU-R S.1587[1].

Annex 1

Method to use in development of a minimum distance for the 5 925-6 425 MHz and 14-14.5 GHz bands

1 Method to determine the distance

The maximum permissible interference power is

$$I_{max} = \left(\frac{I}{N}\right)_{th} + 10\ \log_{10}(k\ T_{FSR} B_{FSR}) \qquad \text{dBW} \qquad (1)$$

where:

$\left(\frac{I}{N}\right)_{th}$: interference to thermal noise power ratio defined in interference criterion (dB)

k: Boltzman's constant (W/(K · Hz))

T_{FSR}: system noise temperature of the fixed service receiver (FSR) (K)

B_{FSR}: bandwidth of FSR (Hz).

Once the short-term interference criterion has been defined, the minimum permissible transmission loss is given by subtracting the FSR's permissible interference power level from the sum of the ESV's e.i.r.p. in the direction of the FSR and the FSR's average antenna gain in its −10 dB beamwidth. The minimum permissible transmission loss is therefore given by:

$$L_{b,min}(p_s) = P_{t,max} + G_t + G_{r,AVE} - I_{max}) - F \qquad (2)$$

[1] The characteristics of the ESVs need to be within the envelope of those initially published in the BR IFIC relating to the corresponding FSS network. Otherwise, the earth stations need to be coordinated in accordance with the current provisions of the RR and the relevant Rules of Procedure (i.e. § 2 of the Rules of Procedure relating to RR No. 11.32).

where:

$L_{b,\ min}$: minimum required basic transmission loss (dB)

$P_{t,\ max}$: maximum transmit power at the ESV antenna input flange (dBW)

G_t: ESV antenna gain in the direction of the FSR (dBi)

$G_{r,\ AVE}$: average gain of the FSR antenna within its −10 dB beamwidth (dBi)

I_{max}: maximum permissible interference power (dBW)

F: loss in the feed from the FSR antenna to the low-noise amplifier (dB).

Because the ESV is not always present, it is not appropriate to use the short-term interference objective time percentage, p_s, directly as the propagation model input parameter, p, which is the time percentage for which the required minimum transmission loss is not exceeded (e.g. in Recommendations ITU-R P.452 or ITU-R P.620). The appropriate p depends on how much time the ESV spends within the –10 dB beamwidth of the FSR. But as is clear in Fig. 1, this amount of time depends on the distance from the ESV to the FSR. Since p depends on this distance and vice versa, an iterative method for determining the minimum distance d_{xxx}, that satisfies the short-term interference criteria is unavoidable.

FIGURE 1

Geometry of modelled scenario

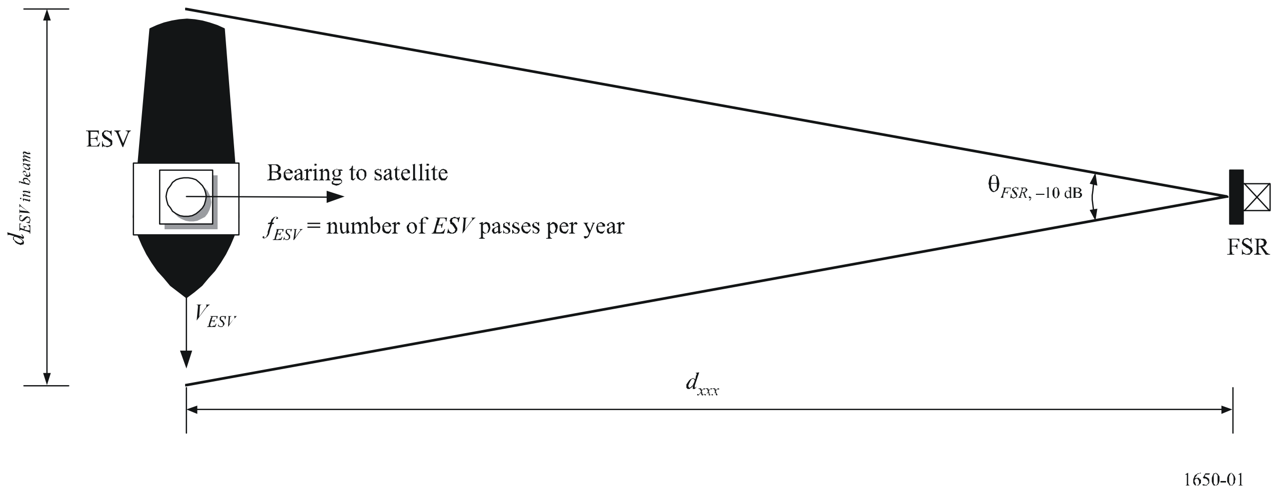
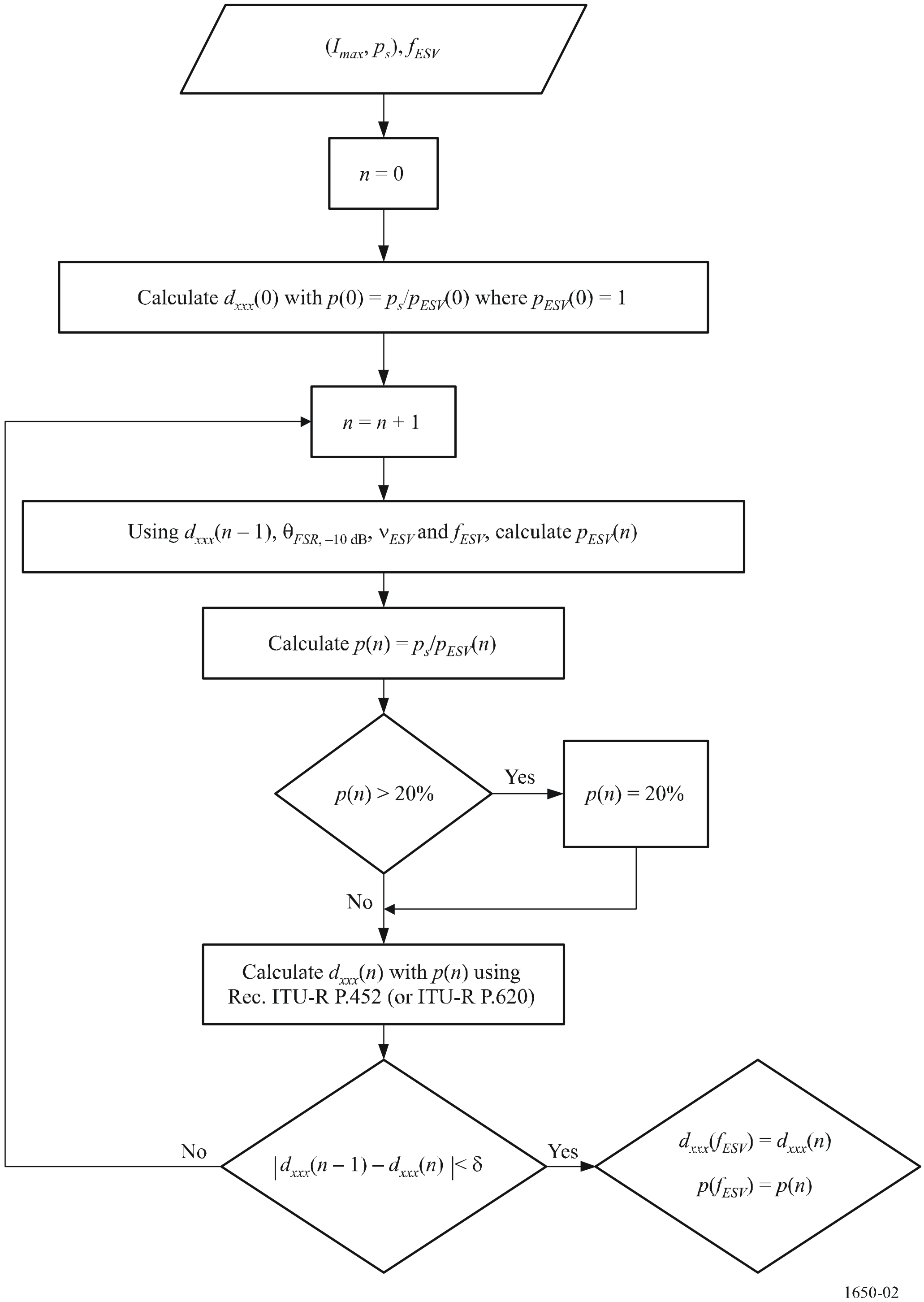


Figure 2 presents a flow chart that details the iterative procedure. The procedure can be initiated under the assumption that the ESV is always present, yielding $d_{xxx}(0)$. The next iteration determines how much time the ESV would spend in the –10 dB beamwidth of the FSR at the distance $d_{xxx}(0)$ and then calculates $d_{xxx}(1)$ based on the resulting value of p. The procedure continues until the difference between d_{xxx} on successive iterations is less than a threshold, δ. It is recommended that δ = 3 km.

FIGURE 2

Flow chart of iterative process



n: stage of the iteration, $n = 0, 1, 2, ...$

I_{max}: maximum permissible interference power (dBW)

P_s: time percentage (annual) for which I_{max} be exceeded (%)

P_{ESV}: time percentage (annual) for which *ESV*s are present (%)

ν_{ESV}: ship's speed (km/h)

p: time percentage (annual) for which minimum required transmission loss is not exceeded (%)

δ: 3 km is recommended (distances < 3 km are not recommended due to the interaction between the iterations of the propagation model and the iterations of this method)

2 Parameter values

The parameter values below do not necessarily represent the worst case of each parameter. However, they are used to develop a representative set of characteristics which are considered to provide adequate protection to the FS from potential interference from ESVs.

2.1 Parameter values for the 6 GHz band

TABLE 1

Parameters used in calculating the minimum distance

ESV parameters		
Parameter	**Value**	**Comment**
Frequency of operation, f (MHz)	6 000	
Antenna height above sea level, h_{ts} (m)	40	
Elevation angle to satellite, φ (degrees)	>10	Lower elevation angles may be used provided that the e.i.r.p. towards the horizon is consistent with the 10° elevation angle operational limitation
Horizon gain angle, θ_h (degrees)	0	Equation (24) of Recommendation ITU-R SM.1448 = 0 in worst case
Maximum transmit power at input to antenna, $P_{t,\,max}$ (dBW)	16.7	
Minimum antenna diameter, D_{min} (m)	2.4	
Antenna gain in direction of FSR, $G_t = G_{ESV}(\varphi)$ (dBi)	+4 to −10	Equation (33) of Recommendation ITU-R SM.1448
Maximum occupied bandwidth, B_{ESV} (MHz)	2.346	
Data rate, R_{ESV} (Mbit/s)	1.544	
Ship's speed, ν_{ESV} (km/h)	18.3	Typical minimum value when out to sea (10 knots)
Frequency of passage, f_{ESV} (passes/year) which fall into FSR receiver channel bandwidth	Variable	See § 3.5
FSR parameters		
Frequency of operation, f (MHz)	6 000	Equal to ESV value
Antenna height above ground, h_{rg} (m)	70	

TABLE 1 (*continued*)

FSR parameters (*continued*)		
Parameter	**Value**	**Comment**
Ground height above mean sea level, h_g (m)	50	
Antenna height above mean sea level, $h_{rs} = h_g + h_{rg}$ (m)	120	Calculation using values above
Maximum boresight antenna gain, $G_r = G_{FSR}(0)$ (dBi)	45	Recommendation ITU-R F.758
–10 dB beamwidth, $\theta_{FSR, -10\ dB}$ (degrees)	1.72	Recommendation ITU-R F.699
Average antenna gain in –10 dB beamwidth, $G_{r,\ AVE}$ (dBi)	42.5	Calculated
Feeder loss, F (dB)	3	
Receiver bandwidth, B_{FSR} (MHz)	11.2	
Noise temperature, T_{FSR} (K)	750	Recommendation ITU-R SM.1448
Data rate, R_{FSR} (Mbit/s)	34	
Reference path length (km)	25	
Short-term interference objective		
Interference criteria, I/N_{th} (dB)	– I/N = 23 dB, not to be exceeded for more than 1.2×10^{-5}% of the time for the severely errored second (SES) level. – I/N = 19 dB, not to be exceeded for more than 4.5×10^{-4}% of the time for the errored second (ES) level	These figures are based on a net fade margin of 24 dB referenced to the 1×10^{-3} BER level. Note that the interference criterion associated with the ES level is the more stringent criterion and hence this is used to determine the required distance
Permissible interference power level, I_{max} (dBW)	–110.4	$= 10 \log(k\ T_{FSR} B_{FSR}) + I/N_{th}$
Time percentage for which $P_{interference,S}$ may be exceeded, p_s (%)	4.5×10^{-4}%	
Tracking accuracy of ESV antenna	±0.2° peak	

TABLE 1 (*end*)

Calculation (dB) of minimum permissible transmission losses		
Parameter	**Value**	**Comment**
Loss, $L_{b,\ min}(p_s)$ (dB)	Calculated	See equation (2)
Range of ESV from FSR, d_{xxx} (km)	Calculated	
Distance travelled by ESV through −10 dB beamwidth, $d_{ESV\ in\ beam}$ (km)	Calculated	$= 2d_{xxx}\tan(\theta_{FSR,\ -10\ dB}/2)$
Time spent by ESV in −10 dB beamwidth, $t_{ESV\ in\ beam}$ (h)	Calculated	$= d_{ESV\ in\ beam}/\nu_{ESV}$
ESV interference percentage, p_{ESV} (%)	Calculated	$= (f_{ESV} t_{ESV\ in\ beam}/8\ 760) \times 100\%$
Time percentage for which $L_{b,\ min}(p_s)$ is not exceeded, p (%)	Calculated	$= (p_s/p_{ESV}) \times 100\%$

2.2 Parameter values for the 14 GHz band

TABLE 2

Parameters used in calculating the minimum distance

ESV parameters		
Parameter	**Value**	**Comment**
Frequency of operation, f (MHz)	14 250	
Antenna height above sea level, h_{ts} (m)	40	
Elevation angle to satellite, φ (degrees)	>10	Lower elevation angles may be used provided that the e.i.r.p. towards the horizon is consistent with the 10° elevation angle operational limitation
Horizon gain angle, θ_h (degrees)	0	
Maximum transmit power at input to antenna, $P_{t,\ max}$ (dBW)	12.2	
Minimum antenna diameter, D_{min} (m)	1.2	
Antenna gain in direction of FSR, $G_t = G_{ESV}(\varphi)$ (dBi)	+4 to −10	
Maximum occupied bandwidth, B_{ESV} (MHz)	2.346	
Data rate, R_{ESV} (Mbit/s)	1.544	
Ship's speed, ν_{ESV} (km/h)	18.3	Typical minimum value when out to sea (10 knots)

TABLE 2 (*continued*)

ESV parameters (*continued*)		
Parameter	**Value**	**Comment**
Frequency of passage, f_{ESV} (passes/year) which fall into FSR receiving channel bandwidth	Variable	See § 3.6
FSR parameters		
Frequency of operation, f (MHz)	14 250	Equal to ESV value
Antenna height above ground, h_{rg} (m)	30	
Ground height above mean sea level, h_g (m)	50	
Antenna height above mean sea level, $h_{rs} = h_g + h_{rg}$ (m)	80	Sum of values above
Maximum boresight antenna gain, $G_r = G_{FSR}(0)$ (dBi)	43	For 1.2 m antenna
−10 dB beamwidth, $\theta_{FSR,\,-10\text{ dB}}$ (degrees)	2.2	Calculated from Recommendation ITU-R F.1245
Average antenna gain in −10 dB beamwidth, $G_{r,\,AVE}$ (dBi)	40.5	Calculated
Feeder loss, F (dB)	3	
Data rate (Mbit/s)	34	
Receiver bandwidth, B_{FSR} (MHz)	14	For 34 Mbit/s link
Net fade margin referenced to the 1×10^{-3} BER level (dB)	24	
I/N applicable to ES criterion (I/N_{th})	19	
Noise figure, NF (dB)	4.5	
Tracking accuracy of ESV antenna	±0.2° peak	
Short-term interference objective		
Parameter	**Value**	**Comment**
Permissible interference power level, $P_{interference,\,S}$ (dBW)	−109	$= 10 \log(k\,T\,B_{FSR}) + NF + I/N_{th}$
Time percentage for which I_{max} may be exceeded, p_s (%)	2.7×10^{-4}	
Calculation (dB) of minimum permissible transmission losses		
Loss, $L_{b,\,min}(p_s)$ (dB)	Calculated	See equation (2)

TABLE 2 (*end*)

Calculation of applicable time percentage for which minimum propagation loss is not exceeded considering that ESVs are not always present		
Sample range of ESV from FSR, d_{xxx} (km)	Calculated	
Distance travelled by ESV through −10 dB beamwidth, $d_{ESV\ in\ beam}$ (km)	Calculated	$= 2d_{xxx}\ \tan(\theta_{FSR,\ -10\ dB}/2)$
Time spent by ESV in −10 dB beamwidth, $t_{ESV\ in\ beam}$ (h)	Calculated	$= d_{ESV\ in\ beam} / \nu_{ESV}$
ESV interference percentage, p_{ESV} (%)	Calculated	$= (f_{ESV}\, t_{ESV\ in\ beam}$ / 8 760) × 100%
Time percentage for which $L_{b,\ min}(p_s)$ is not exceeded, p (%)	Calculated	$= (p_s / p_{ESV}) \times 100\%$

3 Discussion of assumptions and parameter values

3.1 Maximum ESV transmit power

The value of $P_{t,\ max}$ is the power at the antenna input and not the maximum output power from the ESV transmitter high-power amplifier (HPA). The value of $P_{t,\ max}$ must take into account the sum of losses incurred in all waveguides, cables and rotary joints that may be in the signal path between the HPA output and the antenna input flange.

$P_{t,\ max}$ is the assumed power level at the input of the antenna of an ESV transmitting at the maximum bit rate and hence represents the worst-case value of any ESV. For the 6 GHz band, $P_{t,\ max}$ = 16.7 dBW and for the 14 GHz band, $P_{t,\ max}$ = 12.2 dBW. However, the value of transmitter power strongly depends on the required bit rate and on other system characteristics. For 6 GHz ESVs the transmitter power may be about 0 dBW (16.7 dB less than $P_{t,\ max}$) for low bit-rate carriers and for 14 GHz ESVs the transmitter power may be as low as about −13 dBW (25.2 dB less than $P_{t,\ max}$) for low bit-rate carriers.

3.2 ESV gain in the direction of the FSR

Under the worst-case assumption that the azimuth angles from the ESV to the FSR, and from the ESV to the ESV's desired satellite are equal, G_t is defined as follows:

$$G_t = G_{ESV}\ (\theta_{ESV}) \qquad \text{dBi} \qquad (3)$$

where:

$G_{ESV}(\theta)$: ESV antenna gain at off-boresight angle θ, at the transmit frequency (dBi)

θ_{ESV}: elevation angle of the ESV antenna with respect to the horizontal (degrees).

In any other case, G_t would be given by $G_{ESV}(\theta')$ where (θ') is the angle between the ESV antenna boresight and the horizon in the azimuth direction of the FSR ($(\theta') > \theta_{ESV}$). $G_{ESV}(\theta)$ is the boresight (maximum) gain of the ESV antenna and θ is measured with respect to the antenna boresight.

Calculation results are presented for example discrimination angles of 10°, 20° and 36°. The results for 36° are also applicable for all discrimination angles exceeding 36°. The probability of occurrence of each value depends on the relative azimuth of the ESV with regards to the FS direction, the minimum ESV elevation to consider, and finally the latitude under which the ESV operates, which controls the maximum ESV elevation.

It is therefore possible to calculate the antenna discrimination for all the geometrical cases taking into account the ESV azimuth relative to the FSR (from 0° to 360°) and its elevation (from the minimum elevation to the maximum elevation depending, for the latter, on the considered latitude).

On this basis, the distributions of such antenna discrimination for certain latitude are given in Fig. 3 for an assumed minimum elevation of 10°.

As confirmed in Table 3, Fig. 3 shows that the occurrence of antenna discrimination lower than 36° is small, for lower latitudes in particular. A discrimination angle less than 36° occurs in 17.5% of the cases (at 60° latitude) to 4.6% of the cases (at 0° latitude). In addition, a discrimination lower than 20° only represents 2.3% at 45° latitude. It can be noted from Fig. 3 that (for a 10° minimum elevation), 10° discrimination only occurs in one improbable case for which the FS and ESV azimuth are aligned.

FIGURE 3

Distribution of antenna discrimination for different latitudes

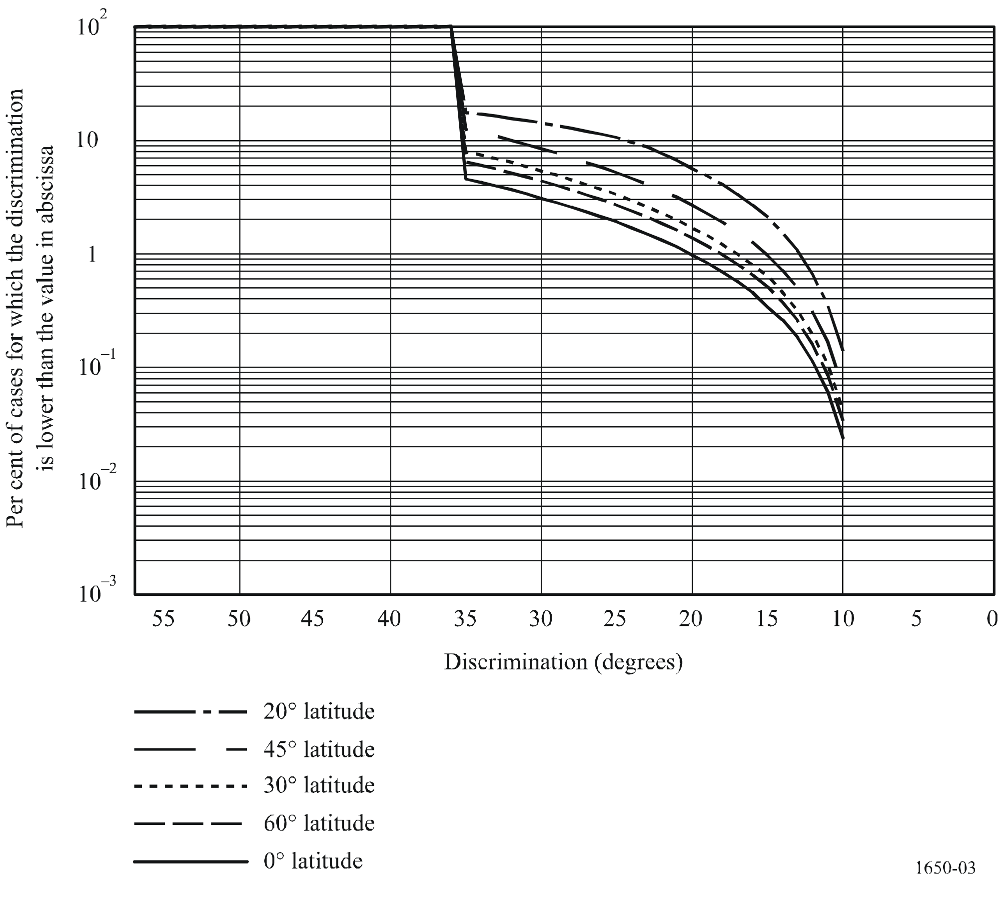


TABLE 3

ESV antenna discrimination angle for different latitudes

Latitude (degrees)	Maximum elevation (degrees)	Percentage for the given discrimination		
		> 36°	< 30°	< 20°
0	**90**	95.4	2.8	0.8
20	**66.6**	93.6	4	1.2
30	**55.8**	92.1	4.9	1.4
45	**38.2**	87.6	7.7	2.3
60	**22**	82.5	13.5	4.8

Noting the percentages in Table 3, distance results for 20° and 36° discrimination only are provided.

3.3 Propagation model

Results are presented based on propagation models in Recommendations ITU-R P.452 and ITU-R P.620.

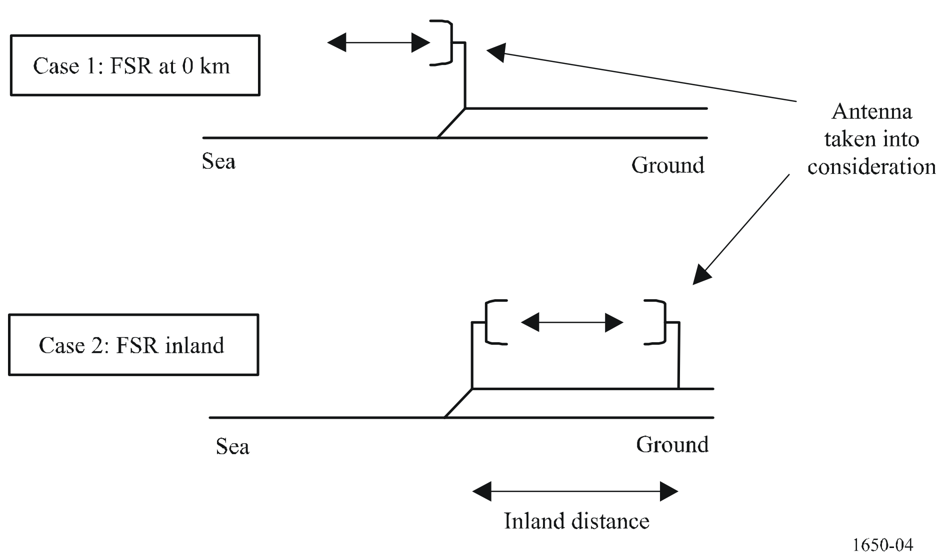
Results are presented for two example latitudes, 45° and 20°.

3.4 Location of FSR

The calculation methodology is based on analysis of interference from the ESV into the main lobe of the FSR antenna. Results are presented for two cases: the FSR located on the coast (0 km inland) and the FSR located some distance inland (25 km inland for the 6 GHz band and 15 km for the 14 GHz band) as shown in Fig. 4.

FIGURE 4

Two cases of FSR location



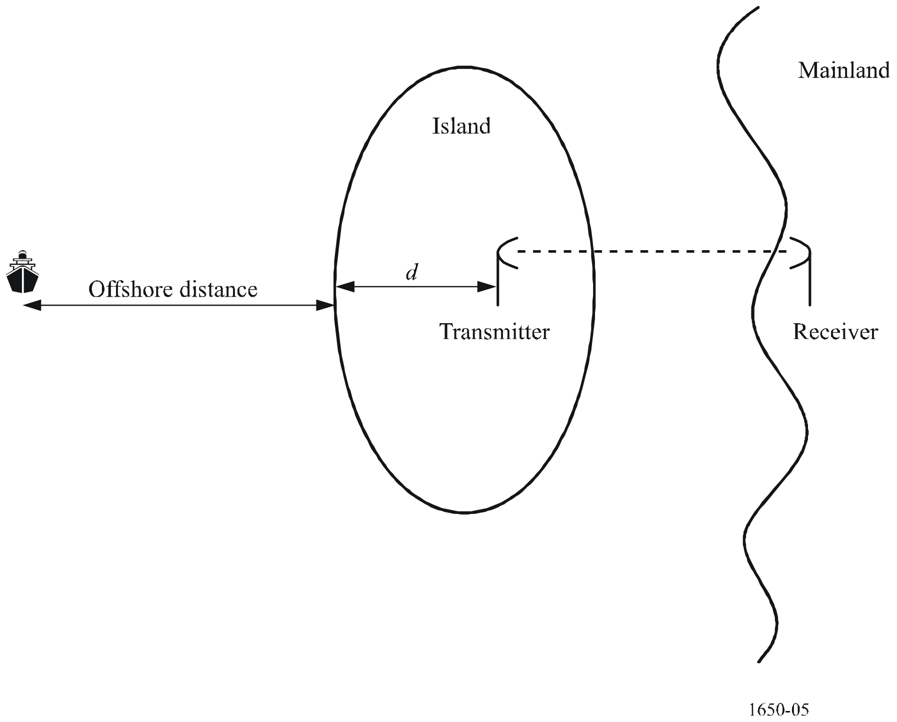
Fixed-link receivers located on the coast will generally be pointing inland. However, due to links serving islands off the mainland, there may be links located on or near the coastline which face directly out to sea. The implications of this scenario could be that the offshore distance should be based on the case of the FSR on the coastline to ensure that all FSRs are protected. However it would be logical to apply the offshore distance from the coast of the island as well as the mainland. This is illustrated in Fig. 5.

The Figure shows that the distance between the ESV and the FSR is the offshore distance + the length of the fixed link + d the distance from the fixed link transmitter on the island to the coast in the direction of the vessel. Hence even for those fixed links serving islands, there is always an additional distance between the FSR and the coast from which the offshore distance is applied.

In the RR, it would not be practical to apply the offshore distance to some types of land and not to others. Hence it is reasonable to assume that the distance would be applied with respect to all land, including islands.

FIGURE 5

FSR receiver located on coast serving an island



3.5 Number of vessels in the 6 GHz band

It is necessary to estimate the number of vessel passes across the beam of the FSR which are received within the receiver bandwidth.

Recommendation ITU-R S.1428 gives some idea of the number of vessels which may currently exist or be predicted for the near future. Table 4 gives the number of terminals.

TABLE 4

System 1	“around”
System 2	“around 50”
System 3	“43”
System 4	“around 50”
Total	“about 183”

There are likely to be other service providers which are not included in the Recommendation, but the number of ESVs currently operating can be assumed to be in the low hundreds. These may be assumed to be operating throughout the world. However, it is reasonable to assume that the number of ESVs will increase in the future.

Although it is necessary to consider the likely future growth in the number of ESVs, this depends on a number of factors which are difficult to quantify.

In view of the above, the distances are calculated for a range of co-frequency vessel passes, i.e. one vessel pass every three days, one vessel pass per day and three vessel passes per day.

3.6 Number of vessels in the 14 GHz band

In the band 14.25-14.5 GHz earth stations located on board vessels are likely to be deployed on ferries. Therefore, the number of vessels is likely to be higher than that for the band 5 925-6 425 MHz. Statistics for the United Kingdom indicate that Dover is its busiest ferry port. In 1999 there were approximately 24 000 ferry arrivals, which equates to around 66 ferries per day. The number of vessel passes per day is therefore estimated at 132 passes per day. If the ESV emissions are evenly distributed across the entire band, i.e. 14-14.5 GHz, the number of vessel passes falling within the band upper 250 MHz can be estimated at 66 passes per day. Assuming one ESV emission at any time in the FSR receiver bandwidth, the number of vessel passes per day becomes $66 \times 17/250$ or 4.5 per day. In order to retain a balanced degree of conservatism, the minimum distance has been calculated on the basis of three vessel passes per day and six vessels per day.

3.7 Height of FSR

For the calculations in the 6 GHz band, the FSR antenna height is taken as 120 m above mean sea level. Although this is representative of most cases, in some countries fixed links can be located on mountains with an altitude of about 1 000 m. If it is also assumed that the FSR is 25 km from the coast, and pointing out to sea, then the corresponding fixed-link transmitter is likely to be at a much lower altitude, and hence the FSR will have a negative elevation angle (of about –2.3°) whereas the elevation angle from the FSR to the ESV at the offshore distance will be about 0°. Hence additional FSR antenna discrimination will exist.

4 Resulting distances

Using the parameter values and the methodology described above, the minimum distance can be calculated as shown in the following Tables.

4.1 Distances for the 6 GHz band

a) Protection distance in the 6 GHz band using Recommendation ITU-R P.620, latitude = 45°

		FSR at 0 km from the coast			FSR at 25 km from the coast(1)		
Antenna discrimination angle (degrees)		10(2)	20	36	10(2)	20	36
L_b (dB)		170.5	163	156.5	170.5	163	156.5
1 vessel every third day	Distance (km)	**420**	**345**	**280**	**375**	**300**	**235**
	p (%)	0.048	0.058	0.071	0.050	0.061	0.077
1 vessel every day	Distance (km)	**445**	**370**	**300**	**405**	**325**	**260**
	p (%)	0.015	0.018	0.022	0.015	0.019	0.023
3 vessels every day	Distance (km)	**465**	**385**	**320**	**425**	**350**	**280**
	p (%)	0.005	0.006	0.007	0.005	0.006	0.007

(1) The proposed distances are referred to the coast which means that the distances in columns corresponding to "FSR at 25 km from the coast" represents the distance to the FSR minus 25 km.

(2) 10° discrimination only occurs in the improbable case for which the FSR and ESV azimuths are aligned, and the ESV operates at the minimum elevation angle.

b) Protection distance in the 6 GHz band using Recommendation ITU-R P.452, latitude = 45º (ΔN = 50)

		FSR at 0 km from the coast			FSR at 25 km from the coast(1)		
Antenna discrimination angle (degrees)		10(2)	20	36	10(2)	20	36
L_b (dB)		170.5	163	156.5	170.5	163	156.5
1 vessel every third day	Distance (km)	**404**	**328**	**265**	**368**	**294**	**233**
	p (%)	0.049	0.060	0.075	0.050	0.072	0.077
1 vessel every day	Distance (km)	**427**	**347**	**283**	**396**	**321**	**258**
	p (%)	0.015	0.019	0.023	0.016	0.019	0.023
3 vessels every day	Distance (km)	**445**	**365**	**298**	**420**	**342**	**279**
	p (%)	0.005	0.006	0.007	0.005	0.006	0.007

c) Protection distance in the 6 GHz band using Recommendation ITU-R P.620, latitude = 20°

		FSR at 0 km from the coast		FSR at 25 km from the coast(1)	
Antenna discrimination angle (degrees)		20	36	20	36
L_b (dB)		163	156.5	163	156.5
1 vessel every third day	Distance (km)	**375**	**307**	**343**	**277**
	p (%)	0.052	0.064	0.053	0.065
1 vessel every day	Distance (km)	**391**	**323**	**362**	**293**
	p (%)	0.017	0.020	0.017	0.020
3 vessels every day	Distance (km)	**408**	**377**	**378**	**308**
	p (%)	0.006	0.007	0.006	0.007

d) **Protection distance in the 6 GHz band using Recommendation ITU-R P.452, latitude = 20° ($\Delta N = 70$)**

		FSR at 0 km from the coast		**FSR at 25 km from the coast**[(1)]	
Antenna discrimination angle (degrees)		20	36	20	36
L_b (dB)		163	156.5	163	156.5
1 vessel every third day	Distance (km)	**348**	**283**	**318**	**253**
	p (%)	0.057	0.070	0.057	0.071
1 vessel every day	Distance (km)	**364**	**297**	**334**	**267**
	p (%)	0.018	0.022	0.018	0.023
3 vessels every day	Distance (km)	**378**	**310**	**347**	**281**
	p (%)	0.006	0.007	0.006	0.007

When considering the results presented above, attention should be given to the discussion on the parameters values and scenarios in § 3. The recommended minimum distance from the low-water mark as officially recognized by the coastal State, beyond which in-motion ESVs would not cause unacceptable interference to the FS is 300 km.

4.2 Distances for the 14 GHz band

a) **Protection distance in the 14 GHz band using Recommendation ITU-R P.620, latitude = 20º**

		FSR at 0 km from the coast		**FSR at 15 km from the coast**[(1)]	
Antenna discrimination angle (degrees)		20	36	20	36
L_b (dB)		155.2	148.7	155.2	148.7
L_1 (dB)		19.7	13.2	19.7	13.2
3 vessels every day	Distance (km)	**165**	**120**	**150**	**105**
	p (%)	0.009	0.013	0.009	0.005
6 vessels every day	Distance (km)	**170**	**120**	**155**	**105**
	p (%)	0.004	0.006	0.004	0.006

(1) The proposed distances are referred to the coast which means that the distances in columns corresponding to "FSR at 15 km from the coast" represent the distance to the FSR minus 15 km.

b) **Protection distance in the 14 GHz band using Recommendation ITU-R P.452, latitude = 20º ($\Delta N = 70$)**

		FSR at 0 km from the coast		**FSR at 15 km from the coast**[(1)]	
Antenna discrimination angle (degrees)		20	36	20	36
L_b (dB)		155.2	148.7	155.2	148.7
3 vessels every day	Distance (km)	**156**	**111**	**140**	**95**
	p (%)	0.007	0.009	0.007	0.005
6 vessels every day	Distance (km)	**160**	**114**	**144**	**98**
	p (%)	0.003	0.005	0.003	0.005

c) Protection distance in the 14 GHz band using Recommendation ITU-R P.620, latitude = 45º

		FSR at 0 km from the coast			**FSR at 15 km from the coast**[(1)]		
Antenna discrimination angle (degrees)		10[(2)]	20	36	10[(2)]	20	36
L_b (dB)		162.7	155.2	148.7	162.7	155.2	148.7
L_1 (dB)		27.2	19.7	13.2	27.2	19.7	13.2
3 vessels every day	Distance (km)	**210**	**160**	**115**	**195**	**140**	**95**
	p (%)	0.007	0.010	0.013	0.007	0.010	0.014
6 vessels every day	Distance (km)	**215**	**165**	**115**	**200**	**145**	**100**
	p (%)	0.004	0.005	0.007	0.004	0.005	0.007

(2) 10° discrimination only occurs in the improbable case for which the FSR and ESV azimuth are aligned, and the ESV operates at the minimum elevation angle.

d) Protection distance in the 14 GHz band using Recommendation ITU-R P.452, latitude = 45º (ΔN = 50)

		FSR at 0 km from the coast			**FSR at 15 km from the coast**[(1)]		
Antenna discrimination angle (degrees)		10[(2)]	20	36	10[(2)]	20	36
L_b (dB)		162.7	155.2	148.8	162.7	155.2	148.8
3 vessels every day	Distance (km)	**202**	**150**	**106**	**183**	**131**	**87**
	p (%)	0.005	0.007	0.010	0.006	0.009	0.014
6 vessels every day	Distance (km)	**205**	**155**	**109**	**187**	**136**	**90**
	p (%)	0.003	0.004	0.034	0.003	0.004	0.007

When considering the results presented above, attention should be given to the discussion on the parameters values and scenarios in § 3. The recommended minimum distance from the low-water mark as officially recognized by the coastal State, beyond which in-motion ESVs would not cause unacceptable interference to the FS is 125 km.