

RECOMMENDATION ITU-R SF.1649-1

Guidance for determination of interference from earth stations on board vessels to stations in the fixed service when the earth station on board vessels is within the minimum distance*

(Questions ITU-R 226/9 and ITU-R 254/4)

(2003-2008)

Scope

This Recommendation provides guidance to administrations for the determination of the interference potential of earth stations on board vessels (ESVs) to stations in the fixed service. Annex 1 provides general considerations for this determination. Annex 2 provides a description of the most basic approach to such a determination. Annex 3 provides several alternative approaches based on simulations. Annex 4 contains material that may be considered in bilateral and multilateral discussion when administrations authorize antennas smaller than 1.2 m in the 14.0-14.5 GHz band to ensure that these smaller antennas are in compliance with the requirements of Resolution 902 (WRC-03).

The ITU Radiocommunication Assembly,

considering

- a) that vessels may be equipped to operate FSS ESVs which transmit in the FSS networks in the 5 925-6 425 MHz band (Earth-to-space) under No. 4.4 of the Radio Regulations (RR);
- b) that vessels may be equipped to operate as ESVs in the 14-14.5 GHz band under RR No. 4.4 or as secondary service in the MSS;
- c) that some of the bands in *considering* a) and b) are shared on a co-primary basis with the fixed service (FS);
- d) that if ESVs were to be permitted to operate in sea-lanes and channels near to shore it would be necessary to define composite areas for these operations;
- e) that Recommendation ITU-R SF.1585 provides a way to define such an area;
- f) that stations in the FS within such an area must be examined to determine whether they will experience more than a permissible amount of interference;
- g) that many FS digital systems operate under automatic transmit power control (ATPC);
- h) that interference events of more than a few seconds can result in significant long-term outages in digital FS systems;
- j) that Recommendations ITU-R SF.1006 and/or ITU-R SM.1448 provide methods that could be used for the determination of interference potential between stations in the FSS and stations in the FS when the ESVs are stationary (see Note 1);

* For the definition of “minimum distance”, see Recommendation ITU-R SF.1650-1.

- k) that the methodology for determining the level of interference from ESVs to FS stations is a matter for agreement between the administrations concerned;
- l) that guidance to administrations on the detailed determination of these levels for performing a preliminary analysis may nonetheless be of value to some in the detailed assessment of interference;
- m) that Recommendations ITU-R F.696 and ITU-R F.1565 define permissible interference criteria for stations in the FS;
- n) that different methods and interference criteria are needed to determine the interference potential from ESVs when these are not fixed,

recognizing

- a) that the World Radiocommunication Conference (Istanbul, 2000) (WRC-2000) called for ITU-R to urgently complete its studies related to earth stations on board vessels (ESVs), in particular not to have the potential to cause unacceptable interference to stations of other services of any administration;
- b) that the RR No. 5.457A specifies that earth stations on board vessels in the bands 5 925-6 425 MHz and 14-14.5 GHz may communicate with space stations of the fixed-satellite service as long as such use is in accordance with Resolution 902 (WRC-03);
- c) that the RR No. 5.457B specifies that earth stations located on board vessels in the bands 5 925-6 425 MHz and 14-14.5 GHz may operate in Algeria, Saudi Arabia, Bahrain, Comoros, Djibouti, Egypt, United Arab Emirates, the Libyan Arab Jamahiriya, Jordan, Kuwait, Morocco, Mauritania, Oman, Qatar, the Syrian Arab Republic, Sudan, Tunisia and Yemen on a secondary basis in the maritime mobile-satellite service with the characteristics and under the conditions contained in Resolution 902 (WRC-03),

noting

- a) that the technical limitations for ESV operation given in Annex 2 of Resolution 902 (WRC-03), in particular the off-axis limits, are applicable in determining the potential for interference;
- b) that Recommendation 37 (WRC-03) (Operational procedures for earth stations on board vessels (ESVs) use) gives the procedures for the operation of ESVs,

recommends

- 1 that the guidance described in Annex 1 may be used as a framework for the overall assessment of interference from ESVs operating within the “minimum distance” to stations in the FS;
- 2 that the guidance in Annex 2 may be used as the basis for the calculation of interference from ESVs (see Note 2 and Note 3);
- 3 that results of the application of the method in Annex 2 can be used to determine whether portions of the frequency bands in *considering* b) may be considered for use by ESVs when operating within the “minimum distance” (see Note 3);
- 4 that the technical material in Annex 4 may be considered by administrations in their bilateral and multilateral discussions when authorizing ESVs operating with antennas smaller than 1.2 m in the band 14.0-14.5 GHz to ensure that these smaller antennas are in compliance with the requirements of Resolution 902 (WRC-03).

NOTE 1 – The methods given in this Recommendation make use of FS interference protection criteria. As an example, Recommendation ITU-R SF.1006 provides such criteria but the short-term criteria may only be compliant with ITU-T Recommendation G.821. On the other hand, Recommendation ITU-R SF.1650 provides FS short-term protection criteria for up-to-date links designed to meet the requirements of ITU-T Recommendations G.826 and G.828.

NOTE 2 – When identifying frequencies for ESVs, mitigation techniques may need to be considered. For example, in the case where the FS frequency arrangements are based on Recommendation ITU-R F.383, the use of the 6 GHz FS central band (close to 6.175 GHz) by the ESV transmitters can significantly reduce the potential interference to the FS receivers since, when considering interference to any FS channel, there would be benefit from receiver filtering.

NOTE 3 – The method in Annex 2 may be supplemented by the use of the method in Annex 3.

Annex 1

Guidance for identifying and using points on the operating contour* for the determination of interference from emissions from an ESV in motion to a station in the fixed service (critical contour point method)

The following method may be used as a framework for the overall assessment of interference from ESVs operating within the minimum distance to stations in the FS.

1 Introduction

The method for assessing interference potential between a station in the FSS and a station in the FS is provided in Recommendation ITU-R SF.1006, which assumes that the FSS and the FS stations have a fixed spatial relationship. ESVs moving into a port or harbour to a dock or anchorage have a variable relationship with FS stations while in motion.

Recommendation ITU-R SF.1585 describes a method for using the operating contour of ESV-equipped vessels to determine an area which can be used in identifying the FS stations that could experience unacceptable interference from an ESV as it is travelling along this contour. Under existing procedures, the potential for such interference would need to be evaluated as if it were stationary at each possible point along a vessel's route whenever it is within this area.

This Annex provides a methodology called the critical contour point method which simplifies the determination of interference potential to FS stations to consideration of a small set of points on the operating contour. Each of these points is designated as a critical contour point (CCP). Some of these points are specific to the operating contour, whereas others are specific to the particular FS station.

* The operating contour is defined in Recommendation ITU-R SF.1585.

2 Considerations in determining the CCP

2.1 Stationary operation

For stationary operation of an ESV, the potential for interference can be assessed using Recommendation ITU-R SF.1006 or ITU-R SM.1448 or by any procedures agreed between the administrations involved as they would be applied to any new FSS station.

2.2 In-motion operation

Each FS station within an area (for example, as described in Recommendation ITU-R SF.1585) must be examined to determine whether it will experience more than a permissible amount of interference. This would normally require assessment of the interference potential with respect to each FS station at each point along the route of an ESV-equipped vessel in motion within the operating contour. However, the CCP methodology offers an approach to reducing such computational requirements by identifying a small number of points for each FS receiver within a certain area.

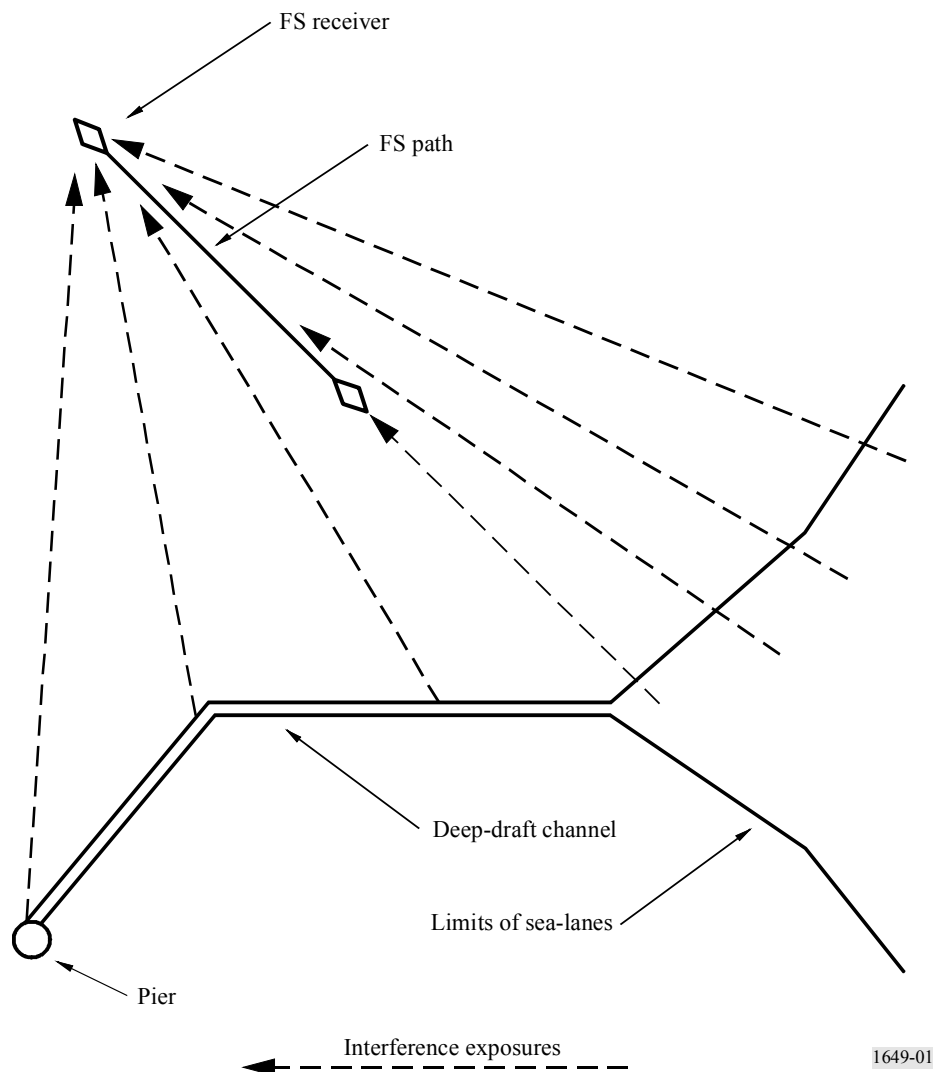
2.2.1 Identification of the CCP for each potentially-affected FS receiver

For any interference exposure of a particular FS receiver from an ESV terminal on a moving ship, there are three position-related variables in the calculation:

- propagation loss exceeded for all but a percentage of time. This loss depends on the length of the interference path, the Radio-Climatic Zones and may include the effects of any blockage that may exist on the interference path;
- FS receiver antenna gain; and
- ESV antenna horizon gain.

For every point within the operating contour as defined by the deep-draft channel (see Fig. 1), each of these three factors can be readily determined.

FIGURE 1
Basic interference geometry



For the purpose of evaluating the potential interference the operating contour is approximated by a set of straight-line segments. The identification of the CCPs depends on the position and alignment of the FS path with respect to the operating contour, and several cases need to be distinguished. In those cases where the azimuth of the main beam axis of the FS antenna does not intersect with any portion of the operating area of the ESV, the critical contour points are the points along the operating contour where the contour changes direction or reaches the off-shore limit beyond which coordination is not required. In those cases where the azimuth of the main beam axis of the FS antenna intersects the operating contour it is necessary to augment and/or modify the number of CCPs. In any event, the same CCPs should be used to consider both the long-term and the short-term interference to any FS station under consideration. Interference from in-motion ESV operations to any FS receiver within the area where the potential interference from the ESV needs to be evaluated is assessed by consideration of the operation at each of the CCPs for each receiver using propagation loss models such as those given in Recommendation ITU-R P.452. The goal of this assessment is the identification of frequencies that can be used for in-motion ESV operations without causing unacceptable levels of interference to FS stations.

For the identification of the CCPs with respect to a specific FS receiver, the following three cases need to be distinguished:

Case 1: In this case the main beam axis of the FS receiving antenna does not intersect any portion of the operating contour. The only CCPs required for this case are the points where the operating contour of the ESV changes direction.

Case 2: In this case, the main beam of the FS antenna (within 10 dB of the maximum antenna gain) lies entirely within one segment of the operating contour. The points on the operating contour where the antenna gain is 10 dB below the maximum, determine two additional CCPs. The segment of the operating contour between these two CCPs contains the natural intersection point (NIP), the point where the main beam axis of the FS antenna intersects the operating contour. The NIP is always taken as a CCP.

Case 3: In this case, the NIP is close enough to one of the points where the operating contour changes direction that the main beam of the FS antenna extends over more than one segment of the operating contour. This case is most likely to arise when the NIP is close to one of the points where the operating contour of the ESV changes direction. The intersection of the operating contour with the antenna 10 dB points determine two additional CCPs as in Case 2; however, in this case the original point within the main beam does not need to be considered as a CCP.

A further possibility: If there is a point on the operating contour of an ESV from which the maximum horizon gain of the ESV antenna is directed toward a FS receiver, that point on the contour may be identified as an additional CCP for that FS receiver regardless of which of the three cases applies.

2.2.2 Consideration of long-term interference

The long-term interference is determined by an aggregation of the interference power from each segment of the operating contour from the pier to the end of the operating contour beyond which coordination is not necessary. That is, from a summation of the contributions resulting from operation between each of the successive CCPs with respect to an FS receiving station*. The procedure as elaborated in Annex 2 uses the principle of fractional degradation of performance (FDP) from Recommendation ITU-R F.1108. The only difference is that the propagation loss needed for the calculation is the propagation loss from each CCP that is exceeded for all but 20% of the time. The contribution to the FDP from each segment may be calculated in closed form based on the average interference power received due to ESV operation within the segment, including the effect of the duration of time spent in the segment in multiple passes of ESVs. For a segment that does not contain an NIP this average is computed by assuming that the sum of the gain (dB) of the FS and the ESV antennas varies linearly over the segment. The average over a segment containing an NIP is determined based on a Gaussian-shaped main beam of the FS antenna as in Recommendation ITU-R F.1245.

The criterion that is applied to this interference is the power level taken for long-term interference in Recommendation ITU-R SF.1006 or ITU-R F.758.

2.2.3 Consideration of short-term interference

The acceptability of short-term interference may be determined by considering whether the interference power due to operations near any CCP exceeds the value specified by the short-term criterion for more than an acceptable percentage of time, p_{ST} . The short-term interference criteria used in Recommendation ITU-R SF.1650 for the 6 and 14 GHz bands may be used for this purpose.

* The operating contour is defined in Recommendation ITU-R SF.1585.

The determination of the short-term interference power due to ESV operation near a CCP depends on the propagation loss on the path from that CCP. In particular, it depends on the propagation loss exceeded for all but a small percentage of time, a percentage that is inversely proportional to the percentage of time, p_{ESVi} , associated with the ESV operation near that CCP. This approach, described in detail in Annex 2, is similar to that used in Recommendation ITU-R SF.1485, or in § 2.2.2 of Annex 1 to Recommendation ITU-R SM.1448. The percentage of time associated with ESV operation near a CCP depends on which situation applies of those that can occur under the three cases described above in § 2.2.1.

In cases where the main beam axis of the FS has a natural intersection point on the operating contour of the ESV, the percentage of time, p_{ESVi} , associated with the ESV operation near that NIP is directly related to the time it takes for an ESV to move along the operating contour between the two 10 dB points of the FS antenna.

Except for the CCPs that are adjacent to an NIP, which are treated as end points of the operating contour, the percentage of time p_{ESVi} depends on the time it takes the ESV to move from the mid-point of the preceding segment of the operating contour to the mid-point of the following segment of the contour. Where the CCP is an end-point of the operating contour, one of these segments does not exist and its contribution is set to zero.

There is also a possibility that more complex situations can occur, but these can be addressed using an approach similar to the one suggested here.

3 Application of CCP methodology in identifying available spectrum

The spectrum available for ESV terminals on ships under way in or near ports can be determined using the CCP methodology to evaluate whether use of a particular frequency will result in more than a permissible amount of interference between the ESV and stations in the FS.

After the CCPs have been determined for an FS receiving station, Annex 2 may be used to determine whether both the long-term and short-term interference levels are acceptable. Those frequency ranges where ESV operation can be shown not to cause unacceptable interference to any FS receiver can then be assigned for use by ESVs that visit that particular port.

Annex 2

The calculation of interference from ESVs

1 Introduction

Resolution 82 (WRC-2000) is concerned with provisions for ESVs operating in the frequency bands 3 700-4 200 MHz and 5 925-6 425 MHz. Three new Recommendations were developed in WP 4-9S, two of these only require consideration of short-term interference criteria. These are Recommendation ITU-R SF.1650 which addresses the off-shore distance beyond which interference into the fixed service need not be considered and Recommendation ITU-R SF.1585, which addresses the determination of the area within which the interference potential of ESVs needs to be considered in instances where the possibility of operations within the off-shore distance are contemplated. The third, this Recommendation, addresses the determination of the potential of ESVs to interfere when operating within the offshore distance.

Annex 1 addresses the determination of points for the determination of potential interference from ESVs. Once this determination has been made, it is necessary to consider interference into stations beyond the radio horizon as well as interference into stations that have line-of-sight coupling to the operating positions of an ESV in motion. In the case of fixed transmitting earth stations, the interference into FS receivers beyond the horizon is limited by applying short-term interference criteria, and interference into receivers with line-of-sight coupling is limited by applying long-term interference criteria. Recommendation ITU-R SF.1006 provides the methodology and interference criteria for both long- and short-term interference assessment and recommends that both criteria be met in the determination of interference potential. While ESVs add complexity to the determination of interference potential, the principles remain the same: distant stations are protected from short-duration high-power interference by short-term criteria; nearby stations are protected by long-term criteria, which protect the fade margin of the receiver. This Annex provides the basis for determining the interference potential in all cases of interest.

Section 2 below describes the statistics of the propagation loss between two stations on the surface of the Earth, and shows, for different length paths, the relation between the loss exceeded for all but a percentage of the time and the long- and short-term interference criteria that are applied when the transmitting earth station is at a fixed location. Section 3 considers how to determine the interference potential in the presence of the additional complexity caused by introducing motion to the position of the interfering station and develops an approach derived from the use of the FDP approach of Recommendation ITU-R F.1108 in conjunction with the CCP methodology of Annex 1 to this Recommendation. It is shown in § 4 that this approach leads to a method for determining the acceptability of the potential interference based on existing long-term interference criteria. An approach to the consideration of short-term interference based on the same set of CCPs is developed in § 5.

2 Minimum required propagation loss for a fixed percentage of time with stationary stations

The minimum required propagation loss required to meet a permissible level of interference power at the antenna terminals of a receiving fixed station for a percentage of time, p , may be obtained with Recommendation ITU-R SM.1448, where the minimum required loss is the loss that needs to be equalled or exceeded by the predicted path loss for all but $p\%$ of the time¹. Thus:

$$L_b(p) = P_t + G_t + G_r - P_r(p) \quad \text{dB} \quad (1)$$

where:

- p : maximum percentage of time for which the permissible interference power may be exceeded
- $L_b(p)$: propagation mode (1) minimum required loss (dB) for $p\%$ of the time; this value must be exceeded by the propagation mode (1) predicted path loss for all but $p\%$ of the time
- P_t : maximum available transmitting power level (dBW) in the reference bandwidth at the terminals of the antenna of a transmitting terrestrial station or earth station
- $P_r(p)$: permissible interference power of an interfering emission (dBW) in the reference bandwidth to be exceeded for no more than $p\%$ of the time at the

¹ When p is a small percentage of the time, in the range 0.001% to 1.0%, the interference is referred to as short term; if $p \geq 20\%$, it is referred to as long term.