



# ECC Report **217**

The Use of Land, Maritime and Aeronautical Earth Stations on Mobile Platforms Operating with NGSO FSS Satellite Systems in the Frequency Range 17.3-20.2 GHz, 27.5-29.1 GHz and 29.5-30.0 GHz

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## 0 EXECUTIVE SUMMARY

Land, Maritime and Aeronautical Earth Stations On Mobile Platforms (ESOMPs)<sup>1</sup> are operating in Ka-band Fixed Satellite Service (FSS) non-Geostationary (NGSO) satellite systems. The ECC Report 184 [1], adopted in February 2013 examined the regulatory and technical aspects applicable to the use of ESOMPs operating in Ka-band GSO networks, making references to similar developments in the C-band and Ku-band where mobile terminals have operated for many years in Geostationary (GSO) FSS networks, under certain technical and regulatory conditions. With the technical conditions given in this Report, ESOMPs may be treated in a similar fashion to uncoordinated FSS earth stations. This Report offers a technical analysis similar to that carried out in the ECC Report 184 [1] [for GSO ESOMPs, and recommends that ESOMPs should be authorised in the Ka-band frequencies already identified by CEPT administrations for the operation of uncoordinated FSS earth stations, with the necessary technical conditions to ensure protection of other satellite and terrestrial services.

This Report identifies certain technical, operational and regulatory requirements, of which some are already included in ECC Decision (15)04 [34] on Ka-band ESOMPs operating to FSS NGSO satellite systems. Such technical requirements are necessary to ensure, among other things, that ESOMPs antennas maintain a high pointing accuracy and do not cause interference to other satellite networks and systems. It should be noted that, in the case of NGSO satellite systems, the pointing accuracy also takes into account that the ESOMPs antenna will need to track the NGSO satellites as they move across the sky. Furthermore, in some cases, for example where one country has authorised a particular band for uncoordinated FSS earth stations and another has authorised the same band for fixed service networks, cross-border interference issues could potentially occur. To address these issues, for maritime ESOMPs this version of the report finds that a Power Flux Density (PFD) threshold applicable to the low-water mark of the territory of an administration is necessary. CEPT have also performed and submitted studies to ITU that advocate a combination of an e.i.r.p. density limit together with a minimum distance which was used as a basis for the decision under WRC-19 A1.5 to adopt a minimum distance of 70 km from the low water mark of coastal state and a maximum e.i.r.p. density of 24.44 dBW/14 MHz. This matter will be further considered in future revisions of this report and ECC Report 184 [1]. For aircraft ESOMPs a PFD threshold at the ground applicable to the territory of a country is needed. This Report identifies the applicable PFD thresholds to be met by maritime and aeronautical ESOMPs.

In the downlink FSS bands (17.3-20.2 GHz), ESOMPs would receive the same protection from interference as equivalent uncoordinated FSS earth stations. In some instances, this means that the ESOMPs would operate on a non-protected basis.

ESOMPs may be deployed globally for land, maritime and aeronautical applications. The ITU has developed ITU-R Report S.2261 [2] on technical and operational requirements for ESOMPs operating to Ka-band NGSO satellite systems. This ITU Report also notes the need for operators to implement methodologies to comply with technical and operational requirements placed on the deployment of ESOMPs by administrations.

This Report, in consistency with ECC Report 184, adopts for aeronautical ESIM connected to NGSO systems the same pfd mask adopted in that Report. This is based on the assumption that the availability of NGSO systems for aeronautical applications does not change the number of connected aircraft in the relevant frequency bands and the take up of this type of services used for the derivation of the mask in ECC Report 184.

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<sup>1</sup> When a reference is made to ESOMPs operating to GSO networks, it is referenced as "GSO ESOMPs".

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<b>Abbreviation</b>	<b>Explanation</b>
<b>AES</b>	Aircraft Earth Station
<b>AMSS</b>	Aeronautical Mobile-Satellite Service
<b>CEPT</b>	European Conference of Postal and Telecommunications Administrations
<b>CPM</b>	Conference Preparatory Meeting (ITU)
<b>EPFD</b>	Equivalent power flux-density
<b>ECC</b>	Electronic Communications Committee
<b>ESOMPs</b>	Earth Station On Mobile Platforms
<b>ESV</b>	Earth Station on board Vessel
<b>ETSI</b>	European Telecommunications Standards Institute
<b>e.i.r.p.</b>	equivalent isotropically radiated power
<b>FS</b>	Fixed Service
<b>FSS</b>	Fixed-Satellite Service
<b>GSO</b>	Geostationary Satellite Orbit
<b>G/T</b>	Gain to system noise temperature ratio (of a receiving earth station)
<b>HEST</b>	High e.i.r.p. Satellite Terminals
<b>HDFSS</b>	High-Density applications in the Fixed Satellite Service
<b>ITU</b>	International Telecommunication Union
<b>LEST</b>	Low e.i.r.p. Satellite Terminals
<b>MS</b>	Mobile Service
<b>MSS</b>	Mobile-Satellite Service
<b>NGSO</b>	Non-Geostationary Satellite Orbit
<b>NCF</b>	Network Control Facility
<b>PFD</b>	Power Flux Density
<b>P-MP</b>	Point-to-Multipoint
<b>PP</b>	Point-to-Point
<b>R&amp;TTE</b>	Radio equipment and Telecommunications Terminal Equipment
<b>VSAT</b>	Very Small Aperture Terminal
<b>WRC</b>	World Radiocommunication Conference

## 1 INTRODUCTION

The growing need for broadband communications will be addressed by, amongst others, non-Geostationary satellite systems operating in the Ka-band. Terminals described as Earth Stations mounted on Mobile Platforms (ESOMPs) will be an integral part of the NGSO satellite systems. ESOMPs will be deployed to provide telecommunications services to ships, aircrafts, trains and other vehicles. ESOMPs are currently deployed with C-, Ku- and Ka-band GSO satellite networks and Ka-band NGSO satellite systems. The deployments of Ka-band GSO networks and NGSO systems are relatively recent, however they demonstrate that operators concerned expect there to be a significant demand for broadband applications, for which ESOMPs will be used. It is also noted that ESOMPs operating to NGSO systems are being deployed within Europe to meet the demand for such applications.

The advances in satellite earth station antenna technology have contributed to the rapid deployment of ESOMPs in the FSS bands. Over the years, stabilised antennas capable of maintaining a high degree of pointing accuracy while on moving platforms have been perfected, and such developments, which also allow for maintaining very stable pointing characteristics, enabled ESOMPs to comply with the interference requirements. These have led to the deployment of ESOMPs within the same interference environment as fixed terminals, while complying with same regulatory constraints as those for typical uncoordinated FSS earth stations.

The ITU Reports ITU-R S.2223 [3], ITU-R S. 2357 [35] and ITU-R S.2261 [4] describe the technical and operational requirements for ESOMPs operating in Ka-band with GSO and NGSO satellites respectively. WRC-03 adopted technical, operational and regulatory provisions for Aeronautical Mobile Satellite Service (AMSS) systems and Earth Stations on-board Vessels (ESVs) to allow these systems to operate in FSS frequencies in the C- and Ku-bands. Since 2003, numerous networks have been operating successfully under these provisions. The ESOMPs for GSO networks and NGSO systems in the Ka-band are similar to those mobile earth stations, like ESVs operating in the C- and Ku-bands and AES operating in Ku-band.

This Report examines the operation of ESOMPs with NGSO satellite systems in the Ka-band frequencies and identifies the necessary technical and regulatory conditions to offer protection to other satellite or terrestrial services sharing the same frequency bands. Such technical and regulatory conditions may be used by the CEPT as the basis for a regulatory approach to be included in ECC Decision (15)04 [32].

The ECC Report 184 [1] on GSO ESOMPs, which identified the technical and operational requirements for Ka-band GSO ESOMPs, including the criteria for the protection of other services, provided the basis for preparation of the ECC Decision (13)01 [5] on GSO ESOMPs titled “the harmonised use, free circulation and exemption from individual licensing of Earth Stations On Mobile Platforms (ESOMPs) within the frequency bands 17.3-20.2 GHz and 27.5-30.0 GHz”. ECC Decision (13)01 has been revised in 2018 to also take into account the electromagnetic compatibility studies between satellite terminals and aircraft avionics in ECC Report 272 [36].

Similarly, an earlier version of this ECC Report 217 has provided the basis for the current ECC Decision (15)04, whose latest revision in 2019 also takes into account the electromagnetic compatibility studies between satellite terminals and aircraft avionics in ECC Report 272.

The criteria used for the protection of other services from Ka-band GSO ESOMPs have been considered as directly applicable for the protection of same services from Ka-band NGSO ESOMPs, and therefore used in this Report.

ESOMPs operating within NGSO satellite systems may utilise the frequency bands 17.3-20.2 GHz (space-to-Earth) and 27.5-29.1 GHz, 29.5-30.0 GHz (Earth-to-space).

## 2 THE USE OF THE BANDS 27.5-29.1 GHz, 29.5- 30.0 GHz AND 17.3-20.2 GHz BY NGSO ESOMPS

Ka-band NGSO ESOMPs utilise the frequency bands:

- 17.3 to 20.2 GHz band is used for space-to-Earth links. The use of these frequencies is not the subject of this Report and therefore not considered further;
- 27.5 to 29.1 GHz and 29.5-30.0 GHz bands are used for Earth-to-space links, i.e. transmissions from NGSO ESOMPs.

ECC Report 152 [6], on the use of the frequency bands 27.5-30.0 GHz and 17.3-20.2 GHz by satellite networks, identified a number of reasons, listed below, why some satellite operators and service providers are moving from Ku-band to Ka-band. In fact, some of the reasons, such as the ability to use smaller user terminals, are particularly relevant to the mobile markets served by ESOMPs, where the size and weight of the user antenna are critical considerations. Ka-band systems provide:

- Improved spectrum efficiency, due to the use of narrow spot beams;
- Better coverage and higher satellite antenna gain (for the same sized aperture), compared to lower frequency bands;
- Smaller user terminal size, due to higher satellite e.i.r.p. and G/T;
- Higher system capacity;
- Greater amount of spectrum available for FSS systems.

Users and businesses requiring communication services on mobile platforms, such as on aircraft, ships, trains and other vehicles, often have no other broadband access alternatives besides satellites.

Ka-band systems described in ECC Report 152 have been brought into use in Europe and elsewhere in the world.

### 3 REGULATORY FRAMEWORKS ESTABLISHED FOR RELATED FSS SYSTEMS AND THEIR RELEVANCE FOR NGSO ESOMPS

Several regulatory frameworks have been established by the ITU-R and CEPT for the deployment of Earth Stations on board Vessels (ESVs) in C- and Ku-bands, and for aircraft Earth stations (AESs) in Ku-band, for maritime and aeronautical applications, respectively. These AESs and ESVs are the forerunners to Ka-band ESOMPs. The regulatory frameworks adopted for AESs and ESVs are presented in this section for information.

In addition, the regulatory frameworks established for the FS in the Ka-band have a significant relevance to the development of regulations on Ka-band ESOMPs. This is because FSS and FS usually carry co-primary allocations, and in subject to CEPT regulations on band plans or band segmentation. These regulations relating FS are also discussed in this section.

#### 3.1 ITU-R

##### 3.1.1 WRC-03 Decisions on a secondary allocation for AMSS in the 14.0-14.5 GHz band

Extensive work was carried out by ITU-R study groups prior to WRC-03 under Resolution 216 [7] (Rev.WRC-2000 and abrogated in 2003), which *invited the ITU-R*:

“to complete, in time for WRC-03, the technical and operational studies on the feasibility of sharing of the band 14.0-14.5 GHz between the services referred to in considering c) [above] and the aeronautical mobile-satellite service, with the latter service on a secondary basis.”

Working Party 4A carried out technical studies which identified several essential requirements that an AMSS system should meet in order to protect FSS. In the case where an AMSS system was implemented within FSS assignments, the ITU-R concluded that the interference levels reaching GSO satellites must at all times be no more than the levels agreed to in coordination. These agreed levels are based on stable antenna platforms with well-defined antenna patterns and aggregate levels that are not to be exceeded. To achieve this goal, the ITU-R identified several requirements that should be placed on AMSS systems to protect FSS:

- Aggregation of off-axis power from multiple aircraft where applicable, for example in systems using spread spectrum multiple access;
- Antenna gain pattern;
- Antenna capture by adjacent satellites;
- Input power to the antenna;
- Antenna mis-pointing.

These factors formed the basis of a Recommendation on use of this band by AMSS and these were adopted as part of Recommendation ITU-R M.1643 [8].

The CPM Report to WRC-03 concluded that sharing with the FSS was possible in the 14.0-14.5 GHz frequency band, “provided aggregate co-frequency AES emissions in the direction of adjacent satellites are limited to levels that are equal to or less than the levels that have been accepted by other satellite networks.”<sup>2</sup>

Because several administrations have implemented Fixed Service (FS) networks in the 14.0-14.5 GHz band, studies were also carried out within former WP-8D to examine the feasibility of sharing between AMSS and the FS. Recommendation ITU-R M.1643 [8] adopted a PFD mask to protect FS networks in the 14.0-14.5

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<sup>2</sup> CPM Report to the 2003 World Radiocommunication Conference (WRC-03) at 2.4.2.

GHz band. In practice, sharing between AMSS and FS networks operating in the 14.0-14.5 GHz band has proven to be more difficult when the services are operating in the same geographic area.

### 3.1.2 WRC-03 Decisions on ESVs operating at C-Band and Ku-Band

In the case of Earth Stations on board Vessels, the former WP-4-9S was the leading working party for studies. Unlike AMSS, ESVs were treated from the start as operating in the FSS.

The CPM report to WRC-03 concluded that ESVs could protect other FSS networks so long as they complied with the off-axis e.i.r.p. limits given in Recommendation ITU-R S.524 [9] WRC-03 added a new footnote in Article 5 to clarify that ESVs shall be considered as operating in the FSS:

**“5.457A** In the bands 5 925-6 425 MHz and 14.0-14.5 GHz, earth stations located on board vessels may communicate with space stations of the fixed-satellite service. Such use shall be in accordance with Resolution 902 [10] (WRC-03)”

WRC-03 adopted Resolution 902 (WRC-03), which included technical and operational constraints to avoid interference from ESVs into terrestrial networks.

### 3.1.3 WRC-03 Decisions on HDFSS

WRC-03 adopted Resolution 143 (Rev.WRC-07) [12] “Guidelines for the implementation of high-density applications in the Fixed-Satellite Service in frequency bands identified for these applications”. As described by Resolution 143 (Rev.WRC-07), “HDFSS are characterised by flexible, rapid and ubiquitous deployment of large numbers of cost-optimised earth stations employing small antennas and having common technical characteristics.”

Resolution 143 (Rev.WRC-07) recognises “that co-frequency sharing between transmitting HDFSS earth stations and terrestrial services is difficult in the same geographical area” and that administrations implementing HDFSS should take into account “that HDFSS deployment will be simplified in bands that are not shared with terrestrial services.”

WRC-03 adopted a footnote which identified bands for use by HDFSS:

**“5.516B** the following bands are identified for use by high-density applications in the fixed-satellite service:

17.3-17.7 GHz (space-to-Earth) in Region 1,

18.3-19.3 GHz (space-to-Earth) in Region 2, 19.7-20.2 GHz (space-to-Earth) in all Regions,

39.5-40 GHz (space-to-Earth) in Region 1,

40-40.5 GHz (space-to-Earth) in all Regions,

40.5-42 GHz (space-to-Earth) in Region 2,

47.5-47.9 GHz (space-to-Earth) in Region 1,

48.2-48.54 GHz (space-to-Earth) in Region 1,

49.44-50.2 GHz (space-to-Earth) in Region 1,

and

27.5-27.82 GHz (Earth-to-space) in Region 1,

28.35-28.45 GHz (Earth-to-space) in Region 2,



- 28.45-28.94 GHz (Earth-to-space) in all Regions,
- 28.94-29.1 GHz (Earth-to-space) in Region 2 and 3,
- 29.25-29.46 GHz (Earth-to-space) in Region 2,
- 29.46-30.0 GHz (Earth-to-space) in all Regions,
- 48.2-50.2 GHz (Earth-to-space) in Region 2.

This identification does not preclude the use of these bands by other FSS applications or by other services to which these bands are allocated on a co-primary basis and does not establish priority in the Radio Regulations among users of the bands. Administrations should take this into account when considering regulatory provisions in relation to these bands. See Resolution 143 (Rev.WRC-07)" [12].

### 3.1.4 Resolution 156 (WRC-15) and ITU RR

WRC-15 adopted footnote No. 5.527A and Resolution 156 (WRC-15) [37] with technical and operational conditions for earth stations in motion communicating with geostationary space stations in the fixed-satellite service operating in the frequency bands 19.7-20.2 GHz and 29.5-30.0 GHz.

## 3.2 CEPT

### 3.2.1 CEPT Regulatory Framework for HDFSS

As a result of the WRC-03 identification of bands for HDFSS, the ECC adopted ECC Decision (05)08 [13] which makes available for HDFSS deployment, subject to market demand, the following bands:

- 17.3-17.7 GHz and 19.7-20.2 GHz (space-to-Earth);
- 29.5-30.0 GHz (Earth-to-space).

ECC Decision (06)02 [14] and ECC Decision (06)03 [15] were also developed, providing exemption from individual licensing of Low e.i.r.p. Satellite Terminals (LESTs) and High e.i.r.p. Satellite Terminals (HESTs). The exemption requires the terminals to have an e.i.r.p. not exceeding 34 dBW for LESTs and 50-60 dBW for HESTs.

The LEST and HEST Decisions do not contain specific off-axis e.i.r.p. limits. Instead, they require compliance with ETSI EN 301 459 [16] or ETSI EN 301 428 [17] or equivalent technical specifications. These Harmonised European Standards contain requirements and test methods for ensuring compliance with the off-axis e.i.r.p. limits contained in Recommendation ITU-R S.524 [9].

Also following the WRC-03 identification of bands for HDFSS, through ECC Decision (05)01 [18] (which replaced ERC Decision (00)09) the CEPT administrations in conjunction with industry decided to "segment" the frequency band 27.5-29.5 GHz between the FS and the FSS (uncoordinated FSS earth stations). The frequency bands 27.5-27.8285 GHz, 28.4445-28.8365 GHz and 29.4525-29.5 GHz were designated for the use of uncoordinated FSS earth stations (including transportable terminals). This represents 768 MHz available for uncoordinated FSS earth stations: one block of 328.5 MHz, one block of 392 MHz and one block of 47.5 MHz.

Also, through Decision ECC Decision (05)01 the frequency band 28.8365-28.9485 GHz was designated for the use of uncoordinated FSS earth stations, without prejudice to the FS systems licensed in this band in some countries before the date of adoption of this Decision. This represents an additional 112 MHz within which no new FS stations can be deployed except in countries which make use of Decides 2) and 4) of this Decision.

It should be noted that as of December 2019, ECC Decision (05)01 has been declared as having been implemented by 34 CEPT administrations (including 6 administrations that had partly implemented the

Decision). Additionally, 2 additional administrations are committed to implementation, with 1 “Not Implemented”, 1 “Implementation Under Study”, and 8 “No Information”.

It should be noted that the NGSO ESOMPs in the Ka-band do not fall within the definitions of HDFSS nor within the definitions of LEST and HEST. Therefore, the e.i.r.p. and off-axis e.i.r.p. limitations stipulated in above mentioned ECC Decisions or the ETSI standards mentioned above do not apply.

### **3.2.2 CEPT Regulatory Framework for AESs and ESVs**

Under established international law, national sovereignty over radio spectrum resources extends above the national territory up to the limits of the atmosphere and out to 12 nautical miles from the low-water mark of the coast. Any ESOMP operating in the territory of a country must be duly authorised by that country.

Three ECC Decisions were adopted following WRC-03 to allow for the free circulation of AESs and ESVs. The Decisions are ECC Decision (05)09 [20] and ECC Decision (05)10 [21] for ESVs operating in the C- and Ku-bands respectively. Also, ECC Decision (05)11 [22] was adopted for Aircraft Earth Stations (AESs) operating in the Ku-band.

These ECC Decisions included technical, operational and regulatory requirements which ensured that the ESVs and AESs had the same interference characteristics as a typical uncoordinated FSS earth station. Since the adoption of these ECC Decisions, hundreds of ESVs and AESs have operated successfully in European waters and airspace. Similar conditions could be adopted and applied to the ESOMPs in parts of the Ka-band identified for uncoordinated FSS operations.

### **3.2.3 Applicability of Previous Frameworks to NGSO ESOMPs in the Ka-band**

The previous frameworks adopted for ESVs in the C- and Ku-bands, AES in the Ku-band and GSO ESOMPs in Ka-band served the purpose well, and demonstrated that ESV, AES and GSO ESOMPs terminals could be deployed without causing interference to other services. These frameworks set the background for the adaption of suitable technical and regulatory measures for the deployment of maritime and aeronautical ESOMPS operating to NGSO systems in the Ka-band.

NGSO ESOMPs operating in the Ka-band present a sharing environment similar to that found in the 14.0-14.5 GHz band for ESV, AES and VSAT networks and in Ka-band for GSO ESOMPs, but with an added element of time variability due to the movement of the satellite across the sky and the ESOMPs terminal tracking it.

ESOMPs in parts of the Ka-band shared between FSS and FS are similar to ESV, AES and VSAT networks, in that sharing between such earth stations and co-frequency FS networks which are located in the same geographic area is difficult for all types of earth stations because they could be located anywhere within the operational area of such an FS network. Similarity also occurs with Ka-band GSO ESOMPs in the portion of the 27.5-29.5 GHz band shared with FS. Such deployment of ESOMPs should be managed carefully to ensure the protection of FS.

Technical, operational and regulatory requirements have been adopted within the ITU-R to ensure that the ESVs and AESs operating between 14.0 GHz and 14.5 GHz have the same interference characteristics as typical FSS earth stations. Regulators have ensured that Ku-band ESVs and AESs operate only in bands which have no use or limited use by terrestrial services. Since the adoption of these regulations, hundreds of ESVs and AESs have operated successfully worldwide on ships and aircraft.

Taking into account the success of the previous ECC Decisions, including ECC Decision (13)01 for Ka-band GSO ESOMPs, a similar regulatory had been adopted in the Ka-band for ESOMPs operating with NGSO, as per ECC Decision (15)04, although initially this decision did not cover aircraft-ESOMPs. The suggested Ka-band frequencies within which ESOMPs may operate within national territory are those identified for uncoordinated FSS earth stations, in particular those identified in ECC Decision (05)01 [18] and ECC Decision (05)08 [13], thereby limiting potential interference to terrestrial services only to some instances of cross-border interference. Technical requirements have been developed to ensure that ESOMPs operating in the Ka-band frequencies identified for uncoordinated FSS operations have the equivalent interference

characteristics of typical uncoordinated FSS earth stations and do not cause unacceptable interference to any terrestrial services operating in the same bands.

The regulatory framework that has been adopted in these bands to accommodate ESOMPs has ensured that it does not prejudice the use of these bands by other FSS and terrestrial applications operating in conformance with other ECC Decisions. It should be noted that specifically the band 28.6-29.1 GHz, according to RR 5.523A, is subject to the application of the provisions of RR 9.11A, and this means all satellite networks are subject to coordination, including the current and future non GSO or GSO FSS networks.

#### 4 CONSIDERATIONS ON THE OPERATION OF ESOMPS IN FSS NGSO SATELLITE SYSTEMS

Several options were considered in deciding on the most appropriate regulatory provisions for ESOMPs. One option was to treat ESOMPs as an application in the Mobile-Satellite Service (MSS), which would need a new MSS allocation in the FSS band(s). Another was to change the definition of FSS to include service to mobile platforms. A third option, which has been finally endorsed, was to treat ESOMPs as an application in the FSS.

ESOMPs represent one of many examples of service convergence that CEPT administrations are experiencing. In the past, any earth station that moved while transmitting was considered to be part of the MSS. Historically, there were significant technical differences between the MSS and FSS, for example MSS antennas were often non-directional, making co-frequency sharing with other MSS systems difficult. Also, MSS systems operated in exclusively allocated bands that were much lower in frequency than those used by FSS systems. Changes in technology have allowed ESOMPs to operate in bands allocated to the FSS.

The issue of convergence is a serious matter for CEPT administrations to consider since it is applicable both in satellite and terrestrial services. The approach adopted by the ECC for ESOMPs should be neutral to both existing and new users. The ECC should also strive to the extent possible to adopt a consistent approach both for satellite and terrestrial services.

Regarding the radio service classification of ESOMPs, several considerations should be taken into account:

- ESOMPs are assumed to be designed and operated in compliance with the existing rules for FSS. No rules exist for MSS in bands above 17 GHz, making implementation as MSS problematic;
- Requiring compliance with existing FSS rules provides FSS operators with certainty that existing systems will be protected;
- While MSS allocations exist in the bands above 17 GHz, the majority of these are secondary allocations or reserved for non-civilian applications. In Region 1, 2 x 100 MHz of co-primary spectrum for MSS is available at 29.9-30.0 GHz / 20.1-20.2 GHz. These allocations are not considered adequate by ESOMPs system operators for five reasons:
  - 1 the existing MSS allocations above 17 GHz are in bands that are subject to Article 22 EPFD limits which further constraints the usability for ESOMPs
  - 2 If ESOMPs networks were required to operate only in the 2x100 MHz allocated to the MSS on a co-primary basis with the FSS, the result would in any case be that they should coordinate with existing and future FSS networks, leading to the same technical constraints as if they were treated as FSS. Hence, there is no benefit to other services or systems by operating ESOMPs in a smaller frequency band;
  - 3 The key-feature of the systems that have been launched or planned to be launched soon is that they will be capable of offering to European citizens travelling on mobile platforms connectivity and network performance similar to those they can experience with terrestrial wired and wireless solutions, where data rates of up to 100 Mbit/s are planned. If only 2 x 100 MHz were available, allowing for the need to assign different frequencies in adjacent beams, only a few 10s of MHz could be made available in each beam, shared among multiple users within it. To allow data rates comparable to terrestrial systems in a satellite system, with sufficient users to support the business case for building and launching a satellite network, at least 2 x 500 MHz of available spectrum would be required;
  - 4 The capital and operating costs of an ESOMPs network operating in 2 x 100 MHz would be similar to those for an ESOMPs network operating in, for example, 2 x 500 MHz. However, the capacity of the system (in terms of number of users of comparable data requirements) is increased five-fold. Hence, the cost of the service to end users is significantly lowered if the system can operate in a larger frequency band, benefiting both the operator and the end users.
  - 5 All systems currently planning to provide ESOMPs services in Europe would be technically capable of operating at least in 2 x 500 MHz FSS spectrum;

- Treating ESOMPs as FSS provides ESOMPs operators and regulators with a well-established and proven set of rules for authorising these earth stations;
- NGSO ESOMPs must comply with the same EPFD limits as typical uncoordinated FSS earth stations operating to NGSO systems;
- In many planned networks, ESOMPs will operate on the same networks and frequencies as stationary earth stations. If ESOMPs are classified as MSS and stationary earth stations are classified as FSS, there may be situations where terminals using the same network and frequencies must comply with different rules simply because one type is in motion and the other is not.

So long as ESOMPs on an aggregate basis per NGSO system are designed and operated in compliance with the same requirements (such as EPFD limits) as those placed on uncoordinated NGSO earth stations, no sharing issues exist between the ESOMPs and other FSS networks.

Taking all of the above into account, it is concluded that all ESOMPs are to be treated as typical uncoordinated FSS earth stations and therefore they shall operate in bands available to uncoordinated FSS earth stations.

## 5 TECHNICAL REQUIREMENTS FOR ESOMPS

### 5.1 SHARING WITH TERRESTRIAL SERVICES

As a general consideration, it should be noted that the work done within both the ITU-R and CEPT has shown that co-frequency sharing between uncoordinated FSS earth stations (primarily considering GSO networks) and terrestrial networks in the same geographic area is difficult to accomplish. The same conclusion holds true for ESOMPs working to NGSO systems. Since implementation of land use of ESOMPs is only contemplated in bands where uncoordinated FSS earth stations are allowed, ESOMPs should not represent any increased interference risk to FS or Mobile Service (MS) networks beyond that presented by uncoordinated FSS earth stations. If administrations conclude that implementation of uncoordinated FSS earth stations is permissible in a band, introduction of NGSO ESOMPs in the same band should not raise any additional interference concern to FS or MS networks.

Like uncoordinated FSS earth stations, ESOMPs receiving in the frequency range 17.7-19.7 GHz shall not claim protection from stations of the FS (see ERC Decision (00)07 [23]).

There is the possibility that neighbouring countries could implement different allocations, in the 27.5-29.1 GHz and 17.7-19.7 GHz bands, either to uncoordinated FSS or to FS applications. Furthermore, ESOMPs operating in international waters and airspace could also operate in any of the above frequencies, subject to not causing interference to terrestrial systems.

Therefore, the aim of this section is to address any sharing issue that could arise with terrestrial systems in the band 27.5-29.1 GHz. Noting that no applications of the MS<sup>3</sup> have been identified in the frequency ranges 17.7-19.7 GHz and 27.5-29.1 GHz, only FS characteristics are used for the terrestrial applications. Sharing studies in this range of frequencies have considered both point-to-point and point-to-multipoint FS systems with the FS characteristics shown in Table 1.

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<sup>3</sup> There is no common European allocation (ERC Report 25) to the MS in these bands, which is present in the national allocation table of some CEPT administrations.

**Table 1: FS characteristics for the band 27.5-29.5 GHz**

Parameter	FS1 (PP)	FS2 (PP)	FS3 (PP)	FS4 (P-MP)	FS5 (PP based on Rec. ITU-R 758-5)	FS6 (P-MP based on Rec. ITU-R 758-5)	Notes
RX antenna height (m)	20	20	20	20	Not specified, 20 m is suggested	Not specified, 20 m is suggested	
RX antenna pattern	Rec. ITU-R F.1245	Rec. ITU-R F.1245	Rec. ITU-R F.1245	Rec. ITU-R F.1336 [25]	Rec. ITU-R F.1245 [24]	Rec. ITU-R F.1336	Rec. ITU-R F.758-5
Receiver noise figure, NF (dB)	6	6	6	6	8	8	See note (1)
RX frequency (GHz)	28 GHz	28 GHz	28 GHz	28 GHz	24.25-29.50 GHz	24.25-29.50 GHz	
RX elevation angle (degrees)	0	5	10	0	Not specified, 10° is suggested	Not specified, 0° is suggested	
RX peak gain (dBi)	45	43	35	18	31.5	6.5	See note (2)
<p>Note 1: The System noise power density (<math>N_0</math> in dB(W/Hz)) shall be obtained from the following equation: <math>N_0 = NF + 10 \cdot \log_{10}(kT_0)</math> where : <math>T_0 = 290</math> K, NF is the noise figure (dB) and k is the Boltzmann constant it results: <math>N_0 = NF - 204</math> (dB(W/Hz))</p> <p>Note 2: The difference between the peak gain values of stations FS1 and FS2 comes from the fact that a typical PP FS station with high elevation angle (10°) is usually employed for short-range links near hilly areas.</p>							

### 5.1.1 ESOMPS installed on land platforms

ESOMPs installed on land platforms do not differ substantially from typical uncoordinated stationary FSS stations. The Recommendation ITU-R SF.1707 [27] provides methods and means to facilitate the implementation of large numbers of earth stations operating in the GSO FSS in areas where terrestrial services are also deployed. This Recommendation could therefore be considered a basis for coordination procedures between NGSO ESOMPs and neighbouring administrations implementing different allocations in this band.

Section 7 of this ECC Report provides an overview of a possible approach for resolving cross-border coordination requirements.

### 5.1.2 ESOMPS installed on maritime platforms

ESOMPs on-board vessels or other mobile maritime platforms have the potential to cause interference to any FS or MS applications deployed in parts of the band 27.5-29.1 GHz. FS or MS systems operating near the coast could receive interference from a maritime ESOMPs, which could be operating in the territorial

waters of another administration, or at international sea (i.e. beyond 12 nautical miles from the low-water mark of the concerned administration).

A PFD threshold at the coast of any country, combined with a suitable mandatory automatic mechanism to regulate the ESOMPs power, dependent on its position, has been studied that would provide adequate protection to FS or MS systems deployed. The PFD threshold could be exceeded only if the concerned administration agreed. The ESOMPs would be able to take into account its actual antenna gain pattern, its pointing and transmitter power to comply with the PFD threshold.

It is recommended to use a PFD threshold at the coastline, taking the same method and corresponding assumptions as in Recommendation ITU-R SF.1650 [28] dealing with ESV in the bands 5925-6425 MHz and 14.0-14.5 GHz.

In the case of ESOMPs operating in the band 27.5-29.1 GHz, this PFD threshold (see ANNEX 1) is -109 dB(W/m<sup>2</sup>) expressed in a reference bandwidth of 14 MHz at a height of 20 m above sea level. In addition, the percentage of time that should be used in the propagation model, when assessing compliance with this PFD threshold, is 0.007%.

This PFD threshold would apply to the frequencies of the band 27.5-29.1 GHz designated to the FS in the CEPT.

CEPT have also performed and submitted studies to ITU that advocate a combination of an e.i.r.p. density limit together with a minimum distance which was used as a basis for the decision under WRC-19 A11.5 to adopt a minimum distance of 70 km from the low water mark of coastal state and a maximum e.i.r.p. density of 24.44 dBW/14 MHz. This matter will be further considered in future revisions of this Report and ECC Report 184 [1].

### 5.1.3 ESOMPS installed on aeronautical platforms

ESOMPs installed on aircraft should be treated differently, because of the particular geometrical scenario in which they operate. Since the earth station is normally operating at an unobstructed altitude<sup>4</sup> above ground, the same cross-border sharing considerations as for other types of earth stations cannot be applied to these aircraft-mounted terminals.

The following PFD mask [1] has been shown to provide adequate protection to FS systems currently deployed or planned to be deployed in CEPT countries:

- $\text{PFD}(\delta) = -124.7$  for  $0^\circ \leq \delta \leq 0.01^\circ$ ;
- $\text{PFD}(\delta) = -120.9 + 1.9 \cdot \log_{10}(\delta)$  for  $0.01^\circ < \delta \leq 0.3^\circ$ ;
- $\text{PFD}(\delta) = -116.2 + 11 \cdot \log_{10}(\delta)$  for  $0.3^\circ < \delta \leq 1^\circ$ ;
- $\text{PFD}(\delta) = -116.2 + 18 \cdot \log_{10}(\delta)$  for  $1^\circ < \delta \leq 2^\circ$ ;
- $\text{PFD}(\delta) = -117.9 + 23.7 \cdot \log_{10}(\delta)$  for  $2^\circ < \delta \leq 8^\circ$ ;
- $\text{PFD}(\delta) = -96.5$  for  $8^\circ < \delta \leq 90.0^\circ$ .

Where:

- $\delta$  is the angle of arrival at the Earth's surface (degrees);
- PFD value is in dB(W/m<sup>2</sup>) in a reference bandwidth of 14 MHz.

PFD is a threshold not to be exceeded on the territory of any Administration requiring protection of FS links, unless a prior agreement has been given by the concerned Administration(s) to exceed this PFD mask.

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<sup>4</sup> In the case where administrations may also choose to allow operation of aircraft mounted ESOMPs on the ground at airports, the cross-border sharing issues would be the same as with other (land based) earth stations.



The PFD mask is not defined as under “free-space” conditions. Hence, when assessing ESOMP compliance with this PFD mask, atmospheric absorption and fuselage attenuation need to be taken into account<sup>5</sup>.

ESOMPs would also be required to have an automatic mechanism to meet the PFD mask to manage the interference environment.

#### 5.1.4 Protection of aircrafts near airfields

ECC Report 272 [36] examined earth stations operating in the vicinity of aircraft and their ability to comply with high intensity radiated field (HIRF) levels established by the European Aviation Safety Agency (EASA) to protect aircraft safety systems. The elements provided by EASA were used to calculate earth station e.i.r.p levels (as specified in Table 2) for various earth station deployments communicating with GSO or NGSO satellites, for which it can be concluded that there will be no impact to the aeronautical safety of aircraft during any phase of the flight (take off, landing, cruising, taxiing). Consequently, no restrictions on operations in the proximity of or within airfields<sup>6</sup> are required for ESOMPs complying with the relevant e.i.r.p levels specified in Table 2 below. ECC Decision (15)04 has already been revised taking these results into account.

**Table 2: Maximum Earth station e.i.r.p. levels to ensure compliance with aircraft HIRF protection criteria**

Earth station deployment type	Maximum e.i.r.p. levels (dBW)		
	4-6 GHz	12-18 GHz	18-40 GHz
Earth station on board aircraft located within airport premises	59.0	60.5	58.4
Earth stations in a fixed location within airport premises	67.0	68.4	66.4
Land mobile earth stations located within airport premises	53.0	54.5	52.4
Fixed earth stations or mobile earth stations on land within a wedge shaped area originating at the departure and arrival end of the runway and extending for 3 nautical miles from the runway over which aircraft would normally track**	73.0	74.5	72.4
Fixed earth stations or land mobile earth stations operating with NGSO satellites located outside the wedge shaped area extending for 3 nautical miles from the runway of an airfield over which aircraft would normally track**	79.0	80.5	78.4
Fixed earth stations or land mobile earth stations operating with GSO satellites located outside the wedge shaped area extending for 3 nautical miles from the runway of an airfield over which aircraft would normally track**	80.7-93.0*	82.2-94.5*	80.2-92.4*
Earth station on vessels	79.0	80.5	78.4
Earth stations on board aircraft in flight	73	74.5	72.4

NOTE 1: For satellite earth stations operating within TDMA networks, the above e.i.r.p values shall be respected after taking into consideration the duty cycle (see section 3.3 and 3.4 of Report 272).  
\* e.i.r.p. values are dependent on earth station latitude (see section 3.4.6) of Report 272.  
\*\* the width of the wedge shaped area originating at the departure and arrival end of the runway and extending for 3 nm from the

<sup>5</sup> For the derivation of the PFD mask the baseline assumptions on the atmospheric loss and aircraft fuselage loss are contained in Annex 2.

<sup>6</sup> Airfield: in the context of this Report covers both, airport and helipads.

Earth station deployment type	Maximum e.i.r.p. levels (dBW)
runway over which aircraft would normally track depends on the airfield and is determined by the airport authority NOTE 2: In the context of this Report, the term "Mobile" refers to the definition in section 3.1.1 of the FAA Report and it relates to earth stations that are not operated in a fixed location	

## 5.2 ETSI standards

Under the R&TTE Directive [29], all radio equipment placed on the market in the EU must meet the essential requirements defined in the Directive. In most cases, the requirements are met by compliance with the relevant ETSI Harmonised European Standard. ETSI has developed a new Harmonised European Standard (ETSI EN 303 979 [34]) for ESOMPs operating in the bands within 17.3-20.2 GHz and 27.5-30 GHz.

## 5.3 OTHER TECHNICAL REQUIREMENTS FOR Ka-BAND ESOMPs

The protection of GSO FSS networks operating in 27.5-28.6 GHz and 29.5-30.0 GHz from ESOMPs operating to NGSO networks is achieved by complying with the EPFD. Limits stipulated in No. 22.5D of the Radio Regulations [30]. The provision of the Radio Regulations is reproduced below:

**22.5D 3)** The equivalent power flux-density (epfd) produced at any point in the geostationary-satellite orbit by emissions from all the earth stations in a non-geostationary satellite system in the fixed-satellite service in the frequency bands listed in Table 22-2, for all conditions and for all methods of modulation, shall not exceed the limits given in Table 22-2 for the specified percentages of time. These limits relate to the equivalent power flux-density which would be obtained under free-space propagation conditions, into a reference antenna and in the reference bandwidth specified in Table 22-2, for all pointing directions towards the Earth's surface visible from any given location in the geostationary-satellite orbit.

Hence, from the perspective of potential uplink interference to other satellite networks, these requirements will ensure that ESOMPs are essentially equivalent to stationary FSS earth stations.

It should be noted that in the band 28.6-29.1 GHz RR 5.523A states

"The use of the bands 18.8-19.3 GHz (space-to-Earth) and 28.6-29.1 GHz (Earth-to-space) by geostationary and non-geostationary fixed-satellite service networks is subject to the application of the provisions of No. 9.11A and No. 22.2 does not apply."

Therefore no additional conditions are placed on the use of this band in the sharing between GSO & NGSO FSS systems.

The level of protection provided to ESOMPs from other satellite networks will be determined through coordination among the concerned administrations/satellite operators, following the same rules and processes as those applicable to all FSS networks. ESOMPs terminals will be protected to the same extent as FSS earth stations included in the inter-system coordination. As there are no limitations on antenna sizes or antenna patterns in these bands for FSS today, there is also no need to define any such additional requirements for ESOMPs.

When considering the level of protection provided to other satellite networks from ESOMPs, technical requirements should be adequately defined in order to prevent mis-pointed or poorly controlled Ka-band terminals (whether fixed or mobile) from causing unacceptable interference to other Ka-band FSS satellites and so prejudice the provision of Ka-band FSS services to European consumers. Furthermore, the use of low-gain antennas and their potential impact on other satellite networks should not be an issue, since any ESOMPs, in order to be able to operate, shall be compliant with the relevant provisions of the Radio Regulations, which stipulate EPFD limits, and with the other instruments such as relevant ITU-R Recommendations or frequency coordination agreements.

Realising that ESOMPs operate in a dynamic environment, it is important to address this aspect in specifying an essential set of technical and operational requirements. The design, coordination and operation of

ESOMPs should be such that, the interference levels generated by such earth stations account for the following factors:

- **Mis-tracking of the NGSO satellite by the earth station antenna.** Where applicable, this includes, at least, motion-induced antenna pointing errors, effects caused by bias and latency of their pointing systems, tracking error of open or closed loop tracking systems, misalignment between transmit and receive apertures for systems that use separate apertures, and misalignment between transmit and receive feeds for systems that use combined apertures
- **Variations in the antenna pattern of the earth station antenna.** Where applicable, this includes, at least, effects caused by manufacturing tolerances, ageing of the antenna and environmental effects. Networks using certain types of antennas, such as phased arrays, should account for variation in antenna pattern with scan angles (elevation and azimuth). Networks using phased arrays should also account for element phase error, amplitude error and failure rate;
- **Variations in the transmit e.i.r.p. from the earth station.** Where applicable, this includes, at least, effects caused by measurement error, control error and latency for closed loop power control systems, and motion-induced antenna pointing errors.

Earth stations on mobile platforms that use closed loop tracking of the satellite signal need to employ an algorithm that is resistant to capturing and tracking other satellite signals. Such earth stations must be designed and operated such that they immediately inhibit transmission when they detect that unintended satellite tracking has occurred or is about to occur. Such earth stations must also immediately inhibit transmission when their mis-pointing would result in EPFD levels above those stipulated in No. 22.5D of the Radio Regulations or with any other limits coordinated with other satellite networks.

In addition to these autonomous capabilities, earth stations on mobile platforms will need to be subject to the monitoring and control by a Network Control Facility (NCF) or equivalent facility and these earth stations should be able to receive at least “enable transmission” and “disable transmission” commands from the NCF. It will need to be possible for the NCF to monitor the operation of the earth station to determine if it is malfunctioning.

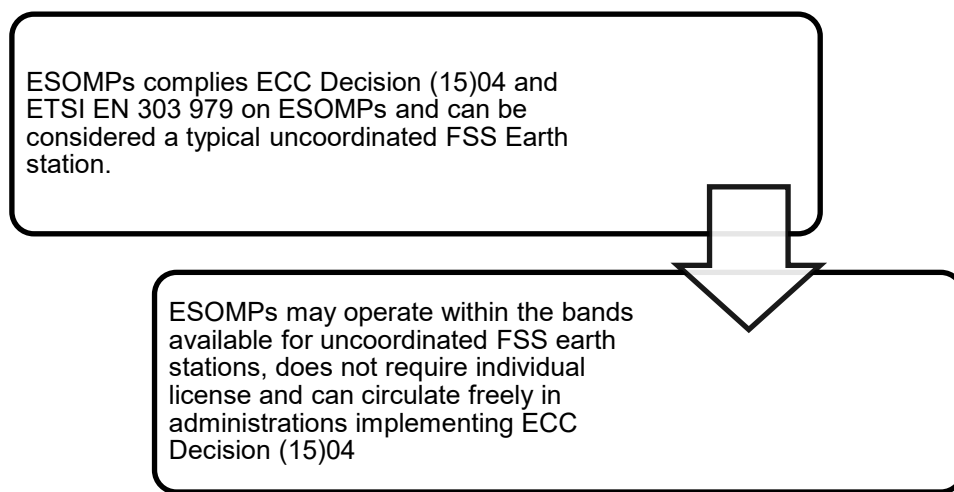
ESOMPs that comply with these requirements will not create unacceptable levels of interference to other FSS systems and terminals operating in the same bands or sub-bands. It is assumed that any ESOMPs operating in the territory of a CEPT administration will have to comply with any relevant CEPT requirements, e.g. a new ECC Decision. Any use of non-compliant equipment would be unlawful and subject to national enforcement provisions and sanctions.

## 6 REGULATORY FRAMEWORK NEEDED TO TREAT AND OPERATE ESOMPS AS FSS IN THE BANDS 27.5-29.1 GHz, 29.5-30.0 GHz AND 17.3-20.2 GHz

Under the recommended approach of this report, ECC Decision (15)04 authorises the use of ESOMPs in the Ka-band frequencies operating to NGSO systems, without any change to the Radio Regulations. The Decision would provide a framework for such ESOMPs to operate in FSS NGSO systems and would establish technical and regulatory requirements.

While, for ESOMPs terminals installed on land, authorisation is managed by the single administrations, in the case of ESOMPs on maritime or aeronautical platforms, a process based on mutual recognition of licences and free circulation may be considered.

Figure 2 outlines the process through which a ECC Decision (15)04 [34] (and ETSI EN 303 979 [33]) could be used for authorising ESOMPs to operate in those parts of the Ka-band allocated to uncoordinated FSS earth Stations.



**Figure 1: Proposed treatment of ESOMPs in CEPT**

The aforementioned ECC Decisions on AESs, ESVs, GSO ESOMPs(ECC Decision (05)09 [20], ECC Decision (05)10 [21], ECC Decision (05)11 [22], ECC Decision (13)01 [5] as well as the WRC Resolution 902 [10], and ITU-R Recommendations on which they are based, provided a basis for developing the requirements for inclusion in the Decision. The following table summarises the requirements from these Decisions, Resolutions and Recommendations that may be used for developing criteria for determining whether a mobile platform communicating with an FSS network may be treated as a typical uncoordinated FSS earth station.

**Table 3: Requirements for C-band and Ku-band ESOMPs to be considered for inclusion in new Regulations on Ka-band ESOMPs**

Requirement	Source
The network must operate under the control of a network control facility (NCF).	Recommendation ITU-R M.1643 [8]
The network should be coordinated and operated in such a manner that the aggregate off-axis e.i.r.p. levels produced by all co-frequency earth stations within the network are no greater than the interference levels that have been published and coordinated for the specific and/or typical earth station(s) pertaining to the FSS networks where FSS transponders are used. (Note that the comparable position for K band NGSO ESOMPS is the compliance with No. 22.5D of the Radio Regulations.)	Recommendation ITU-R M.1643 Recommendation ITU-R S.524 [9]
The design, coordination and operation of the earth stations should take into account: <ul style="list-style-type: none"> <li>▪ Antenna mis-pointing;</li> <li>▪ Variations in antenna pattern of the earth station;</li> <li>▪ Variations in the transmit e.i.r.p. from the earth station.</li> </ul>	Recommendation ITU-R M.1643
Earth stations that use close loop tracking of the satellite signal need to employ an algorithm that is resistant to capturing and tracking adjacent satellite signals. Earth stations must immediately inhibit transmissions when they detect that unintended satellite tracking has happened or is about to happen.	Recommendation ITU-R M.1643
The earth station should be self-monitoring and, should a fault which can cause harmful interference to FSS networks or terrestrial services be detected, the earth station must immediately cease emissions.	Recommendation ITU-R M.1643 Resolution 902 [10]

Some of these requirements are already contained in the ETSI EN 303 979 developed for NGSO Ka-band ESOMPs. Other requirements may need to be included in ECC Decision (15)04.

Establishment of harmonised conditions for the protection of satellite and terrestrial services would allow maritime and aeronautical ESOMPs to comply with such harmonised conditions and benefit from free circulation and licence exemption within the CEPT.

## 7 CROSS-BORDER COORDINATION

The Ka-band frequencies identified for uncoordinated FSS earth stations have been harmonised throughout CEPT by ECC Decisions ECC Decision (05)01 and ECC Decision (05)08. Hence, in the general case, the bands available for ESOMPs operating within national territory will be common throughout Europe, and there would be no cross-border interference issues. However in some cases, for example on the borders of CEPT or in the case of ESOMPs operating in the band 28.8365-28.9485 GHz<sup>7</sup>, a band identified for uncoordinated FSS earth stations by one administration could be used for terrestrial services by a neighbouring administration.

The issue of potential cross-border interference caused by the use of uncoordinated FSS earth stations in one country into FS stations in a neighbouring country has been addressed by Recommendation ITU-R SF.1707 which, among other things, provides an example, based on worst case assumptions, of how to develop a single transmit and a single receive coordination distance for consideration as a means to ease bilateral agreements for a given geographical area. Also, Recommendation ITU-R SF.1719 [31] has examined interference using more typical assumptions and indicates that far smaller separation distances are applicable in most practical cases.

In those cases when ESOMPs mounted on vessels or aircraft are operated in international waters/airspace, the frequency band used by these ESOMPs might be used by FS systems in the surrounding countries. The values proposed in sections 5.1.2 and 5.1.3 would ensure protection of the potentially affected FS systems and are to be used as threshold values for triggering coordination among the concerned administrations and those satellite operators (or related administrations) which might wish to operate above the specified levels.

In the coordination process, the likelihood of interference caused by ESOMPs into FS stations should be assessed by considering the real deployment of FS links. The following provides an example of mitigation factors that may alleviate the level of potential interference:

1. FS stations in one country deployed near the coast not pointing toward the open sea;
2. Countries that have not deployed fixed links in the band 27.5-29.1 GHz;
3. Real FS links which have less sensitive characteristics to interference than those assumed in the sharing studies.

Presence of clutter/terrain blockage and rain/cloud attenuation, which may introduce additional attenuation for the interference path, should be taken into account in cross-border coordination.

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<sup>7</sup>Through ECC Decision (05)01 [18], the band 28.8365-28.9485 GHz is designated for uncoordinated FSS earth stations, but is used by legacy FS systems in some countries.

## 8 CONCLUSIONS

ESOMPs operating to Ka-band NGSO systems are operated in Europe. This report has examined possible technical and regulatory requirements to facilitate the authorisation of ESOMPs by CEPT administrations. It is proposed that an ECC Decision (15)04 for ESOMPs, operating to Ka-band NGSO systems should contain the following elements:

- The ESOMPs are an application within the FSS;
- The frequency bands to be used by ESOMPs operating in national territory are limited to the Ka-band frequencies designated by the responsible administration for uncoordinated FSS earth stations;
- ESOMPs operating in international waters and airspace (which may transmit within the range 27.5-29.1 GHz and 29.5-30.0 GHz), shall ensure protection of fixed service systems deployed by administrations within the CEPT;
- Regarding maritime ESOMPs CEPT have also performed and submitted studies to ITU that advocate a combination of an e.i.r.p. density limit together with a minimum distance which was used as a basis for the decision under WRC-19 AI1.5 to adopt a minimum distance of 70 km from the low water mark of coastal state and a maximum e.i.r.p. density of 24.44 dBW/14 MHz. This matter will be further considered in future revisions of this report and ECC Report 184.
- Technical and operational requirements are necessary for ESOMPs to avoid causing harmful interference to other services and systems, as described in section 5 of this Report. These include the requirement to have an automatic mechanism (under the control of an NCF) for the management of the interference environment and to meet the PFD levels where applicable;
- ESOMPs are exempted from individual licensing and enjoy free circulation and use within CEPT, subject to national licensing requirements.

Taking into account that one Ka-band NGSO system employing ESOMPs has already been deployed and others are in the process of being deployed, it could be in the interest of operators, users and the CEPT regulators to have an agreed framework in place to harmonise such operations as soon as possible.

As maritime and aeronautical ESOMPs operations in particular are international in nature, the work initiated with the ITU-R Report S.2261 on NGSO systems needs to be developed further with the adoption of relevant Reports or Recommendations specific to maritime and aeronautical ESOMPs operating in 17.3-20.2 GHz, 27.5-29.1 GHz and 29.5-30.0 GHz.

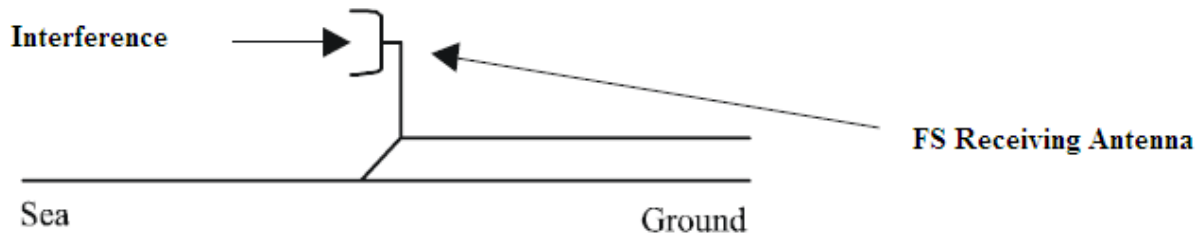
**ANNEX 1: ASSUMPTIONS AND METHODOLOGY USED FOR THE CALCULATION OF THE PFD THRESHOLD FOR MARITIME ESOMPs**

Following a worst case scenario approach, the FS station characterised by the parameters contained in 4 has been considered to be the victim of the interference caused by a maritime ESOMPs operating in international waters (those studies were performed in support of development of ECC Decision (13)01 [5] covering Earth Stations on Mobile Platforms in the Ka-band).

**Table 4: Parameters for victim FS stations operating in the 27.5-29.1 GHz band (see FS1 in Table 1)**

Parameter	FS1 (PP)
RX antenna height	20 m
RX antenna pattern	Recommendation ITU-R F.1245 [24]
Receiver noise figure, F	6 dB
RX frequency	28 GHz
RX elevation angle	0°
RX peak gain	45 dBi

The potentially affected receiving FS station is assumed to operate on the coast line, oriented towards the open sea, as illustrated in the figure below.



**Figure 2: Worst-case interference scenario**

The calculation which follows determines a maximum PFD an ESOMPs can radiate on the coast (and farther inland) of the affected administration, in order to protect FS1 and, consequently, any FS network.

Following the same methodology illustrated in Recommendation ITU-R SF.1650 [28], only a short-term criterion is needed for the aim of this study. A short-term interference criterion of  $I/N = +9$  dB has been considered; this level shall not be exceeded for more than  $p_s = 2.7 \times 10^{-4}$  % of the time<sup>8</sup>.

The following calculation in the table below related to the thermal noise at the input of the receiver used in station FS1, applies.

<sup>8</sup> This short-term interference time percentage is the same as that used for the Ku-band case in Recommendation ITU-R SF.1650-1 [28].



**Table 5: Noise characterisation for FS1 receiver**

Parameter	Value	Unit
Receiver equivalent noise bandwidth ( $B_{Rx}$ )	14	MHz
Receiver Noise Figure (NF)	6	dB
Thermal Noise at the input of the receiver ( $N$ )	-126.5	dBW

The following equations can then be used for obtaining the requested PFD value:

$$I_{max} = N + 9, \quad (\text{dBW})$$

Where:

- $I_{max}$  is the maximum allowed power interfering with the FS station (dBW);
- $N$  is the noise power calculated in 5 (dBW).

Furthermore:

$$PFD = I_{max} - G_{Avg} - A_{eff} + L_{pol}, \quad (\text{dB(W/m}^2\text{)})$$

Where:

- $PFD$  is the requested power flux density (dB(W/m<sup>2</sup>));
- $G_{Avg}$  is the average gain of the receiving antenna within its -10 dB beamwidth (dBi);
- $A_{eff}$  is the effective area ( $10 \log(\lambda^2/4\pi)$ ) of the receiving antenna (dB(m<sup>2</sup>));  $\lambda$  the wavelength (m);
- $L_{pol}$  is the polarisation advantage (dB).

The following calculation is then performed by applying these formulas.

**Table 6: Detailed calculation of the PFD limit**

Description	Parameter	Value	Unit
Rx equivalent noise bandwidth	$B_{Rx}$	14	MHz
Rx Noise Figure	F	6	dB
Reference Temperature	$T_0$	290	K
Thermal noise power	N	-126.5	dBW
Interference Criterion	$(I/N)_{max}$	9	dB
Maximum allowed interference power	$I_{max}$	-117.5	dBW
Transmitter frequency	F	29.25	GHz
Wavelength	$\lambda$	0.01	m
Rx antenna peak	$G_{Avg}$	42.2	dB

Description	Parameter	Value	Unit
gain			
Antenna effective area ( $10 \log(\lambda^2/4\pi)$ )	$A_{eff}$	-51	dB(m <sup>2</sup> )
Polarisation advantage	$L_{pol}$	0	dB
<b>Maximum PFD on the coast</b>	<b>PFD</b>	<b>-108.7</b>	<b>dB(W/m<sup>2</sup>)</b>

It is then concluded that a PFD value of -109 dB(W/m<sup>2</sup>) expressed in a reference bandwidth of 14 MHz at a height of 20 m above sea level is adequate for protecting FS systems from interference caused by maritime ESOMPs.

In addition, compatibly with the methodology contained in Recommendation ITU-R SF.1650-1 [28], the percentage of time  $p$  that should be used, when assessing compliance with this PFD threshold, is 0.007%.

For the case of ESOMPs transmitting to NGSO FSS systems, the value of  $p$  must take into account the combined effect of the propagation loss and of the ESOMPs transmit antenna gain towards the affected fixed terminal, since both variables are time-dependent.

In fact, the protection criterion may be translated into a minimum value of the variable  $L(p_L) - G_{TX}(p_G)$  where:  $L(p_L)$  - is the minimum path loss value which can only be violated during  $p_L$  % of the time, and

$G_{TX}(p_G)$  - is the value of the gain of the ESOMPs transmit antenna gain towards the affected fixed terminal not exceeded for more than  $p_G$  % of the time.

This limit will be referred to here as  $(L - G_{TX})_{REQ}$ .

Since these variables are statistically independent, the % probability of any two values of  $L(p_L)$  and  $G_{TX}(p_G)$  occurring is the product  $p_L p_G/100$  %, and it is this product that must be equal to  $p$ .

The methodology to determine the statistics of  $G_{TX}(p_G)$  for earth station antennas operating with NGSO satellite systems is described in item 3 of Annex 1 of Recommendation ITU-R S.1430-0 [32] (Determination of the coordination area for earth stations operating with non-geostationary space stations with respect to earth stations operating in the reverse direction in frequency bands allocated bidirectionally to the fixed-satellite service).

This Recommendation also contains two methods for the calculation of the coordination distance for these operations which could be adapted to determine the impact of ESOMPs mounted on vessels sailing in international waters and operating in NGSO FSS systems.

Application of these methods relies on the fact that, given the route of a vessel equipped with an ESOMPs, the distances  $d$  to the coastline of the affected country are known for all azimuths towards the coast.

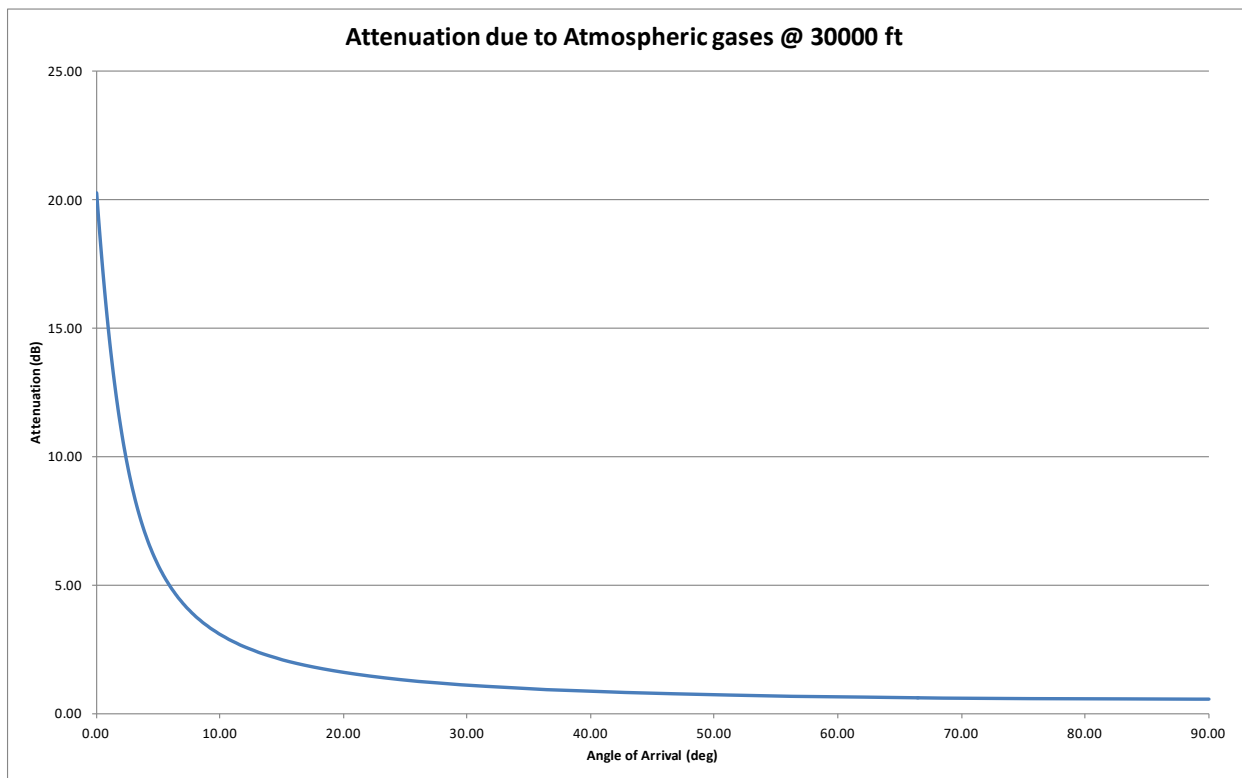
CEPT have also performed and submitted studies to ITU that advocate a combination of an e.i.r.p. density limit together with a minimum distance which was used as a basis for the decision under WRC-19 A1.5 to adopt a minimum distance of 70 km from the low water mark of coastal state and a maximum e.i.r.p. density of 24.44 dBW/14 MHz. This matter will be further considered in future revisions of this report and ECC Report 184 [1].

## ANNEX 2: BASELINE ASSUMPTIONS ON THE ATMOSPHERIC ABSORPTION AND THE FUSELAGE ATTENUATION USED FOR THE CALCULATION OF THE PFD THRESHOLD FOR AIRCRAFT-MOUNTED ESOMPS

This Annex provides some of the baseline assumptions that were used in the derivation of the aeronautical ESOMP PFD (those studies were performed in support of development of ECC Decision (13)01 [5] covering Earth Stations on Mobile Platforms in the Ka-band).

The attenuation due to the atmospheric gases for the geometrical scenario when an aircraft is flying at an example altitude of 30000 ft (9144 m) is provided in Figure 3:. In the figure, the angle on the horizontal axis is the angle of arrival at the location of the interfered FS station.

The aircraft fuselage loss used to derive the PFD mask for aeronautical ESOMPs is provided in Figure 3:, where “off-axis orientation (deg)” refers to (see Figure 4) the angle ( $\phi$ ) in the lower half of the vertical plane perpendicular to the aircraft’s line of the flight; where  $\phi = 0$  and  $\phi = 180$  deg is at the aircraft horizontal axis.



**Figure 3: Attenuation (ITU-R P.676) due to atmospheric gases at 28.0 GHz (for aircraft altitude of 9144 m)**

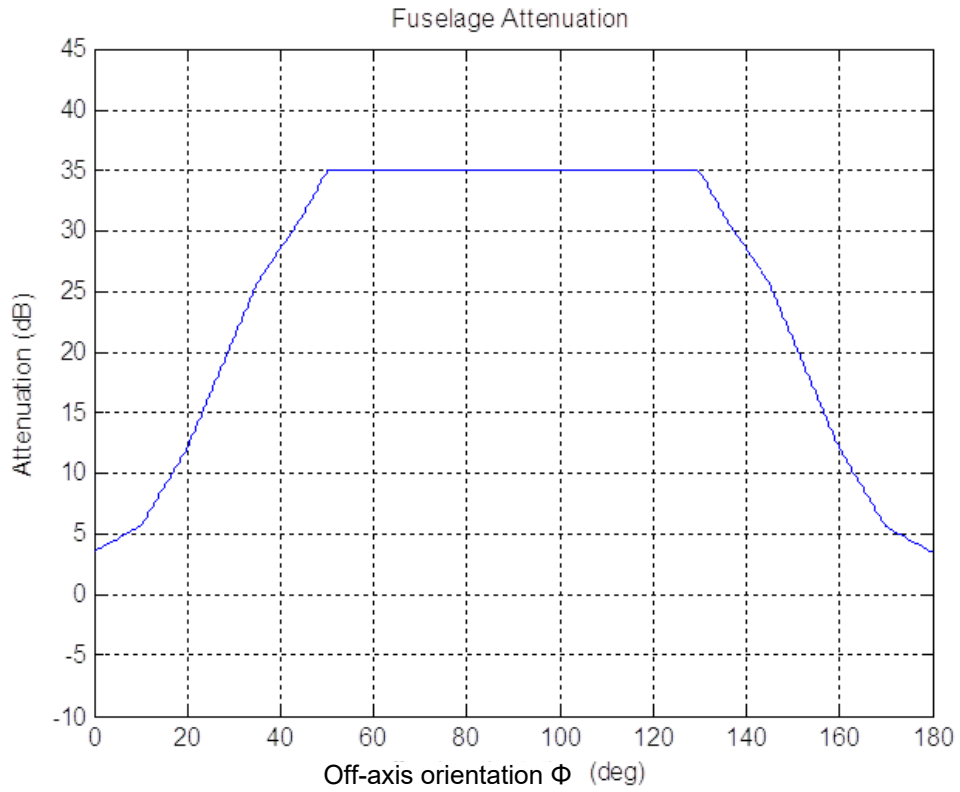


Figure 4: Attenuation due to the fuselage of the aircraft

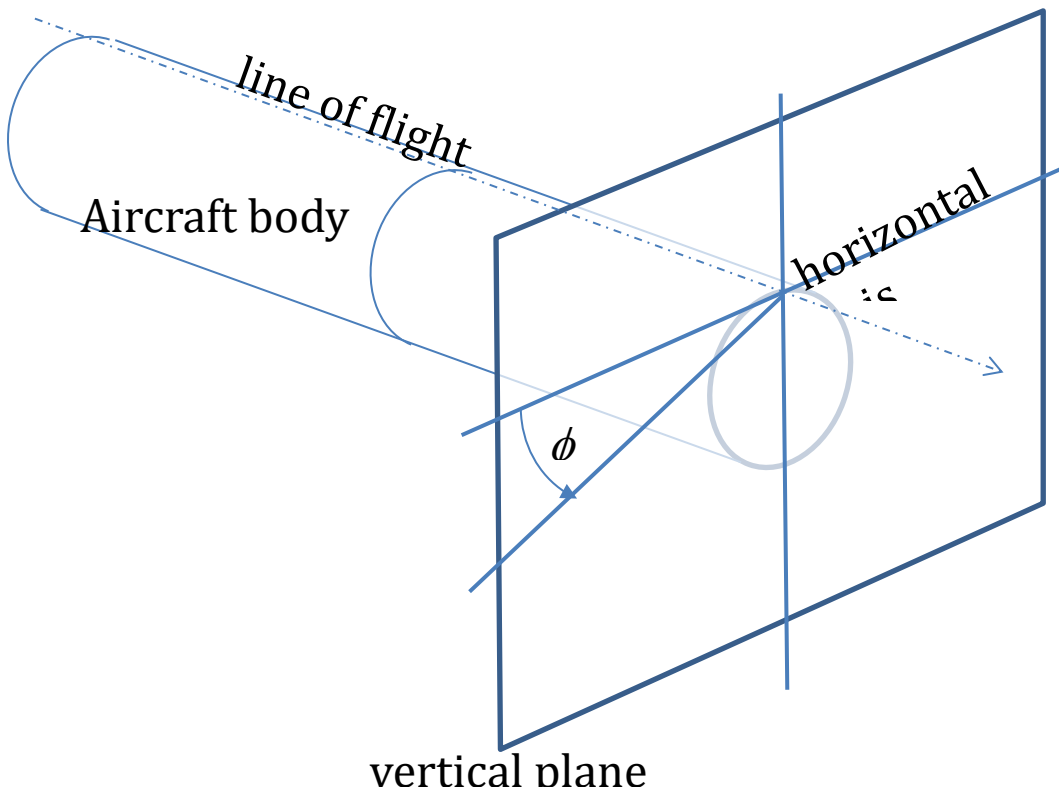


Figure 5: Geometry for defining the angle  $\phi$

### ANNEX 3: LIST OF REFERENCES

- [1] ECC Report 184: “The Use of Earth Stations on Mobile Platforms Operating with GSO Satellite Networks in the Frequency Range 17.3-20.2 GHz and 27.5-30.0 GHz”
- [2] ITU-R Report S.2261: “Technical and operational requirements for earth stations on mobile platforms operating in non-GSO FSS systems in the frequency bands from 17.3 to 19.3, 19.7 to 20.2, 27 to 29.1 and from 29.5 to 30.0 GHz”
- [3] ITU-R Report S.2223: “Technical and operational requirements for GSO FSS earth stations on mobile platforms in bands from 17.3 to 30.0 GHz”
- [4] ITU-R Report S.2261: “Technical and operational requirements for earth stations on mobile platforms operating in non-GSO FSS systems in the frequency bands from 17.3 to 19.3, 19.7 to 20.2, 27 to 29.1 and from 29.5 to 30.0 GHz”
- [5] ECC Decision (13)01: “ECC Decision of 8 March 2013 on the use, free circulation, and exemption from individual licensing of Earth stations on mobile platforms (ESOMPs) in the frequency bands available for use by uncoordinated FSS Earth stations within the ranges 17.3-20.2 GHz and 27.5-30.0 GHz”
- [6] ECC Report 152: “The use of the frequency bands 27.5-30.0 GHz and 17.30-20.2 GHz by satellite networks”
- [7] Resolution 216 (Rev.WRC-2000): “Possible broadening of the secondary allocation to the mobile-satellite service (Earth-to-space) in the band 14-14.5 GHz to cover aeronautical applications (abrogated at WRC-03)”
- [8] Recommendation ITU-R M.1643: “Determination of the coordination area for earth stations operating with NON-GSO space stations with respect to Earth stations operating in the reverse direction in frequency bands allocated bidirectionally to the FSS”
- [9] Recommendation ITU-R S.524: “Maximum permissible levels of off-axis e.i.r.p. density from earth stations in the fixed-satellite service transmitting in the 6 and 14 GHz frequency bands”
- [10] Resolution 902 (WRC-03): “Provisions relating to earth stations located on board vessels which operate in fixed-satellite service networks in the uplink bands 5925-6425 MHz and 14-14.5 GHz”
- [11] Resolution 909 (WRC-12): “Provisions relating to earth stations located on board vessels which operate in fixed-satellite service networks in the uplink bands 5 925-6 425 MHz and 14-14.5 GHz”
- [12] Resolution 143 (Rev. WRC-07): “Guidelines for the implementation of high-density applications in the fixed-satellite service in frequency bands identified for these applications”
- [13] ECC Decision (05)08: “ECC Decision of 24 June 2005 on the availability of frequency bands for high density applications in the Fixed-Satellite Service (space-to-Earth and Earth-to-space)”
- [14] ECC Decision (06)02: “ECC Decision of 24 March 2006 on exemption from Individual Licensing of Low e.i.r.p. Satellite Terminals (LEST) operating within the frequency bands 10.70–12.75 GHz or 19.70–20.20 GHz space-to-Earth and 14.00–14.25 GHz or 29.50–30.00 GHz Earth-to-Space”
- [15] ECC Decision (06)03: “ ECC Decision of 24 March 2006 on exemption from Individual Licensing of High e.i.r.p. Satellite Terminals (HEST) with e.i.r.p. above 34 dBW operating within the frequency bands 10.70 - 12.75 GHz or 19.70 - 20.20 GHz space-to-Earth and 14.00 - 14.25 GHz or 29.50 - 30.00 GHz Earth-to-space.
- [16] ETSI EN 301 459: “Transmitting towards satellites in geostationary orbit in the 29,5 GHz to 30,0 GHz frequency bands covering essential requirements”
- [17] ETSI EN 301 428: “Transmit-only, transmit/receive or receive-only satellite earth stations operating in the 11/12/14 GHz frequency bands covering essential requirements”
- [18] ECC Decision (05)01: “ECC Decision of 18 March 2005 on the use of the band 27.5-29.5 GHz by the Fixed Service and uncoordinated Earth stations of the Fixed-Satellite Service (Earth-to-space)”
- [19] ERC Decision (00)09: “The use of the band 27.5 – 29.5 GHz by the fixed service and uncoordinated Earth stations of the fixed-satellite services (Earth-to-space) (withdrawn by ECC/DEC/(05)01)”
- [20] ECC Decision (05)09: “ECC Decision of 24 June 2005 on the free circulation and use of Earth Stations on board Vessels operating in Fixed Satellite service networks in the frequency bands 5 925-6 425 MHz (Earth-to-space) and 3 700-4 200 MHz (space-to-Earth)”
- [21] ECC Decision (05)10: “ECC Decision of 24 June 2005 on the free circulation and use of Earth Stations on board Vessels operating in fixed satellite service networks in the frequency bands 14-14.5 GHz (Earth-to-space), 10.7-11.7 GHz (space-to-Earth) and 12.5-12.75 GHz (space-to-Earth)”
- [22] ECC Decision (05)11: “ECC Decision of 24 June 2005 on the free circulation and use of Aircraft Earth Stations (AES) in the frequency bands 14-14.5 GHz (Earth-to-space), 10.7-11.7GHz (space-to-Earth) and 12.5-12.75 GHz (space-to-Earth)”

- [23] ERC Decision (00)07: "ERC Decision of 19 October 2000 on the shared use of the band 17.7 - 19.7 GHz by the fixed service and Earth stations of the fixed-satellite service (space-to-Earth)"
- [24] Recommendation ITU-R F.1245: "Mathematical model of average and related radiation patterns for line-of-sight point-to-point radio-relay system antennas for use in certain coordination studies and interference assessment in the frequency range from 1 GHz to about 70 GHz"
- [25] Recommendation ITU-R F.1336: "Reference radiation patterns of omnidirectional, sectoral and other antennas in point-to-multipoint systems for use in sharing studies in the frequency range from 1 GHz to about 70 GHz"
- [26] Recommendation ITU-R F.758-5: "System parameters and considerations in the development of criteria for sharing or compatibility between digital fixed wireless systems in the fixed service and systems in other services and other sources of interference"
- [27] Recommendation ITU-R SF.1707: "Guidelines for the implementation of high-density applications in the fixed-satellite service in frequency bands identified for these applications"
- [28] Recommendation ITU-R SF.1650: "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"
- [29] 1999/05/EC: Radio and Telecommunications Terminal Equipment (R&TTE)
- [30] ITU Radio Regulations – 2012 Edition, ITU-R
- [31] Recommendation ITU-R SF.1719: "Sharing between point-to-point and point-to-multipoint fixed service and transmitting earth stations of GSO and non-GSO FSS systems in the 27.5-29.5 GHz band"
- [32] Recommendation ITU-R S.1430-0: "Determination of the coordination area for earth stations operating with NON-GSO space stations with respect to Earth stations operating in the reverse direction in frequency bands allocated bi-directionally to the FSS"
- [33] ETSI EN 303 979: "Satellite Earth Stations and Systems (SES); Harmonised Standard for Earth Stations on Mobile Platforms (ESOMP) transmitting towards satellites in non-geostationary orbit, operating in the 27,5 GHz to 29,1 GHz and 29,5 GHz to 30,0 GHz frequency bands covering the essential requirements of article 3.2 of the Directive 2014/53/EU" .
- [34] ECC Decision (15)04: "ECC Decision of 3 July 2015 on the harmonised use, free circulation and exemption from individual licensing of Land and Maritime Earth Stations On Mobile Platforms (ESOMPs) operating with NGSO FSS satellite systems in the frequency ranges 17.3-20.2 GHz, 27.5-29.1 GHz and 29.5-30.0 GHz"
- [35] ITU-R Report S.2357: "Technical and operational guidelines for earth stations on mobile platforms" communicating with geostationary space stations in the fixed-satellite service in the frequency bands 19.7 20.2 GHz and 29.5-30.0 GHz"
- [36] ECC Report 272: "Earth Stations operating in the frequency bands 4-8 GHz, 12-18 GHz and 18-40 GHz in the vicinity of aircraft"
- [37] Resolution 156 (WRC-15): "Use of the frequency bands 19.7-20.2 GHz and 29.5-30.0 GHz by earth stations in motion communicating with geostationary space stations in the fixed-satellite service"