CEPT

CEPT ECC
Electronic Communications Committee

ECC Report 184

The Use of Earth Stations on Mobile Platforms Operating with GSO Satellite Networks in the Frequency Ranges 17.3-20.2 GHz and 27.5-30.0 GHz

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0 EXECUTIVE SUMMARY

Earth Stations On Mobile Platforms (ESOMPs) are planned to be operated in Ka-band Fixed Satellite Service (FSS) networks. This report examines the regulatory and technical aspects surrounding such use with reference to similar developments in the C-band and Ku-band where mobile terminals have operated for many years in 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 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 to be included in an ECC Decision on Ka-band ESOMPs. Such technical requirements are necessary to ensure, among other things, that ESOMP antennas maintain a high pointing accuracy and do not cause interference to other satellite networks. 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 a Power Flux Density (PFD) threshold applicable to the low-water mark of the territory of an administration is necessary and for aircraft ESOMPs a PFD threshold at the ground applicable to the territory of a country is needed. This Report identifies the applicable PFD values for maritime and aircraft ESOMPs.

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

As maritime and aeronautical ESOMP operations in particular are international in nature, the ITU has developed ITU-R Report S.2223 [7]. Work is continuing in this area at the ITU-R to define the suitable regulatory measures to be introduced into the ITU Radio Regulations for ESOMPs in 17.3-20.2 GHz and 27.5-30.0 GHz.

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LIST OF ABBREVIATIONS

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

1 INTRODUCTION

Recently there has been an increase in the use of Fixed-Satellite Service (FSS) networks by Earth Stations mounted On Mobile Platforms (ESOMPs) to provide telecommunications services to aircrafts, ships, trains and other vehicles using both the C- and Ku-band. As the demand for these systems evolves, service providers are turning to other FSS bands, in particular Ka-band, to meet this growing need.

Advances in satellite antenna technology, particularly the development of stabilised antennas capable of maintaining a high degree of pointing accuracy even on rapidly moving platforms, have already allowed the development of mobile terminals with very stable pointing characteristics. The pointing accuracy performance of systems currently either in production or under development for use in Ka-band is equal to or better than that currently achieved by Ku-band systems operating on mobile platforms. These mobile terminals are designed to operate in the same interference environment and comply with same regulatory constraints as those for typical uncoordinated FSS earth stations. Ka-band satellite networks with mobile terminals are expected to be operated in Europe from early 2013.

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 systems contemplated for the Ka-band are similar to those mobile earth stations, like ESVs and aircraft earth stations, operating in the C- and Ku-bands.

This Report examines the requirements for ESOMPs in the appropriate Ka-band frequencies, and recommends a regulatory approach which could be adopted by the CEPT. The technical requirements, which would need to be included in an appropriate ECC Decision for Ka-band ESOMPs, are also identified.

This Report covers ESOMPs operating with GSO networks in the Ka-band (17.3-20.2 GHz and 27.5-30.0 GHz). ESOMPs operating with non-geostationary FSS networks are outside the scope of this Report.

2 NEED FOR ACCESS BY GSO ESOMPS TO PORTIONS OF THE BANDS 27.5-30.0 GHz AND 17.3-20.2 GHz

ECC Report 152 [25] 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. In Europe, while studies are underway to identify spectrum for broadband air-to-ground communications, no such spectrum is currently available to the aeronautical community. Similarly, ships, even those in inland waterways, are often beyond the reach of terrestrial wireless networks.

As described in ECC Report 152 [25], Ka-band geostationary FSS systems are now in operation in Europe, with the vast majority of these systems operating their service-links (i.e. using LESTs or HESTs) within the 29.5-30.0 GHz / 19.7-20.2 GHz bands.

Ka-band geostationary satellite systems[1] are intended to support the realisation of the EU Digital Agenda 2013 and 2020 objectives for broadband provision to EU customers and so take part to the realisation of EU policy objectives.

There is also a significant requirement for additional Ka-band FSS satellite capacity (i.e. in addition to the 29.5-30.0 GHz / 19.7-20.2 GHz bands, i.e. 2 x 500 MHz frequency bands) to be deployed over Europe to support FSS type applications.

3 REGULATORY FRAMEWORK FOR ESOMPS

3.1 ITU-R

3.1.1 WRC-03 Decisions on AMSS operating 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 [1] (Rev.WRC-2000), 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 [2].

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."[2]

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 [2] adopted a PFD mask to protect FS networks in the 14.0-14.5 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.

[1] Such as Avanti's HYLAS-1 and Eutelsat's KA-SAT satellite systems.

[2] Report to the 2003 World Radiocommunication Conference (WRC-03) at 2.4.2.

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

In the case of Earth Stations on board Vessels (ESVs), 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 [3]. 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 (WRC-03)"

WRC-03 adopted Resolution 902 (WRC-03) [5], which included technical and operational constraints to avoid interference from ESVs into terrestrial networks.

Resolution 902 [5] is likely to be revised at WRC-15 under AI 1.8 and Resolution 909 (WRC-12) [4]. There is no linkage of the Resolution 902 [5] to the Ka Band and hence, no impact is expected on the ESOMP harmonisation measure within the CEPT.

3.1.3 WRC-03 Decisions on HDFSS

WRC-03 adopted Resolution 143 (Rev.WRC-07) [6] "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) [6], "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)[6] 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 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 these 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).” [6]

3.1.4 Study Group 4 Work on Ka-band ESOMPs

ITU-R SG-4 at its meeting on 29–30 Sep 2011 in Geneva adopted a new ITU-R Report ITU-R S.2223 [7]. This Report identifies the technical and operational requirements for the operation of ESOMPs in Ka-band FSS networks.

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/DEC/(05)08 [10] 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/DEC(06)02 [11] and ECC/DEC(06)03 [12] 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 [3].

Also following the WRC-03 identification of bands for HDFSS, through ECC/DEC/(05)01 [9] (which replaced ERC/DEC/(00)09 [8]) 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/DEC/(05)01 [9], 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.

Given the transnational nature of satellite services operating in the frequency range 27.5-29.5 GHz, it is important that a major proportion of the CEPT administrations implement ECC/DEC/(05)01 [9]. It should be noted that as of July 2012, Decision ECC/DEC/(05)01 [9] has been declared as having been implemented by 31 CEPT administrations (additionally, with 3 “Not Implemented”, 3 “Implementation Under Study”, and 11 “No Information”).

The band 17.3-17.7 GHz is also globally allocated to the FSS (Earth-to-space) on a primary basis, limited to feeder links for the BSS, and is subject to ITU Radio Regulations Appendix 30A [18]. Regarding the potential impact from BSS feeder links (Earth-to-space) into FSS ESOMPs (space-to-Earth), when for example an aircraft mounted ESOMP flies through a BSS feeder link beam, the ESOMP shall not claim protection from BSS feeder links and shall not place any constraints on BSS feeder links (reference is made to ITU footnote 5.516A [19]). This is reflected in decides 4 of ECC/DEC/(05)08 [10].

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. Any aeronautical earth station operating over the territory of a country must therefore be duly authorised by that country. Under maritime law, national sovereignty extends out to 12 nautical miles from the low-water mark of the coast. Similarly, any earth station on vessels operating in territorial waters must also be duly authorised.

Three ECC Decisions were adopted following WRC-03 to allow for the free circulation of Aircraft Earth Stations (AESs) and ESVs, i.e.: ECC/DEC/(05)09 [12] and ECC/DEC/(05)10 [14] were adopted for ESVs operating in the C- and Ku-bands and ECC/DEC/(05)11 [15] was adopted for AESs operating in the Ku-band.

All three 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 ESOMPs in Ka-band

The previous frameworks adopted for AESs and ESVs in the C- and Ku-bands only apply to GSO systems.

ESOMPs for GSO systems operating in the Ka-band present a sharing environment similar to that found in the 14.0-14.5 GHz band for AMSS, ESV and VSAT networks. Each of these types of network is characterised by large numbers of small, technically identical earth stations which are not licensed on an individual basis.

ESOMPs are also similar to AMSS, ESV 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 the three types of earth stations because they could be located anywhere within the operational area of such an FS network.

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 AESs and ESVs have operated successfully worldwide on aircraft and ships.

Taking into account the success of the previous ECC Decisions, a similar regulatory framework could be adopted in the Ka-band. The suggested Ka-band frequencies within which ESOMPs may operate when within national territory are those identified for uncoordinated FSS earth stations, in particular those identified in ECC/DEC/(05)01 [9] and ECC/DEC(05)08 [10], 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 as typical uncoordinated FSS earth stations and do not cause unacceptable interference to any terrestrial services operating in the same bands.

Any regulatory framework adopted in these bands to accommodate ESOMPs should also ensure that it does not prejudice the use of these bands by other FSS and terrestrial applications operating in conformance with other ECC Decisions.

4 CONSIDERATIONS ABOUT THE OPERATION OF ESOMPS IN FSS NETWORKS

In considering what regulatory provisions should be adopted for ESOMPs, several options were available. 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 (such as off-axis e.i.r.p. limits) 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 ESOMP system operators for four reasons:
    1. If ESOMP 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;
    2. The key-feature of the systems that are 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;
    3. The capital and operating costs of an ESOMP network operating in 2 x 100 MHz would be similar to those for an ESOMP 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.
    4. All systems currently planning to provide ESOMP services in Europe would be capable of operating at least in 2 x 500 MHz spectrum;
- Treating ESOMPs as FSS provides ESOMP operators and regulators with a well-established and proven set of rules for authorising these earth stations;
- GSO ESOMPs must comply with same off-axis e.i.r.p. limits as typical uncoordinated FSS earth stations;
- 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 GSO ESOMPs on an aggregate basis per GSO network are designed and operated in compliance with the same requirements (such as off-axis e.i.r.p. limits) as those placed on uncoordinated FSS earth stations, no sharing issues exist between ESOMPs and other FSS networks.

Taking all of the above into account, the ECC concluded that 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 ON 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 and terrestrial networks in the same geographic area is difficult to accomplish. The same conclusion holds true for ESOMPs. Since implementation 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 GSO 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/DEC/(00)07 [26].

There is the possibility that neighbouring countries could implement different allocations, in the 27.5-29.5 GHz and 17.7-19.7 GHz bands, either to uncoordinated FSS or to FS applications. Furthermore ESOMPs operating in international waters or international 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 27.5-29.5 GHz. Noting that no applications of the MS[3] have been identified in the frequency ranges 17.7-19.7 GHz and 27.5-29.5 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.

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	Rec. ITU-R F.1245	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	28 GHz	28 GHz	28 GHz	28 GHz	24.25-29.50	24.25-29.50 GHz	

[3] 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.

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
frequency (GHz)					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)
(1) The System noise power density (N_0 in dB(W/Hz)) shall be obtained from the following equation: N_0 = NF + 10*log10(kT_0) where : T_0 = 290 K, *NF* is the noise figure (dB) and *k* is the Boltzmann constant it results: N_0 = NF– 204 (dB(W/Hz)) (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.							

5.1.1 ESOMPS installed on Land Platforms

ESOMPs installed on land platforms do not differ substantially from typical uncoordinated stationary FSS stations. It should be noticed that Recommendation ITU-R SF.1707 [20] already provides methods and means to facilitate the implementation of large numbers of earth stations operating in the FSS in areas where terrestrial services are also deployed. This Recommendation could therefore be considered a basis for coordination procedures between neighbouring administrations implementing different allocations in this band.

Section 7 of this document 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 27.5-29.5 GHz. FS or MS systems operating near the coast could receive interference from a maritime ESOMP, 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 ESOMP 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 ESOMP 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 [21] dealing with ESV in the bands 5 925-6 425 MHz and 14.0-14.5 GHz.

In the case of ESOMPs operating in the band 27.5-29.5 GHz, this PFD threshold (see Annex 2) is -109 dB(W/m²) 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 27.5-29.5 GHz designated to the FS in CEPT.

5.1.3 Aircraft-mounted ESOMPs

ESOMPs installed on aircrafts 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[4] above ground, the same cross-border sharing considerations as for other types of earth stations cannot be applied to these aircraft-mounted terminals.

Studies [28] conducted by ECC have analysed the potential interference from aircraft-mounted ESOMPs to FS receivers. Simulations have been performed based on typical flight paths for commercial aircraft, with the assumption that aircraft-mounted ESOMPs may not transmit on the same frequencies as those used by FS systems when flying over the same country in which FS systems are deployed, but may do so when flying outside, but near, the border of that country. Different PFD masks have been proposed and analysed, and it has been concluded that the following PFD mask provides adequate protection to FS systems currently deployed or planned to be deployed in CEPT countries.

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

where δ is the angle of arrival at the Earth's surface (degrees) and the PFD value is in dB(W/m^2) in a reference bandwidth of 14 MHz.

The PFD mask proposed 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.

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[5].

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

Studies have also been conducted by CEPT to assess the potential interference from FS transmitters in the band 17.7-19.7 GHz to aircraft-mounted ESOMPs. These studies have shown that the ESOMP could receive interference above the recommended criterion from fixed links operating with a relatively high e.i.r.p.. As a consequence, aircraft mounted ESOMPs receiving in the band 17.7-19.7 GHz should anticipate potential interference from fixed links but should not claim protection from such interference.

5.2 ETSI STANDARDS

Under the R&TTE Directive [22], 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 303 978 [21]) for ESOMPs operating in the bands within 17.3-20.2 GHz and 27.5-30 GHz.

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[4] 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.

[5] For the derivation of the PFD mask the baseline assumptions on the atmospheric loss and aircraft fuselage loss are contained in Annex 1.

5.3 OTHER TECHNICAL REQUIREMENTS FOR KA-BAND ESOMPs

To address potential interference with other co-frequency GSO FSS networks, ESOMPs should comply with the same constraints, such as off-axis e.i.r.p. limits, as those for other FSS earth stations. Such limits would be determined by both the inter-system satellite coordination agreements and the limits in the ETSI standard. In considering aggregate interference levels, it should be noted that there is no evidence that FSS systems supporting ESOMPs will have more spot beams or better frequency reuse than other FSS systems, thus by applying existing FSS rules (at the least) the same level of protection will be provided to neighbouring satellite networks as is currently the case. Hence, from the perspective of potential uplink interference to other satellite networks, these requirements will ensure that such earth stations are essentially equivalent to stationary FSS earth stations.

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. ESOMP 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 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 avoid that mis-pointed or poorly controlled Ka-band terminals (whether fixed or mobile) would cause unacceptable interference to adjacent Ka-band GSO 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 terminal, in order to be able to operate, shall be compliant with the relevant Harmonised ETSI Standard, which includes an off-axis e.i.r.p. limit, and with the other Recommendations and coordination requirements applicable to FSS networks.

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-pointing of 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 adjacent 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 off-axis e.i.r.p. levels in the direction of neighbouring satellite networks above those of other specific and/or typical FSS earth stations operating in compliance with Recommendation ITU-R S.524 [3] or with any other limits coordinated with neighbouring satellite networks. These earth stations also need to be self-monitoring and, should harmful interference to FSS networks be detected, must automatically mute any transmissions.

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 ESOMP 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 27.5-30.0 GHz AND 17.3-20.2 GHz

Under the recommended approach of this report, a new ECC Decision would be developed to authorise the use of ESOMPs in the Ka-band frequencies, without any change to the Radio Regulations. The Decision would provide a framework for ESOMPs to operate in FSS networks 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 platforms, a process based on mutual recognition of licences and free circulation may be considered. When they are operated under certain technical conditions, the same regime could also apply to ESOMPs installed on aeronautical platforms.

Figure 1 outlines the process through which a new ECC Decision (and ETSI Standard) could be used for authorising ESOMPs to operate in those parts of the Ka-band allocated to uncoordinated FSS earth Stations.

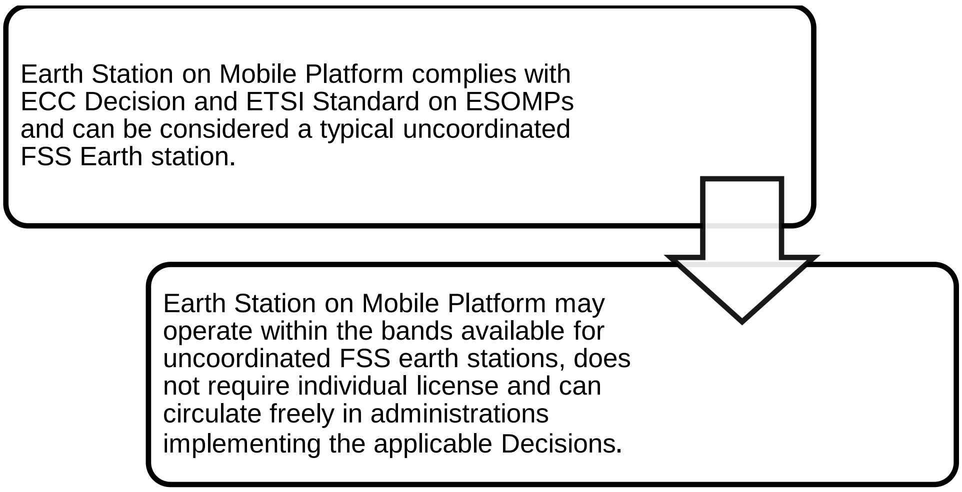


Figure 1: Proposed treatment of ESOMPs in CEPT

The aforementioned ECC Decisions on AESs and ESVs (ECC/DEC/(05)09 [12], ECC/DEC/(05)10 [14] and ECC/DEC/(05)11 [15]) as well as the WRC Resolution 902 and ITU-R Recommendations on which they are based, provide a basis for developing the requirements for inclusion in such a new 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 2: 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 [2]
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.	Recommendation ITU-R M.1643 [2] Recommendation ITU-R S.524 [3]
The design, coordination and operation of the earth stations should take into account: - Antenna mis-pointing; - Variations in antenna pattern of the earth station; - Variations in the transmit e.i.r.p. from the earth station.	Recommendation ITU-R M.1643 [2]
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 [2]
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 [2] Resolution 902 [5]

Some of these requirements are contained in the ETSI Harmonised European Standard [21] for Ka-band ESOMPs. Other requirements may need to be included in the ECC Decision.

Instead of defining distinct decisions for aeronautical and maritime earth stations operating in the Ka-band, more general provisions would be developed defining the conditions under which these earth stations could be treated as ESOMPs operating under the same conditions as typical uncoordinated FSS earth stations. Maritime and aeronautical ESOMPs would then be required to follow similar regulatory requirements to those applicable to typical uncoordinated FSS earth stations operating in the band in order to achieve free circulation for aero and maritime terminals and licence exemption or general authorisation for land based terminals.

This approach provides a simpler and consistent regulatory treatment of such terminals since it requires them to comply with the same type of requirements as the fixed FSS terminals they are designed to emulate.

7 CROSS-BORDER COORDINATION

The Ka-band frequencies identified for uncoordinated FSS earth stations have been harmonised throughout CEPT by ECC Decisions ECC/DEC/(05)01 [9] and ECC/DEC/(05)08[10]. 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[6], 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 [20] 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 [24] 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 on-board aircraft are operated in international waters and airspace, the frequency band used by these earth stations 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 border not pointing toward a neighbouring country that allows aircraft-mounted ESOMPs;
2. FS stations in one country deployed near the coast not pointing toward the open sea;
3. Countries that have not deployed fixed links in the band 27.5-29.5 GHz;
4. Real FS links which have less sensitive characteristics to interference than those assumed in the sharing studies;
5. Presence of clutter/terrain blockage and rain/cloud attenuation which may introduce additional attenuation for the interference path;
6. Real pointing direction of ESOMP, for example in Europe these are generally pointing in the southern direction at the GSO orbital arc, which may not necessarily be aligned with the FS receivers.

8 CONCLUSIONS

Ka-band FSS networks capable of providing ESOMP services in Europe are already in operation and plans are in place to introduce ESOMP services in Europe from early 2013.

This report has examined possible regulatory approaches to allow the CEPT administrations to authorise ESOMPs to operate in FSS networks in the Ka-band. It is proposed that a new ECC Decision for Ka-band ESOMPs should contain the following elements:

- The ESOMPs are an application of the FSS;

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

- 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 or international airspace (which may transmit within the range 27.5-30.0 GHz), shall ensure protection of fixed service systems in the CEPT;
- Technical and operational facilities 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 Ka-band ESOMP networks are planned to be launched in a short time frame, it is in the interest of operators, users and the CEPT regulators to have an agreed framework in place to harmonise their operations as soon as possible.

As maritime and aeronautical ESOMP operations in particular are international in nature, the ITU has developed ITU-R Report S.2223 [7]. Work is continuing in this area at the ITU-R to define the suitable regulatory measures to be introduced into the international Radio Regulations for ESOMPS in 17.3-20.2 GHz and 27.5-30.0 GHz.

ANNEX 1: 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.

The PFD mask was derived from the primary component of off-axis e.i.r.p. requirements specified in ETSI EN 303 978 [21], which combined with:

- the free space spreading loss for an aircraft at 30 000 ft (9 144 m);
- the atmospheric attenuation losses (ITU-R P.676-8 [27]; see Figure 2:); and,
- the fuselage losses (see Figure 2:),

resulted in the PFD mask proposed.

With these assumptions, an ESOMP with an antenna with an elevation angle of 10° can meet the PFD mask proposed at an altitude of 30 000 ft (i.e. 9 144 m). Hence, greater fuselage loss, greater atmospheric absorption loss, or lower e.i.r.p., would allow ESOMPs to operate at a lower altitude, while still meeting the recommended PFD values.

The attenuation due to the atmospheric gases for the geometrical scenario when an aircraft is flying at an example altitude of 30 000 ft (9 144 m) is provided in Figure 2:. 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 (ϕ) in the lower half of the vertical plane perpendicular to the aircraft’s line of the flight; where ϕ = 0 and ϕ = 180 deg is at the aircraft horizontal axis.

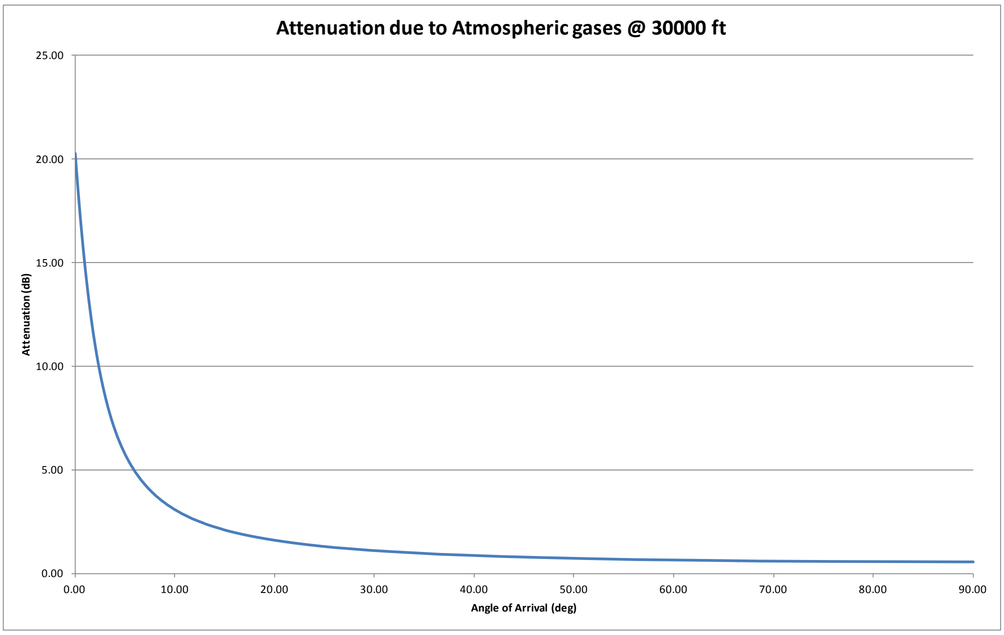


Figure 2: Attenuation (ITU-R P.676-8) due to atmospheric gases at 28.0 GHz (for aircraft altitude of 9 144 m)

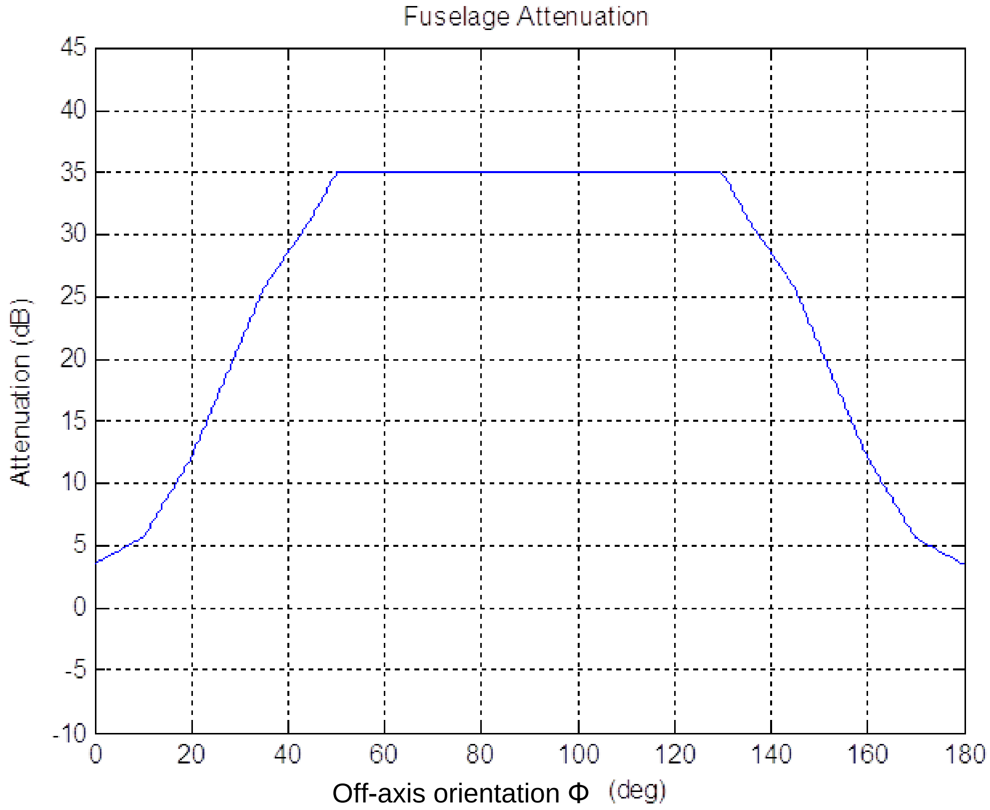


Figure 3: Attenuation due to the fuselage of the aircraft

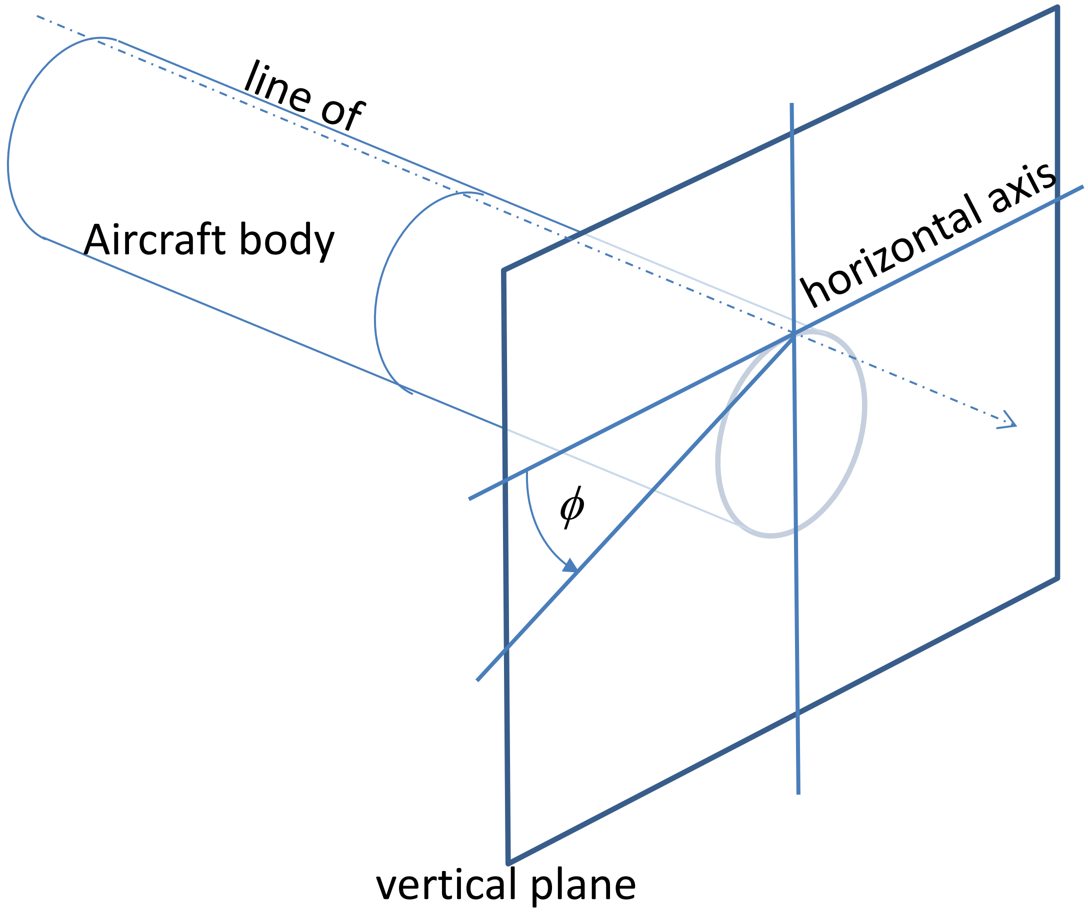


Figure 4: Geometry for defining the angle ϕ

ANNEX 2: ASSUMPTIONS AND METHODOLOGY USED FOR THE CALCULATION OF THE PFD THRESHOLD FOR MARITIME ESOMPs

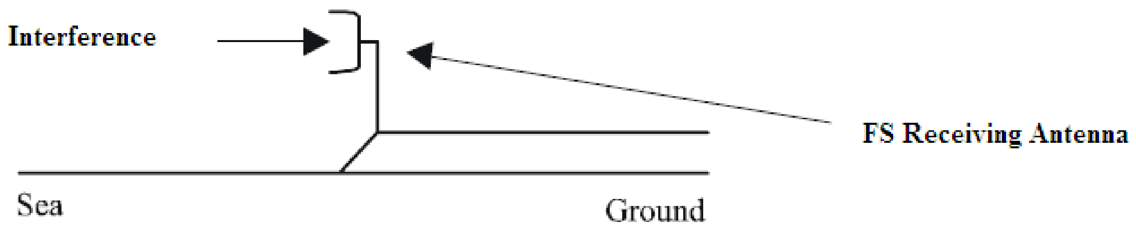
Following a worst case scenario approach, the FS station characterised by the parameters contained in Table 3 has been considered to be the victim of the interference caused by a maritime ESOMP operating in international waters [29].

Table 3: Parameters for victim FS stations operating in the 27.5-29.5 GHz band (see FS1 in Table 1)

Parameter	FS1 (PP)
RX antenna height	20 m
RX antenna pattern	Rec. ITU-R F.1245
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 5: Worst-case interference scenario



The calculation which follows determines a maximum PFD an ESOMP 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.1650-1, 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[7].

The following calculation in Table 4, related to the thermal noise at the input of the receiver used in station FS1, applies.

Table 4: 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:

[7] This short-term interference time percentage is the same as that used for the Ku-band case in Recommendation ITU-R SF.1650-1

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

where:

- I_{max} is the maximum allowed power interfering with the FS station (dBW);

- *N* is the noise power calculated in ***Table 4*** (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^2));
- G_{Avg} is the average gain of the receiving antenna within its -10 dB beamwidth (dBi);
- A_{eff} is the effective area (10 log(λ^2 / 4π)) of the receiving antenna (dB(m^2)); λ the wavelength (m);
- L_{pol} is the polarization advantage (dB).

The following calculation is then performed by applying these formulas.

Table 5: 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 interferencepower	I_{max}	-117.5	dBW
Transmitter frequency	f	29.25	GHz
Wavelength	□	0.01	m
Rx antenna peak gain	G_{Avg}	42.2	dB
Antenna effective area (10log(□²/4 □))	A_{eff}	-51	dB(m^2)
Polarisation advantage	L_{pol}	0	dB
Maximum PFD on the coast	***PFD***	***-108.9***	***dB(W/m^2)***

It is then concluded that a PFD value of -109 dB(W/m^2) 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, the percentage of time that should be used in the propagation model, when assessing compliance with this PFD threshold, is 0.007%.

ANNEX 3: LIST OF REFERENCES

[1] 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”
[2] Recommendation ITU-R M.1643; “Technical and operational requirements for aircraft earth stations of aeronautical mobile-satellite service including those using fixed-satellite service network transponders in the band 14-14.5 GHz (Earth-to-space)”
[3] Recommendation ITU-R S.524-9; “Maximum permissible levels of off-axis e.i.r.p. density from earth stations in geostationary-satellite orbit networks operating in the fixed-satellite service transmitting in the 6 GHz, 13 GHz, 14 GHz and 30 GHz frequency bands”
[4] 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”
[5] 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 14.0-14.45 GHz”
[6] 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”
[7] Report ITU-R S.2223; “Technical and operational requirements for GSO FSS earth stations on mobile platforms in bands from 17.3 to 30.0 GHz”
[8] ERC/DEC/(00)09;”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)”
[9] ECC/DEC/(05)01;“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)”
[10] ECC/DEC/(05)08;“on the availability of frequency bands for high density applications in the Fixed-Satellite Service (space-to-Earth and Earth-to-space)”
[11] ECC/DEC(06)02;“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”
[12] ECC/DEC(06)03; “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”
[13] ECC/DEC/(05)09;“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)”
[14] ECC/DEC/(05)10;“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)”
[15] ECC/DEC/(05)11; “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)”
[16] ETSI EN 301 459;“Harmonised EN for Satellite Interactive Terminals (SIT) and Satellite User Terminals (SUT) 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;“Harmonised EN for Very Small Aperture Terminal (VSAT);Transmit-only, transmit/receive or receive-only satellite earth stations operating in the 11/12/14 GHz frequency bands covering essential requirements”
[18] ITU Radio Regulations Appendix 30A (Rev. WRC-07); “Provisions and associated Plans and List for feeder links for the broadcasting-satellite service (11.7-12.5 GHz in Region 1, 12.2-12.7 GHz in Region 2 and 11.7-12.2 GHz in Region 3) in the frequency bands 14.5-14.8 GHz2 and 17.3-18.1 GHz in Regions 1 and 3,and 17.3-17.8 GHz in Region 2”
[19] ITU footnote 5.516A;“In the band 17.3-17.7 GHz, earth stations of the fixed-satellite service (space-to-Earth) in Region 1 shall not claim protection from the broadcasting-satellite service feeder-link earth stations operating under Appendix 30A, nor put any limitations or restrictions on the locations of the broadcasting-satellite service feeder-link earth stations anywhere within the service area of the feeder link. (WRC-03)”
[20] Recommendation ITU-R SF.1707; “Methods to facilitate the implementation of large numbers of earth stations in the FSS in areas where terrestrial services are also deployed”
[21] 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”

[22] Directive 1999/5/EC of the European Parliament and of the Council of 9 March 1999 on radio equipment and telecommunications terminal equipment and the mutual recognition of their conformity", (The R&TTE Directive)
[23] ETSI EN 303 978; "Satellite Earth Stations and Systems (SES); Harmonized EN for Earth Stations on Mobile Platforms (ESOMP) transmitting towards satellites in geostationary orbit in the 27,5 GHz to 30,0 GHz frequency bands covering essential requirements under article 3.2 of the R&TTE Directive"
[24] 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"
[25] ECC Report 152: The use of the frequency bands 27.5-30.0 GHz and 17.30-20.2 GHz by satellite networks
[26] ERC/DEC/(00)07 on shared use of 17.7-19.7 GHz for the Fixed and Fixed Satellite Service;
[27] Recommendation ITU-R P.676-8: "Attenuation by atmospheric gases".
[28] [28] FM44(12)031: Liaison statement to FM44 concerning the compatibility between aircraft mounted ESOMPS and FS in the band 27.5-29.5 GHz.
[29] [29] FM44(12)016: Liaison Statement on work carried out in support of the new ECC Decision (13)01 covering Earth Stations on Mobile Platforms in the Ka-band.