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| **Radiocommunication Study Groups** |  |
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| Received: 20 October 2021  Source: Document 4A/392 (Annex 22)  Subject: WRC-23 agenda item 1.15 Resolution **172 (WRC-19)** | **Document 4A/503-E** |
| **21 October 2021** |
| **English only** |
| Cameroon (Republic of), Egypt (Arab Republic of), Ghana,  Rwanda (Republic of), Saudi Arabia (Kingdom of),  South Africa (Republic of), Tanzania (United Republic of) | |
| proposed amendment to WORKING DOCUMENT  ON WRC-23 AGENDA ITEM 1.15 | |
|  | |

WRC-19 adopted WRC-23 agenda item 1.15 Resolution **172 (WRC-19)** that addresses the operation of earth stations on aircraft and vessels communicating with geostationary space stations in the fixed-satellite service in the frequency band 12.75‑13.25 GHz (Earth-to-space).

At the last meeting of Working Party (WP) 4A in July 2021 a compilation of the inputs received at the July 2021 WP 4A meeting was attached as a non-agreed document to the Chairman’s Report for information purpose only

This contribution provides further amendments to working document on WRC-23 agenda item 1.15 contained in Document [4A/392](https://www.itu.int/md/R19-WP4A-C-0392/en) (Annex 22) highlighted in green, as attached.

**Attachment:** 1

Attachment

WORKING DOCUMENT ON WRC-23 AGENDA ITEM 1.15

Note: In dealing with e/s on board vessel WRC-03 concluded that the use of pfd to protect terrestrial services of coastal administrations was not appropriate for that reason WRC-03 in Resolution **902 (WRC-03)** and WRC-15 in Resolution **902 (WRC-15)** maintained the fixed distance between the vessel and low water mark of the coastal administration for the establishment of coordination. This was due to the fact that currently there is no coordination procedure to deal with the relation between mobile satellite e/s and terrestrial services. Similarly, for aeronautical ESIM currently there is no coordination procedure to deal with the relation between mobile satellite e/s and terrestrial services, therefore use of a pfd to protect terrestrial services from aero ESIM should be studied and agreed upon taking into account two conditions a) use of the concept of pfd needs to be validated and agreed upon b) a methodology for the BR to examine the conformity with such pfd level needs to be established and agreed upon.

Editor’s note: Highlighted text and revisions are the results of compilation of inputs to the July WP 4A meeting. Further discussion is required on the text so there was no agreement on the text and it will be reviewed at the Oct/Nov 2021 WP 4A meeting.

Editor’s note: This document is a compilation of the inputs received at the July 2021 WP 4A meeting. This document was briefly presented but not discussed and several areas including but not limited to the overall function of system that would operate with aero or maritime earth stations needs more clarification. The entire document was not agreed to at all. In order not to lose sight of the document it was concluded to be attach as a non-agreed document to the Chairman’s Report for information purpose only. Source documents: Docs 260, 265, 286, 287, 315, 323, 339, 337,365.

Difficulties were identified and concerns expressed in dealing with AI 1.15 which stem specifically from the regulatory provisions of AP**30B** procedures including but not limited to Nos. 6.6 and 6.16 of Article 6. In this connection it is worth to mention that studies being carried out and being made available by the Bureau reveals that due to the specificity of regulatory procedures of AP**30B**, including application of paragraphs 6.6 and 6.16 of that Appendix, the maximum number of coordinated and agreed countries to be included in the service area of a given satellite network recorded in the MIFR in a rare case is not more than 50 countries out of 193 member states of the Union. In view of the above the operation of ESIM on board aircraft and vessels referred to under AI 1.15 does not have a global or even a Regional nature in a contiguous manner/approach. The effectiveness and appropriateness of using AP**30B** frequency bands for this purpose is therefore a matter to be further explored and agreed accordingly.

Once the compatibility studies of the maritime ESIM vis a vis mobile service and fixed service are completed the larger distance should be applied.

NOTE:

The meeting comments included the following: That the following three issues regarding the operation of e/s on board aircraft and vessels need to be considered:

a) Country to be served by these operations need to be included in the agreed/coordinated service area of the subject satellite network;

b) That country also needs to authorize the operation of above-mentioned earth station in the territory under its jurisdiction (airspace and territorial waters);

c) The country in which the gateway earth station is established needs to undertake all technical operational, administrative and regulatory obligations for the operation of such gateway earth station.

# 1 Introduction

World Radiocommunication Conference 2019 (WRC-19) adopted agenda item 1.15 that calls for studies on the possible operation of earth stations on board aircraft and vessels communicating with geostationary space stations in the fixed-satellite service in the frequency band 12.75-13.25 GHz (Earth-to-space), in accordance with Resolution **172 (WRC-19)**.

The ITU has addressed aeronautical and maritime earth stations operating with GSO FSS satellites in SG 4 and at several WRCs that adopted technical and regulatory regimes to allow such operations. In the Radio Regulations Resolution **902 (WRC-03),** Resolution **156 (WRC-15)** and Resolution **169 (WRC-19)** define technical and regulatory rules to allow GSO FSS networks to communicate with earth stations on aircraft or vessels to provide broadband communications. These Resolutions include key aspects that would also apply to aeronautical and maritime earth stations operating with GSO FSS networks in the 12.75-13.25 GHz band such as:

– need to employ an algorithm that is resistant to capturing and tracking adjacent satellite signals;

– capability to immediately inhibit transmission when mispointing is detected;

– self-monitoring capability to ensure compliance with applicable rules and, should a fault be detected to automatically mute any transmissions;

– requirement for earth station to be subject to the monitoring and control of a Network Control and Monitoring Center (NCMC) or equivalent facility;

– regulatory and technical rules to protect other allocated services, including terrestrial services.

Resolution **172 (WRC-19)** calls for studies to ensure that RR AP**30B** allotments and assignments as well as other allocated services are protected. Section 2 below provides Information on the services allocated in the frequency band 12.75 – 13.25 and adjacent bands studied under WRC-23 agenda item 1.15 while Section 3 provide overview about The operation of earth stations on board aircraft and vessels communicating with FSS networks has been addressed in unplanned FSS Ku and Ka frequency bands. Section 4 contain expected characteristics of aero and maritime earth stations that would operate in the 12.75-13.25 GHz (Earth-to-space) band. Sections 5 and 6 provide characteristics of fixed service and mobile service stations in the band, respectively and Section 7provides aeronautical radionavigation system characteristics in adjacent bands. The characteristics in Sections 5, 6 and 7 were provided by the expert ITU-R Working Party *[it is noted that further input from these working parties are expected]*. Section 8 addresses compatibility and protection of FSS, including the AP**30B** allotments and assignments.

# 2 Information on the services allocated in the frequency bands studied under WRC-23 agenda item 1.15 and related footnotes

In accordance with Resolution **172 (WRC-19)**, earth stations on board aircraft and vessels need to ensure protection of the existing services to which the 12.75-13.25 GHz band are allocated as well as services in bands adjacent to those, to ensure protection of, and not impose undue constraints on, those services and their future development.

The table below provides information with regard to the services allocated in the 12.75-13.25 GHz frequency band.

11.7-13.4 GHz



|  |  |  |
| --- | --- | --- |
| Allocation to services | | |
| Region 1 | Region 2 | Region 3 |
| 11.7-12.5  FIXED  MOBILE except aeronautical mobile  BROADCASTING  BROADCASTING-SATELLITE 5.492 | 11.7-12.1  FIXED 5.486  FIXED-SATELLITE (space-to-Earth) 5.484A 5.484B 5.488  Mobile except aeronautical mobile  5.485 | 11.7-12.2  FIXED  MOBILE except aeronautical mobile  BROADCASTING  BROADCASTING-SATELLITE 5.492 | |
| 12.1-12.2  FIXED-SATELLITE  (space-to-Earth) 5.484A 5.484B 5.488 |
| 5.485 5.489 | 5.487 5.487A | |
| 12.2-12.7  FIXED  MOBILE except aeronautical mobile  BROADCASTING  BROADCASTING-SATELLITE 5.492 | 12.2-12.5  FIXED  FIXED-SATELLITE (space-to-Earth) 5.484B  MOBILE except aeronautical mobile  BROADCASTING | |
| 5.487 5.487A | 5.487 5.484A | |
| 12.5-12.75  FIXED-SATELLITE (space-to-Earth) 5.484A 5.484B (Earth-to-space)    5.494 5.495 5.496 | 5.487A 5.488 5.490 | 12.5-12.75  FIXED  FIXED-SATELLITE (space-to-Earth) 5.484A 5.484B  MOBILE except aeronautical mobile  BROADCASTING- SATELLITE 5.493 | |
| 12.7-12.75  FIXED  FIXED-SATELLITE (Earth-to-space)  MOBILE except aeronautical mobile |
| 12.75-13.25 FIXED  FIXED-SATELLITE (Earth-to-space) 5.441  MOBILE  Space research (deep space) (space-to-Earth) | | |
| 13.25-13.4 EARTH EXPLORATION-SATELLITE (active)  AERONAUTICAL RADIONAVIGATION 5.497  SPACE RESEARCH (active)  5.498A 5.499 | | |

5.441 The use of the bands 4 500-4 800 MHz (space-to-Earth), 6 725-7 025 MHz (Earth-to-space) by the fixed-satellite service shall be in accordance with the provisions of Appendix 30B. The use of the bands 10.7-10.95 GHz (space-to-Earth), 11.2-11.45 GHz (space-to-Earth) and 12.75-13.25 GHz (Earth-to-space) by geostationary-satellite systems in the fixed-satellite service shall be in accordance with the provisions of Appendix 30B. The use of the bands 10.7-10.95 GHz (space-to-Earth), 11.2-11.45 GHz (space-to-Earth) and 12.75-13.25 GHz (Earth-to-space) by a non‑geostationary-satellite system in the fixed-satellite service is subject to application of the provisions of No. 9.12 for coordination with other non-geostationary-satellite systems in the fixed-satellite service. Non‑geostationary-satellite systems in the fixed-satellite service shall not claim protection from geostationary-satellite networks in the fixed-satellite service operating in accordance with the Radio Regulations, irrespective of the dates of receipt by the Bureau of the complete coordination or notification information, as appropriate, for the non-geostationary-satellite systems in the fixed-satellite service and of the complete coordination or notification information, as appropriate, for the geostationary-satellite networks, and No. 5.43A does not apply. Non-geostationary-satellite systems in the fixed-satellite service in the above bands shall be operated in such a way that any unacceptable interference that may occur during their operation shall be rapidly eliminated.     (WRC‑2000)

# 3 System overview [Option 1]

[Editor’s note: This section requires further clarification in order to establish clearly the various components and aspects related to the operations of the proposed earth stations on board aircraft and vessels.]

Editor’s note: The proponent of this contribution are in the view that option 1 could be deleted as all the information is currently reflected in option 2 below.

Maritime: Current earth stations on vessels communicating with GSO FSS satellites in the Ku-band utilize the frequency range 14.0-14.5 GHz frequency band for uplink communications with conditions specified in Resolution **902 (WRC-03)**.

Aeronautical: Earth stations on aircraft utilize the same frequency range for uplink under aeronautical mobile-satellite service including those using fixed-satellite service network transponders in accordance with Recommendation ITU-R M.1643.

In the downlink direction, frequency range 10.7-12.75 GHz is used on a non-interfering, non-protected basis.

When considering operations of earth stations aircraft and vessels, techniques to maintain pointing accuracy with the associated GSO FSS satellite need to be deployed. These include a stabilized platform detecting angles of the platform and adjusting the azimuth and elevation of the antenna accordingly as well as open and closed loop tracking techniques which are introduced in detail in Report ITU-R S.2357-0[[1]](#footnote-1).

Similarly as defined in Resolution **169 (WRC-19)** for earth station in motion operating in the 17.7‑19.7 GHz and 27.5-29.5 GHz frequency band, earth stations on aircraft and vessels are subject to permanent monitoring and control by a NCMC or equivalent facility in order to comply required provisions, and are capable of receiving and acting upon at least “enable transmission” and “disable transmission” commands from the NCMC or equivalent facility. Network Control and Monitoring Center (NCMC) is an integral part of the satellite system.

For satellite systems that communicate with earth stations on aircraft and vessels, one of the roles of the NCMC is to monitor the operation of these earth stations to determine if the earth stations on aircraft and vessels in the network are meeting the technical and regulatory requirements contained in the Radio Regulations as well as those required in national authorizations. This will include: Transmission level adjustment or shut down, frequency or modulation change, confirming for antenna pointing accuracy and other requirements. As described in the section below the earth stations on aircraft and vessels also have self-monitoring capabilities.

The location and number of NCMC required is directly associated with the particulars of a satellite system.

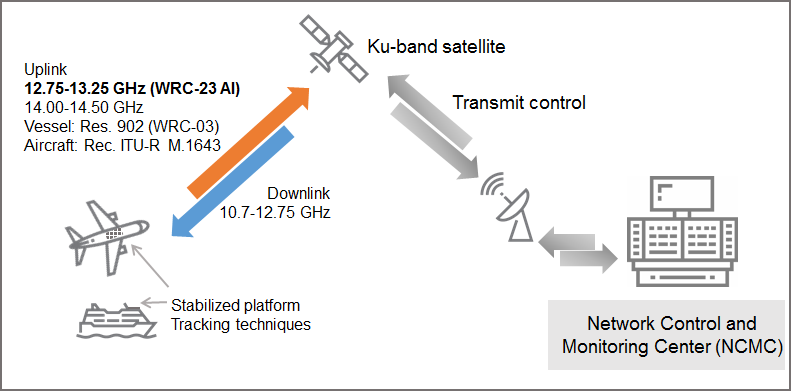
Additionally, earth stations on-board aircraft and vessels shall be self-monitoring and should a fault which could cause harmful interference to the fixed service and/or unacceptable interference to other GSO FSS networks be detected, the earth stations on-board aircraft will automatically adjust e.i.r.p. and if not enough, cease its transmissions. Operations of earth stations onboard aircraft and vessels will employ techniques to maintain pointing accuracy with the associated GSO FSS satellite. For this purpose, the earth station is mounted on a stabilized platform that it is capable of detecting angles of the platform and adjusts the azimuth and elevation of the antenna as needed.

Additionally, earth stations on-board aircraft and vessels employ well-known techniques such as Open-Loop or Closed-Loop algorithms; these techniques can perform the following functions: Setting the maximum transmitted power, locking the terminal to the desired GSO satellite and ultimately ceasing the operation should it become necessary.

Experience in practice has shown that the operation of earth stations on aircraft and vessels incorporate the latest tracking and monitoring technologies and incidents of malfunction and miss‑operation are rare. There is no reason to expect that this will be any different for ESIMs operating in the frequency bands being studies under WRC-23 agenda item 1.15.

Figure 3

Operational topology of earth stations on aircraft and vessels



The communication service to the aircraft and vessel in the satellite network consists of two parts (see Figure 3), a forward link and a return link.

– The forward link carries data from the NCMC to the earth station.

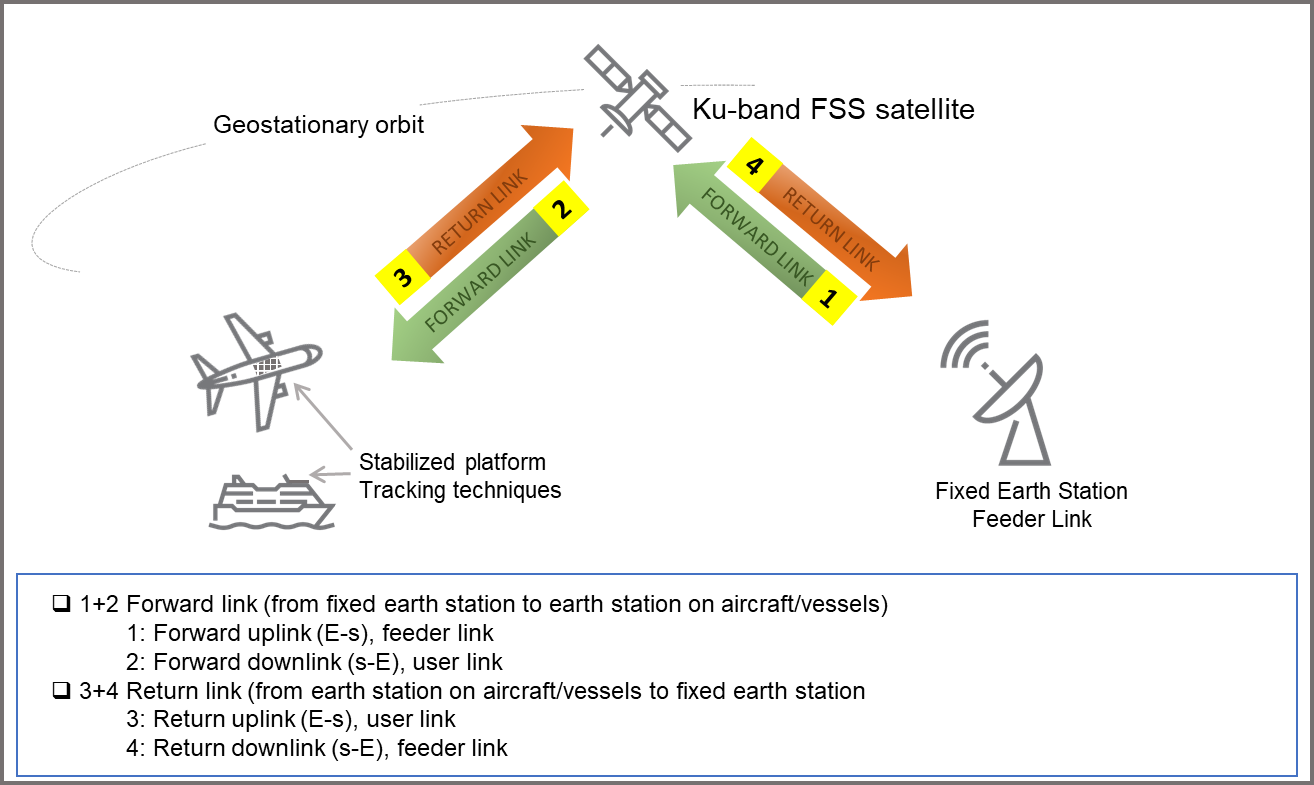
– The return link carries data from the terminals to the NCMC via the satellite.

Transmissions from the terminal are under control of the NCMC. This control includes terminal entry into the network, authorization of transmission frequencies, authorization to change the transmit power and data rate, and control of the authorized transmit power level.

Furthermore, features are included in the system design to ensure that no transmissions take place from a terminal unless it is under control. In addition, the system will include methods to identify and shut down malfunctioning terminals.

A terminal will point to a single orbital position at any given times.

The following figure provides more detail on the links associated with earth station on board aircraft and vessels.



Links 1, 2, 3 and 4 under WRC-23 agenda item 1.15

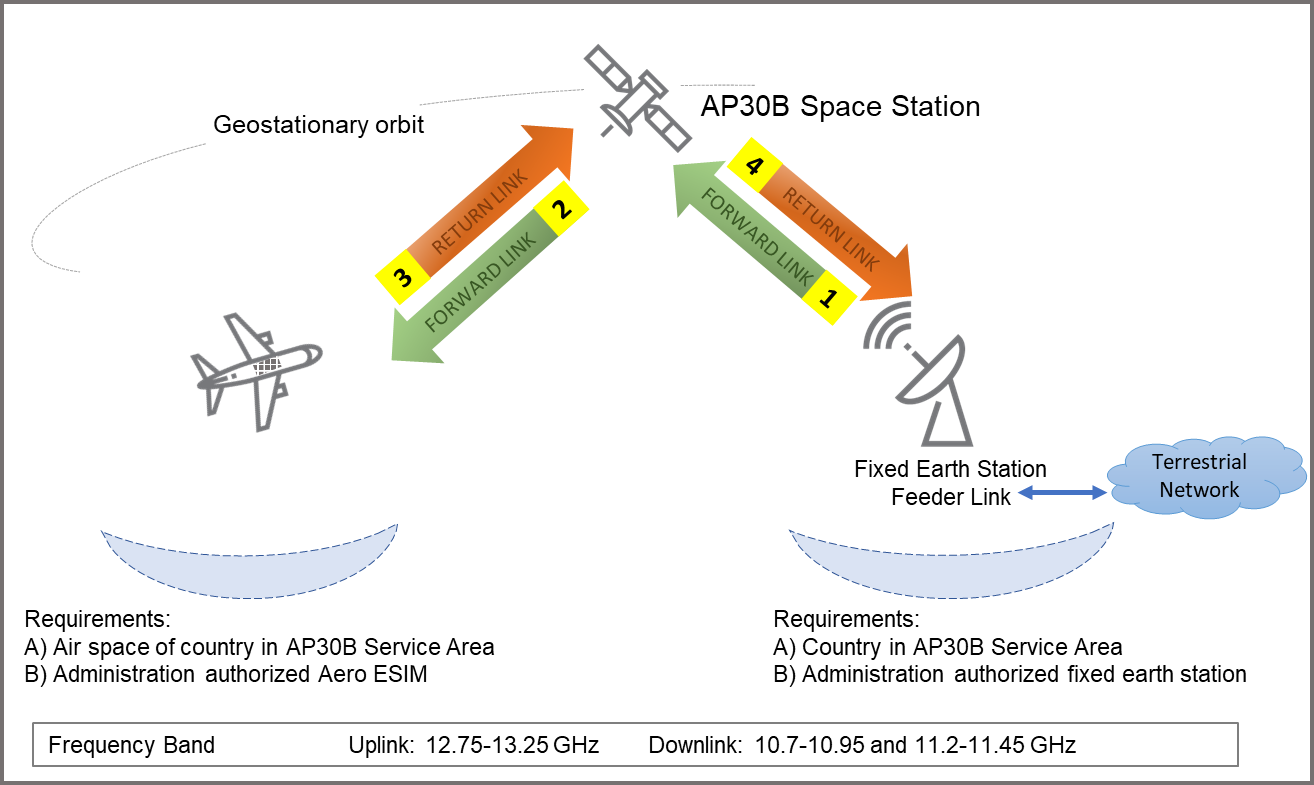
From the system configuration figure provided above, the operations of links 1 and 4, signals to/from fixed earth stations and the RR AP**30B** spacecraft, are currently covered and allowed in an RR AP**30B** network ITU filing. The status of these links and their function will not be different if the RR AP**30B** satellite also communicates with earth stations on aircraft and vessels, which is being studied under WRC-23 agenda item 1.15.

Link 2’s operations in the frequency bands 10.7-10.95 GHz and 11.2-11.45 GHz is for signal reception at an earth station on an aircraft and/or vessel to provide broadband service to the end user on board aircraft and vessels. Such operations shall not claim protection from terrestrial services (similar to Resolution **156 (WRC-15)** and Resolution **169 (WRC-19)**).

Protection of this link from other RR AP**30B** satellites will be the same as the level provided to fixed earth stations associated with the RR AP**30B** filing.

Link 3 operations in the frequency band 12.75-13.25 GHz is for transmission from an earth station on an aircraft and/or vessel to a GSO AP**30B** space station. This link has the potential to cause interference to other AP**30B** FSS allotments and assignments as well as other services allocated in the band, including terrestrial services. Based on studies appropriate technical measures are needed in order to protect other FSS satellites, terrestrial services and other services identified in Resolution **172 (WRC-19)**. It is important to begin these studies for consideration as soon as possible.

The Figure below is provided in order to add further information about the system configuration and the relevant links. It is noted that this figure could be further elaborated upon.



# *Editor’s note: consideration would be given to deleting Option 1 at the Oct/Nov WP 4A meeting*

# 3 System overview [Option 2] *[Editor’s note: from CG-1 meeting]*

The operation of earth stations on board aircraft and vessels communicating with FSS networks has been addressed in unplanned FSS Ku and Ka frequency bands. Under WRC-23 agenda item 1.15, operations of these types of earth station are being considered in the Appendix **30B** Plan Ku-band frequencies, and therefore there are specific regulatory provisions of Appendix **30B** to be addressed.

The overall system configuration, i.e. the associated transmission links, will not differ much between unplanned and planned frequency bands, however the notification and examination process for filing these links differ in some significant ways. As an example, in the Appendix **30B** bands the potential service area of a GSO network is determined by the countries who have explicitly agreed under Section 6.6 of Appendix **30B** to be in the service area of a particular network, whereas for unplanned FSS the service area is defined by the ITU filing. The unique approach in Appendix **30B** typically results in a service area that includes few countries and is typically more non-contiguous than for the unplanned FSS bands. This has been clearly shown based on the analysis provided by the BR on service areas of Appendix **30B** assignments in the Master Register. The RR AP**30B** requires the explicit agreement of an administration for the inclusion of its territory in the service area of a proposed AP**30B** FSS assignment (No. 6.6 of AP**30B**). A review by the BR of the service area of the AP**30B** assignments recorded in the MIFR showed that generally the service areas of AP**30B** networks are non-contiguous and the number of countries in these service areas ranges from one to fifty countries. Additionally, No. 6.16 of AP30B provides that an administration can exclude its territory from the service area of an AP**30B** network at any time. Therefore, aeronautical or maritime earth stations in the 12.75 13.25 GHz band need to have the capability to restrict operations in territories of those administrations where agreement under No. 6.6 has been obtained and authorization for such operations has been granted.

In either case of earth stations communicating with an Appendix **30B** satellite network or an unplanned FSS network authorization from the administration in whose territorial waters and/or airspace under the jurisdiction of that administration the terminals will operate is required as well as the ability to disable or terminate the earth station transmission if the country is not in the service area and has not authorized operations of such earth stations.

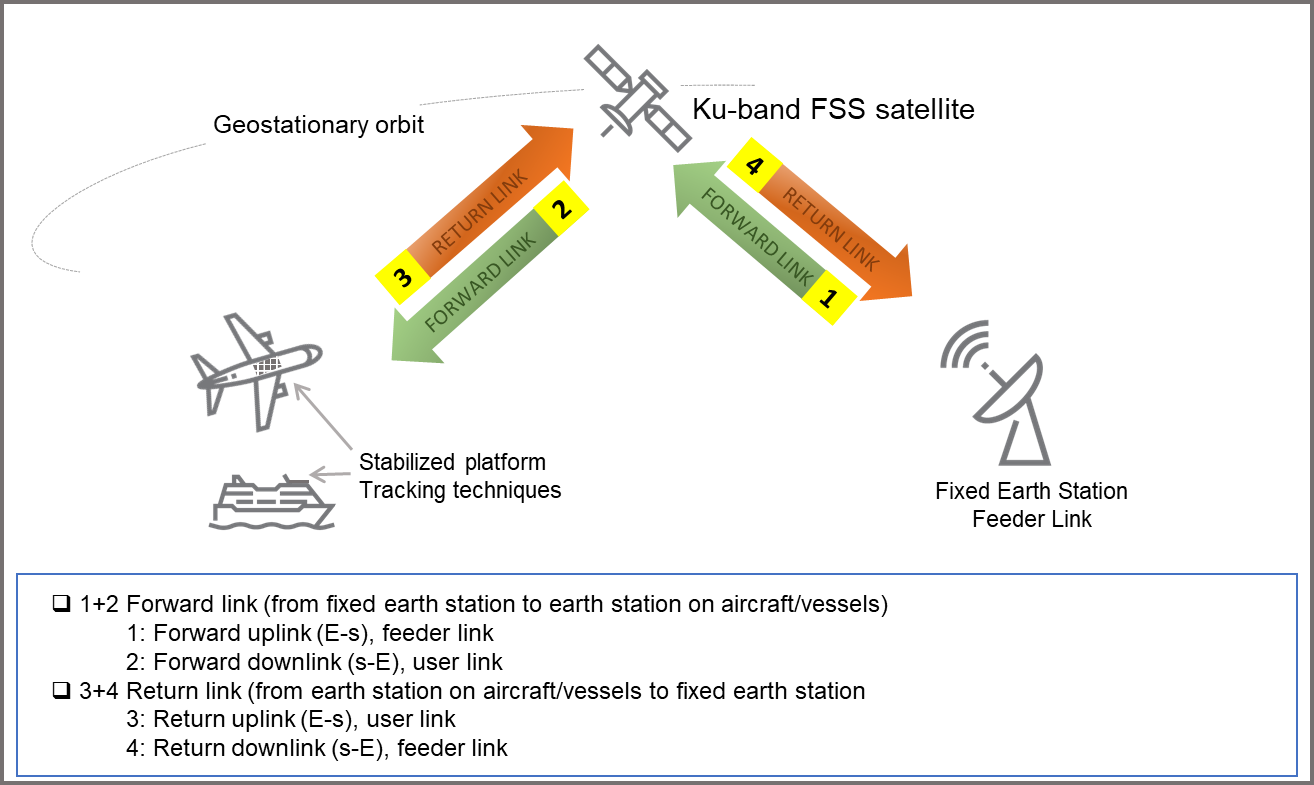
Section 3.1 addresses the overall configuration of the operation of these terminals and Section 3.2 addresses additional technical/regulatory factors.

## 3.1 Overall transmission configuration of ESIM operations

From a system configuration perspective, whether operating in Planned or unplanned frequency bands, the communications from earth station (e/s) on board aircraft and vessels with a GSO FSS satellite involve the transmission links depicted in Figure 3-1.

Figure 3-1

Transmission configuration environment of ESIM type Earth stations



Link 3 is the transmission from these e/s to the satellite; Link 4 is the transmission of this signal from the satellite to a fixed e/s on the ground; Link 1 is the transmission from a fixed e/s to the satellite; and Link 2 is the transmission from the satellite to the e/s on board an aircraft or vessel. It is noted that it is not necessary for the fixed earth station to be in the same country as the earth station on board aircraft and vessels.

Operation of these links under the regulatory procedures of Appendix **30B** requires the following:

a) that the administration had a filing recorded in the the List or MIFR with favourable finding

b) that the satellite has coverage of the relevant location of the e/s;

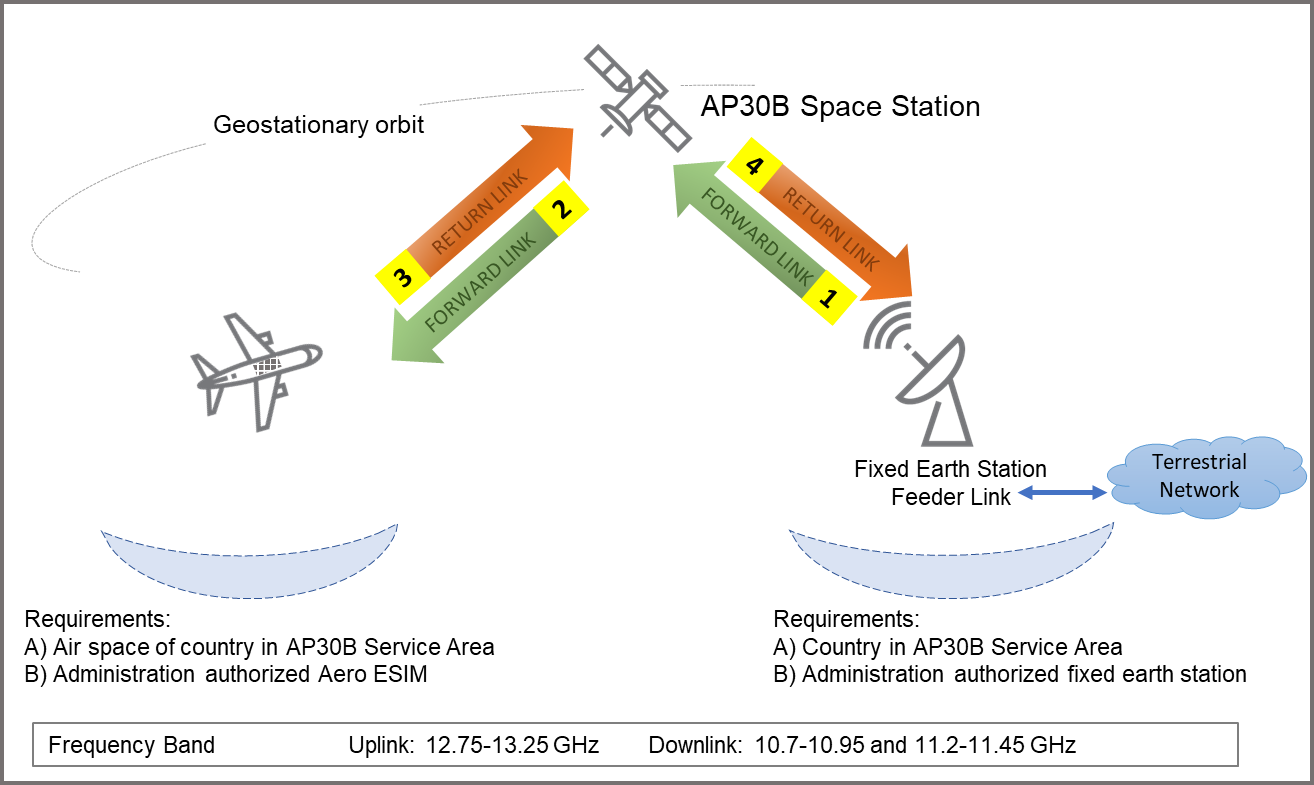
c) that the country is in the service area of the GSO network; and

d) that authorization has been obtained from the country in whose territory, national airspace and territorial waterways the earth stations operate.

For condition c) above for operations in the Appendix **30B** bands, it is necessary for a country to explicitly agree to be in the service area of that network. For additional clarification this is depicted in Figure 3-2, where the blue shaded area represents the territory, territorial waters and airspace of a given country that has explicitly agreed to be in the service area of a network.

Figure 3-2

System operation in the context of operation under Appendix 30B



From the system configuration provided in Figure 3-2, the operation of links 1 and 4, i.e., signals to/from fixed earth stations and the Appendix **30B** spacecraft, are currently covered and allowed in an Appendix **30B** network ITU filing. The status of these links and their function will not be different if the Appendix **30B** satellite also communicates with earth stations on aircraft and vessels, which is being studied under WRC-23 agenda item 1.15.

Link 2’s operations in the frequency bands 10.7-10.95 GHz and 11.2-11.45 GHz is for signal reception at an earth station on an aircraft and/or vessel to provide broadband service to the end user on board aircraft and vessels. Such operations, subject to not claiming protection from other applications of the FSS as well as other radiocommunication services to which the frequency band is allocated according to considering e) of resolution 172 (WRC-19);.

Link 3 operations in the frequency band 12.75-13.25 GHz is for transmission from an earth station on an aircraft and/or vessel to a GSO Appendix **30B** space station. This link has the potential to cause interference to other Appendix **30B** FSS allotments and assignments as well as other services allocated in the band in addition to services in the adjacent bands, including terrestrial services. Based on studies, appropriate technical measures are needed in order to protect other FSS satellites, terrestrial services and other services identified in Resolution **172 (WRC-19)**. These studies are addressed in Section XX of this document.

## 3.2 Additional factors

Operation of earth stations on board aircraft and vessels require the earth station to employ techniques to maintain pointing accuracy with the associated GSO FSS satellite. These techniques, which are well known from already deployed e/s providing these types of services in other frequency bands, include a stabilized platform capable of detecting orientation of the platform and adjusting the azimuth and elevation of the antenna accordingly, as well as open and closed loop tracking techniques which are addressed in Report ITU-R S.2357-0[[2]](#footnote-2).

Furthermore, these earth stations must employ self-monitoring capabilities with the ability to detect its location. Typically, these e/s employ “geofencing” techniques which uses global navigation satellite information to “know” its own location. Geofencing is also used to define geographic boundaries. Once these ‘virtual boundaries’ are established it is possible to trigger different actions based on the location of the e/s. This means one can a priori configure actions based on the location of the e/s. For example, the e/s, when entering a country where the proper authorization has not been obtained, will be disabled and not be permitted to begin transmitting until it enters a country where proper authorization is in place. Given that this is a software driven technique it is possible to modify these virtual boundaries in cases where additional authorizations are obtained or if authorizations are expired or rescinded.

In addition, earth stations on aircraft and vessels are monitored and subject to the control of a Network Control and Monitoring Centre (NCMC) or equivalent facility. A role of the NCMC is to monitor the operation of these earth stations to determine if the earth stations on aircraft and vessels in the network are meeting the technical and regulatory requirements contained in the Radio Regulations as well as those required in national authorizations. This will include: Transmission level adjustment or shut down, frequency or modulation change, confirming antenna pointing accuracy and other requirements. The location and number of NCMC required is directly associated with the specific requirements of a given satellite system.

Experience in practice has shown that the operation of earth stations on aircraft and vessels incorporate the latest tracking and monitoring technologies and incidents of malfunction and mis‑operation are rare.

# 4 Technical and operational characteristics of earth stations on aircraft and vessels

Advances in satellite antenna technology, particularly the development of 3-axis stabilized antennas which are capable of maintaining a high degree of pointing accuracy even on rapidly moving platforms, have allowed the development of earth stations with stable pointing characteristics while operating in motion.

Table 1 shows the typical characteristics of Ku-band[[3]](#footnote-3) aeronautical and maritime earth stations currently used today. Figures 1 and 2 depicts a typical aero fuselage-mounted terminal and a maritime antenna that operate with Ku-band GSO FSS networks respectively.

Table 1

Earth stations on aircraft and vessels typical characteristics

|  |  |  |
| --- | --- | --- |
|  | Maritime | Aeronautical |
| Antenna | Parabolic reflector | Flat panel |
| Size | 45 cm to 2.4 m | 24 cm × 7 cm or larger |
| Steerability | Mechanically steered or electronically steered | Mechanically or electronically steered |
| Transmit peak gain | 34 dBi-49 dBi | 32 dBi-42 dBi |
| Nominal power input | 3W-125W | 10W-40W |
| Max e.i.r.p. | 41 dBW to 67 dBW | 41 dBw to 54 dBW |
| Min operating elevation angle | 5° | 5° |
| Antenna pointing accuracy | 0.2° | 0.2° |
| Typical satellite G/T | 7 dB/K | 7 dB/K |

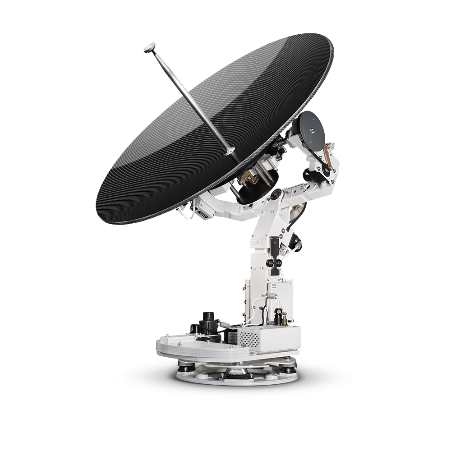
Figure 1

Terminal installed on aircraft



Figure 2

Terminal installed on vessels



# 5 User requirements of earth stations on aircraft and vessels

[Editor’s note: Resolution **172 (WRC-19)** invites the ITU Radiocommunication Sector to study user requirements of earth stations on aircraft and vessels that communicate or plan to communicate with GSO space stations in the FSS in the frequency band 12.75-13.25 GHz (Earth-to-space)]

# 6 Sharing and compatibility studies between earth stations on aircraft and vessels and other services and applications

In accordance with Resolution **172** **(WRC-19)** the sharing and compatibility issues between earth stations on aircraft and vessels communicating with GSO space stations in the FSS and current and planned stations of existing services as well as services in adjacent frequency bands, to ensure protection of, and not impose undue constraints on, those services and their future development, taking into account the provisions of RR Appendix **30B**.

## 6.1 Sharing and compatibility between Earth stations on aircraft and vessels and current and planned fixed service stations

Working Party 5C sent WP 4A a reply liaison statement, Document [4A/47](https://www.itu.int/md/R19-WP4A-C-0047/en), providing information on FS stations in the 12.75-13.25 GHz band. WP 5C indicated that Annex 3 Table 18, reproduced below as Table 6.1-1, of Recommendation [ITU-R F.758-7](https://www.itu.int/rec/R-REC-F.758/recommendation.asp?lang=en&parent=R-REC-F.758-7-201911-I) “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 (11/2019)” contains parameters that can be used for sharing/compatibility studies. Furthermore, WP 5C sent another reply liaison statement, Document WP 4A/265, containing additional information on FS system characteristics for the band 12.75-13.25 GHz and these are provided in Table 6.1-2. The parameters in these two tables besides additional characteristics and operational parameters submitted by administrations directly or indirectly on assignments in the fixed service, as well as any update of the database (MIFR and in-process), that will be provided by the BR before and up to 23 July 2021, should be taken into account in studies under this agenda item.

WP 5C also informed WP 4A of three other recommendations which may help with the sharing and compatibility studies:

1 Recommendation [ITU-R F.699-8](https://www.itu.int/rec/R-REC-F.699/en): “Reference radiation patterns for fixed wireless system antennas for use in coordination studies and interference assessment in the frequency range from 100 MHz to 86 GHz” contains information that may be used in single entry analyses and interference assessments when information concerning the FWS antenna is not available.

2 Recommendation [ITU-R F.1245-3](https://www.itu.int/rec/R-REC-F.1245/en): “Mathematical model of average and related radiation patterns for point-to-point fixed wireless system antennas for use in interference assessment in the frequency range from 1 GHz to 86 GHz (01/2019)” contains information that may be used for aggregate coordination and interference assessment studies when information concerning the FWS antenna is not available.

3 Recommendation [ITU-R F.497-7](https://www.itu.int/rec/R-REC-F.497/en): “Radio-frequency channel arrangements for fixed wireless systems operating in the 13 GHz (12.75-13.25 GHz) frequency band (09/2007)” provides RF channel arrangements for FWS operating in the 12.75‑13.25 GHz band.

Table 6.1-1 (TABLE 18from Rec. ITU-R F.758-7)

System parameters for PP FS systems in allocated bands beyond 12 GHz

|  |  |
| --- | --- |
| Frequency range  (GHz) | 12.75-13.25 |
| Reference ITU-R Recommendation | F.497 |
| Modulation | QPSK |
| Channel spacing and receiver noise bandwidth (MHz) | **3.5**, **7**, **14**, **28** |
| Maximum Tx output power range (dBW) | 10 |
| Maximum Tx output power density range (dBW/MHz) (1) | −4.5…4.6 |
| Minimum feeder/multiplexer loss range (dB) | 0 |
| Maximum antenna gain range (dBi) | 49 |
| Maximum e.i.r.p. range (dBW) | 45 |
| Maximum e.i.r.p. density range (dBW/MHz) (1) | 31…40 |
| Receiver noise figure (dB) | 10 |
| Receiver noise power density typical (=*NRX*) (dBW/MHz) | −134 |
| Normalized Rx input level for 1 × 10–6 BER (dBW/MHz) | −120.5 |
| Nominal long-term interference power density (dBW/MHz)(2) | −134 + *I*/*N* |
| (1) To calculate the values for the Tx/e.i.r.p. densities, channel spacing/bandwidth needs to be identified. In these Tables, the channel spacing indicated in bold text is used.  (2) Nominal long-term interference power density is defined by “Receiver noise power density + (required *I/N*)” as described in § 4.13 in Annex 2 (see also § 4.1 in Annex 1). | |

Table 6.1-2

Additional characteristics of FS stations in the 12.75-13.25 GHz frequency band

|  |  |  |
| --- | --- | --- |
| Frequency range (GHz) | 12.75-13.25 | |
| Reference ITU‑R/CEPT Recommendations | F.497, ERC/REC 12-02 | |
| Modulation | QPSK | 512-QAM |
| Channel spacing and receiver noise bandwidth (MHz) | 3.5, 7, 14, 28, 56 | 14, 28, 56 |
| Feeder/multiplexer loss range (dB) | 0…9.5 | 0…7.6 |
| Antenna gain range (dBi) | 29…48 | 30…50.9 |
| Receiver noise figure typical (dB) | 5 | 5 |
| Receiver noise power density typical (= NRX) (dB(W/MHz)) | −139 | −139 |
| Nominal long-term interference power density (dB(W/MHz)) | −139 + *I/N* | −139 + *I/N* |
| NOTE: It should be noted that the 512-QAM systems with antenna gain above 45 dBi are associated with a feeder/multiplexer loss of 4 dB in this case. | | |

Section 4.2 of Annex 1 of Recommendation ITU-R F.758 also provides general guidance on short‑term interference criteria and it is noted in this section, that the derivation of these criteria depends on individual link design and frequency band. Thus, the short-term interference criteria are to be derived by following the approach defined in the Recommendation [ITU-R F.1494](https://www.itu.int/rec/R-REC-F.1494-0-200005-I/en) but by using the specific fixed service (FS) characteristics for the 12.75‑13.25 GHz band. It should be noted that fixed links with fade margins[[4]](#footnote-4) of 15 dB are assigned in this frequency band which will need to be considered further in these studies.

Methodology for protection of FS

To ensure the protection of FS in 12.75-13.25 GHz, simulation tools are used to model earth station in aircraft and vessels environment. The purpose of this analysis is to calculate cumulative distribution function (CDF) for the interference levels from the earth station on aircraft and vessels into a fixed service station receiver and compare the results to the short-term and long-term permissible interference levels per the provided FS protection criteria.

In order to test all possible scenarios between earth station on aircraft and vessels and FS orientations, a number of trials will be made, assessing multiple combinations of look angle, altitude, distance, elevation angle, off-axis gain etc.

For instance, in the case of earth station on aircraft for each pointing of the FS station, aircrafts are passing in visibility of the FS station at different altitudes and on diverse routes during a simulation duration of one day and then the aggregate *I/N* is computed. The analysis will be undertaken assuming clear air (free space) propagation and including gaseous attenuation. Additionally, in the case of earth station on aircraft, the typical aircraft fuselage attenuation (shielding) assumption may be used to reduce the interference level at the FS depending on the orientations of the earth station on aircraft antenna and FS antenna. The fuselage attenuation (aircraft shielding) used in previous ITU-R studies[[5]](#footnote-5).

Furthermore, Recommendation ITU-R F.758 provides a long-term protection criterion, which is an *I/N* of −10 dB not to be exceeded more than 20% of the time. Subject to confirmation by ITU‑R WP 5C, a short-term criterion could be derived using the methodology in other F-series recommendations. A short-term criterion is available for the band immediately adjacent (i.e. below 12.75 GHz), in Recommendation ITU-R F.1494. This short-term criterion is an *I/N* of +20 dB never to be exceeded. Some FS links with 15 dB fade margin are also assigned which may need to be considered in the studies. In terms of short-term, the worst case is obtained when an earth station on aircraft is within the main beam of the FS station.

### 6.1.1 Compatibility Studies between earth stations on vessels and the fixed service

WP 4A received a study (Document 4A/315) that addresses how the short and long-term protection requirements of the FS can be met by determining a minimum distance from the low-water mark as officially recognized by the coastal State beyond which maritime ESIMS cannot operate without the prior agreement of any administration (the “protection distance”). The study demonstrated that the maximum distance is driven by the short-term protection criteria of the FS station. The methodology in Recommendation ITU-R SF.1650-1 was used in this study for the determination of short-term protection distances. In this study the required distance to protect the FS is 190 km from the low-water mark as officially recognized by the coastal State. The detailed study is provided is Annex 1.

### 6.1.2 Compatibility studies between earth stations on aircraft and the fixed service

Working Party 4A received two studies (Documents 4A**/**287 and 4A/337) protection of FS from earth stations on aircraft, which are provided in Annex 2 to this document.

**Study 1** from Document 4A/287 employed a static methodology to derive an aero pfd mask to protect the FS. During the discussion the following questions were raised: how does the analysis take into account that interference from ESIM is time varying; whether it is appropriate to apply the -10 dB short term criteria 100% of the time; whether the analysis took into account the 4 dB feeder loss for the 50.9 dBi gain FS station; it was noted that further analysis is needed using other FS station antenna gains and there is a need to demonstrate that the short and long term protection criteria for FS stations is met using the proposed mask.

**Study 2** from Document 4A/337 used the Visualyse software to calculate the cumulative distribution function for the interference levels from aero e/s operating at 10 km to FS stations when meeting an assumed pfd mask. The results could determine if the short-term and long-term permissible interference levels are met. Further analysis is needed on the pfd mask and for aero e/s operating at different altitudes.

## 6.2 Sharing and compatibility between Earth stations on aircraft and vessels and current and planned mobile service stations

Working Party 5A sent WP 4A a reply liaison statement, Document [4A/41](https://www.itu.int/md/R19-WP4A-C-0041/en), informing WP 4A about Recommendation [ITU-R M.1824-1](https://www.itu.int/rec/R-REC-M.1824/en) “System characteristics of television outside broadcast, electronic news gathering and electronic field production in the mobile service for use in sharing studies” which addresses some mobile service characteristics in the frequency range 12.75‑13.25 GHz. The technical characteristics of broadcast auxiliary services (BAS) video link systems in the mobile service are summarized in Table 1 of Recommendation ITU‑R M.1824-1 and are reproduced below.

Parameters of BAS video link systems operated in the mobile service   
from Table 1 of Recommendation ITU-R M.1824-1

| Frequency allocation(1) | 10.25-10.45 GHz (R1, R3, 5.480)  10.55-10.68 GHz (R1, R2, R3)  12.95-13.25 GHz (R1, R2, R3) | | Note | |
| --- | --- | --- | --- | --- |
| Antenna type and gain | Parabolic (22-35 dBi) Helix (10-13 dBi) | | H, V or circular polarization | |
| Horn (5-20 dBi) | | Circular polarization | |
| Horn (15-20 dBi) Non-directional  (2 dBi) | | H and V polarization | |
| Tracking method | Automatic or Manual | | |  |
| Modulation | QPSK-OFDM 16-QAM-OFDM 32-QAM-OFDM 64-QAM-OFDM | | 16-QAM-OFDM is normally adopted | |
| FM | |  | |
| Maximum capacity (Mbit/s) | 30 | 60 |  | |
| Channel spacing (MHz) | 9 | 18 | For the digital system | |
| N/A | 18 | For the FM system | |

| Frequency allocation(1) | 10.25-10.45 GHz (R1, R3, 5.480)  10.55-10.68 GHz (R1, R2, R3)  12.95-13.25 GHz (R1, R2, R3) | | | | Note | |
| --- | --- | --- | --- | --- | --- | --- |
| Feeder/ multiplexer loss (typical) (dB) | 1 | | 1 | | For both transmitter and receiver | |
| Maximum antenna input power (dBW) | 4\* | | 7\*\* | | \*–6 dBW in 10.60‑10.68 GHz by the transmitter power.  \*\* –3 dBW in 10.60‑10.68 GHz by the transmitter power.  \*\*\* 1 240-1 300 MHz  \*\*\*\* 2 330-2 370 MHz | |
| e.i.r.p. (maximum) (dBW) | 38\* | | 41\*\* | | \* 29 dBW in 10.60‑10.68 GHz.  \*\* 32 dBW in 10.60‑10.68 GHz.  \*\*\* 1 240-1 300 MHz  \*\*\*\* 2 330-2 370 MHz | |
| Receiver IF bandwidth (MHz) | 9 | | 18 | |  | |
| Receiver noise figure (dB) | 4 | | 4 | |  | |
| Receiver thermal noise (dBW) | –130.5 | | –127.4 | |  | |
| Normal Rx input level (dBW) | –88 | | –85 | | 64-QAM(3/4)  \*\* 16-QAM-MIMO  \*\*\* 16-QAM(2/3) | |
| Rx input level for 1 × 10–3 BER (dBW) | - –120 - –113 –110.7 –108.2 | | - –116.9 - –109.9 –107.6 –105.1 | | BPSK-OFDM QPSK-OFDM 8PSK-OFDM 16-QAM-OFDM 32-QAM-OFDM 64-QAM-OFDM \*Rx input level for 1 × 10–4 BER | |
| Rx input level for CNR = 27 (dBW) | N/A | –100.4 | | For FM system | |
| Nominal long term interference (dBW) | –140.5 | –137.4 | |  | |
| Spectral density (dB(W/MHz)) | –150.0 | –150.0 | |  | |
| (1) Each table contains the letters “R1”, “R2” and “R3”, “r1”, “r2”, “r3”, and the reference to footnote 5.xxx. The letters “R1”, “R2” and “R3” stand for the ITU-R Region which has a primary mobile allocation to the specified frequency band, the letters “r1”, “r2” and “r3” stand for the ITU-R Region which has a secondary mobile allocation to the specified frequency band, and the reference to footnote 5.xxx refers to the country footnote in the Table of Frequency Allocations. | | | | | |

## 6.3 Sharing and compatibility between earth stations on aircraft and vessels and current and planned aeronautical radionavigation systems in the frequency band 13.25-13.40 GHz

*From Document 4A/323*

*[Editor’s note: The July WP 4A meeting sent the study from WP 4A/323 to WP 5B for their review and input]*

Working Party 5B sent WP 4A a reply liaison statement, Document [4A/37](https://www.itu.int/md/R19-WP4A-C-0037/en), informing WP 4A about Recommendation [ITU-R M.2008-1](https://www.itu.int/rec/R-REC-M.2008-1-201402-I/en) “Characteristics and protection criteria for radars operating in the aeronautical radionavigation service in the frequency band 13.25‑13.40 GHz” which contains the technical parameters of aeronautical radionavigation service (ARNS) radars operating in the frequency band 13.25-13.4 GHz on a worldwide primary basis. The different types of radars are reflected in Table 1 of Recommendation ITU-R M.2008-1 and shown in Table 6.2-1 below, which presents the technical parameters of representative ARNS radars operating in this frequency band. These technical parameters were used in analysing the compatibility between radars operating in the ARNS and earth stations on aircraft in the adjacent band. All systems are operated worldwide aboard aircraft. The radars are used for aircraft on-board navigation systems for accurate navigation in all weather conditions with the antenna placement at the bottom of aircraft fuselage.

WP 5B also informed WP 4A that Recommendation [ITU-R M.1461-2](https://www.itu.int/rec/R-REC-M.1461-2-201801-I/en)“Procedures for determining the potential for interference between radars operating in the radiodetermination service and systems in other services” can be used in relevant cases.

TABLE 6.3-1

Technical parameters of ARNS radars in the 13.25-13.4 GHz band  
(Source: Table 1 of of Recommendation ITU-R M.2008-1)

| Parameter | | Units | Radar 1 | Radar 2 | Radar 3 | Radar 4 | Radar 5 | Radar 6 | Radar 7 | Radar 8 |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Platform | |  | Aircraft (helicopter) | Aircraft (helicopter) | Aircraft (airplane) | Aircraft (airplane) | Aircraft (helicopter) | Aircraft (airplane) | Aircraft (airplane) | Aircraft (helicopter) |
| Platform maximum operational altitude | | m | 3 600 | 3 660 | 10 400 | 15 000 | 0-4 500 | 15 000 | 15 000 | 3 500 |
| Radar type | |  | Doppler navigation radar | Doppler navigation radar | Doppler navigation radar | Doppler navigation radar | Doppler radar velocity sensor | Doppler radar velocity sensor | Doppler navigation radar | Doppler navigation radar |
| The range of measured ground speed | | km/h | 333 | 553 | 750 | 1 047 | 250 | 1 100 | 180-1 300 | 50-399 |
| Frequency | | GHz | Fixed single channel | Fixed single channel | Fixed single channel | Fixed single channel | Fixed single channel | Fixed single channel | 13.25 to 13.40 | 13.295 to 13.355 |
| Emission type | |  | Continuous wave | Intermittent continuous wave | Frequency modulated-continuous wave | Continuous wave | Frequency modulated-continuous wave | Unmodulated pulse | Unmodulated continuous wave | Unmodulated continuous wave |
| Pulse width | | μs | Not applicable | 1-4 | Not applicable | Not available | Not applicable (FM) | 4-7 | Not applicable | Not applicable |
| Pulse rise and fall times | | ns | Not applicable | 20 | Not applicable | Not available | Not applicable (FM) | 0.2, 0.2 | Not applicable | Not applicable |
| RF emission bandwidth | −3 dB −20 dB −40 Db | kHz | Not applicable | 2 800 20 000 | 100 250 350 | Not applicable | Not available Not available 150 | 1 000 5 600 95 000 | Not available | Not available |
| Pulse repetition  frequency | | pps | Not applicable | Not available | Not applicable | Not applicable | Not applicable | 80 000 | Not applicable | Not applicable |
| Peak transmitter  power | | W | 0.85 | 0.132 | 0.18 | 1.0 | 0.050 | 40 20 Average | 0.125...10 | 0.15...10 |

TABLE 6.3-1 (*continued*)

| Parameter | Units | Radar 1 | Radar 2 | Radar 3 | Radar 4 | Radar 5 | Radar 6 | Radar 7 | Radar 8 |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Receiver IF −3 dB bandwidth | kHz | 1.4 Estimated | 1.6 Estimated | 55 000 | 2.9 Estimated | 14 | 2 500 | 15 000 | 100 000 |
| Sensitivity | dBm | −135 for 0 dB *S*/*N* | −135 | −134 for  0 dB *S*/*N* | −138 for 3 dB *S*/*N* | −130 for 3 dB *S*/*N* (V = 100 m/s)  −160 for 3 dB *S*/*N* (V = hover) | −96 for 3 dB *S*/*N* (V = 100 m/s) | −110 (acquisition mode)  −120 (tracking mode) | −144 |
| Receiver noise figure | dB | 22 (Homodyne Receiver) | 22 (Dual Conversion Homodyne Receiver) | 12 (Double Conversion Super Heterodyne Receiver) | 22 (Homodyne Receiver) | 22 (Homodyne Receiver) | 7.5 | Not available | Not available |
| Antenna type |  | Parabolic reflector | Phased array | Phased array | Phased array | Printed circuit array | Printed circuit array | Phased array | Horn-reflector |
| Antenna placement |  | Points towards Earth | Points towards Earth | Points towards Earth | Points towards Earth | Points towards Earth | Points towards Earth | Points towards Earth  (Off-nadir angle 9…11 degrees) | Points towards Earth  (Off-nadir angle 18 degrees) |
| Antenna gain | dBi | 27 | 27 | 26 | 29.5 | 26.5 | 18 | 20 | 27.8 |
| First antenna side lobe | dBi | 5.5 | Not available | 9 | 14.2 at 4 degrees | −10 | −10 | 7 | −7.2 |
| Horizontal beamwidth | degrees | 7 | 3.3 | 9 | 4.7 | 4.0 | 20 | Not available | Not available |
| Vertical beamwidth | degrees | 4.5 | 5 | 3 | 2.5 | 3.4 | 4.2 | Not available | Not available |
| Polarization |  | Linear | Not available | Not available | Linear | Linear | Linear | Not available | Not available |
| Number of beams |  | 4 | 4 | 4 | 4 | 4 | 2 | 3 or 4 | 3 |

TABLE 6.3-1 (*end*)

| Parameter | Units | Radar 1 | Radar 2 | Radar 3 | Radar 4 | Radar 5 | Radar 6 | Radar 7 | Radar 8 |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Antenna beam configuration |  | Employs Janus system. Approximate four corners of a pyramid with each 18 degrees off‑nadir | Not available | Employs Janus system. Approximate four corners of a pyramid with each 16 degrees off‑nadir and  10.5 degrees laterally | Employs Janus system | Employs Janus system. Approximate four corners of a pyramid with each 20 degrees off‑nadir | Two beams | Not available | Not available |
| Antenna scan |  | Scan is one beam at a time for each corner of the pyramid | Scan is one beam at a time for each corner of the pyramid | Scan is one beam at a time for each corner of the pyramid | Not available | Scan is one beam at a time for each corner of the pyramid | Not available | Not available | Not available |
| Protection criteria | dB | −10 | −10 | −10 | −10 | −10 | −10 | −10 | −10 |

*Notes to the Table:*

NOTE 1 – The service ceiling of helicopters is generally lower than 7 000 m above mean sea level (MSL), while the service ceiling of fixed-wing maritime patrol aircraft is approximately 15 000 m MSL.

NOTE 2 – The sensitivity calculation (assuming a minimum 3 dB *S*/*N* requirement for tracking) for a Doppler system must account for the bandwidth of the receiver’s tracker. Sensitivity calculated with respect to the wide-open receiver bandwidth will yield a relatively low figure compared with the sensitivity based on the tracker’s dynamic bandwidth. In a current-generation tracker, this bandwidth is comparable to the bandwidth of the back-scattered radar signal’s spectrum, which itself varies with the velocity of the aircraft.

NOTE 3 – The actual instantaneous pointing direction of individual antenna beams depends on the installation attitude of the airborne Doppler radar with respect to the aircraft reference axes (it is not always level), as well as the pitch and roll state of the aircraft. Helicopters flying search patterns or making abrupt acceleration/deceleration manoeuvres will often have roll and pitch values in excess of 30 degrees for short periods of time. The attitude excursions for high‑performance military helicopters are even higher.

NOTE 4 – For systems where no noise figure is available, assume a value of 12 dB for systems employing IF receivers and 22 dB for Homodyne (zero IF) receivers. Reference Fried, W. R.: Principles and Performance Analysis of Doppler Navigation Systems, IRE Trans., Vol. ANE-4, pp.176-196, December 1957.

### 6.3.1 Sharing studies between earth stations on aircraft and aeronautical radionavigation systems

Unwanted emissions resulting from operation of earth stations (e/s) on aircraft in frequency band 12.75-13.25 GHz may fall in the 13.25-13.4 GHz frequency band. Due to the narrow-band nature of the transmissions from the aircraft e/s, interference from unwanted emissions in the out-of-band domain can be mitigated using small guard bands for carriers near the 13.25 GHz edge of the transmit band. However, interference in the spurious domain is not as easy to control, and therefore this document addresses the spurious emissions in detail.

Because the e/s on aircraft will only be installed on airplane platforms, radars 3, 4, 6 and 7 of the Table 1 of ITU-R M 2008-1 were considered in this study.

In accordance to the information provided by the ITU-R WP 5B, the radionavigation radar antenna is located at the bottom of aircraft fuselage, whereas the e/s antenna is located on top of aircraft fuselage, as shown in Figure 6.3-1.

Height of the fuselage of 3.7 m was assumed in the studies, corresponding to the height of the smallest passenger aircraft for which installing an e/s antenna would be relevant (Boeing 737). With assumption of 45° angle from e/s to the radar, the distance used in the studies between antennas *d* is 5.2 m. The attenuation from aircraft fuselage *F* is assumed to be 35 dB, in accordance to Report ITU-R M.2221 “Feasibility of MSS operations in certain frequency bands” Figure 3.6-14, shown below as Figure 6.3-2. Although the measurements detailed within Report ITU-R M.2221 were made at 14.2 GHz, it is assumed that they are applicable to the 12.75-13.25 GHz band due to the proximity of the frequency ranges. It should be noted that the e/s on aircraft is installed using a metal container which leads to additional attenuation towards the radar. This attenuation has not been considered in the studies.

Figure 6.3-2

Fuselage attenuation (aircraft shielding) from Report ITU-R M.2221



Figure 6.3-1

Locations of the earth station on aircraft and radionavigation radar antenna in fuselage.

Diagram, radar chart

Description automatically generated

The characteristics of the e/ s on aircraft used in the studies were selected in accordance to e/s on aircraft currently operating in the 14-14.5 GHz band, as summarized in Table 6.3-2. The parameters are taken from Gogo LLC, Modification to Blanket License for Operation of 1000 Technically Identical Ku-Band Transmit/Receive Earth Stations Aboard Aircraft (FCC File No. SES-MOD- Call Sign E120106)[[6]](#footnote-6).

A minimum elevation angle of 20 degrees is assumed for the e/s antenna, which results in the highest antenna gain in the direction of the radar antenna i.e. leads to worst-case interference. Figure 6.3-3 shows the antenna patterns for a typical e/s on aircraft antenna operating in the 14-14.5 GHz frequency band for elevation angle of 20 degrees and skew angles (sk) which these antennas typically operate when in use. The different colours show the antenna gain for different skew angles between 0 and 35 degrees. The e/s on aircraft is expected to provide the same off-axis gain for the 13.25-13.4 GHz or the 12.75-13.25 GHz bands.

Protection criteria

Recommendation ITU-R M.2008-1 specifies the characteristics and protection criteria of radars 3, 4, 6 and 7 operating in the frequency band 13.25-13.4 GHz. For the radionavigation service considering the safety-of-life function, an increase of about 0.5 dB would constitute significant degradation. Such an increase corresponds to an (*I/N*) ratio of −10 dB. This protection criteria represent the aggregate effects of multiple interferers, when present; the allowable *I/N* ratio for an individual interferer depending on the number of interferers and their geometry.

Figure 6.3-3

A typical e/s on aircraft antenna pattern.

Chart

Description automatically generated

Table 6.3-2

Earth station on aircraft characteristics

|  |  |
| --- | --- |
| Major axis (m) | 0.662 |
| Antenna area (m2) | 0.2183 |
| Antenna effective diameter (m) | 0.53 |
| Antenna efficiency (%) | 34.8 |
| Antenna effective area (m2) | 0.076 |
| Transmit antenna gain (dBi) | 32.70 |
| Amplifier power (W) | 50.0 |
| Minimum bandwidth (kHz) | 128 |
| Feeder loss (dB) | 2.7 |
| Power into antenna (W) | 26.9 |
| e.i.r.p (dBW) | 47.0 |
| Spurious emission block-up-converter (dBc) | -60 |
| Antenna discrimination at 65° off-axis (dB) | 42.7 |

The antenna discrimination used in this study was calculated based on the sidelobe envelope of Recommendation ITU-R S.465-6, in accordance with the document “Evaluating Compliance with FCC Guidelines for Human Exposure to Radiofrequency Electromagnetic Fields”[[7]](#footnote-7). This assumption leads to a more conservative value than that resulting from the patterns of Figure 6.3-3.

Using the characteristics of the radar antennas given in Table 6.3-1, the spurious emissions limit in the radar receive IF bandwidth are calculated as follows.

From the radar receiver noise figure and receiver bandwidth, the total noise power level *N* (dBm) in the radar receive bandwidth is calculated based on Recommendation ITU-R M.1461 as

*N* = −114 dBm + 10 log *BIF* (MHz) + *NF* (1)

where:

*BIF =* receiver IF bandwidth (MHz);

*NF =* receiver noise figure (dB).

Results are shown in Table 6.3-3 for the four different radars under study.

Table 6.3-3

Calculation of the spurious emissions limit in the radar receive IF bandwidth.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  | Radar 3 | Radar 4 | Radar 6 | Radar 7 |
| Radar receiver noise figure | 12 | 22 | 7.5 | 12 |
| Receiver IF -3 dB BW (MHz) | 55 | 0.0029 | 2.5 | 15 |
| Total noise power level *N* (dBW) | −114.6 | −147.4 | −132.5 | −120.2 |
| Protection criteria *I/N* (dB) | −10.0 | −10.0 | −10.0 | −10.0 |
| Spurious emissions limit in the radar receive IF bandwidth (dBW) | −124.6 | −157.4 | −142.5 | −130.2 |

Considering the spurious emissions caused by the e/s on aircraft antenna in the near-field (or Fresnel region) of the main beam, the power density can reach a maximum before it begins to decrease with distance. The extent of the near-field *Rnf* can be described by the following equation:

*Rnf* = (2)

where:

*D* = antenna effective diameter;

λ = wavelength.

The magnitude of the on-axis (main beam) power density varies according to location in the near-field. However, the maximum value of the near-field, on-axis, power density *Snf* can be expressed by the following equation:

*Snf*= (3)

where:

η = aperture efficiency;

*P* = power fed to the antenna;

*D* = antenna diameter.

The distance to the beginning of the far field region, *Rff ,* which marks the end of the transition zone, can be calculated as:

*Rff* = (4)

where:

*D* = antenna effective diameter;

*λ =*  wavelength.

Based on equation (2) the extent of the near-field *Rnf* is 4.839 m and based on equation (4) the far field begins at 11.6 m, which encompass the distance between antennas *d* = 5.2 m assumed in this study. Therefore, the power density in the transition region *St*at the location of interest can be determined from the following equation:

(5)

where:

*Snf* = maximum power density for the near-field calculated in accordance to equation (3);

*Rnf* = extent of the near-field in accordance to equation (2);

*d* = distance to point of interest.

The specification for the spurious emission product levels for the e/s antenna Block-Up-Converter (BUC) is -60 dBc for all spurious components generated beyond 1 MHz offset from the frequency carrier. Therefore, maximum spurious product power density *Ssp* is 60 dB below maximum power density level *St* when operated at saturation.

The interference power received by the radar *ITOT* can be calculated as:

*ITOT = Ssp – ANTD – F + ABL – L + BW* (6)

where:

*Ssp* = spurious level power density at distance *d*;

*ANTD* = e/s antenna discrimination at 65° off-axis;

*F* = fuselage attenuation;

*ABL* = radar antenna back-lobe equivalent area;

*L* = Radar receive insertion loss;

*BW*= Radar receive bandwidth.

In accordance to Report ITU-R M.2221, the back-lobe gain of radar receive antenna *GBL* = -3.5 dB and the radar receive insertion loss *L* = 2.0 dB are assumed. The radar antenna back-lobe equivalent area *ABL* is calculated as

(7)

where:

*GBL* = back-lobe gain of radar receive antenna;

λ *=*  wavelength.

The minimum carrier bandwidth for e/s on aircraft, and thus the minimum bandwidth of the spurious emissions, is 128 kHz. The spurious emissions will not fill the entire bandwidth of the radar, however to illustrate the worst-case condition the calculations considered that to be the case.

Taking into account the assumptions used in this study, the resulting interference from spurious emissions and their margin to the limit of allowed emissions are shown in Table 6.3-4.

The results indicate that for the geometry studied (collocated systems interacting in the transition region as in Figure 6.3-1), there would be margins ranging from around 10 dB to 24 dB for the protection of radars 3, 4, 6 and 7 from Table 6.3-1 from unwanted emissions in the spurious domain from earth stations with the characteristics specified in Table 6.3-2.

Table 6.3-4

Emissions in the spurious domain into radar bandwidth and margins wrt to the radar protection criterion.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  | Radar 3 | Radar 4 | Radar 6 | Radar 7 |
| Spurious emissions limit in the radar receive IF bandwidth (dBW) | –124.6 | –157.4 | –142.5 | –130.2 |
| Spurious emissions caused by e/s on aircraft into radar receive bandwidth (dBW) | –138.8 | –181.5 | –152.2 | –144.4 |
| Margin (dB) | 14.2 | 24.2 | 9.7 | 14.2 |

### 6.3.2 Sharing studies between earth stations on vessels and aeronautical radionavigation systems

From the perspective of aeronautical radionavigation systems, transmissions from earth station on vessels would not lead to more interference than transmissions from fixed FSS earth stations, which are operating within the frequency band 12.75-13.25 GHz in accordance to Appendix 30B. It is therefore not expected that sharing studies would be required between earth stations on vessels and aeronautical radionavigation systems.

## 6.4 Compatibility and protection of FSS, including Appendix 30B allotment and frequency assignments

Editor’s note: Studies to identify technical and regulatory conditions for the protection of FSS, including information related to a) the existing AP**30B** Plan allotments and List assignments as well as those under processing in application of Articles 6 and 7 of Appendix **30B** b) the existing frequency assignments of FSS non-geostationary satellite systems; will be analysed and summarized in this section.

A RR Appendix 30B allotment and frequency assignments

[TBD]

B Non-geostationary FSS satellite systems

Recognizing c of Resolution **172 (WRC-19)** states that the current usage and future development of the allocated services in the frequency band 12.75-13.25 GHz (Earth-to-space) shall be protected without imposing additional constraints on them. This includes non-geostationary-satellite systems, which are using the frequency band 12.75-13.25 GHz under the primary FSS allocation, in accordance with RR No. **5.441**.

Provisions **22.26** – **22.28** of the Radio Regulations, specify limits for the e.i.r.p. emitted by an earth station of a GSO satellite network, operating in the 12.75-13.25 GHz band, for any off-axis angle which is 3° or more off the main-lobe axis of a GSO earth station antenna, thereby limiting emissions from GSO earth stations which could impact satellites in non-GSO satellite systems. These provisions would also apply to earth stations on aircraft and vessels which would limit the e.i.r.p. levels transmitted towards non-GSO satellite systems.

Initial technical studies were performed in Document WP4A/365 demonstrating that additional measures are required beyond the existing provisions of the Radio Regulations. Further studies based on the technical and regulatory information relating to sharing with non-GSO FSS systems are necessary to define the measures to protect non-geostationary-satellite systems considering the change to the interference environment resulting from the introduction of earth stations on aircraft and vessels in the 12.75-13.25 GHz band.

Though there are existing limits in the Radio Regulations intended on limiting interference which maybe caused as a result of off-axis emissions from earth stations, those limits in RR No. **22.26** are specifically designed to protect other GSO networks. Rec. ITU-R S.524-9 similarly contains off-axis e.i.r.p. density limits for ES operating in GSO networks that are 3 dB lower than RR No. **22.26**, but only within 3° of the GSO plane. This 3 dB improvement is of little benefit to receiving non-GSO satellites over that of RR No. **22.26** as such satellites are likely to implement avoidance of the GSO orbit anyway. Outside of a +/-3° band around the GSO arc, the limits are those of No. **22.26**. For comparison purposes, the limits from Res. **902** **(WRC-03)** (used for ESVs in the 14-14.5 GHz band) are shown. These limits, 9 dB lower than those in RR No. **22.26**, are only specified only within 3° of the GSO arc. Incidentally, these limits for VSATs in the 14 GHz band are identical to those in Res. 902 **(WRC-03)**.

The study presented a simple interference assessment from earth station on aircraft and vessels transmitters into the non-GSO FSS system “L5” which operates in the Ku-band and Ka-band and will use the band 12.75 13.25 GHz for service links from small user terminals. The non-GSO system analyzed, implementing orbital avoidance ensures no mainbeam-to-mainbeam coupling. The study assessed 3 possible modes of interference:

• Case 1 – GSO ES mainbeam to Rx Sat far sidelobes

• Case 2 – GSO ES sidelobes (@ min avoidance angle) into Rx Sat mainbeam

• Case 3 – GSO ES sidelobes (@ min avoidance angle) into Rx Sat far sidelobes

The study used the parameters in Table 1 of § 4 for the maritime/aero terminals. Additionally, it was noted that there was no carrier bandwidth associated with either terminal.

{Editor’s note: The lack of carrier bandwidths and earth station antenna patterns will need to be addressed in a future update to the working document.}

In the technical study, off-axis e.i.r.p. densities were derived from the maximum pfd levels contained in Annex 3 of RR AP**30B**. Equivalently, the -133 dB(W/(m² · MHz)) pfd results in an e.i.r.p. density of 26.9 dBW/MHz at 8.4° off-axis. From this off-axis eirp density, on-axis e.i.r.p. densities are derived for various terminal sizes in Table [3]. This derived off-axis e.i.r.p. density level for compliance with Annex 3 is also compared with levels similarly extrapolated from RR No. **22.26** and Res. **902 (WRC-03)**. In some cases, the levels permitted by RR No. **22.6** were noted to exceed what the terminal is capable of producing by > 20 dB.

TABLE [3]

Earth station on aircraft and vessels EIRP Density (dBW/MHz)

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **Earth station on aircraft and  vessels bandwidth**  **(MHz)**  **Parameter** | | **3.5 MHz** | **5 MHz** | **10 MHz** | **20 MHz** | **40 MHz** |
| Ant size (m) |  | 0.6 | .24 by .07 | .45 | 1.0 | 2.4 |
| Gain (dBi) |  | 36.5 | 32.0 | 34.0 | 41.0 | 49.0 |
| Tx Power(W) |  | 63 | 8 | 20 | 125 | 63 |
| e.i.r.p. (dBW) |  | 54.5 | 41.0 | 47.0 | 62.0 | 67.0 |
| e.i.r.p. density(1) (dBW/MHz) | On-axis | 49.0 | 34.0 | 37.0 | 49.0 | 51.0 |
| θ=8.4° | 18.4 | 7.9 | 8.9 | 13.9 | 7.9 |
| θ=48° | 2.6 | -8.0 | -7.0 | -2.0 | -8.0 |
| Annex 3 AP**30B** | θ=8.4° | 26.9 | | | | |
| RR No **22.26** (dBW/MHz) | θ=8.4° | 35.0 | | | | |
| Resolution **902 (WRC-03)** and Recommendation ITU-R S.728-1 (dBW/MHz) | θ=8.4° | 26.0 | | | | |

Table [4] calculates the *I/N* at the Rx non-GSO satellite for Case 1. In 3 of the 5 terminal/bandwidth combinations, the *I/N* > 0 dB. At the same time, it is noted that a dynamic study would be required to determine the probability of occurrence of such an event.

TABLE [4]

Non-GSO FSS Satellite *I/N* for Case 1 - various earth station on aircraft and vessels operations

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **Carrier bandwidth**  **(MHz)**  **Parameter** | | 3.5 MHz | 5 MHz | 10 MHz | 20 MHz | 40 MHz |
| e.i.r.p. density | dBW/MHz | 49.0 | 34.0 | 37.0 | 49.0 | 51.0 |
| *I/N* ratio (dB) | On-axis | 9.4 | -5.6 | -2.6 | 9.4 | 11.4 |

Table [5] calculates the *I/N* at the Rx non-GSO satellite for Case 2. In 2 of the 5 terminal/bandwidth combinations, the *I/N* > 0 dB. In the case of a terminal operating in compliance with RR No. **22.26**, the *I/N* received at the satellite from a terminal interfering into an non-GSO Rx Sat at 8.4° away could exceed 25 dB.

TABLE [5]

Non-GSO FSS Satellite *I/N* (dB) for various earth station on aircraft and vessels operations

| **Carrier bandwidth**  **(MHz)**  **Parameter** | | 3.5 MHz | 5 MHz | 10 MHz | 20 MHz | 40 MHz |
| --- | --- | --- | --- | --- | --- | --- |
| e.i.r.p. density | dBW/MHz | 49.0 | 34.0 | 37.0 | 49.0 | 51.0 |
| Baseline ES on aircraft and vessels | On-axis | 9.4 | -5.6 | -2.6 | 9.4 | 11.4 |
| θ=8.4° | 8.8 | -1.7 | -0.7 | 4.3 | -1.7 |
| θ > 48° (far sidelobe) | -7.0 | -17.6 | -16.6 | -11.6 | -17.6 |
| Annex 3 **AP30B** | θ=8.4° | 17.3 | | | | |
| RR No **22.26** andRec.S.524-9(outside 3° of GSO arc) | θ = 8.4° | 25.4 | | | | |
| θ > 48° (far sidelobe) | 7.4 | | | | |
| Res. **902 (WRC-03)** and Rec. S.728-1 (outside 3° of GSO arc) | θ = 8.4° | 16.4 | | | | |
| θ > 48° (far sidelobe) | -1.6 | | | | |

It is noted, that in some scenarios examined, given the possible ranges on *I/N* calculated in the study and the potential implications for non-GSO operation for various GSO off-axis e.i.r.p. density scenarios (e.g., RR No. **22.26** vs Res. **902 (WRC-03)**), that the outage causing high levels of interference would not be a transient event but a persistent level. It notes that further studies using a dynamic model would provide additional insights into the levels/probabilities of such levels that could be expected. Additional, compatibility studies, based on statistical analysis using more representative antenna patterns for the earth stations on Aircraft and Vessels are required to implement appropriate regulatory solutions to protect non-GSO FSS satellites. Based on such future studies, appropriate sharing conditions can be developed.

## 6.5 Sharing and compatibility between Earth stations on aircraft and vessels and Earth Exploration Satellite and Space Research Services in the frequency band 13.25-13.4 GHz

WP 7C, in response to a request from WP 4A to provide relevant information for studies under WRC-23 AI 1.15 for Earth exploration-satellite service (EESS) (active) in the frequency band 13.25-13.75 GHz, indicated in an a RLS (Document 4A/260) that the following Recommendations and Report should be used:

– Recommendation [ITU-R RS.2105](https://www.itu.int/rec/R-REC-RS.2105/en) – *Typical technical and operational characteristics of Earth exploration-satellite service (active) systems using allocations between 432 MHz and 238 GHz.* This ITU-R Recommendation is currently under review within WP 7C, WP 4A is invited to use in their studies the version which can be found in Annex 1 to Document [7C/186](https://www.itu.int/md/R19-WP7C-C-0186/en);

– Recommendation [ITU-R RS.1166](https://www.itu.int/rec/R-REC-RS.1166/en) – *Performance and interference criteria for active spaceborne sensors* in the EESS (active) allocations between 432 MHz and 238 GHz. This ITU-R Recommendation is currently under review within WP 7C, WP 4A is invited to use in their studies the version which can be found in Annex 2 to Document [7C/186](https://www.itu.int/md/R19-WP7C-C-0186/en);

– [Recommendation ITU-R RS.577](https://www.itu.int/rec/R-REC-RS.577/en) – *Frequency bands and required bandwidths used for spaceborne active sensors operating in the Earth exploration-satellite (active) and space research (active) services*;

– Report [ITU-R RS.2068](https://www.itu.int/pub/R-REP-RS.2068) – *Current and future use of the band 13.25-13.75 GHz by spaceborne active sensors.* This ITU-R Report is currently under revision within WP 7C, WP 4A is invited to use in their studies the version which can be found in Annex 13 to Document [7C/186.](https://www.itu.int/md/R19-WP7C-C-0186/en)

## 6.6 Additional study on the issue of operation of earth station on board aircraft and vessels in international skies/waters

To be updated based on further discussions

For earth station on board aircraft and vessel on international airspace and waters (outside the jurisdictional areas of national administrations), specific measure(s) need to be developed to ensure that earth station on board aircraft and vessel on international airspace/waters will not impact RR Appendix **30B** allotments and assignments. One possible approach is the use of a pfd limit as function of orbital separation of host networks[[8]](#footnote-8). Similar approach could be used to cater for coordination among earth stations on board aircraft and vessels operating over international skies/waters with different satellite networks.

Elements for consideration of agenda item 1.15 under the work plan

Working Party (WP) 4A recognizes that agenda item 1.15 is very complex and requires careful consideration on both regulatory/procedural and technical matters.

“Agenda item 1.15: to harmonize the use of the frequency band 12.75-13.25 GHz (Earth-to-space) by earth stations on aircraft and vessels communicating with geostationary space stations in the fixed-satellite service globally, in accordance with Resolution **172 (WRC-19)**.”

WP 4A noted that there is an inconsistency between the title of the agenda item and the title of the associated Resolution **172 (WRC-19)**, “Operation of earth stations on aircraft and vessels communicating with geostationary space stations in the fixed-satellite service in the frequency band 12.75-13.25 GHz (Earth-to-space)”. The title of the Resolution is more reflective of the studies that should be used to guide the work under the resolves of this agenda item.

Following aspects need to be taken into account:

1. carefully consider Resolution **172 (WRC-19)** in order to identify and group all of the areas/elements that are necessary for the studies. Examples are the methodology, criteria, etc., as included in various parts of the Resolution, in particular the preamble, and the means to address these issues;

2 prepare a skeleton for the corresponding draft WRC-23 Resolution (draft Resolution **AI1.15 (WRC-23)**), and use to the extent practicable, the structure of Resolutions on Agenda Item 1.5 as agreed at CPM-19-2 and WRC-19 Resolution **169 (WRC-19)**, by creating separate sections for applicable existing services: Protection of Space Services; Terrestrial Services; and provisions of general nature. Strive to minimize the number of items in the preamble and minimize number of resolves to respond to the various items of the preamble, as appropriate;

3 to the extent possible / practicable relevant provisions contained in Resolution **169 (WRC-19)** and Resolution **155 (Rev.WRC-19)** should be considered with a view to review the results of studies already carried out and adopted by WRC-19;

4 to review the Rules of Procedure established for all provisions referred to in Resolution **172 (WRC-19)** especially those that apply to Appendix **30B**;

5 to review and take into account allotments, List of assignments recorded in the AP**30B** List as well as those in the MIFR; the assignments submitted under Articles 6 and 7 of RR Appendix **30B** not yet processed or recorded in the AP**30B** List. To request information on these assignments from the BR as necessary;

6 to use the latest information regarding technical characteristics, operational parameters and protection criteria of assignments of services to which the frequency band under consideration is allocated taking into account stations recorded in the MIFR, including those under processing by the Bureau, those provided to the WP in response to Administrative Circular [CACE/955](https://www.itu.int/md/R00-CACE-CIR-0955/en), and liaison statements from the contributing WPs under this agenda item;

7 to review all WP 4A contributions submitted under this agenda item; and include the substance in a document referred to as this stage as “Elements of documents relating to WRC-23 agenda item 1.15. The skeleton of this “Element Document” could have a similar outline to Report ITU-R S.2464 with subsections including introduction, objective, background, system description/diagram of forward and return links, control station, general principles for sharing and compatibility analysis for space service and terrestrial services with subdivisions for GSO, non-GSO, AP**30B** allotments, assignments in List, assignments submitted under Articles 6 and 7 and not yet processed or under processing for subsequent recording in the List;

8 take account of Resolution **170 (WRC-19)**;

9 to review how AP**30B** Plan and List were protected from feeder link to non-GSO in C‑band uplink and verify whether similar approach could be used to protect Ku-band uplink of RR Appendix **30B**;

10 consider adjacent band compatibility and sharing, as appropriate;

11 to study and suggest workable approaches that fully protects RR Appendix **30B** (existing allotment, assignments and planned development) including the objectives of Resolution **170 (WRC-19)**;

12 the result of allowing the operation of aeronautical and maritime earth station should not modify the reference situation of the allotment and assignments beyond the level that which would occur without such operations;

13 start to initiate draft of the CPM Report to which the draft Resolution **AI1.15 (WRC-23)** would be attached.

Annex 1

Technical Studies on the compatibility between earth stations on vessel and FS systems (Source: Doc. 4A/315)

# 1 Technical characteristics

## 1.1 Technical and operational characteristics of fixed systems operating in the frequency band 12.75-13.25 GHz

Working Party (WP) 5C has provided to WP4A information on FS stations in the 12.75-13.25 GHz band.

Recommendation ITU-R F.758-7 provides a long-term protection criterion, *I/N* of –10 dB not to be exceeded more than 20% of the time. This criterion, as mentioned in Recommendation ITU-R F.758-7, is an aggregate criterion (see Table 5 in Annex 2 of this Recommendation).

For the present analysis, the short-term criterion for the 14-14.5 GHz band used in Recommendation ITU-R SF.1650 (*I/N* of +19 dB not to be exceeded for more than 2.7 × 10-4% of the time), was used.

Table 1 depicts the FS protection criteria assumed for the 12.75-13.25 GHz band in this study.

Table 1

**Fixed service permissible interference power in 12.75-13.25 GHz band**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Permissible *I/N*** | **Permissible interference power (dB(W/MHz))** | **Reference** | **Comments** | **Type** |
| 19 dB | −139 + *I*/*N* | ITU-R SF.1650-1 | Not to be exceeded for more than 2.7 × 10-4% of the time | Short term |
| −10 dB | −139 + *I*/*N* | ITU-R F.758-7 | Not to be exceeded for more than 20% of the time | Long term |

**2 Technical analysis**

The following sections address how the short and long-term protection requirements of the Fixed Service can be met by determining a minimum distance from the low-water mark as officially recognized by the coastal State beyond which maritime ESIMS cannot operate without the prior agreement of any administration (the “protection distance”).

**2.1 Short term interference**

**2.1.1 Methodology**

The methodology used in this study for the determination of short-term protection distances is that described in Recommendation ITU-R SF.1650-1.

Because 90% of the maritime ESIMS operate with up to 8W power, the methodology was used to calculate protection distances assuming this power level and the same elevation angle used for the 14 GHz calculations (i.e. 10°), and three types of Fixed Service receiver antennas: the 29 dBi antenna used for QPSK (smallest gain overall), the 48 dBi antenna also used for QPSK (highest gain for 0 dB feed loss) and the 50.9 dBi antenna used for 512-QAM (highest gain overall with  
 4 dB feed loss).

The short-term protection distances derived for the three FSR antenna types, for the 8W, 10° elevation angle maritime ESVS, turn out to be as follows:

|  |  |
| --- | --- |
| FSR antenna gain  (dBi) | Protection distance  (km) |
| 29 | 97 |
| 48 | 190 |
| 50.9 | 172 |

**2.1.2 Description of the analysis**

In Table 2 of Recommendation ITU-R SF.1650-1, the short-term protection requirement in the band 14.0-14.5 GHz calls for a specified power level, measured at the input of the receiver of a fixed-service terminal (FSR) facing out to sea, not to be exceeded for more than 2.7 × 10-4% of the time (*pS* expressed in %).

Using this short-term protection criterion, the applicable power density level not to be exceeded at the input of the FSR receiver for that percentage of time is −120 dB(W/MHz), corresponding to a total power (*IFSR*) in the smallest FSR receiver bandwidth given in Tables 1 and 2 (3.5 MHz) of −114.56 dBW.

The maximum interference power not to be exceeded for more than *pS*% of the time at any FSR receiver is given by the following expression:

*IFSR* = *Pt* + *Gt* + *Gr,AVE* – *F* – *Lb*,*min*(*pS*) (dBW)

where:

is the transmit power measured in the FSR receive bandwidth at the ESIM antenna flange, in dBW;

is the ESIM antenna gain in the direction of the FSR (dBi);

is the average antenna gain of the FSR in a 10 dB beamwidth (dBi);

is the loss in the feed from the FSR antenna to the low-noise amplifier (dB); and

is the minimum required basic transmission loss (dB).

The required (*pS*) is then equal to:

*Lb,min*(*pS*) = *Pt* + *Gt* + *Gr,AVE* – *F* – *IFSR* (dBW)

Recognising that there is likely to be an ESV within that beamwidth for only a relatively small proportion of the time (*pESV* \* 100%), and that this proportion depends on such parameters as the speed of the ESV (*vESV*) and its distance (*d*) from shore when it sails across the beam, Recommendation ITU-R SF.1650-1 describes an iterative process to determine the *propagation model input parameter, p, which is the time percentage for which the required minimum transmission loss is not exceeded (e.g. in Recommendation ITU-R P.452*).

The value of *p* depends on the input parameters to the iterative process and thus varies from case to case, but it will be considerably greater than 2.7 x 10-4 % since there will not be an ESIM within visibility of the FS receive antenna all the time.

*p = pS/pESV*

The relationship found in Recommendation ITU-R SF.1650-1 between the yearly number of passes of the ESVs transmitting within the FSR receiver channel bandwidth (*fESV*) and the product of the required separation distance (*d*) and the time percentage (*p*) associated with the propagation loss is the following:

*fESV* =

where θ*FSR*,-10 dB is the -10 dB beamwidth of the FSR receive antenna.

As indicated in Report ITU-R S.2363, the aggregate interference from ESVs toward the FSR was implicitly assumed at WRC-03 to be equivalent to that of about 11.2 ESV passes per year, all operating at maximum power with a 10° elevation angle, azimuth toward the FSR, and 100% duty cycle.

### 2.1.3 Calculation of protection distances

According to Recommendation ITU-R F.1245-3, for the minimum receive antenna gain provided by WP 5C, i.e., 29 dBi, the values of *Gr,AVE* and θ*FSR*,-10 dB are, respectively, 26.5 dBi and 10.9°.

For these assumptions, the product *p\*d* in the above expression for *fESV* is 20.25.

Assuming further that:

a) the maximum power delivered to the ESV antenna is spread over the minimum FSR receive bandwidth of 3.5 MHz,

b) the ESV transmit antenna sidelobe gain conforms to Rec. ITU-R S.580,

c) *F* = 0 dB,

*Lb,min (pS)* = 10\*log(8) + 29 – 25\*log(10) + 26.5 + 114.56, or

*Lb,min (pS)* = 154.1 dB

Using the methodology of Recommendation ITU-R SF.1650-1, the required path loss exceeded for no more than *p*% of the time and subject to the constraint *p\*d* = 20.25 is 97 km.

For the maximum receive antenna gain provided in Document 5C/TEMP/85 for the QPSK transmissions, i.e., 48 dBi, the values of *Gr,AVE* and θ*FSR*,-10 dB are, respectively, 45.5 dBi and 1.2°.

Under the same assumptions used for the 29 dBi antenna, the product *p\*d* is 184.51 and

*Lb,min (pS)* = 10\*log(8) + 29 – 25\*log(10) + 45.5 + 114.56, or

*Lb,min (pS)* = 173.1 dB

Using the methodology of Recommendation ITU-R SF.1650-1, the required path loss exceeded for no more than *p*% of the time and subject to the constraint *p\*d* = 184.51 is 190 km.

Finally, for the maximum receive antenna gain provided in 5C/TEMP/85-E for the 512-QAM transmissions, i.e., 50.9 dBi, the values of Gr,AVE and θ*FSR*,-10 dB are, respectively, 48.4 dBi and 0.88°. For this case, however, *F* = 4 dB.

Under the same assumptions used for the 29 dBi antenna, the product *p\*d* is 251.61 and

*Lb,min (pS)* = 10\*log(8) + 29 – 25\*log(10) + 48.4 - 4 + 114.56, or

*Lb,min (pS)* = 172.0 dB

Using the methodology of Recommendation ITU-R SF.1650-1, the required path loss exceeded for no more than *p*% of the time and subject to the constraint *p\*d* = 251.61 is 172 km.

## 2.2 Long term interference

### 2.2.1 Methodology

The methodology used in this study for the determination of long-term protection distances is that described in Recommendation ITU-R F.1108, which was used for the determination of similar distances for the adjacent 14 GHz frequency band in Report ITU-R S.2363.

This Report demonstrates, for the 14 GHz frequency band, that the distances required for long-term protection of the FS are shorter than those required for short-term protection, i.e. the required distances are driven by meeting the short-term protection criteria. This is shown to be the case for the 13 GHz frequency band as well, even if we assume 22W and 5° elevation angle for the maritime e/s.

The long-term protection distances derived for the same three FSR antenna types assumed in Section 2.1 are as follows:

|  |  |
| --- | --- |
| FSR Antenna Gain (dBi) | Protection Distance (km) |
| 29 | 77 |
| 48 | 86 |
| 50.9 | 85 |

### 2.2.2 Description of the analysis

The analysis assumes that the maximum power into the ESIM antenna given in Table 4 (i.e., 22 W) is contained entirely within the smallest fixed service terminal receiver noise bandwidth (i.e., 3.5 MHz). For a minimum operating angle of 5° assumed for the ESIM transmit antenna, the off-axis antenna gain is 11.5 dBi, resulting in a maximum e.i.r.p. spectral density toward the horizon of 19.5 dB(W/MHz).

For the 12.75-13.25 GHz frequency band, multipath fading is the primary cause of performance degradations and, consequently, the “fractional degradation in performance” (FDP) as developed in Recommendation ITU-R F.1108 (“Determination of the criteria to protect fixed service receivers from the emissions of space stations operating in non-geostationary orbits in shared frequency bands”) for a similar type of intermittent interference provides a simple means of determining acceptable levels of interference.

FDP is the ratio of the time-average value of the interference power (W/MHz) under nominal propagation conditions on the ESV to FSR path to the receiving system noise power *NFSR* (W/MHz) where both are measured at the receiver input.

From the data provided by WAP 5C, the FS receiver noise power density, *NRX*, is -139 dB(W/MHz).

Long term interference is considered acceptable (see Recommendation ITU-R F.758) if:

or 10 %, for at least 80% of the time,

where:

*IAV* is the average interference power within the FSR bandwidth, and

*NFSR* is the total noise power in the receive bandwidth of the FSR.

This is equivalent in dB to:

dB for at least 80% of the time.

Re-writing equation (2) of Recommendation ITU-R SF. 1650-1, the interference power at the fixed service receiver (*IFSR*) due to an ESIM under long term propagation conditions during a pass through the FSR antenna is:

dBW

where:

is the transmit power measured in the FSR receive bandwidth at the ESIM antenna flange, in dBW;

is the ESIM antenna gain in the direction of the FSR (dBi);

is the average antenna gain of the FSR in a 10 dB beamwidth (dBi);

is the loss in the feed from the FSR antenna to the low-noise amplifier (dB); and

is the propagation loss on the ESIM to FS path that is exceeded for all but 20% of the time as calculated with Recommendation ITU-R P.452 (dB).

Hence, the average interference power in *W* over a year is given by:

W

where *pESIMR* is the probability (in number) that the ESIM will be within the FSR 10 dB beamwidth.

can also be expressed in dBW as follows:

dBW

According to Table 2 of Recommendation ITU-R SF.1650-1, in number can be expressed as a function of the distance between the ESV and the FSR and of the frequency of passes as follows:

where:

*d* is the distance between the ESIM and the FSR in km,

θ*FSR*, -10 dB is the −10 dB beamwidth of the FSR receive antenna,

*fESIM* is the number of passes per year of an ESIM through the receive beam of the FSR receive antenna and transmitting within the FSR receiver channel bandwidth,

8 760 is the number of hours in a year, and

18.3 is the speed of the vessel in km/h.

Consequently, for each value of *fESIM*, the following relationship can be established between *d* and the required value of :

### 2.2.3 Calculation of protection distances

According to Recommendation ITU-R F.1245-3, for the minimum receive antenna gain provided in Table 2, i.e., 29 dBi, the values of *Gr,AVE* and θ*FSR*,-10 dB are, respectively, 26.5 dBi and 10.9°.

Assuming that the yearly number of ESV passes is the same as that used for the derivation of the short-term protection distances for the 14-14.5 GHz frequency band, the last term of the above expression can be calculated for the 29 dBi FSR receive terminal to be equal to -48.75 dB.

By making:

can be re-written as:

dB

Assuming further:

a) that the maximum power delivered to the ESV antenna is 22W, or 13.4 dBW, assumed to be spread over the minimum FSR receive bandwidth of 3.5 MHz,

b) that the ESV transmit antenna sidelobe gain conforms to Rec. ITU-R S.580,

c) that the minimum elevation angle is 5°, corresponding to an antenna off-axis gain of 11.5 dBi,

d) that *F* = 0 dB,

*Lb* = 13.4 + 11.5 + 26.5 + 139 – 10 \* log (3.5) + 10 – 48.75 dB, or

*Lb* = 146.2 dB

The distance *d* is then determined for so that the associated required path loss is exceeded for no more than 20% of the time and subject to the constraint dB.

Using the implementation of the propagation model of Recommendation ITU-R P.452-16 available at the ITU website, the minimum protection distance for a 45° N latitude, 0° longitude FSR antenna at 80 m above ground level is 77 km.

For the maximum receive antenna gain provided in Document 5C/TEMP/85 for the QPSK transmissions, i.e., 48 dBi, the values of *Gr,AVE* and θ*FSR*,-10 dB are, respectively, 45.5 dBi and 1.2°.

Based on these values and under the same assumptions, the expression

is -58.35 dB.

Consequently, the value of Lb for this antenna is

*Lb* = 13.4 + 11.5 + 45.5 + 139 – 10 \* log (3.5) + 10 – 58.35 dB, or

*Lb* = 155.6 dB

and for this case the minimum protection distance for a 45° N latitude, 0° longitude FSR antenna at 80 m above ground level is 86 km.

Finally, for the maximum receive antenna gain provided in Document 5C/TEMP/85 for the 512-QAM transmissions, i.e., 50.9 dBi, the values of Gr,AVE and θ*FSR*,-10 dB are, respectively, 48.4 dBi and 0.88°.

Based on these values and under the same assumptions, the expression

is -59.69 dB.

Consequently, the value of Lb for this antenna is

Lb = 13.4 + 11.5 + 48.4 - 4 + 139 – 10 \* log (3.5) + 10 – 59.69 dB, or

Lb = 153.17 dB

and for this case the minimum protection distance for a 45° N latitude, 0° longitude FSR antenna at 80 m above ground level is 85 km, lower than for the 48 dBi antenna because of the 4 dB feeder loss that applies in this case.

From these results, the worst-case minimum distance to protect the FS terminals assumed in this study is 86 km, associated with the highest FSR antenna gain used for QPSK transmissions.

# 3 Summary of preliminary results

The document provides analysis of distances required to meet the long-term and short-term protection criteria for FS stations. As shown, the maximum distance is driven by the short-term protection criteria of the FS station. For the cases analysed, the required distance is 190 km.

Annex 2

Technical Studies on the compatibility between earth stations   
on aircraft and FS systems

Study 1 (Source: Doc. 4A/287)

**Power flux-density level to ensure the protection of fixed service operating   
in the frequency band 12.75-13.25 GHz**

# 1 Introduction

World Radiocommunication Conference 2019 (WRC-19) adopted agenda item 1.15 that calls for studies on the possible operation of earth stations on aircraft and vessels communicating with geostationary space stations in the fixed-satellite service in the frequency band 12.75-13.25 GHz (Earth-to-space), in accordance with Resolution **172 (WRC-19)**.

To ensure the protection of FS which is allocated in the frequency band 12.75-13.25 GHz, it would be helpful to consider the study results of WRC-19 agenda item 1.5 which was to study for ESIM communicating with GSO FSS in the Ka-band because power flux-density (pfd) level as protection criteria was developed in order to protect terrestrial services from the emission of A-ESIM operating in the same frequency band. Under this agenda item 1.15 of WRC-23, the pfd limit as protection criteria for FS would be also a very effective measure to ensure the protection of FS system from the earth stations on aircraft in the frequency band 12.75-13.25 GHz.

In this contribution, the pfd level for protection of FS system from the earth stations on aircraft operating in the frequency band 12.75-13.25 GHz is proposed as protection criteria based on the FS characteristics submitted by ITU-R WP 5C.

# 2 FS characteristics operating in the frequency band 12.75-13.25 GHz

The last ITU-R WP 5C meeting (May 2021) developed a liaison document to WP 4A (Document [4A/265](https://www.itu.int/md/R19-WP4A-C-0265/en)) for providing the characteristics for fixed service system operating in the frequency band 12.75-13.25 GHz as follows.

Characteristics of FS stations in the 12.75-13.25 GHz frequency band

| Frequency range  (GHz) | 12.75-13.25 | |
| --- | --- | --- |
| Reference ITU‑R | F.497 | |
| Modulation | QPSK | 512-QAM |
| Channel spacing and receiver noise bandwidth (MHz) | 3.5, 7, 14, 28, 56 | 14, 28, 56 |
| Feeder/multiplexer loss range (dB) | 0…9.5 | 0…7.6 |
| Antenna gain range (dBi) | 29…48 | 30…50.9 |
| Receiver noise figure typical (dB) | 5 | 5 |
| Receiver noise power density typical (=NRX) (dB(W/MHz)) | −139 | −139 |
| Nominal long-term interference power density (dB(W/MHz)) | −139 + *I/N* | −139 + *I/N* |
| NOTE: It should be noted that the 512-QAM systems with antenna gain above 45 dBi are associated with a feeder/multiplexer loss of 4 dB in this case. | | |

Taking into account this FS characteristics, the following assumptions are considered to calculate the pfd level to protect FS system from the emission of earth stations on aircraft operating in the frequency band 12.75-13.25 GHz:

– Operational center frequency: 13 GHz

– Protection criteria: *I/N* = −10 dB (long-term)

– Antenna elevation angle of FS system: 0 degree

– Antenna pattern of FS system: Recommendation ITU-R F.699 “Reference radiation patterns for fixed wireless system antennas for use in coordination studies and interference assessment in the frequency range from 100 MHz to 86 GHz”

– Maximum antenna gain: 50.9 dBi

– Receiver noise power density: −139 dB(W/MHz).

# 3 Calculation the pfd level as protection criteria for FS

The pfd values as protection criteria for FS system is derived from the following equation (1):

(1)

where, is the angle of arrival of the radio-frequency wave (degrees above the horizon).

In order to find receiving antenna gain, , it is necessary to compute antenna pattern of FS which can be obtain from Recommendation ITU-R F.699.

For the 13 GHz frequency band, the antenna pattern of Recommendation ITU-R F.699 is calculated as follows:

(2)

where, is the off-axis angle (degree).

FIGURE 1

Antenna pattern of FS system at 13 GHz (Rec. ITU-R F.699)



Using the equation (1) and FS antenna pattern (2), the pfd level according to the angle of arrival as protection criteria of FS which shall not be exceeded from emission of earth stations on aircraft in the frequency band 12.75-13.25 GHz is:

(3)

where, is the angle of arrival of the radio-frequency wave (degrees above the horizon).

FIGURE 2

PFD for protection of FS system



Study 2 (Source: Doc. 4A/337)

A study of compatibility of aeronautical earth stations with the fixed services   
in the 12.75-13.25 GHz frequency band when the aircraft operates   
at an altitude of 10 km

# 1 Introduction

This document provides a preliminary technical study on protection of fixed services from earth stations on aircraft when the aircraft is at an altitude of 10 km and is based on technical and operational assumptions to meet a specified pfd mask on the surface of the Earth. Further analyses will be required to confirm the validity of the pfd mask as well additional analysis for aircraft operating at lower altitudes.

Earth stations (e/s) on aircraft and vessels that operate with geostationary-satellite orbit (GSO) FSS systems present operational characteristics that must be accounted for when performing sharing studies. These include the mobility of the e/s and the changing relative location of the e/s with respect to a terrestrial fixed service receiver and the range of e/s antenna pointing angle. These combined effects result in a time-varying interference at the FS receivers and hence require the use of statistical techniques for interference analysis.

There are different approaches to analyze the compatibility of aero e/s with respect to fixed service (FS) stations. In previous ITU studies, addressing the same scenario in different frequency bands, different approaches were taken with certain studies analyzing the interference of aero e/s operating with a certain GSO space stations and the others analyzing the impact to the FS if the aero e/s met a pfd mask on the ground. The preliminary studies in this document take the latter approach for aircraft operating at an altitude of 10 km.

# 2 ESIM pfd on the Earth surface used in this study

For this study, the transmissions from the aero e/s are assumed to produce on the surface of the Earth pfd levels complying with the following pfd mask that has been applied in other studies[[9]](#footnote-9) to protect FS stations on the ground from aero e/s transmissions in 12.75-13.25 GHz band:

(dB(W/(m2 · 1 MHz))) for

(dB(W/(m2 · 1 MHz))) for

(dB(W/(m2 · 1 MHz))) for

Where θ is the angle of arrival at the Earth’s surface (degrees) and the pfd value is in dBW/m2 in a reference bandwidth of 1 MHz.

This mask is used in the analyses provided below to determine if it would protect the FS stations with the parameters provided by WP5C from an A-ESIM operating at an altitude of 10 km.

Future studies will need to take into account the impact of A-ESIM operating at lower altitudes including taxi and take off/landing of the aircraft.

# 3 Fixed service (FS) systems parameters

The FS parameters used in these studies were those provided by WP 5C.

Recommendation ITU-R F.758-7 provides a long-term protection criterion, *I/N* of –10 dB, not to be exceeded more than 20% of the time. This criterion, as mentioned in Recommendation ITU-R F.758-7, is an aggregate criterion (see Table 5 in Annex 2 of this Recommendation). The short term criteria used is from ITU-R F.1494.

Table 1 provides the FS protection criteria used.

Table 1

Fixed service permissible interference power in 12.75-13.25 GHz Band

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Permissible *I/N*** | **Permissible interference power (dB(W/MHz))** | **Reference** | **Comments** | **Type** |
| 20 dB | −139 + *I*/*N* | ITU-R F.1494 | Never to be exceeded | Short term |
| -10 dB | −139 + *I*/*N* | ITU-R F.758-7 | Not to be exceeded for more than 20% of the time | Long term |

# 4 Propagation models

For the FSS interference to FS, the propagation model used is Recommendation ITU-R [P.528](https://www.itu.int/rec/R-REC-P.528-4-201908-I/en) “A propagation prediction method for aeronautical mobile and radionavigation services using the VHF, UHF and SHF bands”.

# 5 Polarization loss, rain fade, duty cycle and clutter loss

Polarization and rain fade losses have not been included in this analysis, which in both cases would reduce the interference seen at the FS station. Polarization mismatch ranges from 1.5 to 3 dB.

The interference path will experience signal fading, due to rain, before it reaches the FS receiver. The potential satellite interference signal path to wanted link can range up to 357 km at edge of visibility, which is longer than the FS wanted link path, which is typically of a few kilometers. For the frequency range under consideration, the effect of rain fade can be significant, with fades in the range of 1-10 dB. In addition to this, an ESIM duty cycle of 100% is assumed when in reality the duty cycle will be significantly lower.

Additionally, the studies in this document do not include clutter loss which could also reduce the interference seen at the FS station.

Future studies may take these additional aspects into account.

# 6 Visualyse analysis

The Visualyse software analysis calculates the cumulative distribution function (CDF) for the interference levels from the Aero FSS e/s operating at the pfd mask provided in Section 3 into a FS station receiver. This data can be used to determine if the short-term and long-term permissible interference levels are met. The analysis was performed only for aircraft operating at an altitude of 10 km. The analysis used the same center frequency for the FS signal and the interfering aero e/s and assumed a bandwidth of 1 MHz for both signals, thus the aero carrier completely overlapped the FS carrier and there was no frequency separation between the wanted and interfering signal.

## 6.1 Simulation assumptions

In this analysis, a ratio of the area visible to an FS station antenna and the area of a satellite beam coverage was used to determine the maximum number of simultaneously transmitting aero e/s visible to an FS station.

The maximum number of aircraft e/s transmitting on the same frequency at one moment that are visible to an FS station could be calculated by the following equation:

where:

*n.sat*: number of satellites in visibility of the FS station;

*A.vis*: area in visibility of the FS station;

*A.beam*: area covered by one beam of satellite *k*;

*k*: summation variable 1 to *n.sat*.

1 To simplify the calculation, it is assumed that all of the visible satellites use a spot beam, which is a worst case. Visibility of FS station is 357 km for an e/s altitude of 10 km, or an area of 400 000 km2. A sample spot beam would have an area size of approximately 2 400 × 1 200 km, or 2 880 000 km2. It should however be noted that most of the satellites in Ku band use beams covering larger areas compared to a spot beam.

2 Assuming that the minimum required e/s elevation angle is 5°, e/s in the visibility of a fixed station at 51° N latitude could communicate with up to 45 GSO satellites spaced by 3°.

Using the information above, the maximum calculated number of simultaneously interfering aero e/s in the visibility of the fixed station would be 6.25, which represents an absolute worst case, since not all of the assumed interference always occur at the same time.

For the purpose of this analysis 7 simultaneously interfering aircraft are used in the simulations.

## 6.2 Simulation

This study uses a Monte-Carlo based approach where all 7 aircraft locations are randomized at every time step of the simulation for a duration of 24 hours. At each step, an aggregate *I/N* is computed and a cumulative distribution function is derived. The same center frequency and a 1 MHz bandwidth was assumed for the aeronautical e/s carrier and for the FS carrier – so full frequency overlap of the interfering and wanted signals.

Using the Monte Carlo approach, each of the aeronautical e/s locations is randomized within 360 km of the FS receiver. This would be a worst case scenario since all possible orientations between aeronautical e/s's and the FS station within a 360 km radius are taken into account, whereas using flight traffic data there is only a certain number of flight paths considered, missing certain orientations. Additionally, this approach is not location dependent and the results can be applied to any FS station.

## 6.3 Results using *I/N* Criteria

The preliminary results in Figure 1 below used the FS parameters shown in Table 2 and show that the protection criteria for FS stations indicates positive margin for an A-ESIM operating at 10 km

Figure 1

CDF for FS Station parameters in Table 2 (ITU-R F.758-7)

| Study 1 | CDF Results |
| --- | --- |
| ESIM  Height: 10 km  FS  Location: 51° N and 0°E  Height: 10 m  Elevation: 0 deg  –134 dBW/MHz noise power density |  |

The results in Figures 2, 3 and 4 below used the FS parameters shown in Table 3. Figure 2 show results for FS station with antenna gains ranging from 29 dBi to 48 dBi with no feeder loss. Figure 3 shows results with antenna gain ranging from 29 dBi to 48 dBi with a feeder loss of 1 dB (WP 5C provided a range of 0 to 9 dB).

Figure 4 shows the results for FS station with antenna gains of 45.1 dBi and 50.9 dBi and a feeder/multiplexer loss of 4 dB. As shown in these Figures the protection criteria for FS parameters are met for all of these.

Figure 2

CDF for FS Station parameters in Table 3

| Study 2 | CDF results |
| --- | --- |
| ESIM  Height: 10 km FS  Location: 51° N and 0°E  Height: 10 m  –139 dBW/MHz noise power density |  |

Figure 3

CDF for FS Station parameters in Table 3 - with 1 dB feeder loss

| Study 2 | CDF Results |
| --- | --- |
| ESIM  Height: 10 km FS  Location: 51° N and 0°E  Height: 10 m  –139 dBW/MHz Noise Power Density  Feeder loss of 1 dB included |  |

Figure 4

CDF for FS Station parameters in Table 3 for cases with feeder/multiplexer loss

| Study 2 | CDF Results |
| --- | --- |
| ESIM  Height: 10 km FS  Location: 51° N and 0°E  Height: 10 m  –139 dBW/MHz Noise Power Density  Feeder loss of 4 dB included |  |

# 7 Preliminary summary of results

The results of the studies performed show that, using parameters provided by WP 5C , both the long term and the short term protection criteria of FS stations are met, for an aircraft operating at an altitude of 10 km, for the aero e/s not exceeding the PFD mask provided in Section 2. Further studies are needed to address cases where the aircraft is flying at altitudes lower than 10 km or with the aircraft at taxi or take off/landing. It is noted that taking into account rain fade, clutter loss and polarization mismatch loss could further improve the results.

\_\_\_\_\_\_\_\_\_\_\_\_\_\_

1. Report ITU-R S.2357-0 “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”. [↑](#footnote-ref-1)
2. Report ITU-R S.2357-0 “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”. [↑](#footnote-ref-2)
3. 12.75-14.50 GHz (Earth-to-space). [↑](#footnote-ref-3)
4. Fade margin is a key component when calculating the short-term interference criteria. [↑](#footnote-ref-4)
5. Report ITU-R M.2221. [↑](#footnote-ref-5)
6. https://licensing.fcc.gov/myibfs/displayLicense.do?filingKey=-288092 [↑](#footnote-ref-6)
7. https://transition.fcc.gov/Bureaus/Engineering\_Technology/Documents/bulletins/oet65/oet65.pdf [↑](#footnote-ref-7)
8. Host network has to be understood as the RR Appendix **30B** network at which the earth station on board aircraft or vessel is associated. [↑](#footnote-ref-8)
9. Further study is needed to validate this pfd mask. [↑](#footnote-ref-9)