New Spectrum for Audio PMSE

Statement

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About this document

This document sets out Ofcom's decision to allow Audio PMSE users to share access to the 960-1164 MHz band with aeronautical radio navigation services. We will implement this decision in accordance with spectrum management rules agreed with the Civil Aviation Authority.

It also confirms our assessment that sharing with PMSE would also be possible in the 1525-1559 MHz band but we do not consider this to be the most appropriate solution for the long term needs of the PMSE sector.

We further conclude that no specific action is needed at this time to address spectrum access requirements for PMSE applications below 470 MHz and in the 1.5 GHz band for production communications.

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Section 1

Executive Summary

1.1 This Statement sets out Ofcom's decisions in relation to new spectrum for the Audio Programme Making and Special Events (PMSE) sector. It takes account of the 21 responses submitted as part of a consultation published in October 2015[1].

New spectrum for Audio PMSE in the aeronautical band

1.2 Ofcom has decided to provide access to sub-bands within the 960 – 1164 MHz band for the use of audio PMSE devices operating with a radiated power of less than 17 dBm. Ofcom's decision to allow licensed, shared use of these bands will be implemented according to the technical conditions stipulated in spectrum management rules that have been agreed with the Civil Aviation Authority.

1.3 The amount of spectrum available will vary geographically with approximately 50 MHz available in London and significantly more in other areas of the country. Further testing and operational experience may increase the amount of usable spectrum where we can further refine protection guard bands for existing services.

1.4 We believe this band offers the best long term solution and stability for the sector. The nature of its current allocation to Aeronautical Radio Navigation and Aeronautical Mobile Communication Services is extremely unlikely to change in the UK given anticipated deployment of aviation systems meaning that the risk of unmanageable competition for access is likewise low. In view of this and although we have concluded that sharing would be possible in the 1525-1559 MHz band; we do not intend to extend access to this band.

1.5 We can license the use of the bands immediately however we note that equipment for the band is not yet available. We will need to make some changes to our licensing system in order optimise the process and will work with the sector to ensure this is done on a timescale that meets their requirements.

1.6 We have also planned further engagement with stakeholders to improve understanding of and confidence in using spectrum in the new band.

Audio PMSE requirements in other bands

1.7 We confirm the analysis set out in our consultation on new spectrum for PMSE, that the requirements for audio PMSE use of spectrum below 470 MHz and at 1.5 GHz will continue to be met without any specific intervention. This is because we consider that the evidence suggests both supply and demand will remain fairly static for the foreseeable future.

[1] http://stakeholders.ofcom.org.uk/binaries/consultations/new-spectrum-audio-PMSE/summary/new-spectrum-audio-pmse.pdf

Section 2

Introduction

2.1 Following a consultation exercise, this Statement sets out our decision on the provision of alternative spectrum for use by audio Programme Making and Special Events (PMSE) applications, and on the need for intervention in relation to PMSE spectrum requirements for production communications in other bands.

2.2 In reaching the conclusions set out in this Statement we have had regard to and acted in accordance with our statutory duties, including in particular our duty to secure the optimal use of the radio spectrum.

Background

Impact Analysis

2.3 Programme Making and Special Events (PMSE) refers to the use of wireless technology such as wireless cameras and video links ("video PMSE") and wireless microphones and in-ear monitors ("audio PMSE") in the production of multi-media content and live events.

2.4 PMSE is losing access to spectrum due to the reallocation of bands to mobile broadband services. Our decision to make the 700 MHz band (694 – 790 MHz) available to mobile services results in a loss of spectrum access for use by low power audio PMSE. The 470 – 790 MHz band has for many years been the primary spectrum resource for wireless microphones and in-ear monitors. In making the decision on repurposing the 700 MHz band, we recognised the impact this loss of access to the 700 MHz band will have on the sector given the generally high level of PMSE spectrum demand in the UK. We noted that this impact would likely be felt across a broad range of events, including sport, theatre, broadcasting and live music and especially for those events with the greatest spectrum demand.

2.5 We think there is some scope for PMSE users to improve the efficiency of their spectrum use. However, in many cases of peak spectrum demand, efficiency improvements alone may not be sufficient to meet the requirement. Consequently, we believe that new spectrum is needed to ensure PMSE can continue to provide the level of production it does today.

2.6 For PMSE applications that operate in spectrum below 470 MHz, mainly talkback, broadcast quality audio links, data and remote control, our analysis shows there is little expected change in spectrum demand or supply and therefore no changes are needed to satisfy these requirements.

Consultation

2.7 On the 23rd October 2015 we published a consultation "New Spectrum for Audio PMSE"[1]. ("the consultation"). The consultation explained that PMSE users typically access spectrum on a shared rather than exclusive basis. Low power, short range PMSE applications have been able to successfully exploit sharing opportunities with other services such as digital terrestrial television broadcasting (DTT) and with military users. We proposed mitigating the impact of the reduction in spectrum access in the 700 MHz band with a focus upon finding appropriate, alternative spectrum.

2.8 We applied a set of criteria to identify two appropriate bands where we believe low power audio PMSE applications (principally wireless microphones and in ear monitors) can co-exist with incumbent users. These bands are the 960 – 1164 MHz and the 1525 – 1559 MHz bands. In order for Ofcom to propose a new sharing arrangement we need to be confident that the risk of interference to either the incumbent services or the new service operating in the shared environment is low.

2.9 We therefore set out our technical sharing analysis for both bands (this includes the test report from JCSys Ltd on practical coexistence measurements between PMSE and aeronautical services[2]; and the practical coexistence measurements between wireless microphones and Mobile Satellite System receivers in the 1525 – 1559 MHz band[3]). With the agreement of the Civil Aviation Authority (CAA), who were part of the project steering team for the 960 – 1164 MHz feasibility assessment, we concluded with a proposal to allow access to spectrum in the 960 - 1164 MHz band technically coordinated to avoid harmful interference to aeronautical navigation and communication systems.

2.10 In response to a request for further information, we subsequently published an update detailing our general approach to modelling and sharing in the 960 – 1164 MHz band[4]. This update was intended to provide additional background to our proposal by setting out example parameters and methodology for coexistence modelling for both the terrestrial and airborne sharing scenarios. We extended the consultation period to allow stakeholders to review this additional information and provide further comments if necessary.

2.11 Additionally, in the consultation, we set out our review of spectrum supply and demand below 470 MHz and other bands for talkback, audio links and telecommand.[5]

2.12 In our consultation we did not assess adjacent channel interference to Global Navigation Satellite System (GNSS). In response to stakeholder comments we have revisited this and our decision is set out in Section 3.

2.13 Our consideration of responses to the consultation and subsequent decisions are set out in Section 3 of this Statement.

Legal context

Ofcom's specific duties and powers related to spectrum management

2.14 The European Common Regulatory Framework for electronic communications[6] (in particular, the Framework Directive and the Authorisation Directive) sets the broad

[2] http://stakeholders.ofcom.org.uk/binaries/consultations/new-spectrum-audio-PMSE/annexes/annex6.pdf
[3] http://stakeholders.ofcom.org.uk/binaries/consultations/new-spectrum-audio-PMSE/annexes/annex7.pdf
[4] http://stakeholders.ofcom.org.uk/binaries/consultations/new-spectrum-audio-PMSE/summary/audio_PMSE_update_report_08-01-16.pdf
[5] http://stakeholders.ofcom.org.uk/binaries/consultations/new-spectrum-audio-PMSE/annexes/annex5.pdf
[6] The Common Regulatory Framework comprises the Framework Directive (Directive 2002/21/EC), the Authorisation Directive (Directive 2002/20/EC), the Access Directive (Directive 2002/19/EC), the Universal Service Directive (Directive 2002/22/EC) and the Directive on privacy and electronic communications (Directive 2002/58/EC), as amended by the Better Regulation Directive (Directive 2009/140/EC). See http://ec.europa.eu/digital-agenda/en/telecoms-rules.

legal framework for how spectrum use should be authorised and managed in the UK and aims to harmonise the regulation of electronic communications networks and services throughout the European Union.

2.15 The UK's responsibilities for spectrum management under these Directives are given effect in UK law primarily through two Acts of Parliament which confer on Ofcom specific duties and powers in respect of spectrum (and the other sectors we regulate): the Communications Act 2003 (the '2003 Act') and the Wireless Telegraphy Act 2006 (the 'WT Act'). Our principal duties under the 2003 Act are to further the interests of citizens and consumers, where appropriate by promoting competition. In doing so, we are also required (among other things) to secure the optimal use of spectrum.

2.16 In carrying out our spectrum functions, we have a duty under section 3 of the WT Act to have regard in particular to: (i) the extent to which the spectrum is available for use or further use for wireless telegraphy, (ii) the demand for use of that spectrum for wireless telegraphy and (iii) the demand that is likely to arise in future for the use of that spectrum for wireless telegraphy. We also have a duty to have regard, in particular, to the desirability of promoting: (i) the efficient management and use of the spectrum for wireless telegraphy, (ii) the economic and other benefits that may arise from the use of wireless telegraphy, (iii) the development of innovative services and (iv) competition in the provision of electronic communications services.

2.17 We have taken these duties into account in making the decisions set out in this Statement,

Our spectrum management strategy and the role of regulatory intervention

2.18 In exercising our discretion on how we can best fulfil our duties as they relate to spectrum, it is important that we take a strategic approach to managing this scarce and valuable resource. Ofcom's Spectrum Management Strategy statement[7] sets out our strategic approach, which is, in summary: to rely on market mechanisms where possible and effective, but also take regulatory action where necessary.

2.19 The authorisation of spectrum use in the UK is regulated through the application of the WT Act and licences granted under that legislation. These licences confer and define rights of use of spectrum, but generally do not provide exclusivity of use. For example, Ofcom introduced Ultra-Wide Band use in a range of bands including the 2.1 GHz band some years after the 2000 "3G auction", which had allocated rights to use spectrum in this band.

2.20 Therefore, subject to not causing undue interference, new sharing uses may be allowed access to spectrum which has otherwise already been licensed for other use.

Impact assessment and equality assessment

2.21 Impact assessments provide a valuable way of assessing different options for regulation and showing why the preferred option was chosen. They form part of best practice policy-making. This is reflected in section 7 of the Communications Act, which requires Ofcom to carry out impact assessments where its proposals would be likely to have a significant effect on businesses or the general public, or when there is a major change in Ofcom's activities. Our assessment of the impact of our proposals

[7] See http://stakeholders.ofcom.org.uk/binaries/consultations/spectrum-management-strategy/statement/statement.pdf

for the licensing regime for PMSE was set out in our Consultation. This Statement sets out our decision on these proposals, having taken all stakeholder representations into account.

2.22 Ofcom is separately required by statute to assess the potential impact of all our functions, policies, projects and practices on equality. As explained in our Consultation, we do not consider the impact of the decisions in this document to be to the detriment of any group within society and we did not receive any responses to the Consultation which suggested otherwise.

Structure of this document

2.23 The rest of this document is structured as follows:

- In Section 3 we set out our decisions alongside a summary of our consideration of consultation responses.
- In Section 4 we provide information on our revised modelling approach and summarise what this means for spectrum availability for PMSE in comparison with the assessment presented in our consultation.
- In Section 5 we outline further work and engagement we expect to support the implementation of our decisions.
- In Annex 1 we provide a detailed view of stakeholder consultation responses and our comments to these.
- In Annex 2 we detail the spectrum management rules as agreed between Ofcom and the CAA for deriving spectrum availability for PMSE.

Section 3

Our decisions and summary of responses

What we have decided

3.1 We posed the following three questions in the consultation:

Question 1: Do you agree with our assessment that minimal growth in demand and stability in spectrum supply means that we do not need to implement any changes to meet the ongoing requirements for talkback, audio links and telemetry and telecommand applications?

Question 2: Do you agree with our sharing analysis which concludes that audio PMSE (low power microphones and IEMs) could co-exist with incumbent services in the bands 960-1164 MHz and 1525-1559 MHz?

Question 3: Do you have any comments on our proposal to allow low power audio PMSE applications (wireless microphones and IEMs) access to the 960-1164 MHz band?

3.2 Having considered the responses from stakeholders in relation to the above we have decided:

- On question 1. We do not need to take any specific action with regard to the use of spectrum below 470 MHz and in the 1.5GHz band, used predominantly for talkback, audio links and telemetry and telecommand applications.
- On question 2. It is possible for audio PMSE applications to co-exist with incumbent services in either of the 960-1164 MHz band and the 1525-1559 MHz band.
- On question 3. We confirm that we will provide access to the 960-1164 MHz band for low power audio PMSE applications and not the 1525-1559 MHz band. We believe that this solution will best meet the long-term needs of the audio PMSE community. Specifically, we will allow audio PMSE devices, operating with a radiated power of less than 17 dBm, licensed access to sub-bands within the 960 – 1164 MHz band in accordance with spectrum management rules the CAA have agreed are appropriate (these are set out in Annex 2). In detail we:
    - exclude access to the lower 1 MHz channel of the band to protect adjacent channel services;
    - implement a guard band of ± 15 MHz at 1030 MHz and 1090 MHz to protect SSR[8], WAM[9], ACAS/TCAS[10] and ADS-B[11] services; and

[8] SSR: Secondary Surveillance Radar
[9] WAM: Wide Area Mulitlateration
[10] ACAS/TCAS: Airborne Collision Avoidance System/ Traffic Alert and Collision Avoidance System
[11] ADS-B: Automatic Dependent Surveillance – Broadcast

- implement a guard band of 10 MHz at 1154 MHz to protect GNSS[12] receivers above 1164 MHz.

3.3 We are confident that the guard bands proposed in our consultation are sufficient to protect incumbent services in the band but in response to stakeholders' comments we have extended these to provide enhanced protection for services at 1030 MHz and 1090 MHz and for GNSS above 1164 MHz. We think this approach is conservative and we will continue to work closely with the CAA and UK Space Agency to seek to reduce these limits on the basis of technical evidence and risk based assessments if and when appropriate.

Overview of responses

3.4 We received 21 responses to the consultation. Two responses were fully confidential and two were part confidential. The full text on non-confidential responses can be found on our website. Annex 1 provides a list of respondents (non-confidential) and a detailed summary of the comments received with our responses.

3.5 The majority of respondents focussed the weight of their comments on questions 2 and 3. On question 2 respondents from the aeronautical sector broadly disagreed that sharing is possible in the 960 – 1164 MHz band. One response suggested that sharing would be possible on a case by case basis but the mechanism and criteria for sharing would need to be revised from time to time to account for any changes in aeronautical use. Respondents from the satellite sector disagreed that sharing is possible in the 1525 – 1559 MHz band. Responses from the PMSE sector were broadly supportive of our analysis and the conclusion that low power audio PMSE could share in either band.

3.6 In relation to question 3, two responses from satellite stakeholders supported our proposal to make the 960 – 1164 MHz band available to low power audio PMSE. One respondent raised concerns about adjacent channel interference into the Global Navigation Satellite Service above 1164 MHz. Responses from the aeronautical sector which disagreed with our sharing analysis also disagreed with our proposal, citing concerns around flight safety. The PMSE sector was generally supportive although raised concerns regarding the risk of interference into PMSE from aeronautical systems and highlighted that more work would need to be done to provide confidence that the band was usable by PMSE.

3.7 One further response was broadly supportive of our analysis and conclusions but mainly addressed the access arrangements to the bands, proposing that we adopt a dynamic spectrum sharing framework.

How we've structured our assessment

3.8 In the rest of this section we first address issues raised in relation to question 1, then address the remaining points on questions 2 and 3 by spectrum band.

PMSE spectrum requirements in other bands

3.9 Talkback, and similar voice communication applications, make up the majority of PMSE spectrum usage in bands below 470 MHz. Our analysis, set out in Annex 5, of the consultation document focussed on the PMSE bands below 470 MHz as well as

[12] Global Navigation Satellite System

looking at demand in the 1.5 GHz band and for spectrum “loans”(use of spectrum not designated for PMSE) from other sectors such as Business Radio, Emergency Services, Ministry of Defence and other government users. For example, we noted a large number of requests to loan spectrum from bands not designated for PMSE use in the range 137-173 MHz which is generally for international motor racing events. This is because there is little suitable PMSE spectrum available in the VHF band to meet these users’ particular requirement.

3.10 Similarly, for peak demand events such as the Tour de France or Formula 1 Grand Prix, loan spectrum is vital to top-up the spectrum resource available for day-to-day PMSE use and to meet the particular needs of international competitors and broadcasters. So, in addition to those bands designated for day-to-day PMSE use we included these non-PMSE bands in our review of future spectrum availability.

3.11 We do not anticipate changes in spectrum supply affecting designated PMSE bands below 470 MHz and at 1.5 GHz. Similarly, we found no significant risks to the adequate future access to bands that are not designated for PMSE but are frequently used by PMSE.

3.12 Of the 10 respondents who addressed this question only 3 disagreed with our analysis but did not supply any supporting evidence for their views.

On our sharing analysis in the 1525-1559 band

3.13 In response to our assessment of sharing in the 1525 – 1559 MHz band Inmarsat, the Maritime and Coastguard Agency and Thuraya all disagreed with our coexistence analysis. The MCA and Thuraya provided no supporting technical evidence but stated that as the band is globally allocated to MSS, and as terminals can be mobile, coexistence cannot be assured. Transfinite commented that there was a risk of adjacent band interference into GNSS above 1559 MHz.

3.14 Inmarsat disagreed that the testing we carried out accurately measured the failure point of the MSS terminals when subjected to interference and suggested a different interference threshold in its analysis. Inmarsat also disagreed with our choice of propagation model (ITU-R Recommendation P.1411) and chose instead to adopt a different propagation model (ITU-R Recommendation P.452). With these assumptions Inmarsat concluded that required separation distances are greater than those we presented in the consultation.

3.15 For the airborne case Inmarsat suggested that the satellite position we used to derive elevation, angle and the consequential airborne antenna gain could change if the satellite orbital location was changed. Inmarsat therefore assumed a 5º elevation angle in its assessment of PMSE interference into airborne MSS which increases the assumptions about antenna gain towards a PMSE interferer.

3.16 We believe our approach to coexistence in the band is appropriate. For the terrestrial interference case we think that the use of Recommendation P.1411 is more applicable in predicting path loss in the scenario of low height to low height terminals. While it is clear that satellite positions may change there are no indications if this would happen, and if it did that the extent of the change would reduce the elevation angle in Europe to 5º.

3.17 We highlight that in the consultation we did acknowledged a risk of interference into MSS terminals should PMSE and MSS come into close proximity but our view on coexistence was that the profile and density of use of PMSE and MSS means the

chance of this occurring is very remote. Responses from the MSS sector did not address this or provide evidence on density and locations of MSS use to suggest there is a high probability that these two applications would coincide.

3.18 The assessment by Transfinite of adjacent channel interference into GNSS above 1559 MHz assumed a GNSS receiver filter response which we do not think is representative of actual GNSS receiver performance and consequently the risk of adjacent channel interference is significantly lower than that presented. We discuss this further in paragraphs 3.54 to 3.64.

3.19 We therefore maintain that sharing in the band is viable and appropriate as set out in the consultation. This indicates any interference from PMSE to MSS would be localised, which, taken with the profile and density of use of PMSE and MSS, means the risk of such interference is low. A guard band may need to be implemented to protect GNSS above 1559 MHz however, as we have concluded that we will not allow PMSE to share the 1525 – 1559 MHz band we will not further address this or other points relating to the band in detail.

Responses relating to the 960 MHz to 1164 MHz band

3.20 We received five responses from the aeronautical community which expressed concerns on the effect sharing would have on air safety and therefore did not support our sharing analysis, or our proposal to allow PMSE access to the band.

3.21 Matters affecting aeronautical safety are the responsibility of the CAA. We have worked closely with the CAA throughout the co-existence analysis to ensure the sharing framework does not compromise the safe operation of the incumbent aeronautical systems. The spectrum management rules that underpin our sharing proposal have been agreed with the CAA on the basis of available evidence and risk based assessments[13].

3.22 Responses to stakeholder comments received in relation to matters of air safety within this statement are provided by the CAA. These include responses to comments on the test methodology, number of equipment tested and the conclusions.

3.23 The particular points raised by the aeronautical community centred upon:

- the sample size of equipment tested in our practical coexistence study;
- whether the test methodology for the practical coexistence study was representative of the real world spectrum environment;
- whether the criteria applied is appropriate for assessing compatibility; and
- whether the protection of aircraft within published Designated Operational Coverage (DOCs) areas is sufficient as aircraft may interrogate ground stations outside the published DOC.

3.24 We address these in detail in Annex 1, however we summarise our conclusions below.

[13] This applies to UK deployment only.

Insufficient sample size of equipment tested

3.25 Our practical coexistence study conducted in 2015 tested the same sample of receivers previously used and deemed representative in testing for sharing of the band with Joint Tactical Information Distribution System (JTIDS) operated by military authorities. In addition, since the publication of the audio PMSE consultation, JCSys Ltd has carried out further testing on behalf of the CAA (for a different purpose). We note this additional analysis included testing two scanning DME interrogators and there is no evidence that scanning DME interrogators are more susceptible to interference than the equipment used in our study.

3.26 We see no technical rationale to assume other equipment performance would be sufficiently different in operation, than the sample tested, to require a significant adjustment to the spectrum sharing framework. The equipment tested is certified in accordance with aeronautical standards and, as noted above, a similar approach was taken when addressing compatibility between JTIDS and DME. Ofcom and the CAA agree that the range of DME equipment tested does provide a sufficient representative sample of equipment on which to base appropriate conclusions on spectrum sharing with PMSE.

3.27 We acknowledge that the practical testing carried out by JCSys Ltd did not consider a fuller set of SSR receivers or airborne equipment used for ACAS/TCAS and ADS-B. The report by JCSys Ltd recommended that a ± 10 MHz guard band would be sufficient to protect these systems which we proposed in our consultation. Aeronautical stakeholders expressed concerns on this proposal and EUROCONTROL suggested this should be extended to ± 20 MHz but gave no supporting technical justification. NATS stated that ± 10 MHz would be sufficient to protect its ground based receiver at 1090 MHz.

3.28 We have revised our consideration of the guard band requirements and increased this to ± 15 MHz (subject to further testing) on the basis of Minimum Operational Performance Specifications for aeronautical equipment along with associated operational parameters for the typical operational scenarios. This is the foundation of the risk-based assessment that the CAA carried out.

3.29 We discuss the impact of this increased guard band on spectrum availability for PMSE in section 4 of this document.

Coexistence study does not represent the real world spectrum environment

3.30 The practical coexistence studies were conducted in a composite signal environment including the presence of JTIDS (Link-16) signals and overlapping pulses. The Link-16 model, known as the 70 NM Radius Geo Area Any Point in Space model, was developed by JCSys Ltd and the UK CAA. Management of Link-16 operations and training in the UK is based on 70NM APIS GA. This model fully accounts for all JTIDS activity.

3.31 The DME environment used is based on measurements of the real environment completed by JCSys Ltd and is therefore considered representative of the real spectrum environment.

3.32 Due to the nature of the signal environment, no laboratory test, irrespective of fidelity level, will totally reflect the real world environment at all times. However, the testing has set upper limits to interfering signals and the combination of the PMSE signal,

JTIDS, multipath and fading effects for example occurring simultaneously at any given point in time are deemed to be highly exceptional cases.

3.33 The CAA have confirmed they are content that the test methodology and test criteria sufficiently reflect the real world spectrum environment and appropriately reflect the operational characteristics of the incumbent aeronautical services. Consequently, both Ofcom and the CAA are satisfied with the conclusions from the study, and that their adoption in the spectrum management rules limits the risk of interference into DME and other aeronautical systems from low power audio PMSE.

Aircraft may operate outside published Designated Operational Coverage (DOC) areas

3.34 While aircraft may interrogate a transponder and receive replies outside of the assigned DOC, the standard aeronautical frequency management process only guarantees protection of the service within the boundaries of the DOC. The integrity of the system cannot be assured outside of this and DME frequencies are protected globally on this basis.

3.35 However, we recognise that Flight Management Systems utilise information on navigation aids provided from a navigation database. Information on navigation aids, including DME, is coded under the ARINC 424 Navigation System Data Base Standard, the international standard file format for aircraft navigation data. An integer value known as the “Figure of Merit” is used to specify VHF NAVAID facility usable ranges. Within the spectrum management rules, DOC ranges will be set according to the Figure of Merit ensuring that the airspace volume considered in determining PMSE spectrum availability is that over which the DME is likely to be used, even if this is outside the published DOC.

3.36 Table 1 provides the Figure of Merit classification. Where the published DOC range does not match a range in Table 1 the next largest range is adopted in the spectrum management rules. For example, any DOC range between 41 NM and 129 NM is extended to 130 NM. In the event that the published DOC is larger than 130 NM the published DOC range is used.

Table 1: Figure of Merit used to define DME DOCs in navigation databases

Field Content	Description
0	Terminal Use (generally within 25NM / 46.3 km)
1	Low Altitude Use (generally within 40NM / 74.08 km)
2	High Altitude Use (generally within 130NM / 240.76 km)
3	Extended High Altitude Use (generally beyond 130NM / 240.76 km)
7	NAVAID not included in a civil international NOTAM system
9	NAVAID Out of Service

3.37 In addition, advice sought from Boeing and Airbus indicates that RNAV (Area Navigation) systems deployed in the FMS of current and future fleets drive the scanning DME systems in Directed Scan mode only i.e. under the control of the navigation database. There are no foreseeable plans for use of Free Scan mode,

thereby allowing only the DME channels likely to be interrogated at a particular location to be considered in the assessment.

3.38 The CAA is content that the approach outlined will ensure that the airspace volume considered in the spectrum management rules will be that over which the aircraft interrogator can reasonably be expected to operate including outside published DOCs. The integrity of DME signals beyond these ranges cannot be assured and DME frequencies are protected on this understanding.

Comments from the PMSE sector

3.39 Responses were broadly supportive of the work carried out to identify new spectrum sharing opportunities for low power audio PMSE. Our specific responses to comments received are provided in Annex 1. In summary the PMSE sector's main concerns are:

- Risk of interference from aeronautical systems reducing the utility of the 960 – 1164 MHz band;
- Further detail on the effect of future aeronautical communications being deployed in the band; and
- Further clarification on our decision to only allow access to the aeronautical band.

Risk of interference into PMSE from aeronautical systems

3.40 The PMSE sector raised concerns regarding the utility of the band stating that the amount of air traffic carried a significant risk of interference into PMSE. Stakeholders argued that our modelling did not provide sufficient reassurance that the spectrum could meet the high quality requirements of PMSE but did not provide any supporting technical evidence for this view. Some respondents suggested that further monitoring work should be carried out in conjunction with PMSE stakeholders to determine the viability of the band.

3.41 The practical coexistence analysis carried out by JCSys Ltd assessed the effect of interference from aeronautical communication and navigation systems into PMSE receivers. This assessment applied the same metric for audio quality as was agreed with PMSE stakeholders in relation to our coexistence analysis between TV white space devices and PMSE and concluded that a wanted to unwanted threshold of 0 dB was sufficient to meet the audio quality requirements of PMSE. The results of this work conclude that the band is usable by PMSE.

3.42 We recognise that this spectrum environment presents different challenges to the PMSE sector than those they are used to in the UHF TV broadcasting band. We will engage with PMSE stakeholders to assist with their understanding of the new spectrum environment and how it can be successfully exploited. We will hold a stakeholder event to demonstrate our practical analysis to increase stakeholder confidence in the band.

Further detail on the effect of future aeronautical communications systems

3.43 In our consultation we noted that the L Band Digital Aeronautical Communication System (LDACS) is expected to be deployed within the 960 – 1164 MHz band alongside DME. The provisional timescale for the introduction of LDACS is mid-2020s. We suggested that this could reduce spectrum availability by up to 10 MHz in

any given location. In their responses to the consultation, aeronautical stakeholders stated that PMSE sharing would need to take account of LDACS. PMSE stakeholders said that the full impact of this new application would need to be better understood before a view on the band's viability could be determined.

3.44 The CAA facilitated contact with the LDACS Design Authority which is currently engaged in planning the deployment of LDACS. The Design Authority was able to provide further technical details and information on likely deployment.

3.45 LDACS uses a cellular point-to-multipoint concept, which means that the airspace is segmented into cells. In each cell aircraft are connected to a centralised ground station which controls the entire air/ground communication within the cell. LDACS is designed as a frequency-division duplex system which enables the ground station to transmit continuously at a certain frequency (forward link), while all aircraft within the cell transmit in parallel at a different frequency (reverse link) separated by 63 MHz to align with the DME channel arrangement. Channel reuse is expected to be seven or nine channels but could be 12 or 13.

3.46 Channels have a bandwidth of 500 kHz for both the forward (ground to air) and reverse (air to ground) links. Indicative transmit powers and antenna gains are given in Table 2.

Table 2: Technical details of LDACS

	Ground station	Airborne station
Transmit power (dBm)	~41	~42
Antenna gain (dBi)	~8	~5.4
Bandwidth (kHz)	500	500

3.47 Cell sizes will be between 60 – 120 NM with each cell operating on a single channel. Traffic density may require two channels to be utilised in a single cell but detailed, location specific planning would be required to assess this. The overview is that approximately 100 cells will be needed to cover whole of Europe.

3.48 The protocol indicates 512 aircraft can be served by a single cell but the practical reality is that the limit will be 100 – 200 aircraft. Aircraft may listen to a second cell to aid handover but this is not the usual scenario.

3.49 To ensure a reliable data transmission, LDACS has implemented several measures, for example, a strong forward error correction. This forward error correction can also be adapted according to the transmission conditions, which increases the data rate.

3.50 In light of the additional information provided by the Design Authority we have revised our assessment of the reduction in spectrum availability for PMSE once LDACS is deployed. In a worst case scenario we consider:

- a PMSE located at the border of three cells;
- each cell is assigned two LDACS channels (2 × 500 kHz); and
- only the co-channel scenarios are limiting

3.51 For the above scenario we assume that the limiting cases will be interference from PMSE into airborne receivers and airborne LDACS transmissions interfering with DME. We do not consider interference from or to the LDACS ground station due to the PMSE location being 60 – 120 NM from each ground transmitter. Given these assumptions there is a maximum loss of spectrum of 6 MHz as a result.

3.52 It is likely that in most cases additional restrictions on PMSE as a result of the deployment of LDACS will be less than 6 MHz which is less than we assumed in the consultation document. We will continue to monitor the development of LDACS.

Why we proposed sharing in the aeronautical band

3.53 Some PMSE stakeholders expressed a preference for sharing in the MSS band and questioned why we did not offer a choice. We addressed this point in the consultation document. We believe access to the aeronautical band provides the best long term solution for the PMSE sector. We do not think the MSS band performs as well against our criteria as the aeronautical band, specifically around long term security. Although we did not identify any new services on the horizon, the band is commercially deployed and changes could occur rapidly. In the aeronautical band changes occur more slowly and our view is this stable environment provides the best spectrum resource for PMSE.

Concerns of the Global Navigation Satellite Service

3.54 Transfinite provided a partially confidential response to our consultation which suggests that a guard band of at least 30 MHz and preferably 45 MHz is required to protect GNSS operating above 1164 MHz. In their response Transfinite specifically referenced Galileo, the global navigation satellite system being created by the European Union (EU) and European Space Agency. Our response addresses GNSS in general as GPS occupies the same spectrum as Galileo. . As we are not considering PMSE sharing in the 1525 – 1559 MHz band we restrict our comments to GNSS operating above 1164 MHz.

3.55 The GNSS bands of concern are the E5a band (for Galileo) and the L5 band (for GPS) which operate with a centre frequency of 1176.45 MHz with a bandwidth of up to ±11.5 MHz.

3.56 In our consultation we did not address compatibility with adjacent GNSS systems. Our view was that the use of low power PMSE adjacent to the GNSS band would cause an insignificant increase in interference to that caused by DME and TACAN, operating both adjacent to and co-channel with GNSS at power levels orders of magnitude above that of PMSE. Even though GNSS receivers are designed to operate in this pulsed environment it is likely, given the extent of use of the band for DME, that pulses will overlap and form pulse clusters and therefore look more like noise than discrete pulse signals.

3.57 Given this ‘real world’ environment our view is that this, taken with the intermittent profile of use of PMSE, both in terms of location and duration, would result in a very low probability of harmful interference to GNSS attributable to PMSE except in circumstances where it was closely located to a GNSS receiver. However, as a result of stakeholder comments we have revised our assessment and this is outlined below.

3.58 We believe the analysis of adjacent channel interference carried out by Transfinite reflects a ‘worse case’ situation which we think is unlikely to occur in practice, specifically relating to assumptions on GNSS receiver performance and PMSE and GNSS deployment scenarios. Our assessment indicates that adjacent channel interference into GNSS from low power audio PMSE (<17 dBm) is dominated by the GNSS receiver characteristics assumed and not as a result of out of band performance of PMSE transmitters.

3.59 Our assessment considers a range of PMSE deployment scenarios and GNSS receiver performance based on the off-frequency non pulsed interference rejection of GNSS receivers as presented in Figure 8 and Figure 9 of Report ITU-R M.2235[14] and a measured GNSS receiver response taken from Figure 3 and Figure 4 of the report "Characterization of L5 Receiver Performance Using Digital Pulse Blanking." Our assessment considers ground and air use of GNSS with parameter values taken from Recommendation ITU-R M.1905[15].

3.60 For the scenarios outlined above our assessment shows that with a 10 MHz guard band, separation distances required vary significantly depending on the assumptions on receiver performance from several kilometres in the worst case to less than 10 m when considering the measured receiver performance. Applying the receiver characteristics in Figure 8 of Report ITU-R M.2235 the required separation distance is 200 – 300 m.

3.61 For the range of values and scenarios assessed it is clear that the receiver response is a key factor in determining adjacent channel compatibility. We expect that GNSS receiver performance will be better than the Gaussian filter assumed by Transfinite and most likely to be at least as good as, if not significantly better than, that in Figure 8 from Report ITU-R M.2235.

3.62 We have discussed adjacent band compatibility between PMSE and GNSS with the UK Space Agency and the CAA and have agreed that initially we will introduce a guard band of 10 MHz at 1164 MHz, i.e. PMSE will not have access to spectrum above 1154 MHz. We believe this is a conservative measure and will look to refine this arrangement in cooperation with the UKSA and CAA as more information becomes available.

3.63 It is our understanding that commercial utilisation of the E5a and L5 bands is at an early stage. The Radio Equipment Directive (RED), which replaces the existing Radio and Telecommunication Terminal Equipment Directive (R&TTE), has increased emphasis on the effective and efficient use of spectrum, including performance requirements for receivers to screen out radio signals transmitted in adjacent bands and therefore equipment development can fully take into account improved performance requirements.

3.64 Our information indicates that commercial development and deployment of aeronautical GNSS systems that utilise E5a and/or L5 is some years away. At such time as the band starts to be exploited for aeronautical GNSS we can amend the spectrum management rules to incorporate any additional analysis and data on coexistence where appropriate.

Additional comments

3.65 Some PMSE stakeholders were concerned that additional spectrum is only one part of a solution that should also involve harmonisation with other countries, and funding to cover the costs of replacing equipment. We recognise that these are important issues for the sector. We have committed to working with other administrations to provide further information on our proposal where appropriate but note that any decision to provide additional spectrum for PMSE is ultimately a decision for them

[14] Aeronautical mobile (route) service sharing studies in the frequency band 960-1 164 MHz
[15] Characteristics and protection criteria for receiving earth stations in the radionavigation-satellite service (space-to-Earth) operating in the band 1 164-1 215 MHz

3.66 In relation to funding PMSE clearance, decisions are a matter for Government. We are liaising with Government on this issue at the moment and will update stakeholders in due course once these discussions have reached a conclusion.

Section 4

Revised modelling approach

4.1 Our spectrum modelling approach has been agreed between Ofcom and the CAA and this underpins the spectrum management rules set out in Annex 2 and informs our conclusions on the amount of usable spectrum for PMSE applications. This is separate to the co-existence analysis on which we consulted.

4.2 In response to comments received to our initial consultation we published further details on our approach to modelling as further contextual information. We extended the consultation period to allow stakeholders to revise their responses should they wish on the basis of this new information. We received two new response (one of which was partially confidential) and three further responses from stakeholders who had provided comments to our initial consultation document. Only one respondent provided comments on the example modelling approach and parameters used.

4.3 The study carried out by JCSys Ltd derived the interference threshold levels under which coexistence between aeronautical services and PMSE could be achieved. These practical limits set the compatibility criteria. In order to affect these limits we have applied propagation analysis to derive spectrum availability.

4.4 As the communications regulator is our responsibility to manage the spectrum effectively and efficiently. The approach, propagation models and parameter values are appropriate to the sharing scenarios proposed and are balanced between minimising the risk of interference into aeronautical services without being too stringent, for example, we do not assume building loss for assessment of interference from PMSE into airborne receivers and apply a minimum vertical separation distance for aircraft height.

4.5 We apply two different approaches, one for the terrestrial and the other for the airborne interference scenario. For each scenario the approach is as we outlined in our update document, for example use of ITU-R Recommendation P.452 for the terrestrial paths and IF77 (from which are derived the curves in ITU-R Recommendation P.528) for the airborne scenarios.

4.6 For assessing PMSE signal levels into aeronautical ground and airborne receivers the parameters in Table 3 are applied.

Table 3: Modelling parameters

	IF77 (airborne scenario)	ITU-R Recommendation P.452 (terrestrial scenario)
Percentage time	1%	1%
Percentage location	50%	50%
Clutter loss (Urban)	n/a	22.9 dB (Note 1)
Clutter loss (Rural)	n/a	17.9 dB (Note 1)
Building entry loss	0 dB	11 dB
Terrain path profile	n/a	Applied

Note 1: Clutter loss is only applied at the PMSE end (when considering the terrestrial path only) on the assumption that the DME transponder is generally free of clutter. These values are taken from the propagation model ITU-R Recommendation P.1812 and are appropriate to scenarios where the interferer is interferer is not fixed below the notional height clutter.

4.7 No additional safety margin has been applied as there is additional margin incorporated into the modelling methodology and assumed in the practical testing. For example:

- Interference thresholds are defined for a single interferer whereas the test scenario included four interference signals, i.e. the level of interference into the aeronautical receiver is up to 6 dB greater than the interference thresholds we have adopted.

- The PMSE thresholds derived from testing include the effect of JTIDS on DME at the maximum agreed level between the CAA and MOD which is approximately 3 dB.

- No clutter or building losses are considered for the airborne case but in areas where buildings or vegetation obscure the line of sight the obstruction loss will attenuate the PMSE signal by at least 6 dB.

- 3 dB antenna discrimination from the main lobe of the ground beacon antenna is not included in the model.

- 12 dB antenna discrimination from the main lobe of the airborne antenna to other angles where PMSE will be present for much of the time when the aircraft is most vulnerable to PMSE.

4.8 In developing the spectrum management rules we have revised some elements of the model in response to comments received to the consultation. As discussed in Section 3, some respondents commented that our approach to only protect aircraft within the published DOC was not appropriate as aircraft may receive signals beyond these ranges especially in Flight Management Systems where on-board radio navigational systems are under control of a navigation database even though the integrity of the system cannot be assured outside of the published DOC.

4.9 In a navigation database the information on navigation aids, including DME, is coded under the ARINC 424 Navigation System Data Base Standard, the international standard file format for aircraft navigation data. An integer value is used within the navigation file to define the DOC of a DME station. This value is known as the "Figure of Merit" and is used to specify VHF NAVAID facility usable ranges. Table 1 provides the FOM classifications.

4.10 In order to provide protection in all air volumes where aircraft are likely to communicate with a DME station, where the published range does not match a range in Table 1 the next largest range is adopted. For example, any DOC range between 41 NM and 129 NM is extended to 130 NM. In the event that the published DOC is larger than 130 NM the published DOC range is used. We believe this approach ensures the PMSE interference thresholds are appropriately applied to relevant airspace volumes.

4.11 In our update providing further details on approach to modelling and sharing we said we consider an aircraft could be anywhere with the DOC from 0 m to 30,000 m in altitude. With the agreement of the CAA we have adapted this approach to set the minimum height to 100 m as there is no practical justification for an aircraft communicating with a DME ground transponder at 0 m especially if considering the effect of the radio horizon and minimum height rules for aircraft.

4.12 With respect to assessing the quality of spectrum for PMSE, i.e. the level of interference from DME into PMSE, we include some factors in the model which we exclude when considering interference into DME, such as building and clutter loss. We believe that including these elements for PMSE is more representative of the likely interference environment whereas we exclude these for DME in order to provide additional margin.

4.13 In applying the agreed model and thresholds and incorporating the changes we have made in our approach, we have derived spectrum availability at the four example venues previously identified in the consultation and set these out below in Table 4. Within this assessment we have also included the extended guard bands for SSR and other aeronautical systems that operate at 1030 MHz and 1090 MHz and also the 10 MHz guard band to protect adjacent GNSS above 1164 MHz. The values are presented as number of 1 MHz channels so can be read as the amount of spectrum available, e.g. 52 × 1 MHz channels can be considered to be 52 MHz of available spectrum.

Table 4: Spectrum availability for PMSE (consultation figures in parentheses)

	Seven dials (indoor)	**Glastonbury (outdoor)**	**Media City, Salford (indoor)**	**SECC, Glasgow (indoor)**
1 MHz DME channels available[Note1]	51 (50)	54 (56)	67 (81)	92 (105)
Additional channels with frequency offset[Note2]	8 (5)	19 (16)	14 (8)	17 (12)

Note 1: Number of channels available considers all interference thresholds as absolute, i.e. if interference exceeds the relevant thresholds into aeronautical systems or PMSE, the channel is declared unavailable.

Note 2: Additional channels are those where the interference into PMSE could be mitigated by offsetting the PMSE frequency by 300 kHz from the centre channel.

4.14 The spectrum availability figures provided in Table 4 differ from those in the consultation due to the refinement of the modelling approach, for example considering the ARINC format for the DOC which in many cases increases the area over which protection has to be provided to airborne receivers. In addition the larger guard bands introduced further reduce the available spectrum.

4.15 The spectrum availability figures represent the lowest limit for those locations. It is expected that with further analysis of GNSS and aeronautical systems that operate at 1030 MHz and 1090 MHz there is likely to be the opportunity to reduce the associated guard bands. In addition, it is expected that PMSE users should be able to take action to mitigate the effect of interference from airborne interrogators to increase spectrum availability.

Section 5

Next steps

5.1 Having made the decision to allow licensed access to the band 960 – 1164 MHz for low power audio PMSE, this band will be added to the PMSE spectrum portfolio in our licensing system. Access to the spectrum will be authorised under individually coordinated licences which will be frequency, location and time and date specific. We will need to carry out a number of measures to develop and support access arrangements to this new spectrum. These additional steps are outlined below.

Additional data gathering

5.2 As detailed in Sections 3 and 4 of this Statement, we will implement guard bands to protect SSR and associated services at 1030 MHz and 1090 MHz and GNSS above 1164 MHz. We will continue to work to assess the appropriateness of these guard bands in the future by gathering further data and information on 'real world' coexistence, which may include further practical testing. We will also continue to monitor developments on LDACS and incorporate information on this into the spectrum management rules as it becomes available.

5.3 Should this additional data indicate changes to the guard bands are appropriate we will work with the CAA to ensure aspects of aeronautical safety are adequately addressed. Any changes to spectrum availability will be reflected in the spectrum management rules and the spectrum availability plan derived by us through application of these rules.

Implementation

5.4 We recognise that this is a new sharing environment for PMSE. In deriving spectrum availability we need to protect air and ground aeronautical receivers and account for interference from aeronautical systems into PMSE. This is a complex task. We will derive spectrum availability and present what is available for use at any given location in a similar manner to how it is presented for sharing with DTT. As we do for the DTT band we intend to provide an indication of 'spectrum quality' so PMSE users will have some indication of possible levels of aeronautical interference.

5.5 This statement confirms access to the 960-1164 band and if needed, we could license PMSE use immediately albeit via a manual process. However, in order to more efficiently manage the licensing process in this new band we will develop a full spectrum availability plan and incorporate this into our PMSE licensing framework. This will require IS development and updates to the licensing database to incorporate the new spectrum, including updating the online tool to reflect spectrum access and restrictions.

5.6 As there is currently no PMSE equipment that can operate in the aeronautical band we will work with the sector to ensure that an updated licensing service is available in time to support new widespread PMSE use once equipment comes to market.

5.7 Ofcom will soon publish a consultation which will discuss the timing of clearance of the 700 MHz band.

Understanding the spectrum environment

5.8 Our assessment indicates that there is a significant amount of usable spectrum available in the band. We think this is a good spectrum opportunity for PMSE that meets the criteria we set for identifying spectrum for low power audio PMSE use. However, we recognise that the PMSE sector has some concerns around the utility of the band, especially regarding interference from airborne transmitters.

5.9 To improve understanding of and confidence in the new band we intend to continue to work closely with stakeholders. We will carry out additional monitoring in support of our modelling approach and work to improve the spectrum availability plan accordingly.

5.10 We plan to hold a workshop to take PMSE stakeholders through our analysis and assessment of the band. We will provide spectrum monitoring data to help demonstrate the spectrum environment to PMSE stakeholders.

International harmonisation

5.11 As we mentioned in our consultation we have already engaged with other administrations and shared our thinking on alternative bands for audio PMSE. The European Commission has also expressed interest in our work.

5.12 We understand that a harmonised approach is beneficial in creating a larger market and benefits of economies of scale, although this is not something we can guarantee. We note that other administrations do not necessarily acknowledge the same volume of PMSE use and hence view the impact of clearing the 700 MHz band differently to us. We will however, continue to engage with other administrations as appropriate to provide information on our assessment of sharing in the 960 – 1164 MHz band and share our data and analysis.

Annex 1

Stakeholder responses

A1.1 This annex summarises the comments received from stakeholders in response to the consultation together with our responses to their submissions. Responses to comments received relating to aeronautical safety have been provided by the CAA.

A1.2 The consultation period was extended to the 22nd January 2016 to allow stakeholders to time to review our update publication providing further details on our approach to modelling and sharing in the band 960 – 1164 MHz.

A1.3 We received responses from 21 organisations of which two were confidential. Two organisations requested part of their responses were kept confidential but gave permission to reference the response and provide a summary.

A1.4 The organisations we received responses from, excluding the wholly confidential responses, are listed below:

Adrian Bell Sound Ltd Andrew Toms AV British Broadcasting Corporation (BBC) British Entertainment Industry Radio Group (BEIRG) Copsey Communication Consultants (CCC) Deutsche Flugsicherung (DFS) European Aviation Safety Agency (EASA) EUROCONTROL Humberside International Airport Ltd Inmarsat	International Air Transport Association (IATA) Maritime and Coastguard Agency (MCA) National Air Traffic Services (NATS) Nominet Sennheiser Shure Incorporated Sky Thuraya Transfinite

A1.5 Our consultation asked the three questions provided below.

Question 1: Do you agree with our assessment that minimal growth in demand and stability in spectrum supply means that we do not need to implement any changes to meet the ongoing requirements for talkback, audio links and telemetry and telecommand applications?

Question 2: Do you agree with our sharing analysis which concludes that audio PMSE (low power microphones and IEMs) could co-exist with incumbent services in the bands 960-1164 MHz and 1525-1559 MHz?

Question 3: Do you have any comments on our proposal to allow low power audio PMSE applications (wireless microphones and IEMs) access to the 960-1164 MHz band?

A1.6 Some stakeholders provided direct response to the questions while others provided a more general narrative. Our comments provided in Table A1.1, therefore, addresses the themes raised rather being directed at the specific questions. The CAA has reviewed stakeholder comments and contributed responses. These are presented in italicised text.

Table A1.1: Summary of stakeholder comments and our response

Stakeholder	Summary of comment	Our response (CAA response in italicised text)
BBC BEIRG CCC Sennheiser Shure Inc Sky	<u>Utility of the 960 – 1164 MHz band</u> Stakeholders expressed concerns that the interference potential from incumbent aeronautical systems in the band is unpredictable and therefore creates a barrier to coexistence. For example Shure states that more theoretical and practical study is necessary to confirm the actual utility of this band and the BBC raise concerns about sharing with incumbent radar systems which raise the risk of interference to PMSE users. Stakeholders indicated that further work needs to take place in order to fully assess coexistence and provide confidence to the PMSE sector on the band's utility. Shure's response included a reference to channel counts suggesting that initial projection of 50-55 available channels for audio PMSE would not be sufficient supplemental spectrum	We recognise the complexity in sharing in the 960 – 1164 MHz band but we are confident that we can meet the frequency management requirements and provide a clear authorisation process. We are confident that in the evidence presented that the band is usable by PMSE but have committed to work with stakeholders to develop their understanding of the new spectrum environment and how it can be successfully exploited. To demonstrate our findings we will be holding a stakeholder workshop in due course and have undertaken spectrum monitoring of aeronautical signal levels at the Cambridge Theatre and Seven Dials, London to provide additional data for the workshop. When referring to the DME band channels are considered to be 1 MHz wide. In response to Shure's comment on channel count, the spectrum referenced relates to 1 MHz DME channels and not PMSE channels, i.e. 50 channels means 50 × 1 MHz. Even in

	for PMSE. Also Sky noted confusion over the term “channel”.	circumstances where PMSE would need to move away from the DME centre frequency this should still allow two PMSE channels per MHz.
BBC BEIRG CCC DFS EASA EUROCONTROL NATS	<u>Introduction of new aeronautical systems</u> Stakeholders commented on the potential for new aeronautical systems to be introduced in the 960 – 1164 MHz band, with NATS suggesting that 60 MHz is required for a digital communications system (LDACS – L Band Digital Communication System). EASA commented on the possible use of the band for a control link for remotely piloted aircraft systems (RPAS) but noted that this has not been further defined.	We have contacted the design authority for LDACS and provide our response in Section 3. In relation to RPAS we have not seen any credible indication that these systems will operate in this band (although there may be a requirement for GNSS positioning above 1164 MHz). Beyond the introduction of LDACS (expected around 2025) the spectrum environment should remain stable. Ofcom will continue to engage with the CAA and Ofcom to ensure the continued relevance and efficacy of the frequency management rules for PMSE as the aeronautical use of this frequency band evolves.
BEIRG CCC Inmarsat MCA Sennheiser Shure Inc Thuraya	<u>Access to the 1525 – 1559 MHz band (MSS band)</u> Stakeholders noted our proposal to only consider PMSE sharing in the 960 – 1164 MHz band. PMSE stakeholders questioned why, if we considered that PMSE sharing was viable in the band, did we not make this available, stating that sharing would be less complex and more suitable for PMSE as the risk of interference into	We do not think the MSS band performs as well against our criteria as the aeronautical band, specifically around long term security. Although we did not identify any new services the band is commercially deployed and changes could occur rapidly. In the aeronautical band changes occur more slowly and our view is this stable environment provides the best

Transfinite	PMSE is lower than in the aeronautical band. BEIRG referenced the Lamy Report which states that "…PMSE users are left no worse or no better off than they would have been without any clearance of the 700 MHz band." On this basis BEIRG asserts that both bands should be made available. Inmarsat and MCA supported this proposal with Inmarsat providing its own coexistence analysis and conclusion that sharing is not possible in the MSS band. Thuraya also objected to PMSE sharing in the MSS band and Transfinite expressed concerns about adjacent channel interference into GNSS above 1559 MHz. Shure suggested allowing sharing lower in the band, e.g. below 1540 MHz.	spectrum resource for PMSE. We believe that access to the aeronautical band provides the spectrum needed to support the sector and enable the same extent and quality of productions enjoyed today. We disagree with some of the assumptions made, and conclusions of the analysis by Inmarsat such as the interference threshold and modelling approach. Our consultation we acknowledged there is a risk of interference into MSS terminals but our view on coexistence was that the profile and density of use of PMSE and MSS means this risk is acceptably low. Responses from the MSS sector did not address this or provide evidence that density of MSS use is higher than assumed. Stakeholder assessment of adjacent channel interference into GNSS above 1559 MHz assumed a GNSS receiver filter response which suggested a required guard band of between 30 – 45 MHz. We do not think the assumptions of GNSS receiver performance are representative and consequently the risk of adjacent channel interference is lower than that presented. However, it is likely that some level of guard band would be required. We discuss this further in Section 3.
BEIRG CCC	<u>International engagement and harmonisation</u> Stakeholders argued that for successful utilisation of the band international	In looking at alternative sharing options for PMSE we can only secure a spectrum solution for the UK but we

Sennheiser Shure Inc Sky	harmonisation is needed. For example, BEIRG and Sennheiser both comment that a UK only solution is a major concern for PMSE manufacturers and Shure encourages Ofcom to enter into direct conversations with other spectrum administrations about use of this band. Sky notes that manufacturers are likely to require economies of scale across a number of markets in order to commit to developing new equipment and therefore greater European harmonisation is crucial. BEIRG and Sennhesier note that having access to both bands would mitigate the single market worry. Shure also suggests the 1435 – 1525 MHz band should be considered for sharing with PMSE as the United States has already created service rules for wireless microphone use in this band.	understand the desire to have wider adoption. The opportunity for harmonisation was one of the factors in determining the proposed band and we have engaged with other administrations in raising awareness of UK plans. We will share our analysis and conclusions with other administrations. However, we cannot guarantee nor be responsible for securing a harmonised solution. We note that other spectrum options, such as the 1350 – 1400 MHz band and the 1435 – 1525 MHz band made available in the United States are also not harmonised solutions. We do not see that making both bands available would resolve the single market worry. Our view is that this could lead to a more fragmented market if different countries supported different bands. We did initially include the 1.4GHz band in our review of spectrum options. However, the band 1452 – 1492 MHz is now subject to a European Harmonising Decision to make the band available for mobile supplemental downlink. In addition the band 1492 – 1518 MHz has been identified as a future mobile allocation. Consequently the 1.4 GHz band does not meet our criterion for long term security of access and was therefore excluded from further analysis and proposals.
BEIRG BBC	<u>Timing of 700 MHz clearance, PMSE funding and remaining UHF interleaved spectrum</u> Stakeholders commented on the timing of clearance of the 700 MHz band and the	The consultation addresses our assessment of coexistence for low power audio PMSE in the

CCC Sennheiser Sky	timescales for bringing equipment in the 960 – 1164 MHz band to market. For example the BBC notes that procurement and deployment of new equipment to operate in alternative spectrum bands is not something that can be implemented in a short time frame without major capital investment. Replacement should ideally be completed before spectrum is required to be released. If 960 MHz equipment is not available by this time, work may be necessary to determine how audio PMSE demand can be met in the interim period. BEIRG, Sky and others commented on the requirement for funding to assist PMSE users affected by the clearance of the 700 MHz band with equipment replacement costs. BEIRG suggested funding made available to the PMSE sector would encourage manufacturers to consider a UK only market more favourably. BEIRG and Sennheiser suggested that in order to judge the viability of the aeronautical band PMSE users would need to know what the white space landscape will look like after the 700 MHz clearance and the DTT re-plan Sky commented that Ofcom should incentivise the DTT platform to seek greater spectrum	aeronautical and MSS bands and therefore comments on timing of clearance, funding and the configuration of the DTT network are outside the scope of this work. Ofcom will soon publish a consultation which will discuss the timing of clearance of the 700 MHz band In relation to the re-plan of DTT and configuration of interleaved spectrum work is ongoing with our international neighbours to coordinate mutually agreeable DTT network plans. It is expected to finalise the main station frequency plan by the end of March 2016 and remaining relays by mid-2017. We will keep PMSE stakeholders updated but highlight that channel plans are subject to change until formal agreement and some work remains confidential. In response to Sky's comment on incentivising the DTT platform to seek greater spectrum efficiency we

	efficiency adding that a more efficient DTT platform would go some way to alleviating the impact on PMSE. In addition Sky noted that any cleared 700 MHz spectrum continued to be made available through a geo location database until such time as it is deployed for mobile services.	address this question in our discussion document on the future of free to view TV published in May 2014[16]. Any interleaved spectrum within the 700 MHz band which is not being used for broadcasting will continue to be available to interleaved users until such time the spectrum is released for mobile.
BEIRG Shure Inc	<u>New spectrum should not be considered a replacement for the UHF TV band</u> BEIRG and Shure both argued that the new spectrum should be considered as a supplement to, and not a replacement of, the UHF frequencies (470-694 MHz).	We have previously stated that we expect DTT to continue in the 470 – 694 MHz band until at least 2030 and this remains our position
BEIRG Sennheiser	<u>Consideration of Resolution ITU-R 59</u> BEIRG and Sennheiser both asked whether we have considered supporting the introduction of the new spectrum bands into Res.59.	We do not believe it is appropriate at this time to engage at ITU-R on access to the 960 – 1164 MHz band for PMSE. We understand that a harmonised approach is beneficial in creating a larger market and benefits of economies of scale. We have already engaged with other administrations and shared our thinking on alternative bands for audio PMSE. The European Commission has also expressed interest in our work
EUROCONTROL Humberside International	<u>Use of the 960 – 1164 MHz band by JTIDS</u> EUROCONTROL suggested that our statement on the use profile of JTIDS does not reflect	We disagree with EUROCONTROL's suggestion that the use profile of JTIDS does not reflect reality. As we

[16] http://stakeholders.ofcom.org.uk/binaries/consultations/700MHz/discussion/ftv.pdf

Airport Ltd Sky	reality and that the frequency coordination agreement between the UK CAA and MOD cannot be generalised to other countries.	noted in our consultation the nature of the JTIDS signal is such that technical coordination is not possible which does constitute a risk of interference to PMSE with the greatest risk potential being from airborne transmissions. The MOD has stated that typical use is above 10,000 feet in remote area. The Frequency Clearance Agreement between the CAA and MOD restricts use of JTIDS near aircraft and ground navigation facilities and there is protected airspace, such as around airports and major flight lanes, within which the use of JTIDS is further restricted.
	Sky expressed concern that the use of JTIDS does not provide the level of certainty over protection from interference.	We believe that the limits on JTIDS use reduce the risk of interference into PMSE to an acceptable level. In addition, as the interference is airborne, we think PMSE users can take action to further reduce this risk. We agree that the coordination between other countries' aviation authorities and military departments will be different to that of the UK and we made no suggestion in our consultation to suggest that it would be otherwise.
	Humberside International Airport Ltd suggested that there may be an operational requirement for JTIDS to be used in the presence of civilian aviation if there was a major incident and that PMSE demand could increase as news agencies deployed.	We do not consider Humberside International Airport's scenario as being likely.

Shure Inc	<u>Discussions with incumbent users of the 960 – 1164 MHz band</u> Shure asked for clarification of our discussions with incumbent user community of the 960 – 1164 MHz band. Shure noted that we identified three “primary” uses of the band and asked that we identify any other no-primary uses.	Throughout the study we have worked together with the CAA, the UK's specialist aviation regulator, and the MOD and both have agreed with the decision to allow PMSE to access the band. The band is allocated to aeronautical radionavigation and communication services and beyond this there are no other primary or secondary uses. Stakeholders, including those from the aeronautical sector, were able to respond to our consultation.
NATS Nominet Shure Inc	<u>Dynamic spectrum management</u> Nominet agreed with our position to open up additional spectrum for PMSE sharing but suggested that access should be managed under a dynamic spectrum sharing framework. NATS and Shure Inc stated that they would not support the use of dynamic access in the band.	Our proposal is to allow sharing of low power audio PMSE applications. We recognise the safety critical nature of the aeronautical band and our proposal is only to allow sharing of low power audio PMSE applications in accordance with the spectrum management rules detailed in Annex 2. These rules have been agreed between Ofcom and the CAA but may be subject to development as more knowledge of coexistence becomes available. We will apply the spectrum management rules set out in this Statement in order to derive spectrum availability for PMSE. Once this is done for any particular location/venue the spectrum map is likely to be stable as changes to the aeronautical navigation network are infrequent.

		As we are only proposing allowing low power audio PMSE in a spectrum environment which is stable, we do not consider it necessary or appropriate to manage access through a dynamic spectrum management framework.
EUROCONTROL IATA NATS	<u>Equipment sample size</u> Stakeholders commented on the number of equipment tested and that this is not a sufficiently large sample. It was argued that the data presented is insufficient to make conclusions on sharing criteria. Comments also identified scanning DME as being a particular technology to be considered and highlighted that this particular technology had not been considered. Stakeholders also highlighted that other aeronautical applications such as TCAS and ADS-B were not tested and that a larger guard band should be considered. EUROCONTROL suggested extending the proposed guard band around the 1030 MHz frequency band to +/- 20 MHz although did not provide any technical justification for this. However, NATS commented that the +/- 10 MHz guard band around 1090 MHz will most likely be satisfactory to protect its receivers but were unable to comment on whether the proposed guard bands are adequate to protect aircraft reception of 1030 MHz or 1090 MHz for SSR, ADS-B or ACAS/TCAS . EUROCONTROL disagreed with our	*The initial practical coexistence study conducted in 2015 tested the same sample of DME receivers previously used and deemed representative in testing for sharing of the band with JTIDS. In addition, since the publication of the audio PMSE consultation, JCSys Ltd has carried out further testing for a different purpose. This additional testing has included testing of two scanning DME interrogators and there is no evidence that scanning DME interrogators are more susceptible to interference than the equipment used in the original work* We therefore consider that the range of DME equipment tested in the original study and subsequently does provide a sufficient representative sample of equipment on which to base appropriate conclusions on spectrum sharing with PMSE as was the case when addressing compatibility with JTIDS. We see no technical rationale to assume other equipment performance would be sufficiently different in operation than the sample tested to require a significant adjustment to the spectrum sharing framework. In relation to SSR, ADS-B and ACAS/TCAS: *In the absence of data points from testing of a fuller*

	assessment that TACAN is sufficiently similar to DME to not require the need to consider it separately.	*set of SSR systems the CAA is content that MOPS performance thresholds can be met through the proposed technical conditions articulated in Ofcom's PMSE frequency management rules.* *In the scenarios assessed, PMSE equipment operating outside an increased +/- 15MHz guard band would not have an impact on current airborne TCAS/ADS-B/SSR equipment operating within the associated MOPS performance thresholds. However, it is recognised that the situation is evolving and that the introduction of aircraft such as RPAS may require the Ofcom PMSE frequency management rules to evolve. Therefore, as is planned, it is essential that the aviation National Frequency Manger (CAA in the UK) and Ofcom continue to review the PMSE planning rules to ensure their relevance and efficacy* We have therefore decided to increase the required guard band for 1030 MHz and 1090 MHz to ± 15 MHz, subject to any further testing which may take place, and is reflected in the spectrum management rules in Annex 2. Future changes to this guard band will be a matter for Ofcom and the CAA and will be reflected in a revision to the spectrum management rules. We disagree with the comment from EUROCONTROL regarding TACAN. The receiver of a TACAN transponder is considered similar to that of a DME and in some cases is the same receiver type. Testing on TACAN's in the past, e.g. German JTIDS testing, have not identified any significant differences to warrant testing TACAN separately. The UK MOD is of the opinion that TACAN is sufficiently comparable to DME

		not to require specific testing.
EUROCONTROL IATA NATS	<u>Test methodology and results</u> Respondents suggested that the practical coexistence testing carried out by JCSys Ltd did not reflect or take account of the 'real world' spectrum environment. Stakeholders also questioned aspects of the methodology such as testing with the DME identification signal switched off and that the test parameters have been used that appear to favour a more positive outcome for PMSE. EUROCONTROL argued that the testing criteria, for example the 70% Beacon Reply Efficiency limit, were not appropriate for this analysis. NATS commented that the 70% figure is not a fixed operating point for DME transponders in isolation without consideration other real world effects on performance. IATA commented that analysis needs to be based on relevant minimum operational performance standards (MOPS) requirements as described in EUROCAE and RTCA standards for DME performance and NATS suggested that the use of minimum operational performance levels is not appropriate in the context of coexistence studies. NATS suggested that although DME channels normally used for test programmes were used it is not possible to determine if these capture the	The practical coexistence studies were conducted in a composite signal environment including the presence of JTIDS signals and overlapping pulses. The DME environment used is based on measurements of the real environment completed by JCSys Ltd and is therefore considered representative of the real spectrum environment. *Due to the nature of the signal environment, no laboratory test, irrespective of fidelity level, will totally reflect the real world environment at all times. However, the testing has set upper limits to interfering signals and the combination of the PMSE signal, JTIDS, multipath and fading effects for example occurring simultaneously at any given point in time are deemed to be highly exceptional cases.* In the practical coexistence study parameters from ICAO Annex 10, Volume 117 were used as the baseline for the testing and there are similar requirements in both the EUROCAE and RTCA standards *Tests were carried out to determine performance against the levels from the MOPS to test the limit of signal levels for sharing systems. Any other scenario will give greater margin against interference.* Consequently we deemed it appropriate to where PMSE begins to affect the DME and this will be at the

[17] International Civil Aviation Authority, International Standards and Recommended Practices, Annex 10 to the Convention on International Civil Aviation, Volume 1, Radio Navigation Aids

	worst case results for compatibility. Comments were received that the false range indication during the test was not sufficiently examined and the mechanisms involved need to be fully understood, although it was recognised that this was not directly related to the possibility of sharing with PMSE.	limit of operation. The DME channels used allow for the influence of Link-16 channels on either side of the DME channels and are also Link-16 co-channels. Effectively these are worst case DME channels for interference affects. *In relation to false range indications further testing has been carried out to understand this phenomenon. The mechanism varies between receivers but signal levels causing false ranges have been established and the spectrum management rules have been derived to avoid these particular signal level conditions occurring.* We are content that the test methodology and test criteria sufficiently reflect the real world spectrum environment and appropriately reflect the operational characteristics and protection requirements of the incumbent aeronautical services. The CAA supported the study and is satisfied with the conclusions and their adoption in the spectrum management rules
EASA EUROCONTROL IATA NATS	<u>Aircraft operate outside the DOC and scanning DME</u> Stakeholders disagreed with our proposal to only consider protecting aircraft within the published DOC. For example EUROCONTROL noted aircraft may interrogate DME facilities well outside of DOC, especially when used for Area Navigation (RNAV). Further they suggested the avionics have no way to know the DOC of a DME, and DME use often extends to 200 NM. NATS stated that aircraft systems such as scanning interrogators interrogate DME transponders outside their DOCs and that this	*While aircraft may interrogate a transponder and receive replies outside of the assigned DOC the standard aeronautical frequency management process only guarantees protection of the service within the boundaries of the DOC. The integrity of the system cannot be assured outside of this and DME frequencies are protected globally on this basis.* We disagree with EUROCONTROL's statement that avionics does not know the DOC of a DME facility. Flight Management Systems (FMS) utilise information

	may be a standard operating procedure in some cases. IATA noted that aircraft uses multiple DME interrogators to interrogate multiple DME ground stations. The distance information derived from these multiple DMEs is used by the aircraft's Flight Management System to determine its position	on navigation aids provided from an on-board navigation database. Information on navigation aids, including DME, is coded under the ARINC 424 Navigation System Data Base Standard, the international standard file format for aircraft navigation data. An integer value known as the "Figure of Merit" is used to specify VHF NAVAID facility usable ranges. Within the spectrum management rules DOC ranges will be set according the Figure of Merit. Further details are provided in Section 3. *Advice sought from Boeing and Airbus indicates that RNAV systems deployed in the FMS of current and future fleets drive the scanning DME systems in Directed Scan mode only i.e. under the control of the navigation database. There are no foreseeable plans for use of Free Scan mode, thereby allowing only the DME channels likely to be interrogated at a particular location to be considered in the assessment.* We are confident that our revised approach of assuming the ARINC 'Figure of Merit' ranges will ensure that the airspace volume considered in the spectrum management rules will be that over which the aircraft interrogator can reasonably be expected to operate, including outside published DOCs. The CAA has agreed this approach within the spectrum management rules.
EASA	<u>Access arrangements</u> EASA questioned how PMSE would be authorised to access the spectrum and how practical coordination would be achieved. EASA also raised concerns that this equipment could	The spectrum management rules will be applied by Ofcom to derive spectrum availability at any particular location/venue. PMSE licences will be assigned on a geographical and frequency basis determined by the

	be used onboard aircraft.	frequency management rules for events which are time bound. We do not think use of low power audio PMSE on aircraft is a credible scenario and it is not intended that this use would be authorised. In the very unlikely scenario where this might be needed it would require additional specific coordination arrangement.
NATS	<u>DME ground receiver performance</u> NATS commented that high sensitivity receivers which exceed the Annex 10 sensitivity requirements have been deployed and that the Fernau 2020 is rated to 5000 pulse pairs per second. It also argued that Long Distance Echo Suppression was not considered in the compatibility study therefore a worst case testing scenario has not been used.	As above the equipment tested and the approach is the same as carried out for assessing DME compatibility with Link-16. Improved receiver sensitivity may allow distant aircraft to interrogate the DME facility but if this aircraft is outside the DOC the standard aeronautical frequency management process does not ensure the integrity of the system beyond its published limits. Fernau 2020 operating in Y mode is unable to handle loads in excess of 2700 ppps and therefore the worst case scenario suggested by NATS is simply not possible. In addition real world measurements have shown that loading of this magnitude never occurs. We believe the interference thresholds measured for DME and used in the spectrum management rules to derive appropriate geographical separation distances are sufficient to protect DME ground receivers.
	<u>Maintenance and update of sharing criteria</u> DFS noted that sharing may be possible on a	It is recognised that this band is allocated to

DFS	case by case basis and will require continuous work to establish the sharing criteria as aeronautical system specifications are modified and any decisions made at the present time may have to be revised.	aeronautical safety services and as such engagement will be maintained between the CAA and Ofcom to ensure the continued relevance and efficacy of the frequency management rules for PMSE as the aeronautical use of this frequency band evolves.

Annex 2

Spectrum management rules

Spectrum management rules for low power audio PMSE[18] applications to share with aeronautical systems in the band 960-1164 MHz

Introduction

A2.1 The spectrum management rules are agreed between Ofcom and the CAA. The agreement includes the interference thresholds, protection criteria and modelling approach required to minimise the risk of harmful interference to incumbent aeronautical systems in the 960 – 1164 MHz band. The spectrum management rules do not prescribe limits of operation on aeronautical systems and services.

A2.2 The spectrum management rules are designed to allow PMSE to operate in the band while ensuring a very low risk of harmful interference occurs to the incumbent aeronautical systems. The interference thresholds and modelling approach which make up the spectrum management rules are set such that they should provide at least the level of protection required.

A2.3 It is the role of Ofcom to manage the radio spectrum so as to ensure that it is used in the most efficient and effective way for the overall benefit of the UK. Ofcom's statutory duties for carrying out spectrum functions are set out in the Wireless Telegraphy Act 2006 and the Communications Act 2003 and include having regard for availability and demand for spectrum, efficient and economic use, and a number of other duties.

A2.4 It is Ofcom's responsibility to implement the spectrum management rules set out below to derive spectrum availability in the band 960 – 1164 MHz for PMSE. Under these rules Ofcom will develop a 'spectrum map' for each location/venue which will clearly identify the spectrum that Ofcom can grant licenses for PMSE use. This spectrum map will be subject to change on advice from, and with the agreement of, the CAA, for example as a result of a new or amended DME assignment.

A2.5 Access to the spectrum will be authorised on a coordinated licensed basis which will be location, frequency and time/date specific for that particular assignment. Any unauthorised use is an offence and Ofcom can take enforcement against anyone operating without, or outside the terms of, the appropriate licence.

Interference scenarios

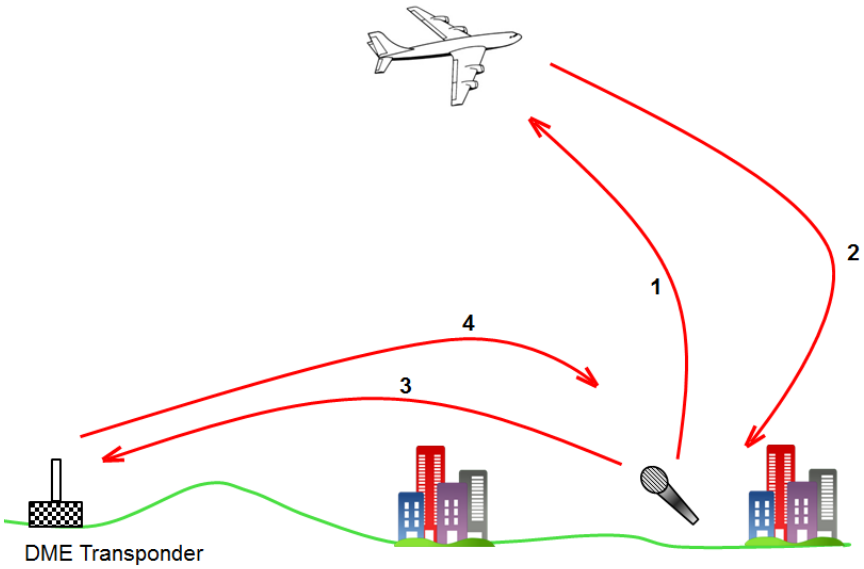
A2.6 There are four interference scenarios (see Figure A2.1):

1. PMSE transmitter to aeronautical airborne receiver
2. Aeronautical airborne transmitter to PMSE receiver
3. PMSE transmitter to aeronautical ground receiver

[18] Programme Making and Special Events

4. Aeronautical ground transmitter to PMSE receiver

Figure A2.1: PMSE/aero Interference scenarios



A2.7 For the purpose of specifying the spectrum management rules this paper only considers the interference scenarios from PMSE into aeronautical systems, i.e. scenarios 1 and 3.

A2.8 The following systems have been standardised for operation in the frequency band 960-1164 MHz and are considered for protection from PMSE:

- ADS-B Automatic Dependent Surveillance – Broadcast (1090 MHz)
- DME Distance Measuring Equipment (960 – 1164 MHz)
- SSR Secondary Surveillance Radar (1030 & 1090 MHz)
- TCAS Traffic alert and Collision Avoidance System (1030 & 1090 MHz)
- WAM Wide Area Multilateration (1030 & 1090 MHz)

A2.9 ICAO is also currently developing standards for LDACS (L-band Digital Aeronautical Communication System) which is currently planned to be implemented after 2025.

A2.10 The PMSE technical parameters used in these spectrum management rules are provided in Table A2.1.

Table A2.1: PMSE parameters

PMSE	
Maximum EIRP (Note 1)	17.0 dBm
Antenna height	1.5 m
Antenna gain	0 dBi

Note 1: This is the regulatory power limit applicable to body worn devices only. Hand held

microphones are limited to 10 dBm. This difference in power limit is to mitigate propagation losses from body absorption and antenna mismatch due to the antenna being close to the body. It is normal practice to consider a factor to account for 'body loss' in any study involving radio equipment in close proximity to the human body, however, for the purpose of developing these spectrum management rules where the potential victim is a safety service no additional loss factor is considered.

SSR, TCAS and ADS-B

A2.11 To protect SSR, TCAS and ADS-B JCSys Ltd recommended a ±10 MHz guard band from 1030 MHz and 1090 MHz. It has been decided that in the absence of sufficient data points from testing a fuller set of SSR and associated systems this guard band is to be extended to ±15 MHz. In addition, to protect ground receive stations for SSR and WAM a 300 m exclusion zone will be implemented.

A2.12 This guard band is subject to review pending any further testing of SSR and associated systems that operate at 1030 MHz and 1090 MHz.

DME

A2.13 The interference thresholds for DME are provided in the JCSys Ltd report "Test Report for the Coexistence of PMSE with Aeronautical Services in the Band 960-1164 MHz." In all cases the most restrictive threshold for each frequency offset is used, providing the most limiting envelope for PMSE licenses. Table A2.2 and Figures A2.2 and A2.3 provide the interference thresholds for DME ground transponders and airborne interrogators.

Table A2.2: DME maximum interference thresholds

Delta F (MHz)	DME Ground transponder maximum interference threshold		DME airborne interrogator maximum interference threshold	
	X-mode Interference threshold (dBm)	Y-mode Interference threshold (dBm)	X-mode Interference threshold (dBm)	Y-mode Interference threshold (dBm)
-8	-56	-50		
-7	-56	-50		
-6	-56	-50	-20	-32
-5	-64	-55	-20	-35
-4	-66	-70	-29	-41
-3	-70	-75	-38	-48
-2	-89	-87	-47	-58
-1	-100	-102	-61	-75
0	-111	-115	-100	-100
1	-100	-100	-61	-69
2	-87	-89	-46	-55
3	-74	-82	-37	-48
4	-60	-77	-29	-40
5	-47	-74	-20	-36
6	-45	-68	-20	-29
7	-45	-63		
8	-45	-63		

Figure A2.2: Transponder interference threshold

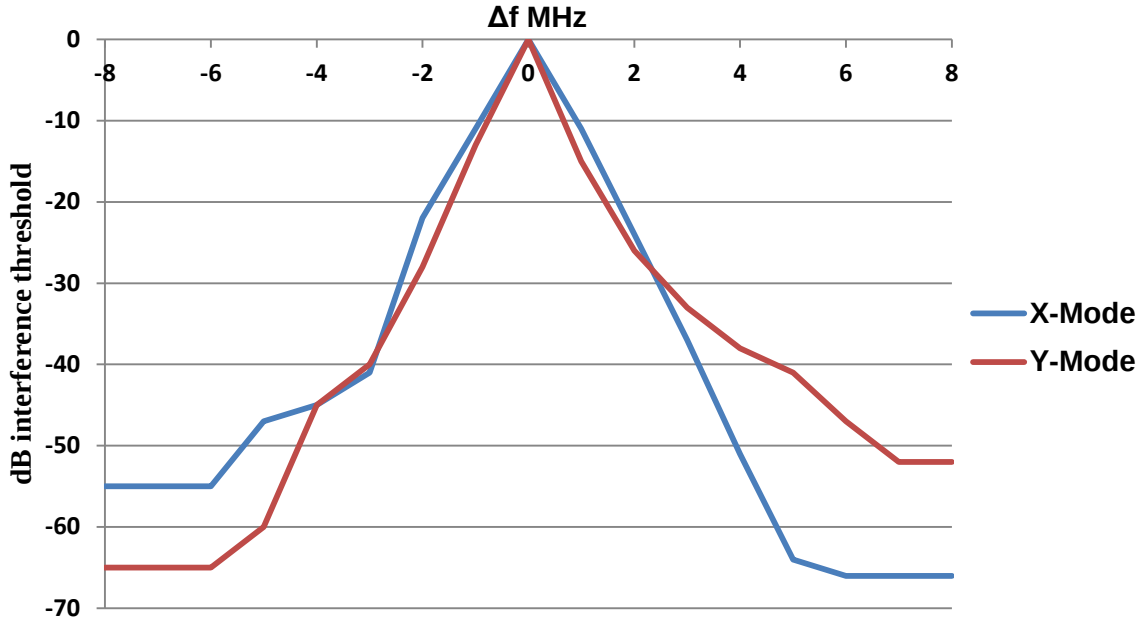
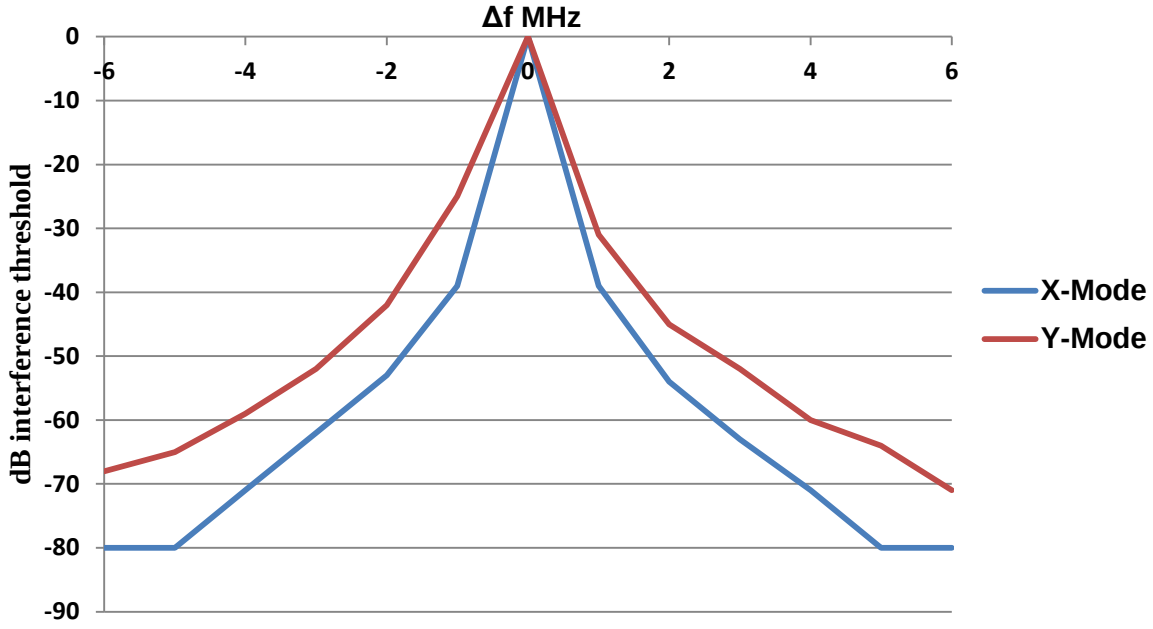


Figure A2.3: Interrogator interference threshold



A2.14 The characteristics of ground and airborne DME terminals applicable to these spectrum management rules are provided in Table A2.3.

Table A2.3: DME parameters

	DME transponder	DME interrogator
Antenna height	10 m	From 328 to 98,425 ft (0.1 to 30 km)
Antenna gain	6 dBi (dB Systems 5100A-D/7 0º to the horizon)	5.4 dBi (maximum) ITU Rec M.1642 (Note 1)
Location/DOC	From AIPs for UK and ICAO COM3 list for Europe	From AIPs for UK and ICAO COM3 list for Europe

Note 1: The antenna pattern provided in Table 1 of Annex 2 of ITU Rec M.1642 is applied for different elevation angles from the PMSE transmitter to airborne receiver.

Designated Operational Coverage (DOC)

A2.15 The DOC of a DME station is provided in Aeronautical Information Publications and recorded in the aeronautical national frequency manager's database, which define the DOC by range and height, e.g. 80 Nautical Miles, 30,000 feet. For the purpose of the spectrum management rules the height of the DOC is fixed at 100 m to 30,000 m with the range adjusted according to published data. However, Flight Management Systems are usually under control of a navigation database where the information on navigation aids, including DME, is coded under the ARINC 424 Navigation System Data Base Standard, the international standard file format for aircraft navigation data.

A2.16 An integer value is used within the navigation file to define the DOC of a DME station. This value is known as the “Figure of Merit” and is used to specify VHF NAVAID facility usable ranges. It is also used to specify when a VHF NAVAID contained in the database is not available for operational use, e.g. is out of service and to flag a VHF NAVAID that is not included in a civilian international NOTAM system. Table A2.4 provides the FOM classifications.

Table A2.4: Figure of Merit used to define DME DOCs in navigation databases

Field Content	Description
0	Terminal Use (generally within 25NM / 46.3 km)
1	Low Altitude Use (generally within 40NM / 74.08 km)
2	High Altitude Use (generally within 130NM / 240.76 km)
3	Extended High Altitude Use (generally beyond 130NM / 240.76 km)
7	NAVAID not included in a civil international NOTAM system
9	NAVAID Out of Service

A2.17 In order to provide protection in all air volumes where aircraft may be using a DME, where the published range does not match a range in Table A2.4 the next largest range is adopted. For example, any DOC range between 41 NM and 129 NM is extended to 130 NM. In the event that the published DOC is larger than 130 NM the published DOC range is used.

Radio planning assumptions

A2.18 The approach for deriving the spectrum management rules for each scenario is different. For scenario 1 (PMSE transmitter to aeronautical airborne receiver) IF77 (from which are derived the curves in ITU-R Recommendation P.528) is applied and for scenario 3 (PMSE transmitter to aeronautical ground receiver) ITU-R Recommendation P.452 is applied. The parameter values used in the modelling are provided in Table A2.5.

Table A2.5: Modelling parameters

	IF77 (airborne scenario)	ITU-R Recommendation P.452 (terrestrial scenario)
Percentage time	1%	1%
Percentage location	50%	50%
Clutter loss (Urban)	n/a	22.9 dB (Note 1)
Clutter loss (Rural)	n/a	17.9 dB (Note 1)
Building entry loss	0 dB	11 dB
Terrain path profile	n/a	Applied

Note 1: Clutter loss is only applied for interference scenario 3 at the PMSE end on the assumption that the DME transponder is generally free of clutter. These values are taken from the propagation model ITU-R Recommendation P.1812, because these are appropriate to a point-to-area model rather than the clutter shielding model in P.452 which is appropriate to cases where clutter is modelled specifically to provide protection from interference.

Methodology

A2.19 For Scenario 3 the approach is as follows:

- Calculate the geographical separation distance (DG_{km}) present between the DME ground station and the PMSE location (using the great circle distance) for all DME ground stations within 500 km of the PMSE location.
- Derive the signal level from PMSE at each DME ground station using the parameters in Tables A2.1, A2.3 and A2.5 as applicable (in this scenario using ITU-R Recommendation P.452).
- Test the derived signal level against the co- and adjacent channel thresholds relevant to the appropriate X or Y mode detailed in Table A2.2.
- In geographic locations where the interference threshold is exceeded the channel is excluded.

Example 1

Venue	**Location Latitude**	**Location Longitude**	**Clutter**	**Indoor/outdoor**
Seven Dials, London	51.51383º	-0.127374º	Urban (22.9 dB)	Indoor (11 dB)
DME name	**DME Latitude**	**DME Longitude**	**Ground transponder receive freq (MHz)**	**Distance DG_{km} (km)**

Barkway	51.98333 º	0.06667 º	1133 (109Y)	53.9
London City	51.5 º	0.05 º	1072 (48Y)	12.4
Clacton	51.85 º	1.15 º	1116 (92Y)	95.7
: :	: :	: :	: :	: :
Berry Head	50.4 º	-3.5 º	1081 (57Y)	266.7

A2.20 For scenario 1 the approach is as follows:

- Assume aircraft can operate anywhere within the DOC[19] from 100 m to 30,000 m height regardless of distance from the ground beacon.
- Calculate location of PMSE with respect to the DOC – Subtract DOC range from distance between venue and DME ground transponder i.e. DG_{km} – DOC.
- If value is positive then venue is outside the DOC.
- If value is negative then venue is inside the DOC.
- For venues within the DOC derive the signal level from PMSE at the aircraft using the parameters in Tables A2.1, A2.3 and A2.5 as applicable (in this scenario using IF77). This assumes a minimum vertical separation of 100 m between PMSE and the aircraft.
- For venues outside the DOC derive the signal level from PMSE at the aircraft using the parameters in Tables A2.1, A2.3 and A2.5 as applicable (in this scenario using IF77). Signal level is derived for a range of aircraft heights every 100 m to 30,000 m along the DOC boundary (and incorporates the aircraft antenna pattern) to find the most limiting geometry. This assumes a minimum vertical separation of 100 m between PMSE and the aircraft.
- Test the derived signal level against the co- and adjacent channel thresholds relevant to the appropriate X or Y mode detailed in Table A2.2.
- In geographic locations where the interference threshold is exceeded the channel is excluded.

Example 2

Venue	**Location Latitude**	**Location Longitude**	**Clutter**	**Indoor/outdoor**	
Seven Dials, London	51.51383º	-0.12737º	Not applicable in the airborne case	Indoor (0 dB)	
DME name	**DME Latitude**	**DME Longitude**	**Air interrogator receive freq (MHz)**	**Distance DG_{km} (km)**	**DOC (km)**
Barkway	51.983 º	0.06667 º	1070 (109Y)	53.9	74.08 (FOM 1)
London City	51.5 º	0.05 º	1135 (48Y)	12.4	46.3 (FOM 0)

[19] This is the adjusted DOC range in accordance with the ARINC 424 Figure of Merit – see Table A2.4

Clacton	51.85 º	1.15 º	1053 (92Y)	95.7	277.8 (> FOM 3)
: :	: :	: :	: :	: :	: :
Berry Head	50.4 º	-3.5 º	1144 (57Y)	266.7	296.32 (>FOM 3)

Example 3

Venue	**Location Latitude**	**Location Longitude**	**Clutter**	**Indoor/outdoor**	
Seven Dials, London	51.51383º	-0.127374º	Not applicable in the airborne case	Indoor (0 dB)	
DME name	**DME Latitude**	**DME Longitude**	**Air interrogator receive freq (MHz)**	**Distance DG_{km} (km)**	**DOC (km)**
Southampton	50.95 º	-1.35 º	1131(44Y)	105.7	46.3 (FOM 0)

A2.21 In the above example the most limiting geometry is calculated to the boundary of the DOC at 59.4 km from the PMSE venue (from DG_{km} – DOC). Any channels that exceed the interference thresholds, including adjacent channel at ± 6 MHz, are excluded at a given location.

A2.22 Spectrum availability for PMSE in the band 960 – 1164 MHz is that remaining after excluded DME channels have been accounted for.

Enforcement and monitoring

A2.23 Ofcom provides both information and practical assistance in identifying sources of harmful interference and seek to resolve the interference and avoid its recurrence. We do so at a level that is consistent with our statutory duties. In providing this service we have discretion as to the means by which we do so, provided that it is exercised reasonably.

A2.24 The Wireless Telegraphy Act 2006 ('WTA') provides for investigation and enforcement action in instances of unlicensed use of wireless telegraphy apparatus or use of wireless telegraphy apparatus operating outside the terms, provisions or limitation of a licence or licence exemption regulations.

In determining the level of service we provide to complaints of harmful interference Ofcom does not distinguish between individual stakeholders or stakeholder groups, we prioritise our response by assessing the impact. To support this we operate a 24/7 Spectrum Management Centre where all interference complaints are reported and will deploy a field engineer as required.

A2.25 Ofcom does not routinely monitor spectrum but does attend a number of PMSE events every year to provide frequency management support and spectrum monitoring to ensure licensees are operating in accordance with their licence. Ofcom's powers allow for enforcement action to be taken against any licensee operating in breach of their licence.

A2.26 Where Ofcom is present at an event the band 960 – 1164 MHz can be monitored to ensure no unauthorised transmissions are taking place.