Preliminary investigations on regulatory and legal issues on the feasibility of introducing low power audio PMSE[[1]](#footnote-2) in the band 960-1164 MHz

approved DD Month YYYY (Arial 9)

ECC Report <No>

# Executive summary

At its 86th meeting, WG FM tasked FM PT51 to carry out a preliminary investigation on the regulatory and legal issues of introducing low power audio PMSE (wireless microphones and in ear monitors operating with a radiated power of less than 50 mW). This Report addresses various regulatory and legal issues with regard to the feasibility of introducing audio PMSE in the frequency band 960-1164 MHz.

Within the International Telecommunication Union (ITU) Radio Regulations (RRs) the frequency band 960-1164 MHz is allocated to the Aeronautical Radionavigation Service (ARNS), Aeronautical Mobile (Route) Service AM(R)S and in part to the Aeronautical Mobile-Satellite (Route) Service (AMS(R)S) (Earth-to-space). In addition, the frequency band is shared with Link16, a military datalink and communications system and Radiolocation Systems for Short Range Navigation (RSBN), a military short-range navigation system. In addition to the Aeronautical Radionavigation Service (ARNS), the adjacent band 1164-1215 MHz is also used by the radionavigation satellite service (RNSS).

Article 4.4[[2]](#footnote-3) of the RRs provides the regulatory mechanism by which administrations could authorise PMSE within the frequency band 960-1164 MHz. However, should administrations allow access to the frequency band for PMSE then they need to ensure compliance with the provisions on Article 4.10[[3]](#footnote-4) of the RRs (as is the case for Link16 operating in the band).

<http://www.icao.int/publications/Pages/doc7300.aspx>The ICAO Convention (Chicago Convention) [1] obliges States to undertake or adopt measures to ensure the safety of overflying aircraft. ICAO Annex 10 includes standards and recommended practices which require aircraft and aeronautical service providers on the ground to operate certain ICAO standardised equipment for Communication, Navigation and Surveillance (CNS).

As per the provisions contained in ICAO Annex 19, “Safety Management” each State, as part of its state safety programme, shall ensure that service providers under its authority implement a safety management system. As part of the safety management system a service provider needs to develop a safety case for each of the systems it operates including the necessary hazard identification and risk management processes[[4]](#footnote-5).

Safety cases are required as means to support aircraft operations by structuring and documenting the demonstration of the safety of air traffic management services and systems. The introduction of a new system in the band 960-1164 MHz would change the RF environment thus invoking the requirement to reviewing the safety cases. The safety risk assessment developed by the aeronautical service provider will need to demonstrate that an equivalent level of safety or an alternative acceptable means of compliance can be achieved.

Safety cases do not only take account of the technical environment, but also of human factor issues. If a new system such as PMSE were to be introduced in an aeronautical frequency band, the safety case analysis would need to take a number of additional factors into account, such as PMSE users not respecting their license conditions (intentional or unintentional wrong frequency selection, wrong location etc.). Similarly, the safety risk assessment would need to address the potential of PMSE equipment not meeting its specifications.

This Report identifies a number of regulatory issues which may affect the feasibility of audio PMSE sharing in the band. It also notes a number of risks and areas of concern that administrations should be aware of. Introducing a new non-aeronautical system in the 960-1164 MHz band without following an appropriate process, including safety assessment and validation, could impact the efficient use of spectrum designated for aeronautical use, and in the worst case cause safety issues. The Report also identifies possible effects of potential harmful interference from PMSE on aeronautical systems and aircraft, including some elements addressing potential costs.

The potential for effectively sharing in the band depends on two conditions, firstly providing adequate protection to incumbent systems, and secondly the spectrum providing sufficient quality for PMSE to operate. A second order consideration is the quantity of spectrum that would be available for use by PMSE, as a small amount would not be operationally or economically viable.

Provided that international radio regulatory and aeronautical safety obligations are met, the introduction of low power audio PMSE in the band 960-1164 MHz is a sovereign decision on the designation of spectrum under the full liability of the state. Such a decision would involve agreement between the national spectrum regulator, the national aviation authorities, ANSPs and Defence.

Testing and trials of PMSE operation in the 960-1164 MHz band has been carried out in the UK since July 2016 by PMSE stakeholders.

TABLE OF CONTENTS

[0 Executive summary 2](#_Toc6479445)

[1 Introduction 9](#_Toc6479446)

[2 Regulatory and operational responsibility of relevant institutions 11](#_Toc6479447)

[2.1 International Telecommunication Union (ITU) 11](#_Toc6479448)

[**2.1.1** **Constitution and Convention** 11](#_Toc6479449)

[**2.1.2** **ITU Radio Regulations** 11](#_Toc6479450)

[2.2 International Civil Aviation Organization (ICAO) 12](#_Toc6479451)

[**2.2.1** **ICAO Standards and Recommended Practices (SARPs)** 12](#_Toc6479452)

[**2.2.2** **SARPs for Radiocommunication and Radionavigation systems** 13](#_Toc6479453)

[**2.2.3** **SARPs for Safety Management** 13](#_Toc6479454)

[**2.2.4** **"No Country left behind" initiative** 13](#_Toc6479455)

[2.3 European Conference of Postal and Telecommunications administrations (CEPT) 13](#_Toc6479456)

[2.4 National regulatory status in CEPT 14](#_Toc6479457)

[2.5 Other organisations 14](#_Toc6479458)

[**2.5.1** **European Union (EU)** 14](#_Toc6479459)

[2.5.1.1 Single European Sky (SES) 14](#_Toc6479460)

[2.5.1.2 European Aviation Safety Agency (EASA) 16](#_Toc6479461)

[2.5.1.3 Single European Sky ATM Research (SESAR) 17](#_Toc6479462)

[2.5.1.4 Spectrum needs for other specific Union policies 18](#_Toc6479463)

[**2.5.2** **EUROCONTROL** 18](#_Toc6479464)

[2.5.2.1 Network Manager Directorate 19](#_Toc6479465)

[**2.5.3** **NATO** 20](#_Toc6479466)

[**2.5.4** **International Air Transport Association (IATA)** 21](#_Toc6479467)

[3 Current and future systems and technologies in the frequency band 960-1164 MHz within CEPT 22](#_Toc6479468)

[3.1 Civil radionavigation and communication systems 22](#_Toc6479469)

[3.2 Military radionavigation and communication 24](#_Toc6479470)

[3.3 Evolution of spectrum usage within the 960-1164 MHz band by aeronautical systems 25](#_Toc6479471)

[4 Legal and Regulatory framework applicable to the band 960-1164 MHz 27](#_Toc6479472)

[4.1 Global level 27](#_Toc6479473)

[**4.1.1** **ITU** 27](#_Toc6479474)

[**4.1.2** **ICAO** 27](#_Toc6479475)

[4.1.2.1 Application of International Law for aeronautical safety oversight 29](#_Toc6479476)

[4.2 Regional and National level 30](#_Toc6479477)

[**4.2.1** **European law** 30](#_Toc6479478)

[**4.2.2** **CEPT** 30](#_Toc6479479)

[**4.2.3** **National regulation** 30](#_Toc6479480)

[5 Economic Aspects 32](#_Toc6479481)

[5.1 Economic aspects of air transport 32](#_Toc6479482)

[**5.1.1** **Employment** 32](#_Toc6479483)

[**5.1.2** Economic aspects 32](#_Toc6479484)

[**5.1.3** **SESAR (Single European Sky ATM Research) objectives** 33](#_Toc6479485)

[**5.1.4** **European airline delay cost** 33](#_Toc6479486)

[5.2 PMSE introduction economic impact 34](#_Toc6479487)

[**5.2.1** **Civil aviation side** 34](#_Toc6479488)

[**5.2.2** **Military side** 35](#_Toc6479489)

[5.3 Safety case amendments 35](#_Toc6479490)

[5.4 Spectrum management 36](#_Toc6479491)

[5.5 Economic value of PMSE (example in UK) 36](#_Toc6479492)

[5.6 Economic value of GNSS 37](#_Toc6479493)

[6 Issues related to a potential introduction of PMSE in the band 960-1164 MHz 38](#_Toc6479494)

[6.1 Impact on existing and future aeronautical systems related to introduction of PMSE in the frequency band 960-1164 MHz 38](#_Toc6479495)

[**6.1.1** **Concerns regarding constraints on current and future aeronautical systems operating in the band** 38](#_Toc6479496)

[**6.1.2** **Safety considerations** 39](#_Toc6479497)

[6.1.2.1 Safety Case 39](#_Toc6479498)

[6.1.2.2 The aeronautical safety assessment in the UK 39](#_Toc6479499)

[6.1.2.3 Flight safety and safety of life 40](#_Toc6479500)

[**6.1.3** **Interference considerations** 41](#_Toc6479501)

[6.1.3.1 A specific case, DME as a component of the Instrument Landing System (ILS) 42](#_Toc6479502)

[6.2 Different approaches to safety and quality management between the aeronautical and PMSE cultures 42](#_Toc6479503)

[6.3 Impact of current and future aeronautical systems on PMSE in the frequency band 960-1164 MHz 44](#_Toc6479504)

[**6.3.1** **Impact of Link 16 on PMSE** 44](#_Toc6479505)

[**6.3.2** **Long-term availability of the 960-1164 MHz frequency band for PMSE** 45](#_Toc6479506)

[6.4 Impact on services in adjacent bands 45](#_Toc6479507)

[ANNEX 1: NATO considerations on the prerequisites for the Introduction of PMSE in the band 960-1164 MHz 46](#_Toc6479508)

[ANNEX 2: Eurocontrol safety considerations 48](#_Toc6479509)

[ANNEX 3: EUROCONTROL Military ATM Board (MAB) on low power audio programme making and special events (PMSE) sharing in the aviation band 960-1164 MHz 50](#_Toc6479510)

[ANNEX 4: UK decision to allow PMSE to share the 960-1164 MHz band summary 52](#_Toc6479511)

[ANNEX 5: Report on Practical PMSE Testing in the UK: June 2016 – March 2019 58](#_Toc6479512)

[ANNEX 6: List of References 60](#_Toc6479513)

LIST OF ABBREVIATIONS

|  |  |
| --- | --- |
| Abbreviation | Explanation |
| ACAS | Airborne Collision Avoidance System |
| ADS-B | Automatic Dependent Surveillance-Broadcast (ADS-B) |
| AIM | Aeronautical Information Management |
| AM(R)S | Aeronautical Mobile (Route) Service |
| AMS(R)S | Aeronautical Mobile-Satellite (Route) Service |
| ANS | Air Navigation Services |
| ANSP | Air Navigation Service Provider |
| APNT | Alternative Position Navigation and Timing |
| ARNS | Aeronautical Radionavigation Service |
| ATAG | Air Transport Action Group |
| ATFCM | Air Traffic Flow and Capacity Management |
| ATM | Air Traffic Management |
| ATSEP | Air traffic safety electronics personnel |
| CAA | Civil Aviation Authority |
| CEPT | European Conference of Postal and Telecommunications Administrations |
| CMA | Continuous Monitoring Approach |
| CNPC | Control and Non-Payload Communications |
| CNS | Communication, Navigation and Surveillance |
| CRCO | Central Route Charges Office |
| CS | ITU Constitution |
| DME | Distance Measuring Equipment |
| EASA | European Aviation Safety Agency |
| ECA | European Common Allocation table |
| EC | European Commission |
| ECC | Electronic Communications Committee |
| EFIS | ECO Frequency Information System |
| EME | ElectroMagnetic Environment |
| ESARR | European SAfety Regulatory Requirement |
| EU | European Union |
| EUR | Euros (€) |
| EUROCAE | EURopean Organisation for Civil Aviation Equipment |
| EUROCONTROL | European Organisation for the Safety of Air Navigation |
| FABEC | Functional Airspace Block Europe Central |
| FABs | Functional Airspace Blocks |
| FCA | Frequency Clearance Agreement |
| FIS-B | Flight Information Service - Broadcast |
| GANP | Global Air Navigation Plan |
| GBP | Pound sterling (£) |
| GND | Ground |
| GNSS | Global Navigation Satellite System |
| GPS | Global Positioning System |
| HF | High Frequency |
| HLA | High Level Agreement |
| IATA | International Air Transport Association |
| ICAO | International Civil Aviation Organisation |
| IFF | Identification Friend or Foe |
| ILS | Instrument Landing System |
| INS | inertial navigation system |
| IOSA | IATA Operational Safety Audit |
| ISAGO | IATA Safety Audit for Ground Operations |
| ITU | International Telecommunication Union |
| JTIDS | Joint Tactical Information Distribution System |
| L-DACS | L-band Digital Aeronautical Communication System |
| MAB | Military ATM Board |
| MIDS | Multifunctional Information Distribution System |
| MLAT | Multilateration system |
| MOPS | Minimum Operational Performance Standards |
| MoC | Means of Compliance |
| MoU | Memorandum of Understanding |
| MUAC | Maastricht Upper Area Control Centre |
| NATO | North Atlantic Treaty Organization |
| NJFA | NATO Joint Civil/Military Frequency Agreement |
| NM | Nautical mile |
| NSAs | National Supervisory Authorities |
| PANS | Procedures for Air Navigation Services |
| PBN | Performance Based Navigation |
| PC | Public consultation |
| PMSE | Programme Making and Special Events |
| PSR | Primary Surveillance Radar |
| QMS | Quality management system |
| RF | Radio Frequency |
| RNAV | Requirements for area navigation |
| RNP | Required navigation performance |
| RNSS | Radionavigation satellite service |
| RPAS | Remotely Piloted Aircraft System |
| RR | Radio Regulations |
| RSBN | Radiolocation Systems for Short Range Navigation |
| SAFIRE | Spectrum and Frequency Information Resource |
| SARPs | Standards and Recommended Practices |
| SES | Single European Sky |
| SESAR | European Sky ATM Research |
| SJU | SESAR Joint Undertaking |
| SMS | Safety Management System |
| SSC | Single Sky Committee |
| SSR | Secondary Surveillance Radar |
| TACAN | TACtical Air Navigation |
| TCAS | Traffic Collision Avoidance System |
| TIS | Traffic Information Service |
| UAS | Unmanned Aircraft System |
| UAT | Universal Access Transceiver |
| USD | United States Dollar (USD) |
| USOAP | Universal Safety Oversight Audit Programme |
| VHF | Very High Frequency |
| VOR | VHF Omnidirectional Range |
| WAM | Wide area multilateration |
| WG FM | Working Group Frequency Management |
| WRC | World Radiocommunication Conferences |

# Introduction

At the 86th meeting of WG FM, it was proposed to ask WG SE to carry out compatibility studies between audio PMSE and incumbent systems in the band 960 to 1164 MHz (960 MHz band). WG FM generated a new work item for FM PT51 ([FM51\_10](http://eccwp.cept.org/WI_Detail.aspx?wiid=592)). This work item was separated into two separate requirements:

* Identify and scope out the requirements for compatibility studies (this was completed May 2017);
* Carry out preliminary investigations on the regulatory and legal status of introducing low power audio PMSE into the 960 MHz band.

Further, at the 89th meeting, WG FM agreed the following guidance to FM51:

* the draft report is an internal WG FM document;
* FM51 shall bring the completed report to the May 2018 meeting of WG FM and that no extensions were envisaged;
* WG FM requires presentation of the issues, with balanced positions when there is no agreement;
* WG FM does not expect conclusions, but a short summary of the issues is appropriate;
* the work in FM51 on this work item will be paused at the May 2018 WG FM meeting and resumed again when the outcome of the WG SE studies is available;
* the final deliverable will be an ECC Report with a deadline of May 2020.

Finally, the 49th ECC meeting concluded that ECC intends to adopt in March 2020 (public consultation in July 2019) an ECC Report on CEPT investigations on possible usage of low power audio PMSE in the band 960-1164 MHz. The main body should be prepared by WG FM and should aim to be rather short, including general frequency management considerations. The deliverables from FM and SE should be included as annexes as follows:

* The deliverable prepared by WG SE on the technical studies relating to sharing of low power audio PMSE (excluding airborne use) with aeronautical applications in the frequency band 960-1164 MHz, to be provided to WG FM at its meeting in June 2019. If there is no consensus on the technical analysis, the report will include all technical analyses under discussion. In this case, the conclusion will be limited to presenting the differences between each analysis from a technical perspective;
* The deliverable prepared by WG FM further developing the report on “Preliminary investigations on regulatory and legal issues on the feasibility of introducing low power audio PMSE in the band 960-1164 MHz” for completion by June 2019.

Background

Spectrum availability for audio PMSE in the band 470 to 790 MHz is reducing as a consequence of the decision to allocate the 700 MHz band (694 to 790 MHz) for terrestrial systems capable of providing wireless broadband electronic communications services. Within CEPT, additional spectrum for audio PMSE has been identified and included in ERC Recommendation 25-10 [2].

Testing and trials of PMSE operation in the 960 to 1164 MHz band has been carried out in the UK since July 2016 by PMSE stakeholders in a variety of scenarios. Trials have predominately been indoors within studios, with a limited number of outdoor deployments. In addition, PMSE stakeholders have also carried out spectrum monitoring (from the perspective of interference into PMSE).

Incumbent use

The 960 MHz band is used by a number of aeronautical safety and regularity of flight systems, for both civil and military purposes, to provide Communications, Navigation and Surveillance (CNS) which require an appropriate coordination between all of them.

The main use of the band is for Distance Measuring Equipment (DME). This is an interrogator (airborne) / transponder (ground based) system which provides an aircraft with its slant range from the ground transponder. The aircraft interrogates the ground transponder on a frequency and the transponder replies on a separate frequency separated by 63 MHz. The military system TACAN is similar in operation to DME but with additional modulation which allows an aircraft to determine its bearing from the transponder as well as its slant range.

In addition to DME there are a number of systems which operate on 1030 and 1090 MHz. Principally this is Secondary Surveillance Radar (SSR) which is also an interrogator/transponder system, however, in this case the interrogator is ground based and transmits on 1030 MHz using a rotating, high gain antenna, and the aircraft responds on 1090 MHz. The radar is then able to determine the range and bearing of the aircraft. Aircraft replies can also include additional data such as aircraft identity, altitude and speed.

In addition to SSR, a number of other systems also utilise 1030 and 1090 MHz such as mutilateration systems and Airborne Collision Avoidance and Traffic Collision Avoidance Systems (ACAS and TCAS). Automatic Dependent Surveillance-Broadcast (ADS-B) provides aircraft identity, aircraft derived position plus other data (this is also receivable in space). The military also use 1030/1090 MHz for Identification Friend or Foe (IFF).

The band 960-1215 MHz is allocated to the Aeronautical Radionavigation Service (ARNS), WRC-07 allocated the 960 to 1164 MHz band to the aeronautical mobile (route) service (AM(R)S) subject to footnote 5.327A ('The use of the band 960-1 164 MHz by the aeronautical mobile (R) service is limited to systems that operate in accordance with recognized international aeronautical standards. Such use shall be in accordance with Resolution 417 (WRC-07)'). WRC-15 revised Res 417 and in the current edition of the Radio Regulations, footnote 5.327A refers to the revised Res 417. The band has been identified for use by L-DACS (L-band Digital Aeronautical Communication System). While not currently operational, standardisation work is underway in ICAO and the system is expected to be introduced in the mid-2020s.

WRC-15 allocated part of the 960-1164 MHz band to the Aeronautical Mobile-Satellite (Route) service (AMS(R)S) (Earth-to-space) in all three ITU Regions.

The adjacent band 1164-1215 MHz is used by the Radionavigation Satellite Service (RNSS) in addition to DME and TACAN. Galileo band E5a (i.e. centre frequency at 1176.45 MHz and receiver reference bandwidth of 20.46 MHz) and GPS band L5 (i.e. 1176.45 MHz with a bandwidth of 12.5 MHz) are immediately adjacent (1164-1189 MHz).

There are other aeronautical systems operating in 960 MHz band, and a full list of incumbent and future systems is provided in section 3.

Regulatory aspects

The 960 MHz band is subject to regulations under a number of regulatory bodies. Some of these relate directly to the spectrum band itself, i.e. the ITU Radio Regulations, and others relate to aeronautical use of the band, i.e., ICAO's responsibility relating to civil aviation Standards and Recommended Practices (SARPs) and policies.

In accordance with current usage of the 960 MHz band, other organisations are involved in the regulatory process. It is important to take into account these regulations if considering introducing audio PMSE into the 960 MHz band.

# Regulatory and operational responsibility of relevant institutions

## International Telecommunication Union (ITU)

### **Constitution and Convention**

The International Telegraph (later Telecommunication) Convention, today the Constitution and Convention of ITU, is the basic treaty that establishes the legal basis for the Union and defines its purpose and structure.

A thoroughly revised Constitution and Convention of the International Telecommunication Union was adopted at the 1992 Additional Plenipotentiary Conference held in Geneva. Subsequent plenipotentiary conferences have adopted only amending instruments to the 1992 documents. The Constitution and Convention currently in force are the Constitution and Convention of the International Telecommunication Union (Geneva, 1992) as amended by subsequent plenipotentiary conferences[[5]](#footnote-6).

The ITU Constitution (CS) states:

* CS Article 40: Priority of Telecommunications Concerning Safety of Life:

191 International telecommunication services must give absolute priority to all telecommunications concerning safety of life at sea, on land, in the air or in outer space, as well as to epidemiological telecommunications of exceptional urgency of the World Health Organization.

* CS No. 1003 (also RR No. 1.169):

1003 Harmful Interference: Interference which endangers the functioning of a radionavigation service or of other safety services or seriously degrades, obstructs or repeatedly interrupts a radiocommunication service operating in accordance with the Radio Regulations.

### **ITU Radio Regulations**

The ITU Radio Regulations (RR) also state:

* ITU RR No. 4.4: Administrations of the Member States shall not assign to a station any frequency in derogation of either the Table of Frequency Allocations in this Chapter or the other provisions of these Regulations, except on the express condition that such a station, when using such a frequency assignment, shall not cause harmful interference to, and shall not claim protection from harmful interference caused by, a station operating in accordance with the provisions of the Constitution, the Convention and these Regulations;
* ITU RR No. 4.10: Member States recognize that the safety aspects of radionavigation and other safety services require special measures to ensure their freedom from harmful interference; it is necessary therefore to take this factor into account in the assignment and use of frequencies;
* ITU RR, Article 43: "Special rules relating to the use of frequencies"

43.1 § 1 Frequencies in any band allocated to the aeronautical mobile (R) service and the aeronautical mobile-satellite (R) service are reserved for communications relating to safety and regularity of flight between any aircraft and those aeronautical stations and aeronautical earth stations primarily concerned with flight along national or international civil air routes.

ITU RR Article 5 (see table 1) states that the band 960-1164 MHz is allocated to the Aeronautical Radionavigation Service (ARNS), Aeronautical Mobile en-Route service AM(R)S and in part to the Aeronautical mobile-satellite en-Route service (AMS(R)S) (Earth-to-space) in all three ITU Regions.

Moreover, the adjacent band 1164-1215 MHz is allocated to the radionavigation-satellite service (RNSS) space-to-Earth) and used by GNSS systems and to the Aeronautical Radionavigation Service (ARNS).

Table 1: RR allocation in the band 960-1164 MHz

|  |  |
| --- | --- |
| Frequency band | RR Allocation to services |
| 960 MHz - 1164 MHz | AERONAUTICAL MOBILE (R) 5.327A  AERONAUTICAL RADIONAVIGATION 5.328  5.328AA |
| 5.327A: The use of the frequency band 960-1 164 MHz by the aeronautical mobile (R) service is limited to systems that operate in accordance with recognized international aeronautical standards. Such use shall be in accordance with Resolution 417 (Rev.WRC-15) (WRC-15)  5.328: The use of the band 960-1 215 MHz by the aeronautical radionavigation service is reserved on a worldwide basis for the operation and development of airborne electronic aids to air navigation and any directly associated ground-based facilities (WRC-2000)  5.328AA: The frequency band 1 087.7-1 092.3 MHz is also allocated to the aeronautical mobile-satellite (R) service (Earth-to-space) on a primary basis, limited to the space station reception of Automatic Dependent Surveillance-Broadcast (ADS-B) emissions from aircraft transmitters that operate in accordance with recognized international aeronautical standards. Stations operating in the aeronautical mobile-satellite (R) service shall not claim protection from stations operating in the aeronautical radionavigation service. Resolution 425 (WRC-15) shall apply (WRC-15) | |

WRC-07[[6]](#footnote-7) has allocated the band 960 to 1164 MHz to the aeronautical mobile (R) service (AM(R)S) in order to make available this frequency band for new AM(R)S systems, and in doing so enabled further technical developments, investments and deployments by the aeronautical sector. This WRC-07 AM(R)S allocation in the band 960-1164 MHz is limited to systems operating in accordance with international aeronautical standards.

This AM(R)S allocation is to support the introduction of applications and concepts in air traffic management supporting safety critical aeronautical communication.

## International Civil Aviation Organization (ICAO)

ICAO is a UN specialized agency, established by States in 1944 to manage the administration and governance of the [Convention on International Civil Aviation](https://www.icao.int/publications/Documents/7300_cons.pdf) [1], also known as the Chicago Convention.

### **ICAO Standards and Recommended Practices (SARPs)**

ICAO works with the Convention’s 192 Member States and industry groups to reach consensus on Standards and Recommended Practices (SARPs) and policies in support of a safe, efficient, secure, economically sustainable and environmentally responsible civil aviation sector.

The SARPs contained in the Annexes to the Convention on International Civil Aviation, constitute the rule of law for international civil aviation. These SARPs and policies, as used by the ICAO Member States, ensure that their national civil aviation operations and regulations conform to global norms, which in turn permits more than 100,000 daily flights in aviation’s global network to operate safely and reliably in every region of the world.

### **SARPs for Radiocommunication and Radionavigation systems**

The SARPs for radiocommunication and radionavigation systems (in aeronautical terms: Communication, Navigation and Surveillance (CNS) systems), as contained in Annex 10 "Aeronautical Telecommunications"[[7]](#footnote-8), are developed in accordance with Article 37 of the ICAO Convention [1] for the purpose of ensuring the safety and regularity of air navigation. In addition to the Radio Regulations, the SARPs and related documents specify interface and performance standards for internationally agreed aeronautical systems to ensure that they meet the specific operational requirements of those aeronautical systems. Several systems used for aeronautical radionavigation and radiocommunication are operated in the band 960-1215 MHz, see section 3 for further details.

### **SARPs for Safety Management**

The SARPs contained in Annex 19 "Safety Management"[[8]](#footnote-9), outline the safety management responsibilities of States, aeronautical service providers and aircraft operators, ensuring preventative action to avoid any issue which would compromise the safety of aeronautical operations. Additional provisions on safety management are provided in ICAO Doc 9859 "Safety Management Manual"[[9]](#footnote-10). Safety Cases are a means of structuring and documenting the demonstration of the safety of air traffic management services and systems as well as aircraft operations. Examples of a requirement for a Safety Case assessment include: Whenever a new system or service is taken into use by an aeronautical operator, e.g. radiocommunication, radionavigation aids or surveillance systems; whenever there may be a significant change to the quality of the service provided by those systems; whenever an aircraft operator starts operating on a new air route or whenever there may be a significant change to operational parameters associated with that air route, such as reduced reliability of radionavigation aids along the air route.

### **"No Country left behind" initiative**

In addition to its core work, ICAO also coordinates assistance and capacity building for States in support of numerous aviation development objectives; produces global plans to coordinate multilateral strategic progress for safety and air navigation; monitors and reports on numerous air transport sector performance metrics; and audits States’ civil aviation oversight capabilities in the areas of safety and security.

## European Conference of Postal and Telecommunications administrations (CEPT)

As refers to EFIS ECA table (see [ERC Report 25](http://www.erodocdb.dk/docs/doc98/official/pdf/ERCRep025.pdf) [3]), the allocation for 960-1164 MHz at CEPT level refers to ITU with additional footnote regarding the harmonisation by NATO in this band.

Table 2: ECA table allocations and applications in the band 960-1164 MHz

|  |  |  |  |
| --- | --- | --- | --- |
| 960-1164 MHz | | | |
| RR (including Region 1) Allocation and RR footnotes applicable to CEPT | European Common Allocation and ECA Footnotes | Applications | Notes |
| AERONAUTICAL MOBILE (R) 5.327A  AERONAUTICAL RADIONAVIGATION 5.328 5.328AA | AERONAUTICAL MOBILE (R) 5.327A  AERONAUTICAL RADIONAVIGATION 5.328  5.328AA ECA36 | Aeronautical military systems  Aeronautical navigation | Military use includes JTIDS/MIDS  Including DME, SSR, TACAN |
| 5.327A: The use of the frequency band 960-1 164 MHz by the aeronautical mobile (R) service is limited to systems that operate in accordance with recognized international aeronautical standards. Such use shall be in accordance with Resolution 417 (Rev.WRC-15). (WRC-15)  5.328: The use of the band 960-1 215 MHz by the aeronautical radionavigation service is reserved on a worldwide basis for the operation and development of airborne electronic aids to air navigation and any directly associated ground-based facilities. (WRC-2000)  5.328AA: The frequency band 1 087.7-1 092.3 MHz is also allocated to the aeronautical mobile-satellite (R) service (Earth-to-space) on a primary basis, limited to the space station reception of Automatic Dependent Surveillance-Broadcast (ADS-B) emissions from aircraft transmitters that operate in accordance with recognized international aeronautical standards. Stations operating in the aeronautical mobile-satellite (R) service shall not claim protection from stations operating in the aeronautical radionavigation service. Resolution 425 (WRC-15) shall apply. (WRC-15)  ECA36: Frequency band, which has been harmonised by NATO and NATO member nations for military use as defined in the NATO Joint Civil/Military Frequency Agreement (NJFA) 2014. Note: A public version of the NJFA 2014 has been provided by NATO and presented to ECC in February 2017. | | | |

## National regulatory status in CEPT

In CEPT countries, the band 960-1164 MHz is allocated to the aeronautical mobile en-Route, aeronautical radionavigation services, and in part to the Aeronautical Mobile satellite en-Route service (Earth-to-space).

One administration has made the decision to make parts of this band available for audio PMSE[[10]](#footnote-11). According to EFIS[[11]](#footnote-12), one administration has made part(s) of this band available for fixed services.

In many CEPT administrations, this frequency band is shared between Civil Aviation and the Military based on national joint agreements and on mutually agreed sharing procedures.

## Other organisations

### **European Union (EU)**

#### Single European Sky (SES)

Within the EU, Single European Sky (SES) legislation (e.g. Commission Implementing Regulations (IR) 1035-2011 [4] and 1034/2011 [5]) is in force[[12]](#footnote-13) and may also have more widespread applicability. This regulatory regime requires that hazard identification as well as risk assessment and mitigation are systematically conducted for any changes to those parts of the Air Traffic Management (ATM) functional system and supporting arrangements within their managerial control by air traffic service providers (ANSPs) before bringing new ATM facilities into use or when changes to existing facilities are foreseen; in the present context such changes to be investigated may include changes to the RF environment.

Since 2004, the European Union (EU) has gained competences in ATM and the decision-making process has moved away from an intergovernmental practice to the EU framework. The EU’s main objective is to reform ATM in Europe in order to cope with sustained air traffic growth and operations under the safest, most cost- and flight-efficient and environmentally friendly conditions. This implies de-fragmenting the European airspace, reducing delays, increasing safety standards and flight efficiency to reduce the aviation environmental footprint, and reducing costs related to service provision. Achievements have already been made at operational, technological and institutional levels; efforts are ongoing to maximise the benefits of activities initiated under the SES framework.

The SES legislative framework consists of four Basic Regulations (N° 549/2004 [7], 550/2004 [8], 551/2004 [9] and 552/2004 [10]) covering the provision of air navigation services (ANS), the organisation and use of airspace and the interoperability of the European Air Traffic Management Network (EATMN). The four Regulations adopted in 2004 (the SES I Package) were revised and extended in 2009 with Regulation (EC) n° 1070/2009 [11] aimed at increasing the overall performance of the air traffic management system in Europe (the SES II Package). On this basis, the Commission adopted and implemented extensive and comprehensive implementing legislation; this framework also includes more than 20 Implementing Rules and Community Specifications ("technical standards") adopted by the European Commission in view of ensuring the interoperability of technologies and systems.

Major developments have been possible due to the extensive involvement of stakeholders from the ATM community: industry partners, air navigation service providers (ANSPs), national supervisory authorities (NSAs[[13]](#footnote-14)), social dialogue with staff unions, airport authorities, the military and the certification authorities, and enhanced cooperation with EUROCONTROL.

The SES framework has been supplemented by an integrated approach towards safety by the extension of the competencies of the EASA in the field of aerodromes, air traffic management and air navigation services, through the establishment of a joint undertaking (JU) on research & development, the SESAR JU (SESAR standing for the Single European Sky ATM Research) and of a SESAR Deployment Manager. A Network Manager for the European ATM network has been created, while an independent Performance Review Body (PRB) supports the Commission in the development and management of the SES performance scheme in which Functional Airspace Blocks (FABs) have a key role to play.

The overall SES objectives will be achieved through a holistic approach that encompasses five interrelated pillars: the performance-based regulatory framework, the safety pillar, the technological contribution, the human factor and the optimisation of airport infrastructure.

The SES does not stop at the border of the European Union. Its extension to third ‘neighbouring’ countries primarily relies on the EU’s policy in the field of international relations. This policy, which gives priority to the association and/or integration of third countries into the EU legal framework, also considers the added value of regional cooperation activities carried out at the level of international organisations, such as the ICAO and EUROCONTROL. EU representatives are active in these organisations to ensure overall consistency between its action in the external field and action undertaken under the aegis of such organisations. Cooperative operational arrangements with ANSPs from key partners of the EU are also being promoted by the Commission as a significant task of the Network Manager in order to better manage intercontinental traffic to/from the EU and improve the performance of the European ATM network.

The Single European Sky (SES) is an ambitious initiative launched by the European Commission in 2004 to reform the architecture of European ATM. It proposes a legislative approach to meet future capacity and safety needs at a European rather than local level.

The key objectives of the SES are:

* To restructure European airspace as a function of air traffic flows;
* To create additional capacity;
* To increase the overall efficiency of the air traffic management system.

In order to fulfil these objectives, the European Commission set the following High-Level Goals:

* Enable a 3-fold increase in capacity which will also reduce delays both on the ground and in the air;
* Improve safety by a factor of 10;
* Enable a 10% reduction in the effects flights have on the environment;
* Provide ATM services to the airspace users at a cost of at least 50% less.

EU Co-operation with EUROCONTROL[[14]](#footnote-15)

The European Commission is working closely together with the European Organisation for the Safety of Air Navigation (EUROCONTROL) to achieve the objectives of the Single European Sky Initiative.

Over the last decade, several elements of the EUROCONTROL regime, such as the charging and performance review and the common air traffic flow management system, have been successfully enhanced under EU law. As a result, EUROCONTROL performs tasks now under the SES legislation. Starting from 2010, the organisation has been charged with four major tasks/roles:

1. technical support to the European Commission and EASA for assisting them in their regulatory actions;
2. the Performance Review Body to assist the Commission in the development and implementation of the performance scheme (designation by the Commission until 2016);
3. the Network Manager for the ATM Network functions;
4. furthermore, EUROCONTROL plays an important role in the SESAR Joint Undertaking's activities as a founding member together with the EU (since 2007).

In December 2012, a High Level Agreement (HLA) was signed which recognises the contribution that each organisation can make to European ATM. The respective roles of the EU as single pan-European regulator and that of EUROCONTROL in technical support of the achievement of the objectives of the SES policy were reaffirmed in this agreement.

The European Union will become a member of EUROCONTROL. Currently the Union’s membership is being implemented on a provisional basis to enable the Union's participation in EUROCONTROL governing bodies. Full membership will be realised when all EUROCONTROL member states have ratified the protocol on the accession of the European Union to the EUROCONTROL convention.

#### European Aviation Safety Agency (EASA)

The European Aviation Safety Agency (EASA)[[15]](#footnote-16) is established under the European Regulation (EC) No. 216/2008 [12] on common rules in the field of civil aviation and establishing a European Aviation Safety Agency in order to:

* ensure the highest common level of safety protection for EU citizens;
* ensure the highest common level of environmental protection;
* establish a single regulatory and certification process among Member States;
* facilitate the internal aviation single market & create a level playing field;
* work with other international aviation organisations & regulators;

EASA undertakes the following activities:

* draft implementing rules in all fields pertinent to the EASA mission;
* certify and approve products and organisations, in fields where EASA has exclusive competence (e.g. airworthiness);
* provide oversight and support to Member States in fields where EASA has shared competence (e.g. Air Operations and Air Traffic Management);
* promote the use of European and worldwide standards;
* cooperate with international actors in order to achieve the highest safety level for EU citizens globally (e.g. EU safety list and Third Country Operators authorisations);

The EU and EASA rules ensure that the flight is safe for passengers and crew, and free from risk of damage to persons and property on the ground. Building on the ICAO regulatory framework, the processes of airworthiness approval, equipment type certification and safety management are described in detail in these rules. As a part of this regulatory process, the radio installations must conform to agreed performance standards, must operate in correct frequency bands, must be licensed by appropriate authorities, and be operated by licensed personnel.

To illustrate the above: The radio in an aircraft requires the assurance of correct functioning after its installation, which includes its performance as a working communications or radionavigation system, as well as its compatibility with other on-board radio and electronic systems. Prior to its installation, the installation must have received approval issued by EASA.

The EASA rules ensure that the flight is safe for passengers and crew, and free from risk of damage to persons and property on the ground. As a part of this regulatory process, the radio installations must conform to agreed performance standards, must operate in correct frequency bands, must be licensed by appropriate authorities, and be operated by licensed personnel.

#### Single European Sky ATM Research (SESAR)

The SESAR Joint Undertaking (SJU) was established under Council Regulation (EC) 219/2007 [13] of 27 February 2007 as modified by Council Regulation (EC) 1361 / 2008 [14] (SJU Regulation) and last amended by the Council Regulation (EU) 721/2014 [15].

As the technological pillar of Europe’s ambitious Single European Sky (SES) initiative, SESAR is the mechanism which coordinates and concentrates all EU research and development (R&D) activities in ATM, pooling together a wealth experts to develop the new generation of ATM. Today, SESAR unites around 3,000 experts in Europe and beyond.

In 2007, the SESAR Joint Undertaking was set up in order to manage this large scale and truly international public-private partnership.

Air traffic management (ATM) is an essential part of European air transport and aviation, connecting cities and people citizens as well as boosting jobs and growth. While unseen and unnoticed by passengers, ATM plays several specific and important roles:

* acts as a guardian of safety;
* connects European cities and Europe with the rest of the world;
* addresses climate change by enabling green and efficient routes;
* maximises current infrastructure while delivering advanced information services;
* acts as a catalyst for Europe’s competitiveness and innovative capacity.

The objective of SESAR is to modernise European ATM by defining, developing and delivering new or improved technologies and procedures (SESAR Solutions).

In order to create the single European sky, on 10 March 2004 the European Parliament and the Council adopted Regulation (EC) No 549/2004 [7] laying down the framework for the creation of the single European sky (the framework Regulation) (1), Regulation (EC) No 550/2004 [8] on the provision of air navigation services in the single European sky (the service provision Regulation) (2), Regulation (EC) No 551/2004 [9] on the organisation and use of the airspace in the single European sky (the airspace Regulation) (3), and Regulation (EC) No 552/2004 [10] on the interoperability of the European Air Traffic Management network (the interoperability Regulation) (4).

The project to modernise air traffic management in Europe, (the SESAR project), is the technological element of the single European sky. It aims by 2020 to give the Community a high-performance air traffic control infrastructure which will enable the safe and environmentally friendly development of air transport, benefiting fully from the technological advances of programmes.

Following the European Community's accession to EUROCONTROL, the Commission and EUROCONTROL have signed a cooperation framework agreement for the implementation of the single European sky and for research and development activities in the field of air traffic control.

The SESAR project includes evaluation of LDACS under SESAR 2020 project (P14.02.01 - FCI Terrestrial Data Link) which is a solution of the PJ14 EECNS[[16]](#footnote-17) (Essential and Efficient CNS). PJ14 EECNS project providing advanced, integrated and rationalised aviation infrastructure for Communication, Navigation and Surveillance (CNS), and providing the underlying technical capabilities to meet the operational improvements described in the European ATM Master plan.

As the technological pillar of the Single European Sky, SESAR (Single European Sky ATM Research) is one of the key contributors with goals through the delivery and deployment of SESAR Solutions with demonstrated and measurable performance benefits. The SESAR performance ambition for 2035 is as follows:

* efficiency and predictability: up to 6% reduction in flight times and up to 30% reduction in departure delays;
* environment: up to 10% reduction in fuel burn and CO2 emissions;
* capacity: a system capable of handling up to 100% more traffic, and up to 10% additional flights landing at congested airports;
* cost-efficiency: up to 40% reduction in air navigation services costs per flight;
* safety: improved by a factor of 3-4 times coping with the expected traffic increase.

#### Spectrum needs for other specific Union policies

Decision No 243/2012/EU [16] of The European Parliament and of the Council of 14 March 2012 established a multiannual radio spectrum policy programme which includes:

Article 8: Spectrum needs for other specific Union policies:

1. Member States and the Commission shall ensure spectrum availability and protect the radio frequencies necessary for monitoring the Earth’s atmosphere and surface, allowing the development and exploitation of space applications and improving transport systems, in particular for the global civil navigation satellite system established under the Galileo programme, for the European Earth monitoring programme (GMES), and for intelligent transport safety and transport management systems.

Galileo is an RNSS system that operates in a range of bands including 1 164 to 1 189 MHz.

### **EUROCONTROL**

EUROCONTROL is an intergovernmental organisation with 41 Member and 2 Comprehensive Agreement States. EUROCONTROL is committed to building, together with its partners, a Single European Sky that will deliver the air traffic management (ATM) performance required for the twenty-first century and beyond.

EUROCONTROL has multiple expertise; covering both operational and technical elements; advising on both civil and military aspects of ATM; having experience at bringing States with different needs together for a common goal.

EUROCONTROL helps its Member States to run safe, efficient and environmentally-friendly air traffic operations throughout the European region. In working together with its partners to deliver a Single European Sky that will help overcome the safety, capacity and performance challenges facing European aviation in the 21st century.

EUROCONTROL supports the European Commission, EASA and National Supervisory Authorities in their regulatory activities.

EUROCONTROL is actively involved in research, development and validation and make a substantial contribution to the SESAR Joint Undertaking aiming to deliver tangible results which will improve the ATM system's performance in the medium-term and in the long-term.

EUROCONTROL has a unique platform for civil-military aviation coordination in Europe.

The single European sky (SES) framework Regulation establishes a harmonised regulatory framework in conjunction with the airspace, service provision and interoperability Regulations and calls for the adoption of implementing rules by the European Commission.

EUROCONTROL develops specifications which can act as Means of Compliance (MoC) to SES regulations. EUROCONTROL also develops guidance material and provides implementation support activities to its stakeholders.

Under the SES framework, the European Commission may develop the implementing rules themselves, but may also issue a mandate to an organisation which is then tasked with implementing rule drafting. EUROCONTROL is one such organisation and has developed numerous draft regulations which were submitted by the EC to the Single Sky Committee (SSC) for its formal opinion.

EUROCONTROL operates a number of stakeholder consultation meetings involving Air Navigation Service Providers (ANSP), regulators, aircraft operator and airport representatives. These forums help shape policy advice for the EU, EASA and ICAO, and are instrumental in setting research priorities and agreeing domain-specific strategies, such as the planned evolution of navigation services to support Air Traffic Management (ATM) improvements. Decisions at forums such as the Navigation Steering Group and its parent CNS Infrastructure team help determine the European ATM Master Plan, consistent with the ICAO Global Air Navigation Plan (GANP).

#### Network Manager Directorate

In its role as the SES Network Manager, it coordinates network management functions relating both to network planning (airspace design) and operations (Air Traffic Flow and Capacity Management (ATFCM), Aeronautical Information Management (AIM)) and also to the coordinated pan-European deployment of operational and technical improvements, including those related to SESAR. It provides support to airport activities; it coordinates safety actions and the management of spectrum, frequencies and scare resources. It also delivers support services to air navigation service providers and FABs (when required) as well as ATM training; finally it monitors the network management contribution to the performance targets of the SES.

The Network Manager has extended the role of the former Central Flow Management Unit and now proactively manages the entire ATM Network (with nearly ten million flights every year), in close liaison with the air navigation service providers, airspace users, the military and airports.

The network functions have been created by the Single European Sky II legislation with the strong support of stakeholders. They are aiming to:

* develop and create Route Network Design;
* organise the management and operations of the functions, including ATFM;
* provide a central function for Frequency Allocation;
* coordinate the improvement of SSR Code Allocation.

The Network Functions Implementing Rule (Commission Regulation (EU) No 677/2011 [17]) lists at Article 4 the tasks to be performed by the Network Manager in relation to the functions listed above. The Network Manager also supports the work of the European Aviation Crisis Coordination Cell, responsible for mitigating events having a negative impact on aviation at network level and to coordinate appropriate responses between Member States; it also contributes to the deployment of SESAR.

The Network Manager, play a vitally important role for the competitiveness of Europe's aviation industry, is a key actor for the operational network performance in the areas of capacity and flight efficiency.

The European Commission’s Single European Sky (SES II) foresaw the creation of a Network Manager as a centralised function. The Network Manager is the operational arm of the SES and manages air traffic management network functions (airspace design, flow management) as well as scarce resources (transponder code allocations, radio frequencies), as defined in Commission Regulation (EU) N° 677/2011 [17].

The European Commission nominated EUROCONTROL as the Network Manager in 2011 (see Commission Decision on 7 July 2011C(2011) 4130 final [18]), with a mandate that runs until the end of the Performance Scheme’s second Reference Period - that is, until 31 December 2019. EUROCONTROL has been undertaking major organisational changes to ensure its re-designation as Network Manager for the period beyond 2019.

The Network Manager addresses performance issues strategically, operationally and technically. Its overarching mission is to contribute to the delivery of air traffic management’s (ATM) performance in the pan-European network in the areas of safety, capacity, environment/flight efficiency and cost-effectiveness.

With the comprehensive picture of the European ATM network and unique in-depth expertise, the Network Manager’s priority is to forge operational partnerships and to foster cooperative decision-making, both of which are needed to achieve the performance targets in a transparent and impartial way.

The European ATM network includes all the European Union’s 28 and EUROCONTROL’s 41 Member States, as well as others which have bilateral agreements with the Network Manager.

Besides the binding legal acts governing the network management functions and tasks of all actors involved, the Network Manager needs to develop the tools to execute those functions and tasks and accomplish the Strategic Objectives as defined in the Network Strategy Plan. Among the contributors are the Network Strategic Projects. They are the main operational and technical evolutions led by the Network Manager. They include network-wide deployment of those technological developments and operational procedures in the course of a Reporting Period.

### **NATO**

The primary role of NATO military forces is to promote peace and to guarantee the territorial integrity, political independence and security of member states. In support of this, NATO use of the radio frequency (RF) spectrum has to be in accordance with ITU Radio Regulations (RR) and also in accordance with NATO military spectrum and frequency doctrine, policies and procedures. Both of these types of governing documents are applicable in times of peace, crisis and war.

The Civil/Military Spectrum Capability Panel (CaP3) is the sole competent source of advice and decisions on the management of the RF spectrum within the Alliance. It works with the NATO Military Committee (MC), the C3 Board (C3B) and the NATO Command Structure (NCS) to satisfy NATO RF spectrum requirements. The CaP3 is composed of representatives from the military and civil spectrum management authorities of NATO member and partner nations, and the Strategic Commands (SCs).

Within NATO the national administrations have agreed to the military use of certain designated frequency bands throughout NATO Europe. This agreement is recorded in the NATO Joint Civil/Military Frequency Agreement (NJFA). The NJFA entries are also reflected in the ECA (ERC Report 25 [3]). In the frequency band 960-1164 MHz, military use includes DME, TACAN, SSR, IFF and also JTIDS/MIDS.

NATO member nations delegated the control of certain frequencies and frequency bands in HF, VHF and UHF ranges to the CaP3, which is supported by the NATO Headquarter C3 Staff / Spectrum & C3 Infrastructure Branch (NHQC3S/SC3IB). The NHQC3S/SC3IB is the supporting staff for the CaP3, and is also the day-to-day staff charged with carrying out the necessary operational work in support of the exercises and operations. In particular, the Staff is dynamically assigning TACAN channels for air/air and deployable land stations. The NATO Maritime Command (MARCOM) is dynamically assigning channels to TACAN maritime stations [26].

### **International Air Transport Association (IATA)**

Founded in 1945, the International Air Transport Association (IATA) is the trade association for the world’s airlines, representing some 284 airlines or 84% of total air traffic. IATA supports many areas of aviation activity and help formulate industry policy on critical aviation issues and is the prime vehicle for inter-airline cooperation in promoting safe, reliable, secure and economical air services - for the benefit of the world's consumers. The modern IATA is the successor to the International Air Traffic Association founded in The Hague in 1919 - the year of the world's first international scheduled services.

Safety and reliability are fundamental to airline operations. The IATA Operational Safety Audit (IOSA) program is an internationally recognized and accepted evaluation system designed to assess the operational management and control systems of an airline. It is the flagship component of a comprehensive strategy that includes audits, cargo, flight operations, infrastructure, training and data collection. IOSA is the global standard for airline safety management that is well recognized by State aviation authorities and government agencies and the IOSA audit creates a standard that is comparable on a world-wide basis. All IATA members are IOSA registered and must remain registered to maintain their IATA membership. Additionally, as of October 2017, 143 (34%) of the 424 airlines on the IOSA Registry are non-IATA member airlines.

The IATA Safety Audit for Ground Operations (ISAGO) is an aviation industry ground service provider registration scheme. It is aimed primarily at establishing safe ground operations and raising cost benefits by, respectively, reducing the risk of aircraft damage and personal injuries and eliminating redundant audits.

# Current and future systems and technologies in the frequency band 960-1164 MHz within CEPT

The frequency band 960-1164 MHz is a globally harmonized radionavigation and communications band which is used intensively, and extensively, to support a number of aviation systems, for both civil and military purposes. It is important to note that these aeronautical systems operate up to 1215 MHz. Moreover, the adjacent band 1164-1215 MHz is allocated to the radionavigation-satellite service (RNSS) (space-to-Earth).

The following tables provide preliminary information on systems designed for use in the band 960-1164 MHz.

It should be noted that some of the uses quoted may extend beyond the band and the lists of systems may not be complete.

## Civil radionavigation and communication systems

Table 3: Civil aeronautical systems currently in use in the band 960 to 1164 MHz

|  |  |  |
| --- | --- | --- |
| System | Frequency (MHz) | Notes/Description |
| Distance Measuring Equipment (DME/TACAN) | 962-1164 Note 1 | Aircraft (interrogator) determines slant range to a ground beacon (transponder) at a known location based on round trip timing of pulses. Aircraft transmits and ground beacon replies on an assigned pair of frequencies separated by 63 MHz both using omnidirectional antennas – for some operational requirements the ground antenna may be directional. Multi-channel interrogators use simultaneous ranging to multiple transponders for the aircraft to determine its location via a multilateration process. DME/TACAN channelisation is across the 960 – 1215 MHz band |
| Secondary Surveillance Radar | 1030 (Gnd Tx, limited Air Tx, Air Rx)  1090 (Air Tx, Gnd Rx, limited Air Rx) | Ground (interrogator) at a known location determines azimuth and slant range of aircraft transponder based on round trip timing of pulses. Ground transmissions on 1030 MHz, using a rotating, high gain antenna; all aircraft reply omnidirectionally on 1090 MHz. Different SSR Modes (A, A/C, S) have different additional capabilities with different signal structures including a data channel. Mode A codes aircraft identity, A/C codes identity and aircraft derived altitude, Mode S as for A/C with ability to selectively call specific aircraft / request other aircraft data. There is also limited use of airborne interrogators transmitting on 1030 MHz and receiving on 1090 MHz |
| Far Field Monitors (FFM) | 1090 (Gnd Tx)  1030 (Gnd Rx) | SSR interrogators have up to two ground based monitors at fixed locations several nautical miles from the interrogator to provide constant confirmation of correct operation and monitoring of health and performance of interrogators |
| Universal Access Transceiver (UAT) (ADS-B and multiple broadcast services) | 978 | Universal Access Transceiver (UAT), an ICAO standardized system and a wideband broadcast data link operating on 978 MHz. UAT supports multiple broadcast services, including flight information services (FIS-B) and traffic information services (TIS-B), in addition to automatic dependent surveillance — broadcast (ADS-B). Currently it is used in a number of states outside of Europe, including China, Republic of Korea, South Africa and United States. Some limited trials are taking place in Europe. UAT is being examined as one enabler technology to support Remotely Piloted Aircraft System (RPAS) and General Aviation (smaller aircraft) use |
| Automatic Dependent Surveillance-Broadcast (ADS-B) | 1090 (Air Tx, Air, Gnd and space Rx) Note 2 | Air-to-air, air-to-ground, air-to-space datalink. Provides aircraft identity, aircraft derived (hence “dependent”) position plus other data. An extension of the SSR Mode S data set (also permitted to be received in space following an allocation by WRC-15). Aircraft fit could be part of SSR transponder or a separate transmitter/receiver |
| Airborne Collision Avoidance System / Traffic Collision Avoidance System (ACAS/TCAS): | 1030 and 1090 (Air Tx and Rx) | Aircraft system on both 1030 and 1090 MHz operating independently of ground-based equipment and air traffic control in warning pilots of the presence of other aircraft that may present a threat of collision. If the risk of collision is imminent, the system initiates a manoeuvre that will reduce the risk of collision |
| Multilateration systems (MLAT) | 1030 (Gnd Tx, Air Rx)  1090 (Gnd and Air Tx, Gnd Rx) | Largely passive network of ground receivers (of order of 40 to 50 for a large airport) to enable independent determination of aircraft (and suitably equipped ground vehicle) position on or near an airport using difference in time of arrival techniques based upon SSR Mode S transmissions. Multilateration systems (MLAT systems) also have several ground based 1030 MHz emitters to elicit additional replies from aircraft transponders where necessary .and 1090 MHz emitters to provide constant confirmation of correct system operation |
| Wide area multilateration (WAM) | 1030 (Gnd Tx, Air Rx)  1090 (Gnd and Air Tx, Gnd Rx) | Similar to MLAT but over a wider geographic area and typically having a greater reliance on active interrogation at 1030 MHz to augment SSR- and Mode S based Radar detection of aircraft. |
| RSBN (Radio system of short range navigation) | 960-1164 | A civil/military Aeronautical Navigation system that operates under ITU footnote RR 5.312 which is a non-ICAO aeronautical system. RSBN provides information for approach / landing and En-Route navigation similar to ILS, VOR, DME and TACAN. |
| Note 1: Airborne transmissions limited to 1025-1150 MHz | | |

Table 4: Civil aeronautical systems foreseen in the band 960 to 1164 MHz

|  |  |  |
| --- | --- | --- |
| System | Frequency (MHz) | Notes/Description |
| L-Band Digital Aeronautical Communication System (LDACS) | 960-1164 | LDACS received an allocation between 960 to 1164 MHz at the WRC 2007 (Resolution 417, revised in 2015) and is presently under standardization by ICAO. LDACS is envisaged to use a cellular point-to-multipoint concept, which means that the airspace is segmented into cells. In each cell, all aircraft are connected to a centralised ground station which controls the entire air/ground communication within the cell. It is designed as a frequency-division duplex system, preferably deployed using an inlay approach, interleaving with DME. Expected to be introduced in the mid-2020s. |
| Mode S Phase overlay | 1090 | Additional Phase Overlay modulation to the 1090 MHz Mode S telegram to enhance the data throughput to ~ 4 MB/s. Currently under standardization within ICAO 1090 MHz transmission and reception |
| Remotely Piloted Aircraft System / Unmanned Aircraft System | 960-1164 | (RPAS/UAS) command and control, known also as Control and Non Payload Communication (CNPC) which refers to Command and Control or Command, Control and ATC Communications (C2 link).  These systems are under development and could be introduced if seen as a viable solution (EUROCAE WG-105). |
| Improved DME for Alternative Position Navigation and Timing (APNT) | 960-1164 | Alternative Position Navigation and Timing (APNT), using DME, is planned for use during outage of GNSS. DME performance improvements are projected to occur in the near term with minimal ground-system changes and unchanged avionics. When used for surveillance, the goal is that APNT meet or exceed the required position precision during GNSS outages, thus ultimately reducing dependence on surveillance radar. |
| Integrated CNS System | 960-1164 | The 13th Air Navigation Conference (2018) recommended that ICAO launch a study to evolve the required CNS and frequency spectrum access strategy and systems roadmap in the short, medium and long term, to ensure that CNS systems remain efficient users of the spectrum resource. The frequency band 960-1164 MHz has been identified as a home for future integrated aeronautical CNS Systems. |

## Military radionavigation and communication

Table 5: Military aeronautical systems currently in use in the band 960 to 1164 MHz

|  |  |  |
| --- | --- | --- |
| System | Frequency (MHz) | Notes/Description |
| Tactical Air Navigation (TACAN) | 962-1164 (Note 1) | Similar to DME in that it allows determination of slant range from aircraft to a known location but with the addition of further modulation(s) that allow aircraft to determine their bearing from the ground beacon. TACAN is also used by Civil Aviation as DME. TACAN also has an air-to-air mode, where aircraft transmit on the beacon frequencies. |
| Interrogation Friend or Foe (IFF) | 1030 and 1090 | Mode 4 and it’s successor IFF Mode 5 operating on the SSR frequencies 1030 and 1090 MHz, since about 1980. Employs different modes (signal structures) with different capabilities. |
| Joint Tactical Information Distribution System/Multifunctional Information Distribution System (JTIDS/MIDS) – also known as Link16 | 51 channels across the range 969 to 1207 (Note 2) | Link16 is a multi-platform (air, ground, sea) military datalink and communications system providing secure, flexible and highly survivable communications links which are resistant to jamming. The system employs TDMA and frequency hopping, spread spectrum over 51 distinct channels. Equipment is required to use standardised additional capabilities to mitigate risks of interference to aviation systems. |
| RSBN (Radio system of short range navigation) | 960-1000.5 | A civil/military Aeronautical Navigation system operates under an ITU footnote RR 5.312 which is a non-ICAO aeronautical system. RSBN provides information for approach / landing and En Route navigation similar to ILS, VOR, DME and TACAN. |
| Note 1: Airborne transmissions are limited to 1025-1150 MHz except for TACAN used in air-to-air mode for which channels in the whole band could be used (the transponder and the interrogator are both on-board) [[17]](#footnote-18).  Note 2: A frequency remapping of the 51 channels for JTIDS/MIDS is currently being implemented in some terminals. This would lead to a reduction in the number of frequencies used by those JTIDS/MIDS terminals, and a corresponding increase in the usage of the remaining frequencies.  Note 3: The standard performance criteria for MIDS terminal equipment to be used by all military are defined in STANAG 4175 . In particular the purpose of its Annex A is to define the technical characteristics required to:  a) Achieve interoperability among MIDS terminals;  b) Ensure that the electromagnetic emissions from MIDS will not unduly interfere with other users of the frequency bands employed by MIDS. | | |

## Evolution of spectrum usage within the 960-1164 MHz band by aeronautical systems

On a global basis, the frequency band 960-1215 MHz is used for Distance Measurement Equipment (DME) systems. In most airspaces, it is required to navigate using multiple DME ground stations for position determination (DME-DME navigation). DME also provides an essential element of the Instrument Landing System (ILS) precision approach (CAT I, CAT II and CAT III) enabling reduced visibility and automatic landing of aircraft. Use of DME will continue and increase well beyond 2030.

ICAO has defined the Performance Based Navigation (PBN) concept which specifies aircraft area navigation system performance requirements, defined in terms of accuracy, integrity, continuity and functionality, needed within a particular airspace. DME-DME can meet the performance requirements for area navigation (RNAV 1, 2 and 5) and the required navigation performance (Basic RNP 1)[[18]](#footnote-19) as specified in ICAO Doc 4444 [19].

In addition to DME, GNSS navigation sensors are also used as a navigation aid for PBN operation.

Use of GNSS for PBN and precision approach is increasing; however, due to its vulnerability to interference it is not considered reliable enough as a sole means of area navigation or for use with ILS precision approach systems for CAT II and CAT III. During the 12th Air Navigation Conference (2012), ICAO Contracting States agreed to develop an alternative means of navigation in the event of a loss of or disruption to GNSS signals (APNT). APNT solutions will use modified versions of the existing DME (APNT DME) and hybrid approaches including LDACS. Accordingly, DME navigation capability continues to be a fundamental long-term requirement.

Two sub-bands centred around the frequencies 1 030 MHz and 1 090 MHz are used for Secondary Surveillance Radar (SSR) as well as by a number of other aviation systems, including MLAT, WAM, ACAS, ADS-B and ADS-B reception by satellite. The use of these frequencies for these systems is expected to increase well beyond 2030. Added capabilities are being developed for some of these systems, such as ADS-B IN and ACAS-X including the ACAS-Xu designed as detect and avoid systems for Unmanned Aircraft System (UAS).

# Legal and Regulatory framework applicable to the band 960-1164 MHz

## Global level

### **ITU**

Referring to the ITU-R RR, there is no appropriate allocation supporting PMSE in the band 960 - 1164 MHz which is globally allocated to the Aeronautical Radionavigation Service (ARNS), Aeronautical Mobile Route Service AM(R)S and in part to the Aeronautical Mobile-Satellite Route Service (AMS(R)S Earth-to-Space).

However, the ITU-R Regulations do not prevent any administration introducing PMSE applications in the band 960-1164 MHz, providing that such uses shall not cause any harmful interference to the aeronautical systems, within or outside the national borders, or claim protection from harmful interference.

The following ITU RR Article should be considered:

* Article 4.4: "Administrations of the Member States shall not assign to a station any frequency in derogation of either the Table of Frequency Allocations in this Chapter or the other provisions of these Regulations, except on the express condition that such a station, when using such a frequency assignment, shall not cause harmful interference to, and shall not claim protection from harmful interference caused by, a station operating in accordance with the provisions of the Constitution, the Convention and these Regulations."

Then, at this stage, PMSE could only operate under RR N° 4.4 as referred to above that means, in particular, that no protection can be ensured for the usage of PMSE in the band 960-1164 MHz.

* Article 1.169: "harmful interference: Interference which endangers the functioning of a radionavigation service or of other safety services or seriously degrades, obstructs, or repeatedly interrupts a radiocommunication service operating in accordance with Radio Regulations (CS)."
* Article 4.10: "Member States recognize that the safety aspects of radionavigation and other safety services require special measures to ensure their freedom from harmful interference; it is necessary therefore to take this factor into account in the assignment and use of frequencies."

### **ICAO**

The various articles of the ICAO Convention (Chicago Convention) [1] oblige States to undertake or adopt measures to ensure the safety of overflying aircraft. These measures include standards and recommended practices which require aircraft and aeronautical service providers on the ground to operate certain ICAO standardized equipment for Communication, Navigation and Surveillance.

The 960-1164 MHz frequency band is in extensive use on a worldwide basis for aeronautical safety of life systems. In line with the consistent annual growth of air traffic of 5% on a global basis, the use of those systems keeps growing and flexibility in changing frequency assignments is a key element in managing the band.

At WRC-07, WRC-12 and WRC-15, ICAO and the aviation community looked for additional spectrum allocations to support new aviation safety systems. After study, the approach chosen was to implement those systems under new allocations to aeronautical services in bands already allocated and in use by other existing aeronautical services. This approach was only possible because aviation controls the environment in these bands, through the mandatory use of international aeronautical standards (SARPs[[19]](#footnote-20)) and regionally coordinated air navigation agreements.

Due to its safety of life nature, aviation cannot afford to be reactive. Hence the ICAO regulatory framework provides provisions not only on equipment standardization and certification, but also on safety management and aeronautical safety oversight, thus ensuring preventative action to minimise operational risks to an acceptable level, consistent with safe aircraft operation. When the regulatory regime is judged to be insufficient, then aviation has to take appropriate action to maintain safety. That action will be in the form of modifying or in the worst case (e.g. volcanic ash from Eyjafjallajökull Iceland) cease operations with a resultant economic and political impact.

There is an example of a non-civilian aeronautical system (JTIDS/MIDS) operating in an aeronautical frequency band. This was accomplished through implementation of terminal-resident EMC features that shut the emitter down if it attempts to operate outside the parameters assumed in the safety case. It should be noted the form and function of those EMC features required aviation certification. The current arrangements are the ongoing results of over 40 years of experience.

Aircraft operations need to be supported by appropriate safety cases as a means of structuring and documenting the demonstration of the safety of air traffic management services and systems. In addition to the ICAO regulatory framework, see for example Commission Implementing Regulation (EU) 2017/373 [20]. Risk classification schemes have been developed at a global level, e.g. ICAO Doc 9859 – Safety Management Manual, and at European level, e.g. EUROCONTROL ESARR 4 - Risk Assessment and Mitigation in ATM[[20]](#footnote-21). In addition, national authorities have also developed guidance on hazard identification, risk assessment and the production of safety cases, for example CAP 760 in the UK.

In accordance with Annex 8 to the ICAO Convention, aeronautical equipment is required to undergo stringent certification (e.g. ETSO, issued by EASA) and in accordance with Annex 19, its operation is required to undergo safety-cases to ensure safe operation of aircraft. If any new system sharing an aeronautical safety of life frequency band is introduced, the existing aeronautical safety cases shall be reviewed.

The current safety cases are conducted on the basis that any aeronautical equipment and its operation in the band must be standardized, certified and licensed[[21]](#footnote-22) for operation in each specific aircraft type (e.g. assurance against causing a safety issue to the aircraft due to equipment malfunction), and comply with appropriate standards and the items listed above, or shut off. If a new system does not comply with these standards is introduced, a new framework for the safety cases needs to be developed.

Human factors principles need to be observed in the design and certification of radio navigation aids and surveillance systems (Ref: ICAO Annex 10 Vol I, Navigation Systems and Vol IV, Surveillance Systems). From the aviation sector perspective, the same considerations should apply to any other systems, which may affect the operations of the radionavigation aids and surveillance systems.

Many airport ILS/DME installations have been certified at the highest level of precision approach procedures (CAT IIIc) and are authorised to be used for autoland operations. Any loss of DME operation in normal or low visibility conditions results in the need for alternative ranging information that require ATC intervention and associated impacts to the operation of that airport, for example flow control being applied with much lower throughput than during normal operations. Any loss of a component part of the ILS requires a demonstration period to be completed, providing fault rectification or resolution to the issue that caused the loss. Depending on the severity of the loss varying periods will be required to prove the stability and operational capability of the facility, for example this could be between 24 and 300 hours or as specified by the ANSP for that aid.

In several Regions, Universal Access Transceiver (UAT), provides frequency diversity for ADS-B applications and has proven highly effective in enhancing aviation safety. UAT, which operates on 978 MHz, also provides real-time weather and traffic information.

The frequency 978 MHz is globally used and UAT is an ICAO standardized system, which provides /will provide aviation a longer term solution of frequency diversity for ADS-B applications while being fully capable of handling the expected growth.

#### Application of International Law for aeronautical safety oversight

In accordance with the Chicago Convention [1], national safety oversight obligations require States to undertake measures to ensure that every aircraft flying over or manoeuvring within its territory complies with the specific operating regulations relating to the flight and manoeuvre of aircraft therein.

ICAO's Universal Safety Oversight Audit Programme (USOAP) was initially launched in January 1999, in response to widespread concerns about the adequacy of aviation safety oversight around the world. Initially, USOAP activities consisted in regular and mandatory audits of ICAO Member States' safety oversight systems. In 2010, a new approach, Continuous Monitoring Approach (CMA), based on the concept of continuous monitoring and incorporating the analysis of safety risk factors was introduced. USOAP CMA is performed by ICAO based on several principles, and includes the following.

* 1. Universality: All Member States shall be subject to continuous monitoring activities by ICAO, in accordance with the principles, methodologies, processes and procedures established for conducting such activities, and on the basis of the Memorandum of Understanding (MoU) signed by ICAO and each Member State;
  2. All-inclusiveness: The scope of USOAP CMA includes the ICAO SARPs contained in all safety-related Annexes to the Convention, Procedures for Air Navigation Services (PANS), guidance material and related procedures and practices.

Based on this MOU as described above, to provide the necessary air navigation services and aerodromes, States are obliged to adopt and apply appropriate aeronautical standard systems and communications procedures and other operational practices and rules. Compliance with the State’s regulatory requirements is obligatory. Exemptions or exceptions of these requirements should not be granted by the State if such measures would not be supported by appropriate, robust and documented safety risk assessments or aeronautical studies and imposition of limitations, conditions or mitigation measures as appropriate (Ref: ICAO Doc 9734 "Safety Oversight Manual").

Any exception or exemption should only be granted on the basis of a robust rationale. Therefore, the issuance of exceptions or exemptions that are not supported by safety risk assessments or aeronautical studies and by thorough reviews by the competent authority is not acceptable. A safety risk assessment or aeronautical study should be developed by the service provider to demonstrate whether an equivalent level of safety or an alternative acceptable means of compliance can be achieved (Ref: ICAO Doc 9734 "Safety Oversight Manual").

Aeronautical systems operate in accordance with the International Law principles stated above. There is an example of a non-civilian aeronautical system (JTIDS/MIDS) operating in an aeronautical frequency band. This was accomplished in a manner ensuring compliance with the requirements described above, thus ensuring that international obligations were met.

In light of the above, ICAO is of the opinion that introduction of any new system in the 960-1164 MHz band would not be safe unless it can be ensured that:

* the new system is completely compatible with existing and planned aviation systems based the new system is completely compatible with existing and planned aviation systems based on testing and analysis that has been agreed by aviation regulators;
* the parameters for the new system will be captured in an internationally recognized standards document;
* the new system will be certified (including software and hardware) by the competent national regulatory authorities; will be maintained to meet throughout its service life the operational parameters assumed in the aviation testing/studies; will perform self-monitoring to ensure that it shuts down if it moves outside those agreed parameters; and the self-monitoring/shutdown function itself will also be certified[[22]](#footnote-23);
* the new system will include time-stamped logging of essential transmitter parameters, such as frequency use and power levels for post incident/accident investigation purposes;
* the new system will not impact:
  1. the ability of aviation to manage existing and planned aviation systems;
  2. the ability of aviation authorities to modify operating frequency assignments, powers and signal contents of the aviation systems without introducing additional coordination mechanisms.
* the operator of the new system must accept all legal liability in case of interference to aviation systems (e.g. due to false channel selection, excessive power, human error, device failure), and recognize that aviation systems operators have no liability in case of interference to the new system; and
* personnel responsible for the operation of non-aviation systems in the 960-1164 MHz band shall be required to achieve similar levels of certification to those stipulated in the Radio Regulations for operators of aviation systems (radio operator's certificate).

## Regional and National level

### **European law**

Within the EU, Single European Skies (SES) legislation, i.e. Commission Implementing Regulations (EU) 2017/373 [20] is in force[[23]](#footnote-24). This regulatory regime requires that hazard identification as well as risk assessment and mitigation are systematically conducted for any changes to those parts of the ATM functional system and supporting arrangements within their managerial control by air traffic service providers (ANSPs) before bringing new Air Traffic Management facilities into use or when changes to existing facilities are foreseen.

For the considerations of EUROCONTROL, refer to ANNEX 2:.

### **CEPT**

Within CEPT in addition to the work at WG FM, it has been agreed that WG SE will carry out compatibility studies between low power audio PMSE and incumbent aeronautical systems in the 960-1164 MHz band (this will include compatibility studies with services in adjacent bands).

Based on the results of the technical compatibility studies, cross border coordination between concerned administrations may be required.

### **National regulation**

Provided that international radio regulatory, aeronautical safety obligations are met, the introduction of low power audio PMSE in the band 960-1164 MHz is a sovereign decision on the designation of this public resource.

Therefore, the introduction of PMSE into the band is a national decision, under the full liability of the State, which would involve cooperation between the spectrum regulator, the aviation authorities and Defence. The introduction of audio PMSE in the band 960-1164 MHz could imply review/updating of the national sharing framework between current users. This may be unacceptable to these users if these updates have impacts on their operational environment and requirements.

The amount of spectrum potentially available for audio PMSE applications in the 960-1164 MHz band may differ from country to country depending on incumbent usage as well as national decisions and agreements, including those of other countries.

In case of CEPT harmonisation measure, an administration may decide not to implement PMSE applications in the band 960-1164 MHz.

In general, authorisation for audio PMSE differs across administrations, i.e. licence exempt, general authorisation or individual licence.

For the introduction of audio PMSE in this band 960-1164 MHz, an individual licensing regime is likely to be required in order to have control of the PMSE usage in this band.

Detection of interference to the aircraft navigation systems by its pilot can be very difficult if not impossible. During a flight, the first priority for the pilot is the safety of the flight. Hence, typically a report of interrupted or reduced reception or performance of the air navigation system will not be filed by the pilot until after the flight, i.e., hours after the incident. In case of interference resulting in an incident or accident (aircraft new route, plane crash …) leading to economic, ecological, environmental, legal or human impacts, responsibilities have to be clarified and established, corrective actions need to be taken and liability issues have to be addressed in accordance with international law.

A PMSE user causing interference (due to the use of wrong channel selection, too high power emission, human error, device problem, etc.) should be identifiable in order to assume the legal and economic consequences of any impact (delays, incidents, re-routing, route-closures, and accidents) to the Air traffic flow.

On the other hand, Administrations would assume the responsibility of safety, legal and economic consequences if it appears that a PMSE user is in full respect of the issued authorisation/regulation and interference still occurs. Considering that the administration in charge of enforcement might be also responsible for harmful interference and also its impact and consequences, appropriate methodology needs to be identified to ensure that all cases are appropriately resolved.

# Economic Aspects

## Economic aspects of air transport

The economic value of aviation described below relates to the total value of all activities directly and indirectly related to the air transport industry. The estimates include catalytic effects of tourism, i.e. employment and income generated in the economy through air travel tourism, and induced economic benefits, i.e. through people employed in the aviation industry or tourists spending their money on other goods and services. There is no assessment of the economic value of the use of spectrum.

Air traffic is growing. Historically, it is doubling activity every 15 years. A key requirement to sustain growth is the capability to reduce the separation between aircraft while maintaining or increasing the current levels of safety. This is only possible if sufficient performance of the radionavigation and surveillance systems operating in the band 960-1164 MHz (DME-DME and surveillance separation when available) and the adjacent band 1164-1215 MHz (DME-DME and GNSS/GPS - although GNSS in this frequency range is not yet standardised for use) can be ensured.

The level of safety, as enforced by the Air Traffic Services allows for a strong public confidence, which in turn fosters overall economic development. The high level of safety and reliability of operations has enabled massive financial investments in aircraft fleets, ground equipment, and facilities by businesses and commercial operators in order to provide their services. Making a dedicated spectrum of radio frequencies available for safe operations is an integral part of establishing the required level of safety. Due to the many years of reliable and interference free operations enabled by the strictly controlled environment in the 960-1164 MHz band, a worldwide economic and social benefits model has been built.

The data of this section comes from "Aviation: Benefits Beyond Borders"[[24]](#footnote-25) and "Study on the Modelling of Airport Economic Value"[[25]](#footnote-26).

### **Employment**

In 2014, the air transport industry supports 62.7 million jobs globally:

* It directly creates 9.9 million jobs worldwide (60% for airports, 27% for airliners, 11% for aerospace sector, 2% for air navigation service providers (ANSPs), etc.);
* 11.2 million indirect jobs are created via purchases of goods and services from companies in the air transport supply chain;
* 5.2 million jobs are induced through spending by industry employees;
* Almost 36.3 million direct and indirect jobs are created through air transport’s catalytic impact on tourism.

Moreover, it is estimated that aviation supported 67.7 million supply-chain jobs in 2016 and underpinned 3.0 trillion USD in value-added output globally.

### Economic aspects

* Aviation provides the only worldwide rapid transportation system which makes it essential for global business and tourism (approximately 3.57 billion passengers transported in 2015);
* Aviation’s total global economic impact (including direct, indirect, induced and the catalytic effects of tourism) is estimated at 2.7 trillion USD, equivalent to 3.5% of world gross domestic product (GDP);
* Aviation carried 51.2 million tonnes of freight in 2015 and 35% of interregional exports of goods by value; daily value of goods sent by air is now 17.5 billion USD;
* Research conducted in the US suggests that for every 100 million USD invested in aerospace yields an extra 70 million USD in GDP year after year.

### **SESAR (Single European Sky ATM Research) objectives**

The band 960-1164 MHz directly supports the development of SESAR objectives.

The objective of European Commission is to reduce the extra costs of close to 5 billion Euro each year to airlines and their customers and to develop means to allow airlines to fly their preferred (and more direct) routes (<http://europa.eu/rapid/press-release_IP-13-664_en.htm>).

This spectrum resource is considered as strategic for the Single European Sky to improve air traffic.

Currently, LDACS is further developed and prototypes are built within the framework of the SESAR 2020. Two well-known European aviation equipment manufacturers, namely Frequentis AG and Leonardo, are currently producing LDACS prototypes.

SESAR will be supported by terrestrial data link. The only frequency band available for those operations is the band 960-1164 MHz via LDACS and later on by the integrated CNS systems. The 4D trajectory will be supported by the 960-1164 MHz band and will permit to reach the SESAR performance ambition (see section 2.5.1.3).

### **European airline delay cost[[26]](#footnote-27)**

The delay costs outlined in this section are from a report designed as a reference document to assess European delay costs incurred by airlines. The report notes that the costs modelled draw on expert judgement and assumptions, based on published statistics and robust data wherever possible. The report also notes that, as with any such research, some caution is indicated in the use of the findings. The delay costs are independent of the cause of the delay.

The cost of delay is calculated separately for strategic delays (those accounted for in advance) and tactical delays (those incurred on the day of operations and not accounted for in advance). The type of strategic cost focused on is adding buffer to the airline schedule.

Interference in the 960-1164 MHz band may generate additional delays (e.g. during landing approach and departure, en-route, etc.) which could be considered as tactical delays.

Tactical delay costs are given for 5, 15 and 30 minutes. These are scaled up to the network level because on the day of operations, original delays caused by one aircraft (‘primary’ delays) cause ‘knock-on’ effects in the rest of the network (known as ‘secondary’ or ‘reactionary’ delays). For example, in 2009, in Europe, for each minute of primary delay, on average, another 0.8 minutes of reactionary delay were generated in the network.

The data presented here, are dominated primarily by passenger costs, and then fuel burn differences. Maintenance, crew and reactionary costs are also taking into account.

Table 6: Delay airline cost (EUR) EN-ROUTE and full tactical cost for 12 core aircraft

|  |  |  |  |
| --- | --- | --- | --- |
| Delay (mins) | 5 | 15 | 30 |
| Boeing 737-300 | 270 | 1130 | 3400 |
| Boeing 737-400 | 280 | 1200 | 3670 |
| Boeing 737-500 | 250 | 1030 | 3090 |
| Boeing 737-800 | 300 | 1290 | 3990 |
| Boeing 757-200 | 360 | 1570 | 4840 |
| Boeing 767-300 | 700 | 2710 | 7600 |
| Boeing 747-400 | 1160 | 4340 | 11810 |
| Airbus 319 | 270 | 1110 | 3390 |
| Airbus 320 | 280 | 1200 | 3720 |
| Airbus 321 | 320 | 1400 | 4380 |
| ATR42-300 | 80 | 360 | 1160 |
| ATR72 | 110 | 480 | 1530 |

It should be noted that the table above doesn't take into account several points:

* the cost of an eventual diversion due to the interference (which is between 5870 and 64 600 €);
* the cost of an eventual cancellation;
* the passenger value of time (which is 47 to 60 € per hour and per passenger);
* the extra charge from the airport;
* the cost of the Air Navigation Services;
* the cost of harmful interference researches that leads to the delay (usually a flight inspection is required);
* the amount of emissions released by fuel burn and the cost of pollutants;
* the noise impact due to the delay;
* the network effect of the delay.

## PMSE introduction economic impact

### **Civil aviation side**

PMSE introduction in the 960-1164 MHz band, if not properly managed by national administrations, or if the aviation sector does not have confidence in using this band, may slow down, constrain or freeze the global evolution of aeronautical systems (see section 3.3). The potential impact on meeting the SESAR performance ambition for 2035 in terms of efficiency and predictability, environment, capacity, cost-efficiency, safety may need also to be considered.

One of the additional concerns is that potential interferences may result in an increase of the separation distance between aircraft to ensure safety and lead to an extra cost for airports and airliners.

Another concern is that, if at a later stage, a need is identified to modify the aeronautical equipment in order to better cope with a scenario with interference caused by not-properly-managed PMSE, this would be associated with a very high cost. The average recurring cost of an airborne air transport DME is roughly 50 k USD (aircraft are equipped with two DMEs). As order of magnitude, any modification, new qualification and certification of a DME on an aircraft (validation, laboratory and flight tests) would lead to a non-recurring cost between 400 k EUR and 500 k EUR for a given aircraft program. However, an alternative to reengineering of airborne DME equipment would be to withdraw authorisation for audio PMSE to use the band 960-1164 MHz and remove existing and future equipment from the market.

When a DME facility is removed from service (potentially as a result of aggregate interference) due to aircraft reports of unavailability, there will be a negative impact on airport capacity and the published approach procedures cannot be maintained.

To restore the DME back to service as a published navigation aid, this would normally require a flight inspection verification of the system parameters during an airborne analysis. The cost of operating a flight inspection aircraft to restore a navigation aid back to operational service can range from 3000 to 7000 EUR per hour, depending on the aircraft type and the location it must fly from to perform the inspection.

### **Military side**

The Link 16 is operated on non-interference-basis to aeronautical radionavigation systems. In every country a national frequency clearance agreement between Defence and Civil Aviation Authorities (CAA) specifies the sharing conditions and constraints for the use of Link 16 in the national airspace. In many Nations, Defence is required to perform comprehensive laboratory compatibility tests to assess the impact of Link 16 on aeronautical radionavigation systems in the band taking into account the whole electromagnetic environment (EME).

Each CAA may require its Defence counterpart to perform a new test campaign with new EME scenarios due to the introduction of PMSE in this band (albeit this was not the case in UK). These laboratory tests are resource intensive in terms of time and money, and even the scenarios and parameters to produce the PMSE-induced EME may be difficult to define accurately for proving the non-interference to civil aeronautical radionavigation systems.

Furthermore, NATO considerations on the prerequisites for the introduction of PMSE in the band 960-1164 MHz are provided in ANNEX 1: and EUROCONTROL military ATM Board in ANNEX 3:.

## Safety case amendments

It is worth studying the cost implications of reviewing all safety cases, before changing the regulatory framework.

The mitigation of certain hazards may require that additional requirements may be placed in order to adequately reduce the associated risks to appropriate levels, perhaps involving additional functionality, processes, training of personnel etc.

This means practically that analyses need to be carried out during the development of the new / changed system as particular hazards may require mitigations that involve changes in design or additional functionality, processes or training that must be implemented before the change may be implemented.

Risk classification schemes have been developed at a European level, e.g. EUROCONTROL ESARR 4 - Risk Assessment and Mitigation in ATM, which provides minimum requirements.

Where the changes to facilities are deemed to have certain levels of potentially severe outcome then the competent authorities are required to review the safety arguments provided by the ANSPs associated with the new functional systems or proposed changes to existing functional systems. This collation of the safety arguments etc. can be known as a “safety case”.

It appears to be appropriate that consideration of the sharing of frequency bands within which ATM equipment operates should also be subject to a similar process of systematic hazard identification, risk assessment and mitigation consideration. It may be that the mitigation of certain risks may require technical mitigations to be introduced in the PMSE equipment and this may require additional requirement to be included in system standards.

In spectrum management, costs incurred by incumbent users as a consequence of a change should be considered against the potential benefits. If the benefits outweigh the costs then the spectrum management authority may conclude that the change is worth making. The approach taken in the UK was based on requiring no change of equipment or operation by the incumbent users (both civil and military). The approved Safety Assurance Case may be used by the Air Traffic Service Providers to review their safety cases and update them if they consider it necessary.

## Spectrum management

Administrations may have to consider the cost of planning, supervision and enforcement of technical and regulatory constraints that would be necessary to allow PMSE use in the band.

## Economic value of PMSE (example in UK)

It has to be noted, that this economic value has no direct link with the particular band 960-1164 MHz but is in relation with the current frequency bands that PMSE are using.

Audio PMSE is present in almost every media, cultural, sporting and entrainment activity it is dynamic and evolving. Producers continually seek new experiences for audiences exploiting the rapidly changing landscape including virtual reality, HD TV, 3D, and the web with consequential changes in demand for spectrum. Productions, particularly large-scale events, require significant investment and planning and have the potential to realise substantial returns on that investment. Consequently, a high degree of professionalism is applied in order to protect that investment.

As explained in ECC Report 204 [21], it is difficult to clearly identify the specific financial and social value of PMSE as it is an enabling technology which allows for the production or event to take place. However, in the UK there have been studies and the entertainment and event sector do provide economic reports on a regular basis.

The Wyndham Report (now out of print) from the London School of Economics (LSE) in 1998 showed that an average of 4.4 GBP was spent in the wider West End economy by theatregoers for every 1 GBP they spent at the Box Office on tickets. There is no reason to suppose the overall ratios have changed.

The Society of London Theatre’s 2016 Box Office figures provide economic figures for London’s theatre industry:

* attendances –14.3 million
* gross box office revenue - 645 million GBP
* VAT paid - 107.5 million GBP

Applying the multiplier from the Wyndham Report, this equates to an additional 2,838 million GBP for the economy.

UK Music is an industry-funded body established in October 2008 to represent the collective interests of the recorded, published and live arms of the British music industry. In its 2017 report on the contribution of live music to the UK economy[[27]](#footnote-28), it notes the following economic results for music tourism in 2016:

* 12.5 million music tourists;
* 656 million GBP in box office spend on tickets;
* 4 billion (bn) GBP in direct and indirect spend generated by music tourism.

The economic benefits presented here are just for two examples of activities supported by PMSE in the UK only.

Additionally, the UK Government’s Department of Digital Culture Media and Sport has reported (in November 2017) that in 2016, the creative industries’ combined input to the UK economy was 92bn GBP. This was an increase on the 2015 figure of 85bn GBP – meaning that, in 2016, the creative sector grew by twice the rate of the UK economy. At the front end of content production, PMSE has played a pivotal role in that growth.

## Economic value of GNSS

The adjacent band 1164-1215 MHz is also used by the GNSS. Consumers and citizens benefit in an extremely wide way from GNSS such as Galileo. The benefits include those which are quantifiable and also others which are non-quantifiable. Note that most of the value is at the user side and the majority of this usage involves the freely available service. Most of the value is at the user end and not visible to the GNSS community.

The Global Navigation Satellite Service (GNSS) Market Report No. 5[[28]](#footnote-29) identified that:

* 5.7 bn GNSS devices in use globally in 2017, forecast to increase to almost 8 bn by 2020,
* within Europe there were on average 1.3 devices / capita in 2015, expected to grow to 2.4 by 2025;
* overall European GNSS systems are expected to generate a total discounted benefit of around 60 bn EUR by 2027.

A study by Oxera Consulting Ltd for Google[[29]](#footnote-30) on the impact of geo-services identified that the geo-services sector generates 150-270 bn USD of revenue globally, with a GVA (gross value added) of around 113 bn USD.

# Issues related to a potential introduction of PMSE in the band 960-1164 MHz

## Impact on existing and future aeronautical systems related to introduction of PMSE in the frequency band 960-1164 MHz

### **Concerns regarding constraints on current and future aeronautical systems operating in the band**

The frequency band 960–1164 MHz is used by aeronautical applications under the ARNS, AM(R)S and AMS(R)S allocations worldwide. This internationally recognised status allows worldwide-harmonised aeronautical systems to be standardised by ICAO (International Civil Aviation Organisation), as necessary in order to support air traffic services on a worldwide basis.

Currently many States are working on improving and optimizing their networks of DME stations to better support PBN applications. While GNSS generally provides better positioning accuracy than DME, its signals are vulnerable to failure, disruption and interference by natural causes or motivated action, e.g. jamming.

Although PMSE would be introduced on a non-protected, non-interfering basis, similar to the current situation in the UHF band, where PMSE is using white-space TV spectrum, the civil aviation community remains concerned that the introduction of PMSE may compromise the possibility to modify/adjust/optimise the use of the globally harmonized aeronautical spectrum within Europe for global aircraft operation, as well as the implementation of future aeronautical systems.

The idea of PMSE sharing the 960-1164 MHz band is to provide a long-term solution to accommodate local and temporary PMSE bandwidth demands. If administrations choose to make this band available for PMSE, they may later, within their spectrum management responsibilities, need to limit or withdraw the access to PMSE within the band in order to avoid potential constraints to new aeronautical systems being introduced in the band.

The development of the Unmanned Aircraft Systems (UAS) (also known as Remotely Piloted Aircraft Systems) is proceeding at a fast rate. Hence the need for spectrum for UAS Control and Non-Payload Communication (CNPC) and for aeronautical "detect and avoid"[[30]](#footnote-31) systems is foreseen to increase already in the short term. CEPT studies have begun to examine a subset of these issues with studies in other bands. The aviation community are considering whether the smaller UAS in particular will make use of UAT (operating at 978 MHz) for their secondary surveillance requirements. In the middle term, SESAR deployment supported by LDACS may constrain PMSE deployment in the band. And in the long term, integrated CNS systems are foreseen to be deployed in the whole band 960-1164 MHz in order to provide Communication, Navigation and Surveillance functions for future civil aviation applications providing for more efficient use of the airspace.

Current global studies of APNT are looking into modifying the existing DME (APNT DME) or using hybrid approaches. LDACS is another system which may be used for APNT. If additional non-aviation users need to be accommodated in the same band, one concern is that this may require time for research, and consequently may cause delay and complicate any such system evolution. While aviation does not expect to be given new spectrum, current research efforts assume that the current spectrum allocations can be retained without additional sharing so that the infrastructure can be evolved within already allocated bands to serve the expanding bandwidth needs or air navigation services.

Due to the large radio horizon, European countries which choose to make the band 960-1164 MHz available for PMSE need to ensure the protection of any aeronautical systems deployed in this band (DME, UAT and CNPC for UAS, LDACS and integrated CNS) in neighbouring countries.

### **Safety considerations**

#### Safety Case

Safety cases are required as means to support aircraft operations by structuring and documenting the demonstration of the safety of air traffic management services and systems. ICAO Annex 11[[31]](#footnote-32) and ICAO Doc 9735[[32]](#footnote-33) instruct that any significant safety-related change to the ATS system, shall only be effected after a safety assessment has taken place and demonstrated that an acceptable level of safety will be met, and after all affected users have been consulted. The introduction of a new system in the band 960-1164 MHz would change the RF environment thus invoking the requirement to review the safety cases.

In addition to a generic safety assessment of the PMSE itself under the authorization of relevant State authorities or agencies[[33]](#footnote-34), aeronautical service providers have the responsibility to re-assess their current safety risk assessments and/or develop new ones, taking account of the possible effects that PMSE may have to the air-navigation and surveillance systems operating in the band.

The safety risk assessment developed by the aeronautical service provider will need to demonstrate that an equivalent level of safety or an alternative acceptable means of compliance can be achieved. This may involve inputs and participation by civil aviation authorities, spectrum regulator, the aviation safety regulator and other interested parties (e.g. military, air navigation service providers, airports, airlines, etc.). Aircraft operators and concerned aeronautical service providers may be required to review their safety cases for existing airport, take-off, landing and en-route operations due to the potential impact on aeronautical navigation and surveillance systems and procedures.

Safety cases do not only take account of the technical environment, but also of human factor issues. Current safety cases rely on the assurance that users are properly trained and qualified (e.g. Air Traffic Safety Electronics Personnel). If a new system such as PMSE were to be introduced in an aeronautical frequency band, the safety case analysis would need to take a number of additional factors into account, such as PMSE users not respecting their license conditions (intentional or unintentional wrong frequency selection, wrong location etc.). Similarly, the safety risk assessment would need to address the potential of PMSE equipment not meeting its specifications. In coordination with the CAA/NSA, the initial risk assessment could be developed by the spectrum management authority and be provided for reference by ANSPs in their review and possible revision of their safety cases.

If PMSE use is allowed in the 960-1164 MHz band before an appropriate safety risk assessment has taken place, this may result in potential restrictions being necessary to normal airspace access until the new required safety risk assessment has been developed, taking full account of the potential change to the RF environment. If the safety risk assessment identifies PMSE to have a potential impact on aeronautical navigation or surveillance systems then mitigation measures would have to be identified and put in place.

#### The aeronautical safety assessment in the UK

In December 2018, the UK Spectrum Regulatory Authority (UK Ofcom) and the UK Civil Aviation Authority (UK CAA) released a joint communication indicating UK Ofcom’s decision to operate PMSE within the 960-1164 MHz band. This decision was made possible due to the acceptance of UK CAA of a Safety Assurance Case (SAC) developed by UK Ofcom.

It should be noted that, in accordance with the ICAO (Ref: ICAO Annex 19; ICAO Doc 9734) and EASA regulatory frameworks, a Safety Case, which has to be developed by the affected Air Traffic Service Providers and approved by the national Civil Aviation Authority. The SAC document is intended to facilitate the development of safety cases by the affected Air Traffic Service Providers.

It should be noted that the decision by the UK CAA to agree the SAC was made based on the assumptions on the PMSE usage and licensing process relevant for the situation in the UK.

#### Flight safety and safety of life

This section assesses the impact on the safety in case of interference. As procedures are only published for current systems, this section only studies the impact of interference on a DME and on 1030 & 1090 MHz frequencies.

Figure 1 assesses the safety impact of interference into a DME airborne receiver. With DME-DME positions, an aircraft can perform a navigation accuracy of 1 NM (RNAV 1). In other words, the aircraft is able to determine its position with an accuracy of 1 NM. GNSS and DME/DME/IRU (inertial reference unit) also meet the criteria for RNAV 1.

Position updating for RNAV 1 DME applications requires a minimum of two DMEs. When interference occurs on one of those DMEs, the accuracy of the DME/DME positioning may be degraded or lost and the aircraft will have to rely solely, or partly, on other navigation systems. If the aircraft is equipped with a GNSS receiver this should not present a significant problem, however approval for RNAV 1 does not require GNSS, therefore many aircraft do not have a GNSS receiver and in the scenario described would lose their ability to navigate to RNAV 1 requirements. If the capability of the remaining navigation systems does not support RNAV 1, then the separation and therefore safety of aircraft on the original route cannot be maintained.

As can be seen on the figure, if there is loss of 1NM accuracy of the RNAV 1 route due to interference, aircraft positions cannot be accurately known and the aircraft may be in dangerous proximity with other aircraft on other routes. In this case, in order to maintain the required level of safety of aircraft operations, de-conflicting actions need to be taken by air traffic control.

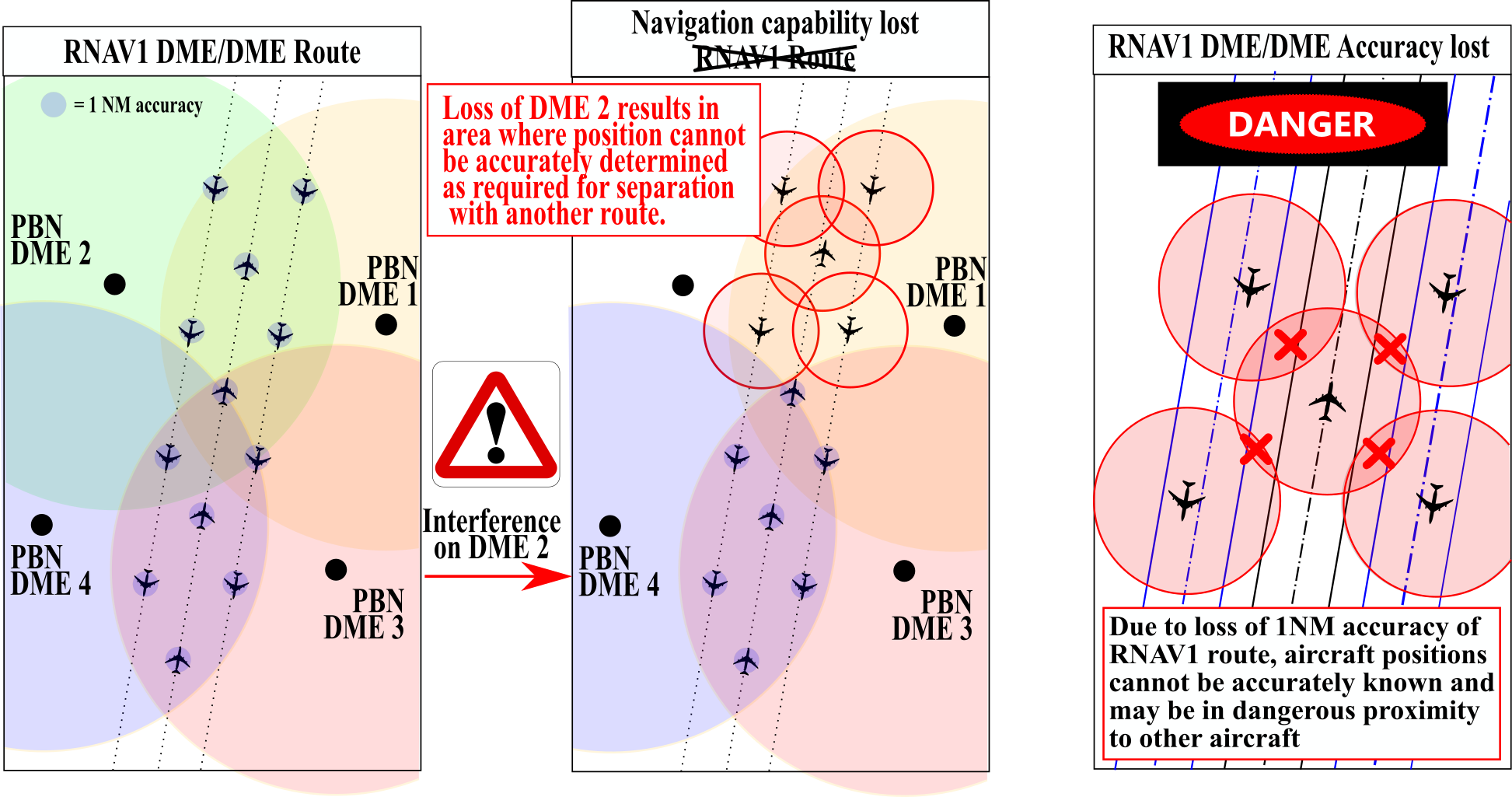


Figure 1: Safety impact on DME in case of interference in 960-1164 MHz band

Figure 2 assesses the safety impact interferences into the two frequencies 1030 & 1090 MHz of an airborne receiver.

During the final approach phase before landing, the air traffic controller uses secondary surveillance radar and/or ADS-B and/or Multilateration to apply separation between aircraft, thus ensuring a minimum separation of, typically, 3 NM. In case of interference on 1030 or 1090 MHz the air traffic controller will not be able to ensure the separation and will have to de-conflict the aircraft accordingly. It has to be noted that the level of safety decreases during this transitional phase. Until sufficient separation is reached between the aircraft a non-safe flight environment is being experienced.

It also has to be noted that an interference on the two frequencies 1030 & 1090 MHz has a direct impact on the air traffic controller screen, e.g. by not giving a full and accurate display of the air traffic. This may lead to very hazardous situations.

In case of interference during a TCAS/ACAS event, there is a direct risk of mid-air collision.

One of the mitigation measures to prevent interference at 1030/1090 MHz is to implement appropriate guard bands, which should be agreed on a Europe-wide basis. PMSE equipment should be designed to be unable to operate within these frequency guard bands.

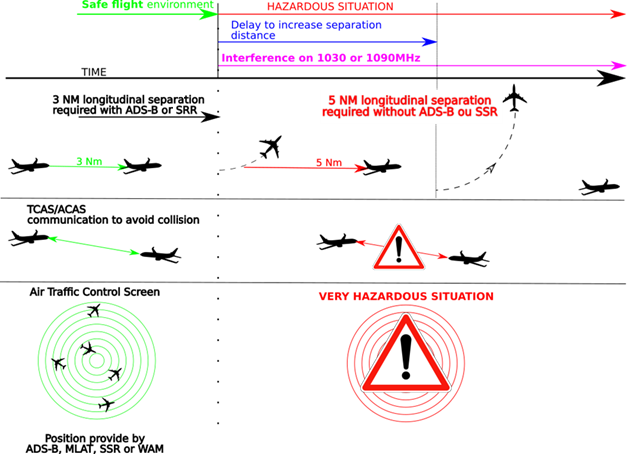


Figure 2: Safety impact in case of interference to the frequencies 1030 & 1090 MHz

### **Interference considerations**

It should be also noted that identification, sourcing and the research of any harmful interference in the band 960-1215 MHz is a very complex and expensive undertaking as it involves critical safety services that are in continuous use. Having an established or published navigational aid removed from service due to harmful interference would be an unacceptable situation.

If a case of harmful interference in the band 960-1164 MHz leads to the removal of a safety service from operational use, an airborne flight inspection analysis would be required and usually take more than 12 hours to be implemented. As possible harmful interference caused by PMSE will be of short duration (less than 12 hours) and potentially intermittent, it will be difficult to identify the main interfering source and to remove the interference in an expeditious manner. Aviation stakeholders believe that time-stamped logging of PMSE usage may be required for post incident and accident investigation purposes.

Availability of accurate PMSE license and usage information could be used to correlate interference reports within a specific geographical location and useful in identifying the interfering source. However, interference from potential unlicensed use of PMSE would be very difficult to locate and remove.

#### A specific case, DME as a component of the Instrument Landing System (ILS)

The safe operation of aeronautical navigation systems, in particular ILS CAT I/II/III requires availability and integrity which is comparable to few if any other radio services, or of the order of magnitude of 1 ‑ 1\*10‑6 or better (the specified required integrity for CAT II/III is 1 ‑ 1\*10‑9). Such high availability and integrity can only be achieved by ensuring there is no interference to the various components of the ILS from other systems. In this context, extreme propagation anomalies need to be taken into account, as well as intentional or inadvertent co-sharing of a DME frequency by the PMSE user.

Some testing of potential interference scenarios has taken place in the UK to-date [22]. This testing showed that increasing the PMSE signal to greater than -97 dBm caused one interrogator under test to suffer from false range readings, and that PMSE signals greater than -90 dBm caused it to fail to meet the -78 dBm Acquire Stable Operating Point criterion which was derived from the minimum DME signal level specified in ICAO Annex 10 for this test setup. Erroneous indication from any navigation system can be considered even more dangerous than the navigation system becoming inoperable due to interference. As there was a limited number of test scenarios, it may be possible that DME receivers may exhibit this behaviour at even lower signal levels.

Another issue of note is that even a short duration interference to DME, when used as a component of the ILS CAT I/II/III may not only have an impact on the safety of flight, due to aircraft not being able to initiate the CAT I/II/III approach and landing procedure during the interference event, this may also have a longer term effect on the efficiency of airport operations. Strict Air Traffic Control intervention would be required for the provision of alternative ranging information for each flight, this implies flow control with much reduced capacity. A demonstration period would need to be completed before normal operations could be restored, proving fault rectification or resolution to the issue that caused the loss. Depending on the severity of the loss, varying periods will be required to prove the stability and operational capability of the facility, for example this could be between 24 and 300 hours or as specified by the ANSP for that aid. In the meantime, the airport operations will be required to take place at a much lower capacity, thus causing significant financial burden.

## Different approaches to safety and quality management between the aeronautical and PMSE cultures

All personnel currently involved in the operation of aeronautical and military systems in the band 960-1164 MHz are required to understand the principles of both quality management system (QMS) and SMS. While the PMSE industry may already plan events and operate equipment under a methodology similar to QMS, as indicated in ICAO Doc 9718, in order to continue safe aircraft operations and based on the aeronautical regulatory framework, any user operating within this frequency band would also need to apply SMS to their operation in order to ensure no adverse effect to the safety of aircraft operations.

Table 7: Principles of SMS and QMS [27]

|  |  |
| --- | --- |
| QMS | SMS |
| Quality | Safety |
| Quality assurance | Safety assurance |
| Quality control | Hazard identification and risk control |
| Quality culture | Safety culture |
| Compliance with requirements | Acceptable level of safety performance |
| Prescriptive | Performance-based |
| Standards and specifications | Organisational and human factors |
| Reactive > Proactive | Proactive > Predictive |

In addition to professionally managed large-scale radio and/or television production events, PMSE is also commonly used for smaller scale public or private events, at any location, e.g. Sporting, Music, Theatrical, Religious, Political, Hobby and Corporate Retailing. CEPT Report 32 [24] differentiates PMSE users between critical use ("professional"), and less critical use. Less critical use is defined as "typically community users covering local events. Their use is generally not coordinated with other users. These users are often called 'consumers'. They expect easy access to a small amount of spectrum with no cost and typically use a limited amount of equipment."

Under the existing operational environment, events and productions means that, particularly for large scale, economically and culturally significant productions, sound design is entrusted to highly experienced and highly skilled individuals and organisations that can demonstrate the required proficiency to deliver interference-free live audio in a complex RF environment.

The proficiency of individuals and organisations operating in the PMSE sector is typically gained through prolonged experience within the sector and who are widely recognised, by consensus, as having the essential skills and knowledge to plan and manage the spectrum to deliver the necessary level of production free of interference. In many sectors the definition of an expert is well established by consensus and therefore it is not necessary for individuals to have a professional or academic qualification for them to be accepted as an expert, and this is the case across the PMSE sector.

ICAO Doc 9718 [28] states: “Non-safety-of-life services, willing to share a safety-of-life band, have to comply with the aviation safety requirements applicable in that band including certification of radio equipment, software and radio operators, as well as assumption of liability”. It is highlighted that ICAO Doc 9718 identifies its status as "This handbook contains the ICAO spectrum strategy and policy statements relevant to the aviation requirements for radio frequency spectrum, as approved and amended by the ICAO Council".

ICAO Doc 9868 [29] and ICAO Doc 10057 [30] and European Regulation (EU) 2017/373 [20] contain the required provisions for training and assessment of air traffic safety electronics personnel, building on the provisions and requirements contained in Articles 18 and 37 of the Radio Regulations. ICAO Doc 9868 specifies that “any practical training should be performed under the supervision of an instructor qualified and competent in the technical domain for which the certificate of competency shall be issued. In instances where practical training is provided through on-the-job training, the instructor shall be qualified and competent in the technical domain, and the training shall be conducted under the safety management system of the air navigation service provider”.

In order to maintain the safe RF operating environment of the safety critical aeronautical radionavigation and surveillance systems operating in the frequency band 960-1215 MHz, ICAO has indicated that the personnel responsible for the operation of the non-aviation systems in the 960-1164 MHz band would need to be required to achieve similar levels of certification. This is especially true due to the current vastly different operational cultures in aviation on the one hand and in the PMSE industry on the other hand.

The existing authorisation practice of administrations for audio PMSE has a strong influence on the operational behaviour of PMSE users. In countries with an individual licensing policy, PMSE users apply for access to spectrum and are usually assigned a specific frequency for a given period of time and at a given location; whereas in countries with general authorisation, users have to find available spectrum themselves, which may be done by scanning for interference free spectrum.

It is recognised in this Report that an individual licensing regime is appropriate for a possible introduction of audio PMSE in the band 960-1164 MHz (see section 4.2.3). If individual licensing represents a different licensing regime from that used for other audio PMSE operations (e.g. in the UHF band), then additional measures to assist compliance with the individual licensing regime may be appropriate, for example additional training.

Special note should be taken of the large differences between the operational environment of white spaces between television channels in the 470 and 700 MHz bands on the one hand and the aeronautical environment in the 960-1215 MHz on the other hand. In the television broadcast band, if a channel is free of interference from a nearby television broadcast, then it is normally clear for low-power PMSE use. On the other hand, the aeronautical radionavigation systems in the 960-1215 MHz band operate with a 63 MHz offset between transmit and receive, hence the PMSE user cannot assume that a frequency is clear if he does not detect a signal on the frequency. In the case of PMSE operating on the interrogator (aircraft) receive frequency, the PMSE user may be shielded from the transponder transmit frequency. However, in the case of PMSE operating on the transponder (ground) receive frequency, a PMSE user will likely suffer interference from airborne interrogator transmissions, see figure 3, making the channel unusable for PMSE.

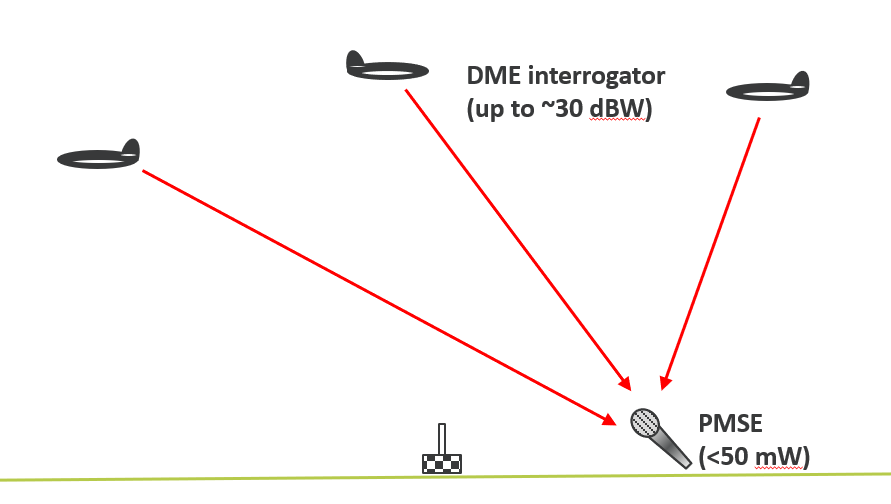


Figure 3: Geometries for airborne interference into PMSE receivers

Due to the various issues highlighted above, experience and knowledge gained from operation in traditional PMSE bands may only be partially applicable to the 960-1164 MHz band.

## Impact of current and future aeronautical systems on PMSE in the frequency band 960-1164 MHz

### **Impact of Link 16 on PMSE**

The frequency band 960-1164 MHz is shared with military application Link16 (JTIDS) which are used for aircraft interception that might pose a terrorist threat under ‘Renegade’ procedure.

The operational use of Link16 differs significantly from one country to another one due to the strategy on their national security specific for each administration. Careful provisions are set within various countries as part of joint civil aviation/military agreement in order to ensure that Link16 can be used in accordance with their operational requirements and without causing any threat to civil aviation systems. Some countries allow Link 16 to be used anytime and anywhere in their territory.

Considering that JTIDS/MIDS operates in fast frequency hopping mode all over the frequency band 960-1164 MHz (except guard bands around 1030/1090 MHz), it appears that interference free operation of audio PMSE cannot be ensured in the presence of JTIDS/MIDS. Administrations should therefore carefully consider the reliability of the band 960-1164 MHz for supporting the desired quality of service for audio PMSE users.

### **Long-term availability of the 960-1164 MHz frequency band for PMSE**

As indicated in the ICAO Global Air Navigation Plan (5th edition, 2016[[34]](#footnote-35)) (GANP), the frequency band 960-1164 MHz is already highly populated with safety critical aeronautical systems and is intended as the home for the implementation of evolving aeronautical systems.

On a global basis, the frequency band 960-1215 MHz is used for Distance Measurement Equipment (DME) systems; this use will continue well beyond 2030.

The variety of Civil/Military radionavigation and communication systems in use today in addition to DME, as well as future civil aeronautical systems in the band 960-1164 MHz, is described in section 3.

The introduction of new aeronautical systems typically takes many years to realise. These long lead times and slow evolution of aeronautical systems may be beneficial to the management of spectrum sharing by regulators and allow plenty of time to respond to any changes in the band. However, care needs to be taken not to constrain the evolution of the aeronautical systems in the band. The introduction of some aeronautical systems is already underway.

ICAO is currently developing international Standards and Recommended Practices (SARPs) for Unmanned Airborne Systems (UAS), indicating this band as one of the bands used for control and non-payload communications (CNPC), while taking into account existing civil aviation applications (DME, SSR...) and governmental applications. ICAO is also considering future CNS systems for operation in this band.

The frequency band 960-1164 MHz is the identified band by ICAO for LDACS, which is furthermore considered as part of the European Union Single European Sky programme. LDACS flight tests began in Germany in Q1 2019[[35]](#footnote-36).

The evolution of aeronautical systems in the band 960-1164 MHz should be carefully considered in order to assess whether the band 960-1164 MHz can offer a sufficient amount of spectrum as well as long term stability to the PMSE sector.

## Impact on services in adjacent bands

The adjacent band 1164-1215 MHz is also allocated to the RNSS and used by GNSS. GNSS systems have become essential for a very wide range of services, user groups and communities with many business and operations relying on its ubiquitous and continuous availability. For example, Galileo has operational signals in the 1164-1215 MHz band to provide dual frequency GNSS services to significantly improve performance and robustness, as will GPS and GLONASS in the future. Appropriate protection such as a guard band should therefore be in place to protect these services, which could include safety of life applications.

1. NATO considerations on the prerequisites for the Introduction of PMSE in the band 960-1164 MHz

The inclusion of new non-safety of life systems in an ARNS and AM(R)S frequency band necessitates robust EMC and regulatory studies, and strict compliance to avoid interference to the incumbent aeronautical and critical military systems. Safety of life aeronautical systems operating in that band must go through a certification process for both the equipment and the operators using the equipment. The band is shared with the military (governmental systems), which are subject to similar civil aviation safety constraints (i.e. Link 16). A system, such as PMSE, would also be expected to have similar requirements placed upon it potentially implying a significant expense of resources to prove compatibility. Additionally, the proliferation of commercial non-safety of life equipment operating in the band can lead to an uncontrolled usage subject to operator error or illegal or unlicensed operation of PMSE equipment in disregard of various national requirements if equipment was procured in another country with different PMSE limitations. This would not be compatible with the safety requirements of existing and future aeronautical systems[[36]](#footnote-37). It is important to note that interference in this band can have catastrophic and irreversible consequences.

Of utmost interest to NATO is the fact that the introduction of PMSE equipment into the band 960-1164 MHz could impact the current and future operation of NATO systems that operate in the band, including TACAN, DME, Link 16, IFF/SSR, and UAS/RPAS CNPC system links that may be required for military UAs. Especially at risk is Link 16 which is operated under Article 4.4 of the Radio Regulations (RR) in the band. It should be ensured that the presence of PMSE operations will not affect the level of Link 16 compatibility with the primary aeronautical systems and the necessary Link 16 Frequency Clearance Agreement (FCA) criteria that should be met (i.e. no added Link 16 restrictions either for peacetime or large coordinated operations when necessary)[[37]](#footnote-38). While interference from PMSE equipment to military ground based equipment could be controlled by applying a necessary separation distance (if those locations are known and can be shared), overcoming the impact to an aircraft receiver which can fly essentially at any point in air space is much more difficult to achieve if not impossible. Thus, for example, PMSE equipment could impact airborne military TACAN operations due to the unknown locations and channel assignments for the associated and paired surface mobile TACAN beacons (e.g. shipboard, and ground transportable beacons). This same impact could result during air to air TACAN operations. In other words, the airborne TACAN channel and aircraft location may not be known making it difficult to de-conflict those operations through frequency and distance management.

The incorporation of a continuously transmitting signal such as PMSE in this band raises compatibility concerns as receiver requirements for ICAO and governmental incumbent systems have not been specified to handle non-pulsed type modulated emissions. The additional ICAO requirements needed to support a continuously emitting transmitter would require specifications for robust receiver frequency selectivity and immunity from spurious responses. It is for this reason that all the incumbent system types operating in the band 960-1164 MHz must be tested.

To authorise a system such as the PMSE, it is envisioned that a conservative robust test bench program between the PMSE equipment (both as a source and a victim) and a panel of the primary or incumbent aeronautical equipment, representative of the different technologies and implementations, would be required. This test program should be performed in a simulated maximum RF environment including signals of all systems received under operationally realistic conditions experienced by the aeronautical equipment in the applicable CEPT nations, using the most stringent of compatibility criteria. The tests should consider the PMSE transmitter as a source of interference as well as interference to the PMSE receiver as a victim of the existing RF environment.

The PMSE should also be certified to ensure that any equipment waveform characteristics are compatible and designed such that even in cases where the PMSE radio malfunctions, no interference is caused. To meet the latter requirement, monitor circuitry should be considered for integration into the PMSE device which prevents it from operating on unauthorized channels or deviating from transmission characteristics from those that have been determined necessary for compatibility. Also to be considered is that the operation of PMSE equipment outside the licensed position/country should be inhibited in unauthorized locations. Equipment acceptance testing should be performed to verify that the device is operating in accordance to required compatibility standards. Additionally, the operational use of the equipment must be verified to meet the special frequency management requirements for a system not operating under the proper service allocation in the band (i.e. non-primary user in the frequency band). For example, the military Link 16 radio terminals are required to incorporate EMC Features monitor circuitry and undergo these requirements as a condition for operating as a non-interference system in the band 960-1215 MHz.

The evaluation process should also consider interference to airborne equipment operation not only in that nation’s airspace but also to airborne and ground equipment within a potentially large distance radio line of sight (RLOS) in another country. Criteria for cross border coordination should be established for those cases, when the aggregate signal of PMSE devices operated in one country can interfere with airborne or ground equipment in another country. Cross border coordination for systems and equipment operating on NIB are presently non-existent in CEPT and need to be established. This would also set the conditions for its operation under frequency management rules.

1. Eurocontrol safety considerations

From the early days of aviation, the aviation industry develops, maintains and operates safety of life and safety and regularity of flight systems operating in adequately protected spectrum.

The ITU Constitution (CS) and the ITU-R Radio Regulations (RR) have captured the absolute importance to protect safety-of-life spectrum.

By design aviation systems do not expect in-band interference from non-safety systems operating in the same band; it goes the same for processes and operational procedures developed around these environments. Safety cases and mitigation techniques are also developed based on the same assumption.

The ICAO Doc 9718 states: “Non-safety-of-life services, willing to share a safety-of-life band, have to comply with the aviation safety requirements applicable in that band including certification of radio equipment, software and radio operators, as well as assumption of liability”.

Safety related issues of the aeronautical sector are supervised by a designated National Supervisory Authority (NSA). If a radio regulator plans to license a non-safety-of-life user in a frequency band used for safety-of-life purposes, the regulator needs to coordinate with the designated NSA in a manner that provides sufficient evidence that:

1. All aspects of sharing an aviation safety-of-life band are taken into consideration to preserve the safety of the aviation operational environment;
2. Effective actions are taken to prevent any proliferation of equipment having the capability to transmit in the safety-of-life band in question;
3. Efficient market surveillance is performed to ensure that manufacturing and importing of such equipment are fully under control;
4. Efficient monitoring of the band is performed to prevent any illegal use and potential interferences with safety-of-life systems;
5. Licenced non-safety systems are manufactured in conformance with the internationally agreed standards;
6. Traceability of non-safety systems manufactured equipment;
7. Users of the non-safety systems are qualified to operate in ARNS, AM(R)S and AMS(R)S bands and hold a valid certificate; and:
8. Their operational handbooks are valid and maintained properly;
9. Their safety management system (SMS) is accepted and validated by the NSA;
10. They are insured for their liability;
11. An effective and continuous monitoring of the RF environment is put in place;
12. Measures are taken and resources are made available for a diligent intervention;
13. Non-safety systems users can seek a licence only when they can provide evidence that their equipment, processes, operational procedures, SMS, safety cases and mitigations technics are approved by the National Supervisory Authority NSA;
14. It is the responsibility of the NSA to coordinate with the CAA and ANSPs;
15. The performance of non-safety systems’ users regarding the scrupulous respect of rules and terms of their licence shall be recorded by the radio regulator and made available to the NSA;

Non-safety systems users sharing a safety-of-life band cannot be under the responsibility and authority of the CAA; they have to operate under the full responsibility of the Radio Regulator having delivered the licence. As a CAA is liable for licences delivered to Air Navigation Service Providers (ANSPs), Airports, etc; the same processes and procedures shall apply to the Radio Regulators to maintain the required safety-of-life protection. As ANSPs and Airports are liable for their operations, the same processes and procedures shall apply to non-safety systems users sharing a safety-of-life band.

1. EUROCONTROL Military ATM Board[[38]](#footnote-39) (MAB) on low power audio programme making and special events (PMSE) sharing in the aviation band 960-1164 MHz

The MAB acknowledge the consultation and studies related to the 960-1164 MHz aviation band[[39]](#footnote-40) for the possible use of low power audio Programme Making and Special Events (PMSE) equipment.

The band in question is used to support fundamental safety-of-life services for both civil and military aviation. These are based on the operation of systems such as DME, TACAN, SSR, ACAS, Mode S, IFF and some bands of GPS and GALILEO. JTIDS/MIDS uses a set of frequencies in this band.

The MAB acknowledge the risks associated with the UK OFCOM decision. Such risks result from sharing this L-band spectrum used for safety-related services with commercial and market-driven non-aviation services which would require strict governance to safeguard the aviation use of the band.

The MAB highlight the importance of relevant regulatory and technical studies to be conducted on the feasibility of such spectrum sharing to completely mitigate the risks of interference with a negative impact on aviation safety. In this respect the MAB fully support the approach described in the ICAO letter E3 5.15, dated 19/04/2017, to the CEPT ECC WG FM Chairman in particular to the 7 caveats identified as pre-conditions to be met to be able to accept any sharing of the band:

1. the new system is completely compatible with existing and planned aviation systems based on testing and analysis that has been agreed by aviation regulators;
2. the parameters for the new system will be captured in an internationally recognized standards document;
3. the new system will be certified (including software and hardware) by the competent national regulatory authorities; will be maintained to meet throughout its service life the operational parameters assumed in the aviation testing/studies; will perform self-monitoring to ensure that it shuts down if it moves outside those agreed parameters; and the self-monitoring/shutdown function itself will also be certified;
4. the new system will include time-stamped logging of essential transmitter parameters, such as frequency use and power levels for post incident/accident investigation purposes;
5. the new system will not impact the ability of aviation to manage existing and planned aviation systems and the ability of aviation authorities to modify operating frequency assignments, powers and signal contents of the aviation systems without introducing additional coordination mechanisms;
6. the operator of the new system must accept all legal liability in case of interference to aviation systems (e.g., due to false channel selection, excessive power, human error, device failure), and recognize that aviation systems operators have no liability in case of interference to the new system;
7. personnel responsible for the operation of non-aviation systems in the 960-1164 MHz band shall be required to achieve similar levels of certification to those stipulated in the Radio Regulations for operators of aviation systems (radio operator's certificate).

In addition to the ICAO caveats, the MAB could only support the introduction of any new system in the 960-1164 MHz band if it can also be ensured that:

* the related liability aspects be identified and clarified in advance; - In case of (harmful) interference, (for instance due to wrong PMSE channel selection, too high power emission, human error, device problems,…) resulting in any incident and/or accident (infringement of safety), responsibilities have to be established and corrective actions need to be taken in a timely manner;.
* no additional technical and operational constraints, resulting from a possible sharing of this band with low power audio PMSE, be imposed to aeronautical applications in 960-1164 MHz band including the military systems.

In respect to the technical studies to be conducted, respecting the fact that NATO could not come to a unanimously agreed position on this issue as obligated to take a formal NATO position and to nevertheless respond to the request of WG FM to represent the military interest, NATO submitted the CaP 3 military session paper ‘PMSE Equipment EMC Evaluation Requirements’ Doc. SE7(17)083 dated 18 September 2017 to WG FM, WG SE and SE7 of CEPT. This document sets the technical parameters to be taken in account for the studies to protect the military interest and use in the respective band. This document and its content is fully supported. The MAB in particular want to stress the rigorous and robust test and evaluation process that needs to be established including hardware testbeds in order to fully assess the electromagnetic compatibility situation.

1. UK decision to allow PMSE to share the 960-1164 MHz band summary

Working with the Civil Aviation Authority (CAA) and Ministry of Defence (MOD), and operating within its statutory duties, rights and obligations as set out in all relevant national and international regulations, Ofcom decided to allow low power audio PMSE (wireless microphones and in ear monitors with a radiated power of less than 50 mW) to operate in the 960 to 1164 MHz band, sharing the spectrum with civil and military aeronautical navigation and communication systems. In December 2018 the CAA agreed the safety assurance case which assesses the risk of PMSE sharing in the band.

Spectrum availability for PMSE is derived through the Spectrum Management Rules (SMRs). The SMRs identify usable spectrum for PMSE on a geographically interleaved basis with DME/TACAN assignments. The SMRs do not allow access to spectrum within ±15 MHz of 1030 and 1090 MHz (to mitigate the risk of harmful interference to all aeronautical systems that operate at 1030/1090 MHz), or to spectrum below 961 MHz and above 1154 MHz to protect services in adjacent bands. Access to the band is on a licensed basis which authorises the frequency, location and duration of the PMSE assignment.

This annex summarises the rationale for looking at additional spectrum for PMSE and the analysis and steps taken to assess compatibility and ensure spectrum sharing in the 960 MHz band can be effectively and safely implemented.

* 1. Background

Following the decision at the World Radio Conference in 2012 to agree a co-primary allocation for mobile and broadcasting in the 700 MHz band (694-790 MHz) in ITU Region 1, Ofcom carried out an impact assessment of loss of access of this band on Programme Making and Special Events. This analysis concluded that the majority of PMSE users and events would be able to satisfy their spectrum requirements from the remaining spectrum between 470 to 694 MHz. The analysis showed that 93% of events required 24 or fewer assignments which could be accommodated in 20 to 24 MHz of spectrum. This level of demand can comfortably be met in the spectrum between 470 to 703 MHz[[40]](#footnote-41) that PMSE will continue to have access to after the release of the 700 MHz band.

The remaining 7% of events make up the peak demand that would start to be affected by the change of use of the 700 MHz band. However, for only a small subset of these events, with a high count of simultaneous (or near-simultaneous) co-located assignments, the remaining spectrum between 470 to 703 MHz may not be adequate.

To mitigate the loss of access to the 700 MHz band, Ofcom assessed new spectrum sharing opportunities. In looking to identify candidate spectrum Ofcom applied the criteria as set out in Table 8.

Table 8: Criteria to identify candidate spectrum sharing opportunities for low power audio PMSE

| Criterion | Rationale |
| --- | --- |
| Not already allocated to Mobile | Risk of interference. Audio PMSE applications require high quality of service which can only be provided by spectrum with a low risk of harmful interference. On this basis sharing with mobile services is not considered viable |
| Not already identified as a candidate mobile band and unlikely to be so in the medium to long term | Any spectrum identified as a candidate mobile band is at risk of reallocation at some future time. While this reallocation may be some time in the future it is not possible to provide any certainty around security of access |
| The incumbent use of the candidate band is harmonised at least Europe wide | This would provide the opportunity for other countries to adopt the sharing solution leading to economies of scale in equipment production and distribution |
| Provides a substantial block of contiguous spectrum | A fragmented spectrum supply would not be viable for PMSE users. Equipment owners and hirers would need to hold multiple items to access small, discrete parcels of spectrum which is not considered economically viable |
| Introduction of PMSE to be neutral to any incumbent | Access to the band by PMSE should not constrain or require any remedial action by the current users of the band such as a change of working practice or equipment |
| Below 2 GHz | The current industry consensus is that higher frequencies are inappropriate for PMSE applications due to their propagation characteristics |

All bands between 790 MHz and 2 GHz were assessed against the criteria in Table 8. This identified the 960 to 1164 MHz band as the most viable option for low power audio PMSE as it meets all the above criteria. In particular, given the slow rate of any changes to incumbent use in the band, access for PMSE can be considered to be a viable long-term opportunity.

* 1. compatibility

Compatibility between PMSE and aeronautical services in the 960 to 1164 MHz band is ensured through the application of the Spectrum Management Rules (SMRs) which define the framework for how spectrum for PMSE is derived. The SMRs identify what spectrum can be used by PMSE and provide an indication of the ‘quality’ of that spectrum (by assessing the level of potential interference into PMSE from aeronautical services).

Aeronautical services that operate at 1030/1090 MHz (e.g. SSR, ACAS, ADS-B etc.) are protected by ±15 MHz guard bands. GNSS operating above 1164 MHz is protected by a 10 MHz guard band from 1154 to 1164 MHz. Services below 960 MHz are protected by a 1 MHz guard band. This means that the spectrum is split into three sub-bands in which PMSE can operate:

* 961-1015 MHz;
* 1045-1075 MHz;
* 1105 1154 MHz (10 MHz guard band at 1154 MHz).

Within the sub-bands noted above the primary sharing arrangement is PMSE geographically interleaving with DME (and TACAN) assignments. The UK Interface Requirement 2038 (for PMSE) clearly identifies the bands that can be used by PMSE and technical limitations such as maximum power and bandwidth.

* 1. Approach to assessing compatibility

Working closely with the CAA and the MOD, Ofcom carried out a detailed compatibility study between aeronautical systems that operate in the 960 –1164 MHz band and low power audio PMSE equipment.

To assess compatibility a series of practical coexistence tests were carried out. These tests were agreed with the CAA, MOD and Ofcom and used the same approach and civil and military aeronautical equipment as those practical tests used to derive the UK’s Link16 Frequency Clearance Agreement (FCA) between the CAA and MOD. It was agreed that using the same approach for determining compatibility between Link16 and aeronautical systems would be suitable for deriving the compatibility between those systems and low power audio PMSE.

The tests included the full Link16 signal environment as defined in the FCA. This was to ensure that the introduction of PMSE into the band would be neutral to both civil and military use and not cause a need to review or revise the FCA to take account of PMSE.

Testing was carried out by JCSys[[41]](#footnote-42). Interference thresholds were determined through measurement for a range of aeronautical ground and airborne DME and SSR equipment, for both analogue and digital microphone equipment. The tests also assessed the ‘quality’ of the spectrum to support PMSE services. The full reports can be found on Ofcom’s web site[[42]](#footnote-43). The results of the compatibility tests were used to assess spectrum availability for PMSE. The propagation modelling parameters were agreed with the CAA.

Ofcom consulted on its analysis and assessment of spectrum availability, and in March 2016 published its statement setting out its decision to allow low power audio PMSE to operate in the 960 to 1164 MHz band[[43]](#footnote-44).

* 1. Spectrum availability

Spectrum availability for PMSE is location dependent as frequency assignments for aeronautical services (DME and TACAN) are based on frequency planning criteria using a 1 MHz channel raster (DME channels are identified by number and ‘X’ or ‘Y’). By incorporating this assignment data in the SMRs it is possible to identify usable spectrum for PMSE, geographically interleaving with DME. Figure 4 summarises the approach.

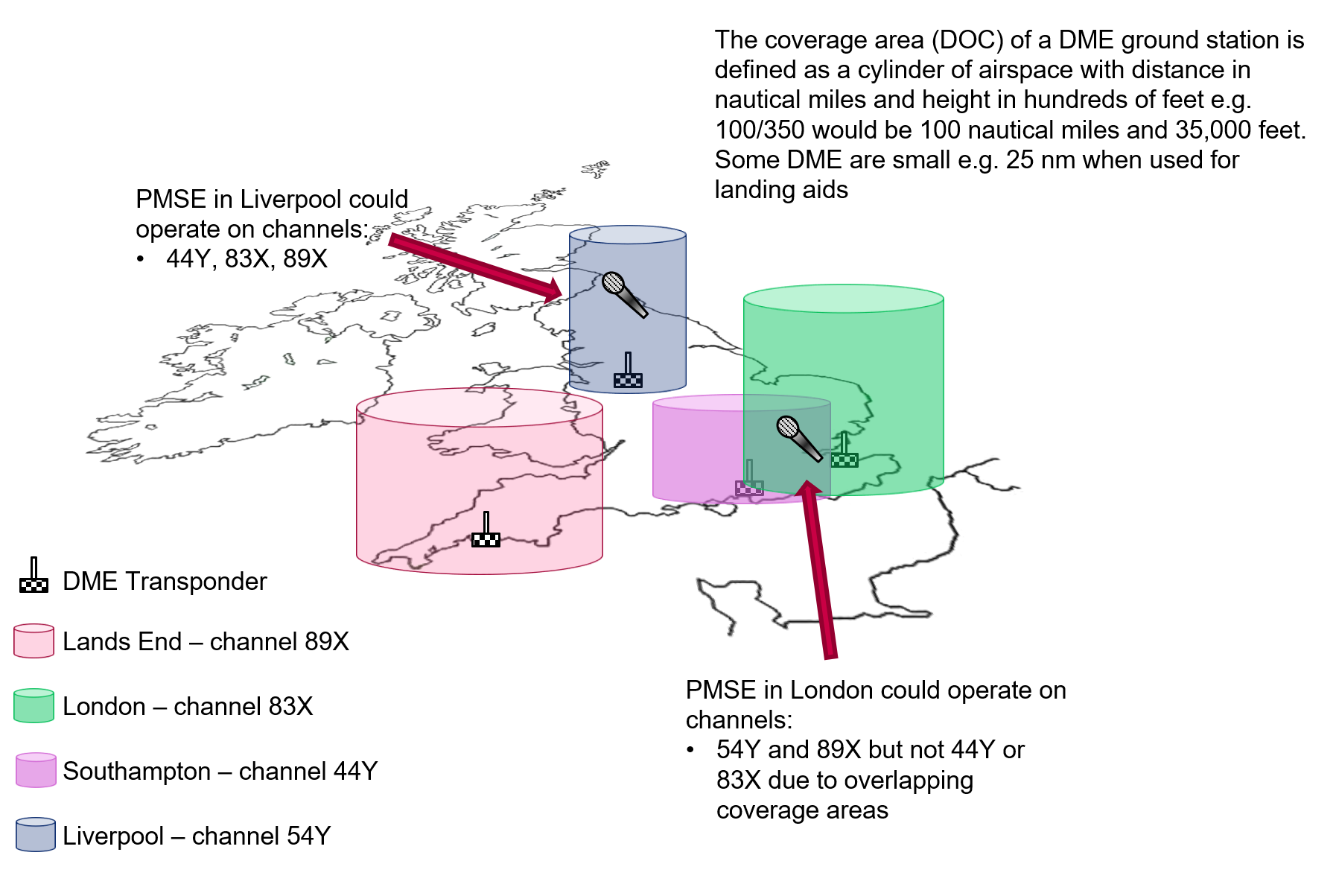
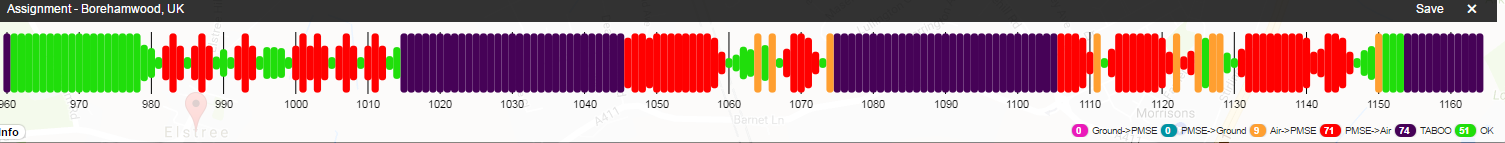


Figure 4: Example of location dependent spectrum availability for PMSE

Information on DME frequency assignments, including location of ground equipment and operational coverage areas, is taken from EUROCONTROL’S Spectrum and Frequency Information Resource (SAFIRE).[[44]](#footnote-45) The SMRs and licensing platform apply these data to the location of the proposed PMSE assignment to calculate available spectrum. The guard bands at 1030/1090 MHz, below 961 MHz and above 1054 MHz are hard coded into the licensing platform so are shown as not available.

Figure 5 provides some examples of spectrum availability for BBC studios at Elstree, North London and Pacific Quay, Glasgow. As can be seen in the figure, the guard bands are clearly shown as unavailable (“taboo”) and spectrum availability is different between the two locations, i.e. 60 MHz in Elstree and 110 MHz in Pacific Quay. This is because there are more DMEs to be considered in the south east of the UK than in Scotland.

Elstree – 60 MHz available of which 9 MHz at risk of interference into PMSE from airborne DME





Pacific Quay Scotland – 110 MHz available of which 17 MHz at risk of interference into PMSE from airborne DME

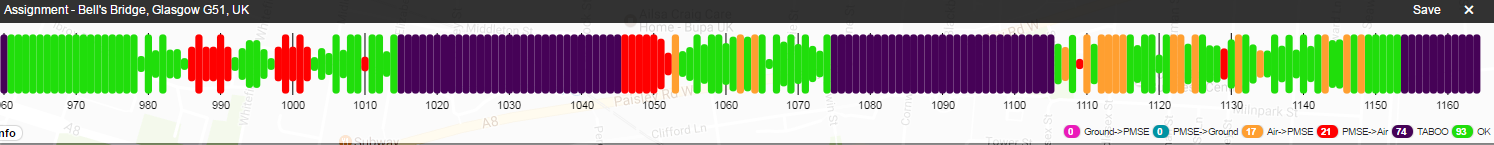




Figure 5: Examples of spectrum availability for low power audio PMSE

* 1. Tests and trials of PMSE equipment

Since 2016, PMSE users have carried out tests and trials within the 960-1164 MHz band (authorised via a trial and innovation licence) to determine whether it provides sufficient quality for productions. These have included long-term monitoring of the band (both indoors and outdoors) and use of wireless microphones within and outside studios, including in live productions at the Sky studios near Heathrow Airport. Further details can be found in ANNEX 5.

Ofcom identified that due to the nature of the Link16 signal, technical coordination is not possible and does constitute a risk of interference to PMSE. The MOD provided information on the typical use for Link16 in the UK, i.e. above 10,000 feet in remote areas. The FCA restricts use of Link16 near aircraft and ground navigation facilities, and there is protected airspace around airports and major flight lanes. Based on the information provided by the MOD, Ofcom concluded that the risk of interference from Link16 is low.

The results of these trials show that spectrum availability and ‘quality’ aligns with Ofcom’s the output from the SMRs. Also, the trials and long-term monitoring (including outdoors) has shown no instances of spectrum use, such as Link16, that would cause harmful interference to PMSE.

UK PMSE users have gained confidence in the band and have stated that it provides a suitable spectrum sharing option to support the high-quality requirements of programme and event production.

* 1. Safety assurance

As part of the implementation of PMSE sharing in the 960 MHz band Ofcom has developed a safety assurance case (SAC). The SAC is based on the classification/tolerability matrix from CAP 760, published by the CAA.[[45]](#footnote-46)

The SAC assesses the risk on the safe operation/navigation of aircraft from the expected operation of PMSE equipment, such as wireless microphones and in-ear-monitors operating with a radiated power of less than 50 mW. This SAC demonstrates that, based on a real understanding of PMSE stakeholder performance, the system will be safe. The 960MHz band is currently already shared with Link 16 (JTIDS). The assessment for PMSE has been developed to be consistent with some of the transferrable assumptions and data presented in the Link 16 baseline safety case.

The SAC considers what consequences would arise if elements of the system were to fail, the ‘failure case’, and identifies any mitigations needed to ensure the system remains safe. There are three principal areas of risk which are dealt with within the SAC:

* Interference with systems on 1030/1090 MHz;
* Interference with GNSS systems above 1164 MHz;
* Interference with DME systems.

The SAC has been reviewed by the CAA and it is satisfied that any proposed change to the radio spectrum environment from the introduction of PMSE into the band can be implemented and maintained without interference to aeronautical services.

* 1. feasibility of PMse operating in the 960-1164 mhz band

Working with the CAA and MOD, Ofcom has carried out theoretical studies and practical compatibility measurements to develop appropriate sharing criteria between PMSE and aeronautical systems in the 960 MHz band. These criteria have been incorporated into the Spectrum Management Rules through which usable spectrum for PMSE is identified and authorised (via a coordinated PMSE licence which is frequency, location and date/time specific), and aeronautical services protected from harmful interference.

Spectrum sharing in bands used by aeronautical systems must respect the high safety standards of the aviation industry. Ofcom has developed the following documents to support the spectrum sharing arrangements:

* Test reports for the coexistence studies of PMSE with aeronautical services;
* Spectrum Management Rules for the licensing of PMSE users in the 960 to 1164 MHz band;
* A safety assurance case setting out how PMSE can share access to this spectrum safely.

The UK CAA has reviewed the documentation and is satisfied that any proposed change to the radio spectrum environment can be implemented and maintained without interference to aeronautical services. Ofcom will continue to work closely with the CAA to provide assurance that the licensing process, spectrum management rules and safety case remain valid, and that the operating practices of PMSE users conform to the rules and assumptions made.

The possibility of any new aeronautical system being introduced in the band is addressed in both the processes and procedures for maintaining the spectrum management rules (SMRs), and in the safety assurance case itself.

1. Report on Practical PMSE Testing in the UK: June 2016 – March 2019

Following the publication of a statement from Ofcom UK on the 10 March 2016 [23], Shure engaged with Ofcom to initiate practical testing of wireless microphone systems in the 960 MHz band. The BBC and Sky participated in the trials to assess whether the 960 MHz band could support the high-quality requirements of PMSE.

For the length of these trials, some 21 months, no interference has been received to the PMSE systems and there have been no reported cases of interference to aeronautical systems. Spectrum availability and quality are in line with Ofcom’s spectrum lookup tool.

Ofcom has authorised the use of PMSE equipment in the 960–1164 MHz band since July 2016 via its Innovation and Trial licence; from January 2019 commercial use can be authorised under Ofcom’s standard, coordinated PMSE licence. Trials have taken place by the BBC at Borehamwood, Glasgow, Birmingham, Broadcasting House (London) and by Sky at their studio complex at Osterley, West London plus the Cambridge theatre in central London. In addition, long term monitoring and some PMSE use has taken place at Edgcott near Oxford. To date, no interference to or from PMSE has been noted, which generally endorses the Ofcom view that for the UK under current conditions this band is viable spectrum for secondary use by PMSE.

The Ofcom spectrum tool has been validated and has proven to identify clear spectrum for PMSE. Licensing continues under both the Innovation and Trial regime and standard coordinated authorisation; licences have been issued or renewed as appropriate.

Trials have predominately been indoors within studios, with a limited number of outdoor deployments. This has been a consequence of practical issues rather than any interference concerns with the DME spectrum. Some additional outdoor trials have been made since the initial report on PMSE trials was issued in January 2017. External operation and monitoring using 10 PMSE channels has been carried out at Edgcott for extended periods to assess the risk of intermittent, short-term interference.

During November 2017 an additional 16 channels of Shure and 2 channels of Wisycom equipment have been in use. All equipment has been inspected in the laboratory and found to meet the technical requirements of ETSI EN 300-422-1 [25].

From the initial trials, sufficient confidence was gained in the viability of the spectrum that from early in 2018 Sky extended the trials to use in live productions at the its studios near Heathrow Airport, which is considered one of the heaviest aircraft use areas in the UK, with live programs lasting up to six hours without any interruptions or interference; these trial is ongoing.

* 1. Spectrum Tool

Ofcom generates a “map” of available spectrum at a given location by considering both interference to aeronautical services and to PMSE use over the 960-1164MHz band. The calculation needs to consider all aeronautical services which may be affected. Channels were then labelled:

* OK;
* Taboo; or
* Showed the potential interference to PMSE.

In addition to an Excel table, the tool produces graphs that are coloured to indicate spectrum quality and availability:

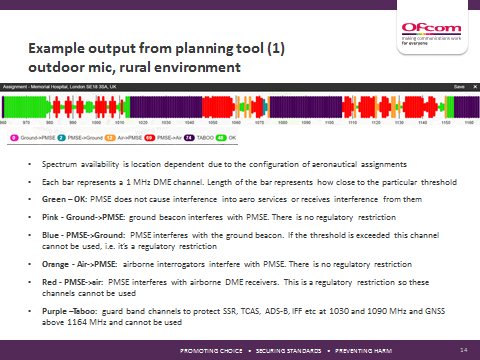


Figure 6: Example output from planning tool (outdoor microphone, rural environment)

* 1. Use Of the band

The industry regards the 960-1164 MHz spectrum as “top up” for large shows where the remaining 670-694 MHz spectrum is insufficient. Cost and availability of equipment in the 960 MHz compared with that in the 470 MHz band where there is a significant range of cheaper equipment available will have a filtering effect on use.

* 1. Noise Floor & Propagation

The BBC has carried out extensive monitoring of the 960 MHz and compared this with what is experienced in the 470 MHz band and found the noise floor to be similar. In addition, testing has shown that both bands provide similar link budgets, which is a great advantage when reequipping a site.

1. List of References
2. Convention on International Civil Aviation - Doc 7300 (<http://www.icao.int/publications/Pages/doc7300.aspx>)
3. ERC Recommendation 25-10 : Frequency Ranges for the Use of Terrestrial Audio and Video Programme Making and Special Events (PMSE) applications
4. ERC Report 25 : The European Table of Frequency Allocations and Applications in the frequency range 8.3 kHz to 3000 GHz (ECA table).
5. Commission Implementing Regulation (EU) No 1035/2011 of 17 October 2011 laying down common requirements for the provision of air navigation services and amending Regulations (EC) No 482/2008 and (EU) No 691/2010
6. Commission Implementing Regulation (EU) No 1034/2011 of 17 October 2011 on safety oversight in air traffic management and air navigation services and amending Regulation (EU) No 691/2010
7. Commission Implementing Regulation (EU) 2016/1377 of 4 August 2016 laying down common requirements for service providers and the oversight in air traffic management/air navigation services and other air traffic management network functions, repealing Regulation (EC) No 482/2008, Implementing Regulations (EU) No 1034/2011 and (EU) No 1035/2011 and amending Regulation (EU) No 677/2011
8. Regulation (EC) no 549/2004 of the European Parliament and of the Council of 10 March 2004 laying down the framework for the creation of the single European sky (the framework Regulation)
9. Regulation (EC) No 550/2004 of the European Parliament and of the Council of 10 March 2004 on the provision of air navigation services in the single European sky (the service provision Regulation)
10. Regulation (EC) No 551/2004 of the European Parliament and of the Council of 10 March 2004 on the organisation and use of the airspace in the single European sky (the airspace Regulation)
11. Regulation (EC) No 552/2004 of the European Parliament and of the Council of 10 March 2004 on the interoperability of the European Air Traffic Management network (the interoperability Regulation)
12. Regulation (EC) No 1070/2009 of the European Parliament and of the Council of 21 October 2009 amending Regulations (EC) No 549/2004, (EC) No 550/2004, (EC) No 551/2004 and (EC) No 552/2004 in order to improve the performance and sustainability of the European aviation system (Text with EEA relevance)
13. Regulation (EC) No 216/2008 of the European Parliament and of the Council of 20 February 2008 on common rules in the field of civil aviation and establishing a European Aviation Safety Agency, and repealing Council Directive 91/670/EEC, Regulation (EC) No 1592/2002 and Directive 2004/36/EC
14. Council Regulation (EC) No 219/2007 of 27 February 2007 on the establishment of a Joint Undertaking to develop the new generation European air traffic management system (SESAR)
15. Council Regulation (EC) No 1361/2008 of 16 December 2008 amending Regulation (EC) No 219/2007 on the establishment of a joint undertaking to develop the new generation European air traffic management system (SESAR)
16. Council Regulation (EU) No 721/2014 of 16 June 2014 amending Regulation (EC) No 219/2007 on the establishment of a Joint Undertaking to develop the new generation European air traffic management system (SESAR) as regards the extension of the Joint Undertaking until 2024
17. Decision No 243/2012/EU of the European Parliament and of the Council of 14 March 2012 establishing a multiannual radio spectrum policy programme
18. Commission Regulation (EU) No 677/2011 of 7 July 2011 laying down detailed rules for the implementation of air traffic management (ATM) network functions and amending Regulation (EU) No 691/2010
19. Commission Decision of 7.7.2011 on the nomination of the Network Manager for the air traffic management (ATM) network functions of the single European sky
20. [ICAO Doc 4444 – Procedures for Navigation Services – Air Traffic Management](https://ops.group/blog/2016-16th-edition-icao-doc-4444/)
21. Commission Implementing Regulation (EU) 2017/373 of 1 March 2017 laying down common requirements for providers of air traffic management/air navigation services and other air traffic management network functions and their oversight, repealing Regulation (EC) No 482/2008, Implementing Regulations (EU) No 1034/2011, (EU) No 1035/2011 and (EU) 2016/1377 and amending Regulation (EU) No 677/2011
22. ECC Report 204 : Spectrum use and future requirements for PMSE
23. JCSys/C053/004/3 : Test Report for the Coexistence of PMSE with Aeronautical Services in the Band 960-1164 MHz, 23 September 2015
24. OFCOM - New Spectrum for Audio PMSE, 10 March 2016
25. CEPT Report 32: Mechanisms to improve co-existence of Multipoint (MP) systems.
26. ETSI EN 300-422- Wireless Microphones; Audio PMSE up to 3 GHz; Part 2: Class B Receivers; Harmonised Standard covering the essential requirements of article 3.2 of Directive 2014/53/EU
27. Allied Spectrum Publication 01 (ASP-01), Spectrum Management In Military Operations, Oct 2017
28. ICAO Doc 9859 “Safety Management Manual”, Table 5-1
29. ICAO Doc 9718 “Handbook on Radio Frequency Spectrum Requirements for Civil Aviation”
30. ICAO Doc 9868 “Procedures for Air Navigation Service Training”
31. ICAO Doc 10057 “Manual on Air Traffic Safety Electronics Personnel Competency-based Training and Assessment”

1. Programme Making and Special Events [↑](#footnote-ref-2)
2. Article 4.4: Administrations of the Member States shall not assign to a station any frequency in derogation of either the Table of Frequency Allocations in this Chapter or the other provisions of these Regulations, except on the express condition that such a station, when using such a frequency assignment, shall not cause harmful interference to, and shall not claim protection from harmful interference caused by, a station operating in accordance with the provisions of the Constitution, the Convention and these Regulations [↑](#footnote-ref-3)
3. Article 4.10: Member States recognize that the safety aspects of radionavigation and other safety services require special measures to ensure their freedom from harmful interference; it is necessary therefore to take this factor into account in the assignment and use of frequencies [↑](#footnote-ref-4)
4. A safety case is a structured argument, supported by evidence, intended to justify that a system is acceptably safe for a specific application in a specific operating environment [↑](#footnote-ref-5)
5. <http://www.itu.int/en/history/Pages/ConstitutionAndConvention.aspx> [↑](#footnote-ref-6)
6. RESOLUTION 417 (WRC-15) : Use of the band 960-1164 MHz by the aeronautical mobile (R) service

   https://www.itu.int/net/ITU-R/conferences/docs/ties/wrc-res-417-en.pdf [↑](#footnote-ref-7)
7. <https://www.pilot18.com/icao-annex-10-telecommunication/> [↑](#footnote-ref-8)
8. <https://www.easa.europa.eu/sites/default/files/dfu/ICAO-annex-19.pdf> [↑](#footnote-ref-9)
9. <https://www.icao.int/safety/SafetyManagement/Pages/GuidanceMaterial.aspx> [↑](#footnote-ref-10)
10. In the one example of PMSE sharing in the 960 MHz band, guard bands of ±15 MHz have been introduced to protect 1030/1090 MHz and a 10 MHz guard band at 1154 MHz is applied to protect RNSS above 1164 MHz. To protect ground station receivers, additional frequency restrictions based on geographic exclusion zones are also implemented e.g.  ±25 MHz guard band at 1090 MHz within 500 m of an SSR ground receiver. [↑](#footnote-ref-11)
11. [www.efis.dk](http://www.efis.dk) (see applications of Georgia for military use) [↑](#footnote-ref-12)
12. 1034/2011 and 1035/2011 have been repealed by COMMISSION IMPLEMENTING REGULATION (EU) 2016/1377, the main provisions of which become applicable on 1 January 2019 [↑](#footnote-ref-13)
13. National Supervisory Authorities (NSAs) ensure the supervision of the regulatory framework in all Member States. They are responsible, in particular, for certifying and overseeing air navigation service providers as well as for the preparation of national performance plans of the Member States concerned [↑](#footnote-ref-14)
14. <https://ec.europa.eu/transport/modes/air/single_european_sky/co-operation_eurocontrol_hr> [↑](#footnote-ref-15)
15. [www.easa.europa.eu](http://www.easa.europa.eu) [↑](#footnote-ref-16)
16. <https://cordis.europa.eu/project/rcn/206409/factsheet/en> [↑](#footnote-ref-17)
17. TACAN operates in the UHF (1000 MHz) band with 126 two-way channels in the operational mode (X or Y) for 252 total;

    Air-to-ground DME frequencies are in the 1025-1150 MHz range;

    Ground-to-air frequencies are in the 962-1213 MHz range. [↑](#footnote-ref-18)
18. RNAV and RNP systems are fundamentally similar. The key difference between them is the requirement for on-board performance monitoring and alerting. A navigation specification that includes a requirement for on-board navigation performance monitoring and alerting is referred to as an RNP specification. One not having such requirements is referred to as an RNAV specification. An area navigation system capable of achieving the performance requirement of an RNP specification is referred to as an RNP system. [↑](#footnote-ref-19)
19. ITU RR Article 37 calls for the adoption of international Standards and Recommended Practices (SARPs) dealing with, inter alia, communications and navigation aids. SARPs normally address all interface parameters, including radio frequency (RF), performance, coding etc. to ensure worldwide interoperability. These provisions form the major part of the international framework for aviation safety in regard to the radio systems carried by aircraft. It should be noted that ICAO SARPs are only adopted for systems which are standardized on a worldwide basis, and hence do not include such self-contained systems as radio altimeters and airborne weather radar, carried as a mandatory requirement by many aircraft, and which also meet the certificate of airworthiness requirements. [↑](#footnote-ref-20)
20. <https://www.eurocontrol.int/articles/esarr-4-risk-assessment-and-mitigation-atm> [↑](#footnote-ref-21)
21. ICAO Annex 11 "Air Traffic Services"; ICAO Annex 19 " Safety Management"; ICAO DOC 9718  "Non safety of life services, willing to share a safety of life band have to comply with the aviation safety requirements applicable in that band including certification of radio equipment, software and radio operators, as well as assumption of liability".; Commission regulation (EC) 1321/2014: "on the continuing airworthiness of aircraft and aeronautical products, parts and appliances, and on the approval of organisations and personnel involved in these tasks" [↑](#footnote-ref-22)
22. In the USA, the frequency band 1435-1525 MHz has been made available for audio PMSE based on specific conditions as outlined in [FCC 15-100 Report and Order](https://docs.fcc.gov/public/attachments/FCC-15-100A1.pdf). The licensing conditions specify that coordination with AFTRCC prior to operation is required and that automated shutdown is desirable. As yet the detailled conditions have not been agreed. [↑](#footnote-ref-23)
23. Commission implementing regulations 1034/2011 [5] and 1035/2011 have been repealed by Commision implementing regulation (EU) 2016/1377 [6], which applies from 1st January 2019. [↑](#footnote-ref-24)
24. <http://www.atag.org/component/downloads/downloads/346.html> [↑](#footnote-ref-25)
25. <http://www.eurocontrol.int/sites/default/files/publication/files/airport-economic-value-final-report.pdf> [↑](#footnote-ref-26)
26. <https://www.eurocontrol.int/sites/default/files/content/documents/sesar/business-case/european_airline_delay_cost_reference_values_2011.pdf> [↑](#footnote-ref-27)
27. UK Music: Wish You Were Here (2017) – The contribution of live music to the UK economy [↑](#footnote-ref-28)
28. <https://www.gsa.europa.eu/system/files/reports/gnss_mr_2017.pdf> [↑](#footnote-ref-29)
29. <https://www.oxera.com/wp-content/uploads/2018/03/What-is-the-economic-impact-of-Geo-services_1.pdf> [↑](#footnote-ref-30)
30. ICAO Annex 2 defines detect and avoid as "The capability to see, sense or detect conflicting traffic or other hazards and take the appropriate action." [↑](#footnote-ref-31)
31. ICAO Annex 11 “Air Traffic Services” [↑](#footnote-ref-32)
32. ICAO Doc 9735 “Universal Safety Oversight Audit Programme Continuous Monitoring Manual” [↑](#footnote-ref-33)
33. In ICAO Annex 19, the term “relevant authorities or agencies” is defined “in a generic sense to include all authorities with an aviation safety oversight responsibility, which may be established by the State as separate entities. This includes: Civil Aviation Authorities, Airport Authorities, Air Traffic Service Authorities, Accident Investigation Authority and Meteorological Authority”. [↑](#footnote-ref-34)
34. <https://www.icao.int/airnavigation/Pages/GANP-Resources.aspx> [↑](#footnote-ref-35)
35. [https://www.eurocontrol.int/news/ldacs-aviation’s-future-terrestrial-datalink-takes-big-step-forward](https://www.eurocontrol.int/news/ldacs-aviation's-future-terrestrial-datalink-takes-big-step-forward) [↑](#footnote-ref-36)
36. Interference statistics have been addressed within the CEPT where over a staggering 1700 cases of interference have been reported to aeronautical services within the CEPT nations; “CEPT ECC Working Group FM Report with subject “Summary of the Annual Interference Statistics Questionnaire for Reported Cases in 2016” dated 19 May 2017 [↑](#footnote-ref-37)
37. Such restriction or controls would range from total loss of existing or potential Link 16 authorization to operate to affecting peacetime training by further limiting the levels of operation in a geographic area, disallowing required functionality, restricting location of operations and adding separation distances to other in-band users [↑](#footnote-ref-38)
38. The Military ATM Board is part of the EUROCONTROL consultation arrangements and advises the DG and the PC. Its major role is to act as pan-European military focal point for ATM matters. One of its resulting major tasks is to develop harmonized pan-European military position in regard to civil-military ATM coordination. MAB membership is open to all ECTL member States, NATO, EDA and S-JU have observer status. [↑](#footnote-ref-39)
39. Considered by the International Telecommunications Union (ITU) as a band for Aeronautical Radio Navigation Service (ARNS), Aeronautical Mobile (Route) Service (AM(R)S and, around 1090 MHz for Aeronautical Mobile Satellite (Route) Service (AMS(R)S). [↑](#footnote-ref-40)
40. In November 2017 Ofcom published its decision to allow PMSE users to access the 700 MHz guard band, 694 to 703 MHz. This additional 9 MHz was not included in the original impact assessment. This band was not included in the PMSE impact assessment. [↑](#footnote-ref-41)
41. JCsys is the key advisor to the UK MOD providing subject matter expertise support for the Frequency Clearance Agreement compliance and testing [↑](#footnote-ref-42)
42. https://www.ofcom.org.uk/consultations-and-statements/category-2/new-spectrum-audio-pmse [↑](#footnote-ref-43)
43. https://www.ofcom.org.uk/\_\_data/assets/pdf\_file/0021/62481/New-Spectrum-for-Audio-PMSE-statement.pdf [↑](#footnote-ref-44)
44. SAFIRE provides a platform to manage the coordination and publication of the aviation frequency assignments in the ICAO European region. SAFIRE is built on a database which contains information about every aeronautical frequency assignment in the communication, navigation and surveillance aviation bands. [↑](#footnote-ref-45)
45. Guidance on the Conduct of Hazard Identification, Risk Assessment and the Production of Safety Cases [↑](#footnote-ref-46)