UNOFFICIAL MACHINE TRANSLATION

Analysis of the current and future use of the 4 GHz band

Prepared for the Ministry of Industry and Trade

[November 2024]

Grant Thornton

Contents

1 Definition of terms

This report uses a number of abbreviations. Some are defined in this section, but many others are defined in the main body of the report when they first appear. In a few cases, we assume that some are already so well known (e.g. MHz, GHz, etc.) that they do not require further definition.

5G – the fifth generation of mobile telecommunications developed by the 3GPP standardisation organisation. According to the 3GPP website, 5G was defined in 'Release 15, functionally frozen in June 2018 and fully specified by September 2019... Release 15 specifies Phase 1 of 5G, which introduces a new radio transmission technology [NR] and other key concepts, such as industrial-grade reliability, enhanced modularity and faster response times... [As a result, 5G] is ready for use across all industrial sectors and for time-critical applications.."[1] The 3GPP working groups are currently preparing specifications for Releases 18 and 19. Further information is available at:

- 3GPP TR 21.915 V15.0.0 (2019-09): "Release 15 Description; Summary of Rel-15 Work Items" – https://www.3gpp.org/ftp//Specs/archive/21_series/21.915/21915-f00.zip
- 3GPP TS 22.261 V19.8.0 (2024-09): "Service requirements for the 5G system; Stage 1 (Release 19)" – https://www.3gpp.org/ftp/Specs/archive/22_series/22.261/22261-j80.zip
- 3GPP TS 38.300 V18.3.0 (2024-09): "NR and NG-RAN Overall Description; Stage 2 (Release 18)" - https://www.3gpp.org/ftp/Specs/archive/38_series/38.300/38300-i30.zip
- 3GPP TR 38.817-01 V16.4.0 (2022-09): "General aspects for User Equipment (UE) Radio Frequency (RF) for NR (Release 16)" – https://www.3gpp.org/ftp/Specs/archive/38_series/38.817-01/38817-01-g40.zip
- 3GPP TR 38.817-02 V15.11.0 (September 2023): "General aspects for Base Station (BS) Radio Frequency (RF) for NR (Release 15)" – https://www.3gpp.org/ftp/Specs/archive/38_series/38.817-02/38817-02-fb0.zip

The Aeronautical Radionavigation Service (ARNS) is defined by the International Telecommunication Union as "a radionavigation service intended to meet the needs of aircraft and to ensure the safety of their operations."[2] Altimeters (also known as radio altimeters or short-range radio altimeters) are a type of radar used in the ARNS to determine precisely how high an aircraft is above the ground. They are particularly important during landings in conditions of reduced visibility (in fog, at night or during a storm). Further information is available at:

- European Commission Staff Working Document 'EU Roadmap for ensuring the safe coexistence of mobile networks and aviation altimeters in the 3.4–4.4 GHz frequency band in the Union' (Version 1, 18 April 2024) - https://circabc.europa.eu/sd/a/9e35cb97-0cac-422a-959e-b1b920a26dfc/EU%20Roadmap_WBB-RA_Coexistence_v1.pdf.
- [Draft] ECC Report 362, Parts 1 & 2: Compatibility between MFCNs operating in the 3400–3800 MHz band and low/medium-power wireless broadband systems (WBB LMP) operating in the 3800–4200 MHz frequency band with radio altimeters (RA) operating in the 4200–4400 MHz band (July 2024) – https://cept.org/files/9522/Draft-ECC-Report-362-part-1.docx and https://cept.org/files/9522/Draft-ECC-Report-362-part-2_rev.1.docx.
- Frank H. Sanders et al., *Measurement of spectral and spatial transmission power of new 5G radio networks for the analysis of interference to radar altimeters*, NTIA Report 22-562 – https://its.ntia.gov/publications/download/TR-22-562.pdf.
- ITU-R Question 229/7: 'Frequency sharing between the Earth exploration-satellite (passive) service and airborne altimeters in the aeronautical radionavigation service in the 4 200–4 400 MHz band' (2000) – https://www.itu.int/dms_pub/itu-r/opb/que/R-QUE-SG07.229-2000-MSW-E.doc
- ITU-R M.2319-0 (2014): 'Compatibility analysis between wireless aeronautical in-flight communication systems and systems in existing services in the 4 200–4 400 MHz frequency band' – https://www.itu.int/pub/R-REP-M.2319-2014

[1] 3GPP, "5G System Overview," (2022) - https://www.3gpp.org/technologies/5g-system-overview

[2] International Radio Regulations (2024 edition) – https://www.itu.int/hub/publication/r-reg-rr-2024/ and the National Frequency Table

The ITU defines *broadband wireless access* as "wireless access [for end-users] where connection speeds exceed... 1,544 kbits/s"[3] Examples of BWA technologies include wireless metropolitan area networks (IEEE 802.16, ETSI BRAN), radio local area networks (RLAN), IMT-2000 and IMT-Advanced. Further information is available at:

- ITU-R Recommendation F.1763: MSW-E.docx: 'Radio interface standards for broadband wireless access systems in the fixed service operating in the band below 66 GHz' (2014) – https://www.itu.int/dms_pubrec/itu-r/rec/f/R-REC-F.1763-1-201402-I!!MSW-E.docx
- ITU-R Report F.2086-1: 'Technical and operational characteristics and applications of broadband wireless access in the fixed service' (2010) – https://www.itu.int/dms_pub/itu-r/opb/rep/R-REP-F.2086-1-2010-PDF-E.pdf..
- ETSI TR 101 856 V1.1.1: 'Broadband Radio Access Networks (BRAN) – Functional requirements for fixed wireless access under 11 GHz: HIPERMAN" (2001) - "https://www.etsi.org/deliver/etsi_tr/101800_101899/101856/01.01.01_60/tr_101856v010101p.pdf

Conference Preparatory Meeting (CPM) – a series of meetings of administrative bodies preparing for the next ITU World Radiocommunication Conference (WRC). The purpose of the CPM is to discuss, compile and draft an information document (Report) summarising the issues, study results and options to be discussed at the next WRC. The aim of the report is to clarify where there is consensus (so that further discussion is unnecessary) and to specify where positions are divided, so that discussions at the WRC can focus on resolving policy differences. The CPM report is therefore an authoritative document with considerable influence. Further information is available at:

- "Conference Preparatory Meetings," in *ITU-R Radiocommunication Study Groups* (2020) - https://www.itu.int/dms_pub/itu-r/opb/gen/R-GEN-SGB-2020-PDF-E.pdf#page=56
- ITU, *Report of the CPM to the WRC-23* (2023) - https://www.itu.int/dms_pub/itu-r/opb/act/R-ACT-CPM-2023-PDF-E.pdf

Earth Exploration-Satellite Service (EESS) – EESS satellites use active and/or passive sensors to acquire data on the Earth's land, oceans and atmosphere for the purposes of studying and monitoring the climate and the environment, and for other related scientific applications. The ITU uses the term 'Earth exploration satellites', but in the open literature these satellites are often referred to as 'remote sensing satellites' or 'Earth observation satellites'. Further information is available at:

- ITU-R SA.1020 Recommendation: 'Hypothetical reference system for Earth exploration satellite services and meteorological satellite services' (1994) - - https://www.itu.int/dms_pubrec/itu-r/rec/sa/R-REC-SA.1020-0-199403-I!!MSW-E.doc
- ITU-R Recommendation SA.1023: "Methodology for establishing sharing and coordination criteria for systems in Earth exploration satellite services and meteorological satellite services" (1994) - https://www.itu.int/rec/R-REC-SA.1023/recommendation.asp?lang=en&parent=R-REC-SA.1023-0-199403-I

The Fixed Satellite Service (FSS) is defined in the ITU Radio Regulations as: "a radiocommunication service between earth stations at specified locations using one or more satellites; these locations may be specific or any fixed points within specified areas; in some cases, this service includes links between satellites, which may also be operated in the inter-satellite service; the fixed-satellite service may also include modulating links for other space radiocommunication services."[4] Further information is available at:

- ITU-R Recommendation SF.766: "Methods for determining the effects of interference on the performance and availability of terrestrial radio-relay systems and systems in the fixed-satellite service" (1992) – https://www.itu.int/rec/R-REC-SF.766/recommendation.asp?lang=en&parent=R-REC-SF.766-0-199203-I
- Recommendation ITU-R SF.1006-0: "Determination of the interference potential between earth stations of the fixed-satellite service and stations in the fixed service" (1993) – https://www.itu.int/rec/R-REC-SF.1006/recommendation.asp?lang=en&parent=R-REC-SF.1006-0-199304-I
- Recommendation ITU-R SF.1486: "Sharing methodology between fixed wireless access systems in the fixed service and very small aperture terminals in the fixed-satellite service in the 3 400–3 700 MHz band" (2000) - https://www.itu.int/rec/R-REC-SF.1486/recommendation.asp?lang=en&parent=R-REC-SF.1486-0-200005-I
- Recommendation ITU-R S.734: "The application of interference cancellers in the fixed-satellite service" (1992) – https://www.itu.int/rec/R-REC-S.734/recommendation.asp?lang=en&parent=R-REC-S.734-0-199203-I
- ITU-R Recommendation S.737: "Relationship of technical coordination methods within the fixed-satellite service" (1992) - https://www.itu.int/rec/R-REC-S.737/recommendation.asp?lang=en&parent=R-REC-S.737-0-199203-I
- ITU-R Recommendation S.1856: "Methodologies for determining whether an IMT station at a given location operating in the 3 400–3 600 MHz band would transmit without exceeding the power flux-density limits in the Radio Regulations

[3] José M. Costa, "BWA Standards and Spectrum", presented at the ITU/BDT regional seminar on Broadband Wireless Access (BWA) for the CIS, Central and Eastern Europe and the Baltic States, Moscow, 26–29 November 2007 – https://www.itu.int/ITU-D/tech/events/2007/MoscowNovember2007/Presentations/Presentation_Moscow_JCosta.pdf

[4] Ibid.

Nos. 5.430A, 5.432A, 5.432B and 5.433A" (2010) – https://www.itu.int/dms_pubrec/itu-r/rec/s/R-REC-S.1856-0-201001-I!!MSW-E.doc

The ITU defines *the Fixed Service (FS)* as "a radiocommunication service between specified fixed points."[5] Fixed service stations are also referred to as terrestrial radio-relay systems. For decades, and even today, the Fixed Service has been characterised by the use of microwave links employing highly directional antennas and radio frequencies in the GHz range to deliver information via point-to-point (P2P) links. A more recent variant of the Fixed Service is the point-to-multipoint (P2MP) topology, in which an omnidirectional or sector antenna, or a small cluster of antennas at a single location, serves several terminals equipped with directional antennas aimed at the distribution station. Further information is available at:

- ITU-R Recommendation F.382: "Radio-frequency channel arrangements for fixed wireless systems operating in the 2 and 4 GHz bands" (2006) – https://www.itu.int/rec/R-REC-F.382/recommendation.asp?lang=en&parent=R-REC-F.382-8-200604-I
- ITU-R Recommendation F.592: "Vocabulary of terms for the fixed service" (2007) –https://www.itu.int/rec/R-REC-F.592/recommendation.asp?lang=en&parent=R-REC-F.592-4-200709-I
- Recommendation ITU-R F.746-11: "Radio-frequency arrangements for fixed service systems" (2023) – https://www.itu.int/rec/R-REC-F.746/recommendation.asp?lang=en&parent=R-REC-F.746-11-202312-I
- Recommendation ITU-R F.755: "Point-to-multipoint systems in the fixed service" (1999) - https://www.itu.int/rec/R-REC-F.755/recommendation.asp?lang=en&parent=R-REC-F.755-2-199905-I
- Recommendation ITU-R F.758: "System parameters and considerations in the development of criteria for sharing or compatibility between digital fixed wireless systems in the fixed service and systems in other services and other sources of interference" (2019) - https://www.itu.int/rec/R-REC-F.758/recommendation.asp?lang=en&parent=R-REC-F.758-7-201911-I
- ITU-R Report F.2086: "Deployment scenarios for point-to-point systems in the fixed service" – https://www.itu.int/pub/R-REP-F.2086
- ITU-R Report F.2323: "Fixed service use and future trends" (2023) – https://www.itu.int/pub/R-REP-F.2323

The ITU defines Fixed Wireless Access (FWA) as "an application in which the locations of the end-user's terminal and the network access point to be connected to the end-user are fixed."[6] The difference between FWA and 'traditional' fixed wireless systems lies in the fact that one end of the FWA wireless link is connected to the end-user's terminal equipment and the other end is connected to the fixed telephone network, rather than being integrated into a chain of stations, so that both ends of the link form part of a larger infrastructure, which may or may not be a telephone network. It follows from ITU-R Recommendation F.1490-1 ('Generic requirements for fixed wireless access systems', 2007) [7] that FWA was originally intended to provide services similar to wired telephony, but without a wire. This means: voice communication as the primary use, with the ability to send or receive faxes and transmit data at speeds comparable to ISDN or a dial-up modem. In other words, FWA was intended as a means of bringing basic telephone services to areas where wired cable networks were uneconomical. However, the data transfer speeds expected from FWA increased rapidly, just as end-users' expectations of it surpassed those of dial-up modems. More importantly, the assumption of fixed access has been replaced by expectations of fixed, nomadic and mobile access. FWA has thus been incorporated into the broader category of broadband wireless access (BWA). Further information is available at:

- *ITU-R Handbook on Land Mobile (including Wireless Access) – Volume 1: Fixed Wireless Access* (2001) – https://www.itu.int/pub/publications.aspx?lang=en&media=electronic&parent=R-HDB-25-2001
- ITU-R Recommendation F.1401: "Considerations for the identification of possible frequency bands for fixed wireless access and related sharing studies" (2004) - https://www.itu.int/rec/R-REC-F.1401/recommendation.asp?lang=en&parent=R-REC-F.1401-1-200401-I
- ITU-R Recommendation F.1489: "A methodology for assessing the level of operational compatibility between FWA and radiolocation systems when sharing the 3.4–3.7 GHz band" (2000) - https://www.itu.int/rec/R-REC-F.1489/recommendation.asp?lang=en&parent=R-REC-F.1489-0-200005-I
- Recommendation ITU-R F.1490-1: "Generic requirements for fixed wireless access systems" (2007) – https://www.itu.int/rec/R-REC-F.1490/recommendation.asp?lang=en&parent=R-REC-F.1490-1-200709-I

Interference is "the effect of unwanted energy introduced into a radiocommunication system by one or more transmissions, emissions or induction at the receiving end, manifesting itself as a reduction in transmission quality, misinterpretation or loss of information, which would not have occurred in the absence of such unwanted energy."[8]

---

[5] Ibid.

[6] ITU-R Recommendation F.1399-1: "Vocabulary of terms for wireless access" (2001) – https://www.itu.int/dms_pubrec/itu-r/rec/f/R-REC-F.1399-1-200105-I!!MSW-E.doc

[7] https://www.itu.int/rec/R-REC-F.1490-1-200709-I/en

[8] *ITU Radio Regulations and NKT.*

- **Accepted interference**: “Interference accepted by agreement between two or more administrations during the coordination of allocations, without prejudice to other administrations, which exceeds the level of interference defined as permissible interference.”[9]
- **Harmful interference**: “Interference which jeopardises the operation of the radionavigation service or other safety services, or which seriously degrades the quality, repeatedly interrupts or prevents the operation of a radiocommunication service operating in accordance with the Regulations ”[10]
- **Permissible interference**: “Observed or predicted interference which complies with the quantitative criteria for interference and sharing contained in the Regulations or in ITU-R Recommendations or in specific agreements pursuant to the provisions of the Regulations during coordination between administrations.”[11]

The term ‘WBB LMP’ is used by CEPT to refer to ‘wireless broadband systems providing local network connectivity (i.e. networks with low or medium radiated power). Two WBB LMP technologies are under consideration, one based on 3GPP technical specifications and the other on DECT-2020 NR standards. All studies assume an authorisation regime in which the location of WBB LMP networks or base stations is known... [The] following base station power levels have been defined for 3GPP WBB LMP:

- Low power up to 31 dBm/100 MHz e.i.r.p.;
- Medium power up to 51 dBm/100 MHz e.i.r.p.;

These power levels form part of the harmonised technical conditions of CEPT/ECC. For studies based on 3GPP technology, the technical characteristics were derived from current 3GPP standards. Assumptions regarding emission limits (out-of-block and out-of-band) for WBB LMP base stations were derived from ECC Decision (11)06[12] (3400–3800 MHz). The DECT-2020 NR parameters were taken from ETSI TS 103 636-2 v1.4[13] .”

International Mobile Telecommunications (IMT) is the ITU’s term for standards for telecommunications network equipment developed by 3GPP – although ITU Resolution R 56-3[14] , which contains the official definition, states that the ITU “has sole responsibility for defining and recommending standards and frequency arrangements for IMT systems”, without mentioning 3GPP at all. In fact, 3GPP does not use the term ‘IMT’ in its standards. Nevertheless, IMT encompasses GSM, LTE, 4G, 5G and all their variants.

Wireless Avionic Intra-Aircraft Communications (WAIC) provide radio communication links between two or more airborne stations integrated into or installed on a single aircraft and support the safe operation of the aircraft. WAIC systems are essentially an alternative to wired connections. They do not provide radio communication links between the aircraft and the ground, another aircraft or a satellite. They operate during all phases of flight, including on the ground.

---

[9] See footnote 11.

[10] Ibid.

[11] ‘Permissible interference’ and ‘accepted interference’ are terms used in the coordination of frequency allocation between administrations.

[12] ECC Decision (11)06: “Harmonised frequency arrangements and least restrictive technical conditions (LRTC) for mobile/fixed communications networks (MFCN) operating in the 3400–3800 MHz band,” (approved in December 2011, last revised on 26 October 2018) – https://docdb.cept.org/download/1531

[13] ETSI TS 103 636-2 v1.4: “DECT-2020 New Radio (NR); Part 2: Radio reception and transmission requirements; Release 1” (2023) – https://www.etsi.org/deliver/etsi_ts/103600_103699/10363602/01.04.01_60/ts_10363602v010401p.pdf

[14] ITU Resolution R 56-3: “Naming for International Mobile Telecommunications” (2007–2012–2015–2023) – https://www.itu.int/pub/R-RES-R.56-3-2023

2 List of selected abbreviations

AAS – Adaptive antenna systems; these are usually active antennas

ACLR – Adjacent channel leakage power ratio, the ratio of power in a given channel to power in adjacent channels

BEM – Block edge mask, a spectral mask for the ‘edges’ of a block

BS – Base station

CEPT – European Conference of Posts & Telecommunications

CPE – Customer premises equipment

CSDP – [Europe’s] Common Security and Defence Policy

DL – Downlink

ECC – CEPT’s Electronic Communications Committee

ECS – Electronic Communications Services

EIRP – Equivalent isotropic radiated power (power fed into the antenna multiplied by the antenna gain)

EC – European Commission

ETSI – European Telecommunications Standards Institute

FAA – [US] Federal Aviation Administration **FDD** – Frequency-division duplex

FSS – Fixed Satellite Service

FWB – Fixed wireless broadband

HS – Harmonised standard

ICAO – International Civil Aviation Organisation

ICCAIA – International Coordinating Council of Aerospace Industries Associations

IEEE – Institute of Electrical and Electronics Engineers

ILS – Instrument landing system (for aircraft)

IMT – International Mobile Telecommunications (ITU’s name for 3GPP technologies)

ITU – International Telecommunication Union

LEO – Low Earth orbit (up to 2,000 km)

LMP – Low/medium power

LRTC – Least restrictive technical conditions (LRTC) include provisions relating to coexistence between WBB ECS systems in the form of a block edge mask (BEM).

MFCN – Mobile/fixed communication networks

MOPS – Minimum Operational Performance Standards

NATO – North Atlantic Treaty Organisation

NLOS – Non-line-of-sight

NPN – Non-public cellular network

NR – New Radio, 5th-generation IMT network independent of the 4G network

OBUE – Operating band unwanted emissions

OJEU – Official Journal of the European Union

PMP, P2MP – Point-to-multipoint

PNI-NPN – Public network integrated non-public network

PT – Project team

PTP, P2P – Point-to-point

RA – Radio altimeter

RDFT – Radio device fixed terminal (DECT-2020 NR specification),

RDPT – Radio device portable terminal (DECT-2020 NR specification)

RSC – (EU) Radio Spectrum Committee, the European Commission’s Radio Spectrum Committee

RSPG – (EU) Radio Spectrum Policy Group, an advisory body to the European Commission

SNPN – Standalone non-public cellular network

TD – Threshold degradation (in the context of the effect of interference on the degradation of the receiver’s threshold level)

TDD – Time-division duplex

TPC – Transmit power control

TRP – Total radiated power

WAIC – Wireless avionics intra-communications

WBB – Wireless broadband

WG – Working group

WMO – World Meteorological Organisation

WRC – World Radiocommunication Conference

3 Recommendations

The timing of this study places it on the eve of imminent changes in the use of the 3400–4400 MHz band. This creates a paradoxical situation: there is both an increased need for insight into the upcoming changes and a need to accept that no assessment carried out whilst these changes are taking place can be definitive, as many key details are not yet known. We do not yet know what interference mitigation capabilities will be required of radio altimeters in the future. Nor do we know how active antennas might help 5G networks coexist with other users of the band, or how they might undermine the assumptions on which current rules regarding safe distances or transmitter power limits are based. It is not known how great the demand will be for enterprise 5G networks or for satellite broadcasts of African television programmes for diaspora audiences in Europe.

This study has sought to incorporate the latest available information whilst also highlighting key decisions and reports expected in the near future. As mentioned, the plenary session of the CEPT Electronic Communications Committee took place in Vienna, Austria, from 5 to 8 November 2024. Several key documents concerning the 4 GHz band were discussed and voted on. Prior to the meeting, draft documents for discussion were uploaded to the CEPT website. It is possible that these already differ from the drafts cited in this study and will differ again once approved. Nevertheless, here are their titles and locations:

- Draft CEPT Report 88 on WBB LMP in the 3.8–4.2 GHz band – ECC(24)061Annex02

  https://api.cept.org/documents/ecc/85953/ecc-24-061annex02_draft-cept-report-88-on-wbb-lmp-in-3_8-4_2-ghz

- Draft Decision ECC (24)01 on WBB LMP in the 3.8–4.2 GHz band – ECC(24)061Annex03

  https://api.cept.org/documents/ecc/85954/ecc-24-061annex03_draft-ecc-decision-24-01-on-wbb-lmp-in-3_8-4_2-ghz

- Draft ECC Report 362, Part 1, on compatibility between mobile or fixed communication networks (MFCNs) operating in the 3400–3800 MHz band and low/medium-power wireless broadband systems (WBB LMP) operating in the 3800–4200 MHz frequency band with radio altimeters (RA) operating in the 4200–4400 MHz band – ECC(24)062Annex01

  https://api.cept.org/documents/ecc/85934/ecc-24-062annex01_draft-ecc-report-362-part-1

- Draft ECC Report 362, Part 2, on compatibility between mobile or fixed communication networks (MFCNs) operating in the 3400–3800 MHz band and low/medium-power wireless broadband systems (WBB LMP) operating in the 3800–4200 MHz frequency band with radio altimeters (RA) operating in the 4200–4400 MHz band – ECC(24)062Annex02

  https://api.cept.org/documents/ecc/85935/ecc-24-062annex02_draft-ecc-report-362-part-2

- Non-technical summary of Draft ECC Report 362 – ECC(24)062Annex04
  - ECC(24)062Annex04

  https://api.cept.org/documents/ecc/85937/ecc-24-062annex04_non-technical-summary-of-draft-ecc-report-362

Documents Approved by the ECC will be be for a few days after the plenary session in this directory: https://cept.org/ecc/groups/ecc/client/meeting-documents?flid=31309

It is also expected that the Radio Technical Commission for Aeronautics (RTCA) will issue DO-155A: 'Minimum Operational Performance Standards (MOPS) for Short-Range Radio Altimeters' for final review and comments by the end of 2024. A link to the draft text (when available) will be published at https://www.rtca.org/committees-overview/documents-under-review/

It would be pointless to attempt to address the compatibility and coexistence issues between the services and applications discussed in this study (FS, FSS, IMT, WBB LMP, altimeters and WAIC) prior to the publication of these documents, as in many cases they may provide definitive guidance or reveal new harmonised standards that should be implemented.

Nevertheless, the authors of these documents have indicated where further action is required:

> “CEPT will draw up guidelines to ensure, on a case-by-case basis, the protection and future development of FSS receiving earth stations and terrestrial fixed links sharing the 3.8–4.2 GHz band with WBB LMP, for the management of coexistence between WBB LMP networks and between WBB LMP and MFCN below 3.8 GHz.”

CEPT has also undertaken to draw up recommendations on interference from WBB LMPs to radio altimeters and WAICs in the 4.2–4.4 GHz band, as well as on mutual interference between WBB LMP networks.

However, we can propose some further recommendations.

It appears that fixed satellite transmissions to Central Europe below 3,800 MHz have ceased, but this finding is based solely on observations of television transponders. It is not certain whether this extends to telemetry and control channels. Monitoring of satellites visible over the Czech Republic should reveal whether there are any FSS transmissions below 3800 MHz in the Czech Republic that still require protection from IMT/MFCN or WBB LMP.

The draft CEPT Report 088 found that “it is not possible to define general technical conditions that would guarantee the protection of fixed services (FS) from interference caused by wideband low-power mobile connectivity (WBB LMP).” This can be seen as a call to investigate whether case-by-case coordination or other measures are still feasible – or whether WBB LMP should be excluded from the band where FS stations are still active. If solutions exist, they are likely to depend on precise location data for LMP transmitters and receivers, which would imply some form of localised licence. We propose a
‘light licensing’ or registration, at least for low-power stations. If the Czech Telecommunications Office (ČTÚ) were to create a geodatabase system for dynamic/revocable licences for location-aware devices, similar to that established in the USA for devices in TV broadcasting ‘white spots’, WBB LMP networks in the fixed services band could serve as a good starting point.

(Draft) ECC Report 362 revealed that radio altimeters are not affected by many current types of equipment operating at frequencies below 4200 MHz. With one exception: simulations suggest that aircraft flying below 200 feet (60 m) could face an unacceptable level of interference from WBB LMP transmitters with active antennas. Aircraft fly this low only during landing or prior to a crash. No information was provided regarding the transmitted frequencies – whether they were above or below 4,100 MHz – but the fact that the interference threshold was exceeded was sufficient to suggest that 60 m may be too conservative a limit and that the risk begins at higher altitudes. This should be discussed and agreed with aviation industry organisations that deal with the practical implications of interference. However, it suggests that certain restrictions on the siting of WBB LMP transmitters with active antenna systems (AAS) near airport runways should be considered.

The table in this report summarises the European allocations for private 5G networks and illustrates the considerable diversity of authorised frequency bands:

Belgium	3800–3840 MHz, 3880–3960 MHz
Czech Republic.	3400–3440 MHz
Denmark	3740–3800 MHz
Finland	3410–3800 MHz
France	3490–4200 MHz
Luxembourg	3700–3800 MHz
Germany	3700–3800 MHz
Netherlands	3400–3450 MHz, 3750–3800 MHz
Norway	3800–4200 MHz
Poland	3900–4200 MHz
Greece	3400–3800 MHz

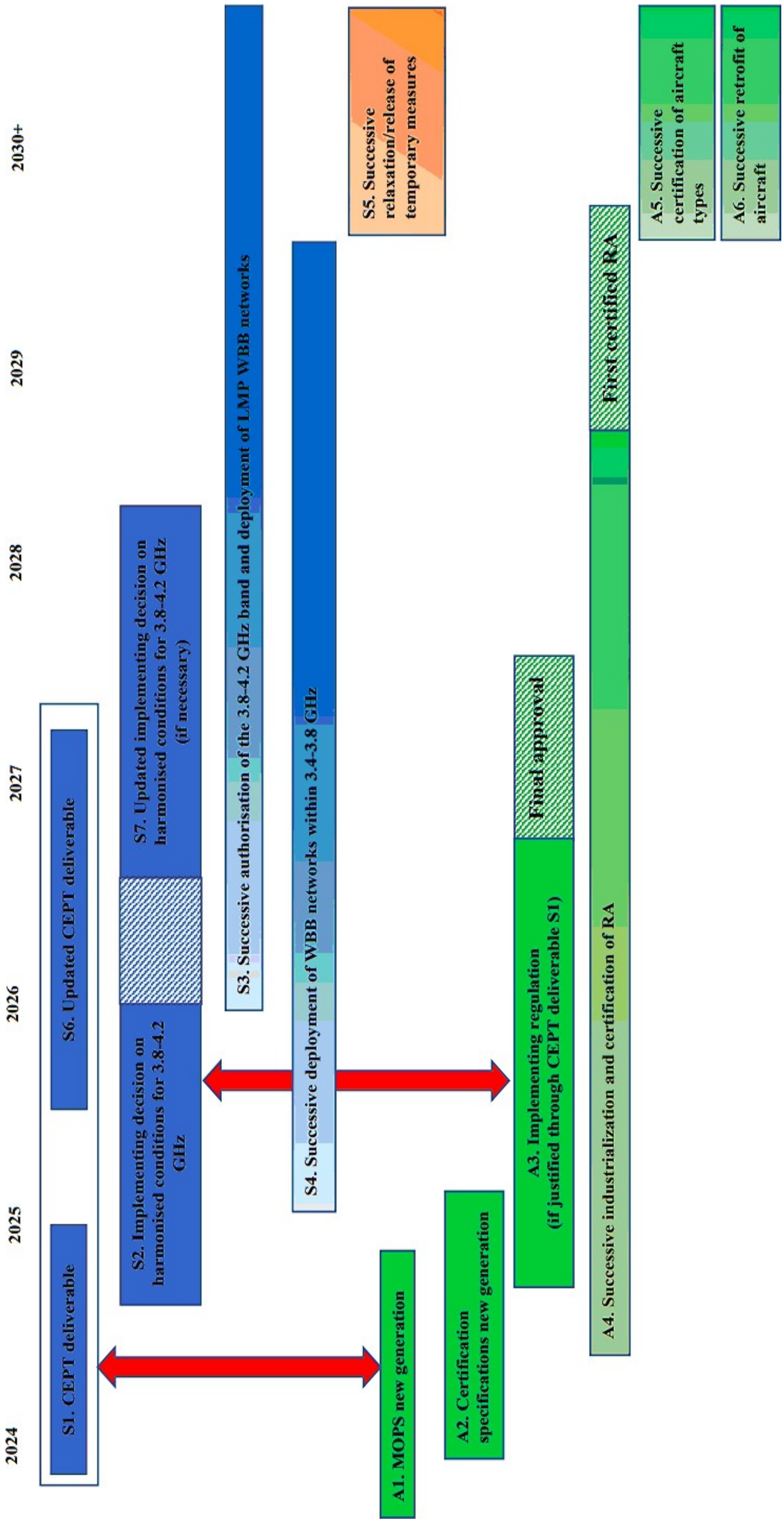
Slovakia	3600–3800 MHz
Slovenia	3400–3420 MHz
United Kingdom	3800–4200 MHz
Sweden	3720–3800 MHz
Switzerland	3400–3500 MHz

This lack of consistency is likely to pose a problem for equipment manufacturers, and it would therefore be advisable for CEPT to define a harmonised band. (The RSPG's proposal for 3800–4200 MHz is not in line with most existing allocations.) The CTU may request that CEPT grant it a mandate to this effect.

And if it has not already done so, the ČTÚ should investigate the requirements for protection against interference to the GALILEO radio telescopes in Wettzell, Germany, some 20 km from the Czech border.[15] They may require an exclusive zone for frequencies around 4 GHz that extends into the Czech Republic, if they do not already have one.

Last but not least, we would like to draw attention to the diagram at the end of this report, in the chapter on altimeters. It is displayed in landscape orientation, which makes the text so small that it is difficult to read. Given the importance of the information on planning and procedures that it contains, this data is reproduced here. (Taken from a European Commission staff working document entitled 'EU Roadmap for ensuring the safe coexistence of mobile networks and aircraft radio altimeters within the 3.4–4.4 GHz frequency band in the Union' (18 April 2024) –https://circabc.europa.eu/sd/a/9e35cb97-0cac-422a-959e-b1b920a26dfc/EU%20Roadmap_WBB-RA_Coexistence_v1.pdf:

[15] In Wettzell, there are two 13-metre satellite dishes located at 49° 08' 38.1" N x 12° 52' 39.4" E and 49° 08' 36.4" N x 12° 52' 41.6" E.


2024
2025
2026
2027
2028
2029
2030+
S1. CEPT deliverable
S6. Updated CEPT deliverable
S2. Implementing decision on harmonised conditions for 3.8-4.2 GHz
S7. Updated implementing decision on harmonised conditions for 3.8-4.2 GHz (if necessary)
S3. Successive authorisation of the 3.8-4.2 GHz band and deployment of LMP WBB networks
S4. Successive deployment of WBB networks within 3.4-3.8 GHz
S5. Successive relaxation/release of temporary measures
A1. MOPS new generation
A2. Certification specifications new generation
A3. Implementing regulation (if justified through CEPT deliverable S1)
Final approval
A4. Successive industrialization and certification of RA
First certified RA
A5. Successive certification of aircraft types
A6. Successive retrofit of aircraft

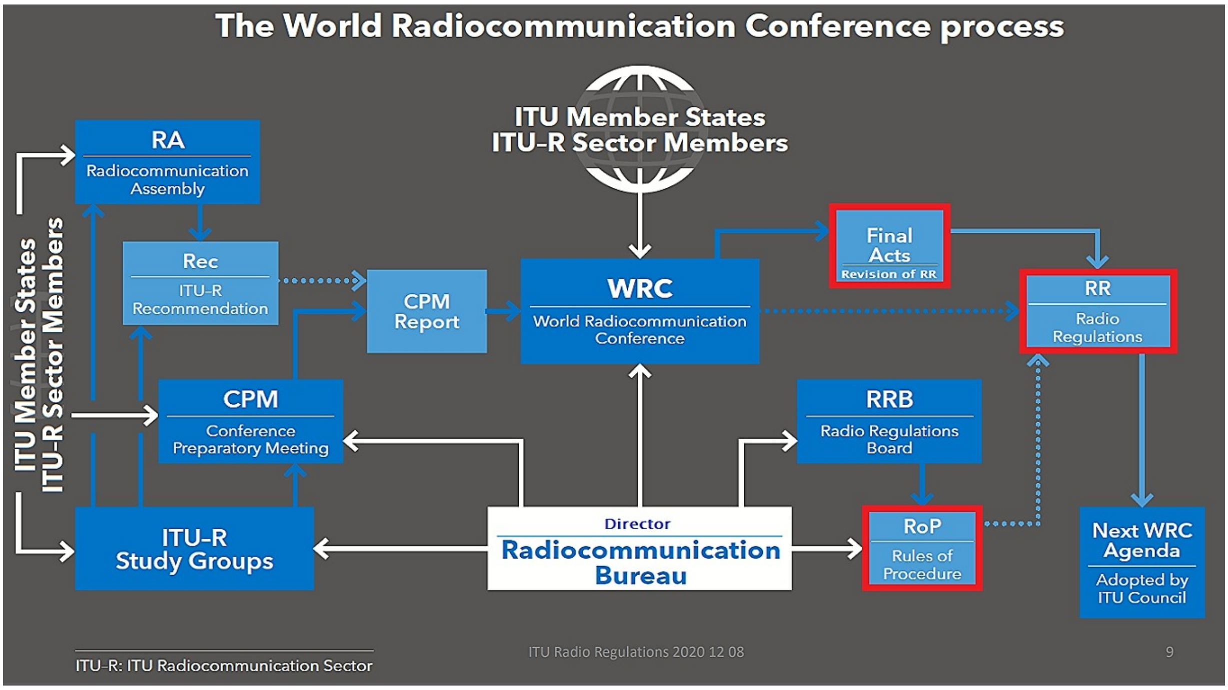
4 Analysis of the current status of 4 GHz band usage

4.1 The current legal and regulatory framework

4.1.1 International Telecommunication Union (ITU)

The deliberations and decisions made at the World Radiocommunication Conferences (WRCs) convened by the ITU form the basis for the topics addressed in this analysis, as do numerous reports and recommendations from ITU-R study groups.[16]

Figure 1: The ITU-WRC decision-making process



Source: V. Glaude (ITU, 2020)[17]

[16] Recommendations and reports set out the conclusions of studies carried out by ITU-R study groups. Although they do not have the contractual status of regulations, each recommendation must be approved by all ITU-R governing bodies before it enters into force; consequently, published recommendations are regarded as authoritative.

[17] Veronique Glaude, "International Regulation of Radio Frequencies and Associated Orbits," presented at the UN Conference on Space Law and Policy, 8 December 2020 – https://www.unoosa.org/documents/pdf/spacelaw/activities/2020/SLC2020Presentations/SLC2020PDFPresentations/F._Glaude_-_8_Dec_2020_-_UN_Space_Law_Conference_-_ITU_Frequency_Regulations_20201208_v0.pdf

For example, WRC-12 adopted Resolution No. 154[18] , in which it called upon ITU-R, to “study, in certain countries of Region 1, possible technical and regulatory measures to support existing and future FSS earth stations in the 3 400–4 200 MHz band, which are used for satellite communications relating to the safe operation of aircraft and the reliable distribution of meteorological information”, and to report its conclusions to WRC-15. WRC-15 revised Resolution 154[19] , noting that “ITU-R has carried out comprehensive compatibility studies between FSS on the one hand and fixed wireless access systems and IMT applications on the other in the 3 400–4 200 MHz frequency band, and has summarised the results of these studies in ITU-R Recommendation SF.1486[20] as well as in the reports ITU-R S.2199[21] , ITU-R M.2109[22] and ITU R S.2368[23] ; these reports contain a set of interference mitigation techniques that could be used for international coordination and at national level to facilitate the coexistence of FSS systems, fixed services and mobile services. [24]

However, Recommendation SF.1486 was issued prior to the development of 5G, which has different operational characteristics to earlier generations of IMT, such as the use of active antenna systems. SF.1486 and the other reports mentioned (as well as Report F.2328-0[25]) therefore need to be reviewed. Resolution 73[26] adopted at WRC-23 provides a mandate for this review, the conclusions of which are to be made available in good time before WRC-27.

4.1.1.1 World Radiocommunication Conferences (WRCs)

Three agenda items at WRC-23 in Dubai (20 November – 15 December 2023) concerned the following topics in particular:

- Agenda item 1.3 concerned upgrading the status of the mobile service (excluding the aeronautical mobile service) in the 3600–3800 MHz band in ITU Region 1 from secondary to primary. WRC-23 approved this change; however, for Region 1, the band is not identified for IMT. CEPT supported this proposal ‘on condition that it is possible to continue the current use of the 3400–3800 MHz frequency bands and to protect priority services in accordance with the existing CEPT regulatory framework, and that no disproportionate restrictions are imposed on existing services and their future development.’ Consequently, CEPT supports the extension of the technical and regulatory conditions applicable to the 3400–3600 MHz band to the 3600–3800 MHz band as well, in particular to ensure that the pfd limit -154.5 dBW/m²/4 kHz is not exceeded for more than 20 per cent of the time at a height of 3 m above ground level at the boundary, in order to protect neighbouring countries...” [27] These conditions are set out in footnote 5.434A, attached to the 3600–3800 MHz band in the International Frequency Allocation Table.

  The ‘Radio Spectrum Utilisation Plan for the 2700–4200 MHz frequency band’ of the Czech Telecommunications Office (ČTÚ) (PV-P/7/02.2022-3) states that: ‘In the Czech Republic, the mobile service already has priority and this item will not affect the radio spectrum utilisation plan in the Czech Republic.’[28]

---

[18] RESOLUTION 154 (WRC-12): “Consideration of technical and regulatory actions in order to support existing and future operation of fixed-satellite service earth stations within the 3 400–4 200 MHz band, as an aid to the safe operation of aircraft and the reliable distribution of meteorological information in some countries in Region 1” – *Final Acts, WRC-12*, pages 231–232 – https://search.itu.int/history/HistoryDigitalCollectionDocLibrary/4.133.43.en.100.pdf

[19] RESOLUTION 154 (REV.WRC-15): “Consideration of technical and regulatory actions to support the existing and future operation of fixed-satellite service earth stations within the 3 400–4 200 MHz frequency band, to aid the safe operation of aircraft and the reliable distribution of meteorological information in some countries in Region 1” – https://www.itu.int/dms_pub/itu-r/oth/0C/0A/R0C0A00000F0045PDFE.pdf

[20] “Sharing methodology between fixed wireless access systems in the fixed service and very small aperture terminals in the fixed-satellite service in the 3 400–3 700 MHz band” (2000) - https://www.itu.int/dms_pubrec/itu-r/rec/sf/R-REC-SF.1486-0-200005-I!!PDF-E.pdf

[21] “Studies on compatibility of broadband wireless access systems and fixed-satellite service networks in the 3 400–4 200 MHz band” (2010) – https://www.itu.int/dms_pub/itu-r/opb/rep/R-REP-S.2199-2010-PDF-E.pdf

[22] “Sharing studies between IMT-Advanced systems and geostationary satellite networks in the fixed-satellite service in the 3 400–4 200 and 4 500–4 800 MHz frequency bands” (2007) – https://www.itu.int/dms_pub/itu-r/opb/rep/R-REP-M.2109-2007-PDF-E.pdf

[23] “Sharing studies between International Mobile Telecommunication-Advanced systems and geostationary satellite networks in the fixed-satellite service in the 3 400–4 200 MHz and 4 500–4 800 MHz frequency bands in the WRC study cycle leading to WRC-15” (2015) – https://www.itu.int/dms_pub/itu-r/opb/rep/R-REP-S.2368-2015-PDF-E.pdf

[24] “Consideration of technical and regulatory actions to support the existing and future operation of fixed-satellite service earth stations within the 3 400–4 200 MHz frequency band, as an aid to the safe operation of aircraft and the reliable distribution of meteorological information in some countries in Region 1” – https://www.itu.int/dms_pub/itu-r/oth/0C/0A/R0C0A00000F0045PDFE.pdf

[25] ITU-R Report F.2328-0: “Sharing and compatibility between international mobile telecommunication systems and fixed service systems in the 3 400–4 200 MHz frequency range” (2014) – https://www.itu.int/pub/publications.aspx?lang=en&parent=R-REP-F.2328-2014

[26] ITU-R Resolution 73: “Use of International Mobile Telecommunications technologies for fixed wireless broadband in the frequency bands allocated to the fixed service on a primary basis” (2023) - https://www.itu.int/dms_pub/itu-r/opb/res/R-RES-R.73-2023-PDF-E.pdf

[27] CEPT-ECC, “Report of the Fourth Week of the WRC-23” (15 December 2023) – https://cept.org/files/130712/wrc-23%20report%20from%20week%204_83hd536dza.pdf The parameters quoted are consistent with footnote 5.434A in the International Table of Frequency Allocations.

[28]https://ctu.gov.cz/sites/default/files/obsah/ctu/sdeleni-o-vydani-opatreni-obecne-povahy-casti-planu-vyuziti-radioveho-spektra-c.pv-p/7/02.2022-3-pro-kmitoctove-pasmo-2700-4200-mhz/obrazky/pvrs7p.pdf

- Item 1.2 of the agenda considered the ‘identification of the 3,300–3,400 MHz, 3,600–3,800 MHz, 6,425–7,025 MHz, 7,025–7,125 MHz and 10.0–10.5 GHz for International Mobile Telecommunications (IMT), including possible additional allocations to the mobile service on a priority basis in accordance with Resolution 245 (WRC-19). The results of this agenda item were best summarised by the EU Radio Spectrum Policy Group:

  a) 3 600–3 800 MHz (Region 2)

  There was no EU position on this frequency band in Region 2... Administrations wishing to introduce IMT must obtain the consent of neighbouring countries to ensure the protection of the fixed-satellite service (downlink). [29]

  b) 3 300–3 400 MHz (Region 2)

  The EU position called on Member States to “oppose any change to the regulatory provisions applicable to international mobile telecommunications (IMT) stations in the 3,300–3,400 MHz frequency band in ITU Region 2, in particular any relaxation of these provisions relating to the radiolocation service.”

  “WRC-23 decided to extend the allocation of this frequency band for IMT, previously limited to a few countries in Region 2, to the whole of Region 2, but left unchanged the provisions applicable to IMT concerning coexistence with the radiolocation service.

  c) 3 300–3 400 MHz (amend footnote in Region 1)

  The 3 300–3 400 MHz frequency band is a NATO-harmonised band used by military radars, including those on board ships and aircraft, and is therefore relevant to the EU’s Common Security and Defence Policy (CSDP). The EU’s position calls on Member States to:

  - oppose any change to the current IMT designation in the 3 300–3 400 MHz frequency band in ITU Region 1 that would lead to the extension of the IMT designation to the whole of ITU Region 1.
  - oppose any change to the regulatory provisions applicable to IMT stations in (this) band, in particular any relaxation of the provisions relating to radar services.

  WRC-23 confirmed the general position without change. However, offline discussions took place regarding the inclusion of footnotes 5.429A and 5.429B for certain countries concerning the mobile service and the IMT designation, but no consensus was reached due to concerns regarding the protection of critical radar services in the band, used both at national level and in international waters and airspace by NATO countries. In particular, this is intended to ensure that any national deployment of IMT stations does not cause harmful interference to systems in the radar service outside the territory of those countries, nor does it claim protection from such interference, and is subject to the consent of neighbouring countries…

  Summary of agenda item 1.2
  Overall, the discussions on this agenda item were particularly difficult and complex…[30]

Further resolutions and recommendations adopted at WRC-23 relate to the 3800–4200 MHz band and adjacent frequency bands. For further source texts, see the chapter on altimeters.

[29] Notes elsewhere in the RSPG report suggest that this statement (“Administrations wishing to introduce IMT will obtain the consent of neighbouring countries”) applies to any band that IMT would share with other radio services granted equivalent rights of use.

[30] “RSPG Report on the Outcomes of WRC 2023,” RSPG24-017 FINAL (June 2024) – https://radio-spectrum-policy-group.ec.europa.eu/document/download/3d8d393b-2067-48c4-98f9-b95f4d8ed960_en?filename=RSPG24-017final-RSPG_Report_%20WRC23.pdf

- Resolution 683 (WRC-23): “Studies of technical and operational issues and regulatory measures to support inter-satellite service transmissions in the 3 700–4 200 MHz and 5 925–6 425 MHz frequency bands for non-geostationary satellite earth stations communicating with geostationary satellite earth stations… the ITU Radiocommunication Sector to complete [these studies] in good time before the WRC in 2031…”[31]

4.1.1.2 International Radio Regulations

The update to the International Radio Regulations following WRC-23[32] will enter into force on 1 January 2025. The frequency allocation table in these revised regulations shows that the Fixed Service (FS) and the (space-to-Earth) downlinks of the Fixed Satellite Service (FSS) are co-primary services sharing the 3800–4200 MHz band globally. The mobile service shares these frequencies as a secondary use in ITU Region 1. The absence of footnotes attached to the allocation table entry for 3800–4200 MHz (which would indicate special conditions, exceptions, exclusions or deviations) suggests that there is little disagreement regarding the current allocation in this band.

However, several footnotes are attached to the bands adjacent to 3800–4200 MHz. These footnotes merit attention as they identify services and applications that could be affected by new and out-of-band emissions from the 3800–4200 MHz band. The European Commission is aware of these risks and has tasked the CEPT and the ECC with carrying out studies to identify the conditions for acceptable coexistence before any changes to the allocation for the 3800–4200 MHz band are approved. Footnotes in neighbouring bands also indicate conditions that could be attached to the 3800–4200 MHz band in the future, should this band be harmonised with the 3600–3800 MHz band to create a wider continuous band for the identified services.

The following footnotes apply to the bands adjacent to 3800–4200 MHz in the new edition of the International Radio Regulations:

> **‘5.434A** The priority use of the 3 600–3 800 MHz frequency band by the mobile service (other than the aeronautical mobile service) in Region 1 is subject to an agreement reached in accordance with No. **9.21**[33] , provided that the power flux density (pfd) limit specified below is exceeded. Provisions No. **9.17** and **9.18** shall also apply during the coordination phase. Before an administration in Region 1 puts a station in the mobile service in the 3 600–3 800 MHz frequency band into operation, it shall ensure, for the protection of stations in the fixed and fixed-satellite services, that the pfd produced 3 m above ground level does not exceed -154.5 dB(W/(m^2 × 4 kHz)) for more than 20 per cent of the time at the boundary of another administration’s territory. Stations in the mobile service operating in the 3 600–3 800 MHz frequency band shall not require greater protection from space stations than that specified in Table 21.4 of the Radio Regulations (WRC-23).’

Figure 2: Relevant section of Table 21-4 of the Radio Regulations

TABLE **21-4** (Rev.WRC-23)

Frequency band	Service*	Limit in dB(W/m^2) for angles of arrival (δ) above the horizontal plane			Reference bandwidth
		0°-5°	5°-25°	25°-90°	
3 400-4 200 MHz	Fixed-satellite (space-to-Earth) (geostationary-satellite orbit)	-152	$-152 + 0.5(\delta - 5)$	-142	4 kHz

[31] This proposal appears to originate from Luxembourg: “Proposal for an agenda item for WRC-27 – Spectrum allocation and associated regulatory provisions to support the use of the 3,700–4,200 MHz and 5,925–6,425 MHz frequency bands for inter-satellite links between non-geostationary (non-GSO) and geostationary (GSO) user space stations,” CPG23 PTA#8, Doc. PTA(23)063, 24 April 2023 – https://cept.org/Documents/cpg-pta/77156/pta-23-063_input-on-ai-10-c-band-isl

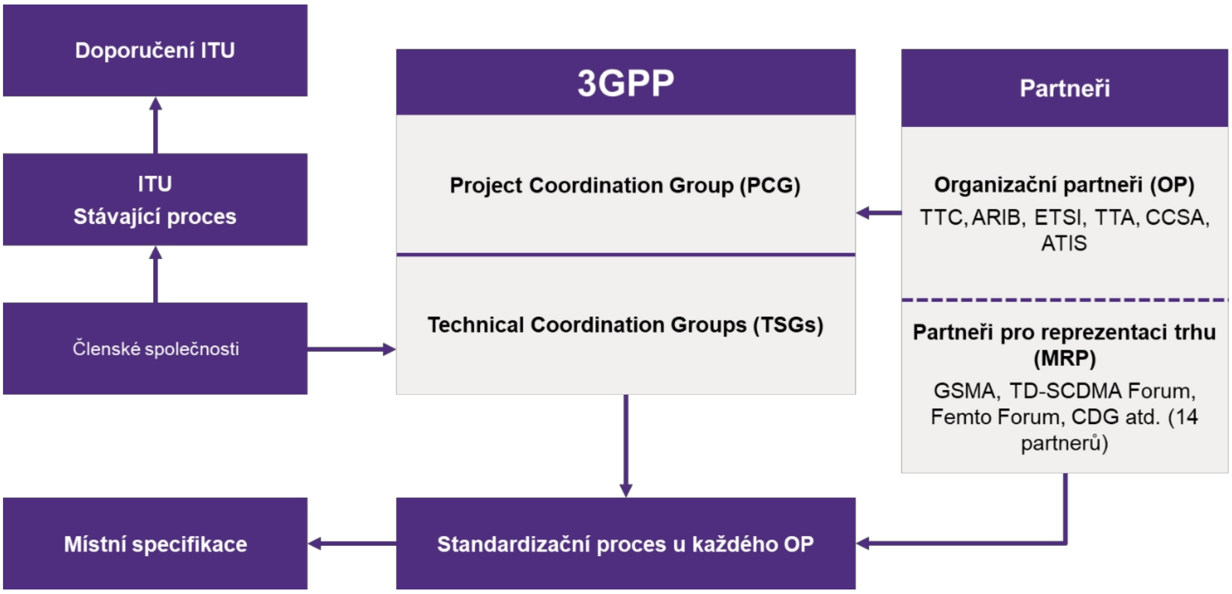
[32] https://www.itu.int/hub/publication/r-reg-rr-2024/

[33] This relates to Sub-section IIA of the International Radio Regulations: **‘Requirement and request for** coordination… Before an administration notifies the ITU Bureau or implements a frequency allocation in any of the cases listed below, it shall, as necessary, carry out coordination with other administrations listed under No.
9.27… **[9.17]** for any specific earth station or typical mobile earth station in frequency bands above 100 MHz allocated with the same rights to the space and terrestrial services…, where the earth station coordination area includes the territory of another country… **[9.18]** for any Earth station of the Earth Station Service in the bands listed in No. 9.17 within the coordination area of the Earth station… **[9.21]** for any station of the service for which the requirement to obtain the consent of another administration is included in a footnote to the Frequency Allocation Table referring to this provision... **[9.27]** The frequency allocations to be taken into account when carrying out coordination are set out in **Annex** 5...”

4.1.2 3rd Generation Partnership Project (3GPP)

3GPP is not a regulatory authority. However, its influence is global, as it is now the leading organisation for the development of standards for mobile telecommunications. It works closely with the ITU, network operators and major mobile device manufacturers.[34]

Figure 3: The role of 3GPP in the development of IMT standards



Source: Own compilation, based on Nakamura/3GPP (2009)[35]

ETSI developed a set of GSM technical standards that made mobile telephony a global success, and then in 1998 helped to establish 3GPP to continue the development of standards for mobile networks outside Europe. ETSI continues to provide support services for 3GPP at its headquarters in Sophia Antipolis, France. Although 3GPP is a global organisation, it has its roots in Europe. Consequently, 3GPP often incorporates the harmonised technical standards developed by CEPT and ETSI for Europe into its own standards, whilst CEPT and ETSI regularly diverge from 3GPP when developing standards for Europe.

Like CEPT, 3GPP conducts its activities with a high degree of transparency, with most of its working documents and outputs freely available online. The volume of its outputs usually exceeds 40,000 documents per year. Although a thorough study of the standards is essential for compatibility studies, in this section we limit ourselves to listing a few documents and reports relevant to the frequencies discussed in this report, without attempting to extract or summarise their content:

- 3GPP TR 37.840 V12.1.0 (2014-01): "Technical Specification Group Radio Access Network: Study of Radio Frequency (RF) and Electromagnetic Compatibility (EMC) requirements for Active Antenna Array System (AAS) base station (Release 12)" – https://www.3gpp.org/ftp/Specs/archive/37_series/37.840/37840-c10.zip
- 3GPP TS 37.105 V18.5.0 (2024-06): "Active Antenna System (AAS) Base Station (BS) transmission and reception (Release 18)" – https://www.3gpp.org/ftp/Specs/archive/37_series/37.105/37105-i50.zip
- 3GPP TS 38.101-1 V18.7.0 (2024-09): "NR; User Equipment (UE) radio transmission and reception; Part 1: Range 1 Standalone (Release 18) – https://www.3gpp.org/ftp/Specs/archive/38_series/38.101-1/38101-1-i70.zip
- 3GPP TS 38.104 V18.6.0 (2024-06): "NR; Base Station (BS) radio transmission and reception (Release 18)" - https://www.3gpp.org/ftp/specs/archive/38_series/38.104/38104-i60.zip
- 3GPP TS 38.113 V18.3.0 (2024-06): "NR; Base Station (BS) Electromagnetic Compatibility (EMC) (Release 18) – https://www.3gpp.org/ftp/Specs/archive/38_series/38.113/38113-i30.zip

[34] The IEEE was also active in this field as a competing standardisation organisation (particularly in the development of Wi-Fi and WiMAX) until it signed a cooperation agreement with 3GPP in 2016. In 2017, the IEEE agreed that "3GPP will act as the governing body for all wireless systems available globally." See the *IEEE* White Paper *'5G and Beyond Technology Roadmap'* (2017), pp. 13– https://futurenetworks.ieee.org/images/files/pdf/ieee-5g-roadmap-white-paper.pdf

[35] Takehiro Nakamura, "Proposal for Candidate Radio Interface Technologies for IMT-Advanced Based on LTE Release 10 and Beyond (LTE-Advanced)", presented at the third ITU-R WP 5D seminar on IMT-Advanced, 15 October 2009 – https://www.slideshare.net/slideshow/3gpp/5330111#5

- 3GPP TS 38.124 V18.1.0 (2023-12): "NR; Electromagnetic Compatibility (EMC) requirements for mobile terminals and ancillary equipment (Release 18)" – https://www.3gpp.org/ftp/Specs/archive/38_series/38.124/38124-i10.zip
- 3GPP TR 38.813 V15.0.0 (2018-03): "Technical Report: New frequency range for NR (3.3–4.2 GHz) (Release 15)" – https://www.3gpp.org/ftp//Specs/archive/38_series/38.813/38813-f00.zip This report contains band masks for mobile devices and base stations.

3GPP uses its own numbering system to refer to the frequency bands covered by this analysis. This system may be useful when searching for the relevant standards and reports.

Table 3.a: 3GPP numbering system

5G New Radio (NR) operating bands	LTE operating bands
n48 (3550–3700 MHz)	42 (3400–3600 MHz)
n77 (3300–4200 MHz)	43 (3600–3800 MHz)
n78 (3300–3800 MHz)	48 (3550–3700 MHz)
n79 (4400–5000 MHz)	49 (3550–3700 MHz, licensed assisted access)

Source: Compiled by the author, based on 3GPP

4.2 Regional legal and regulatory framework

As the highest level of regional administration, the European Commission (EC) has both administrative and legislative powers. Within the scope of its administrative powers, it oversees the implementation of EU law. In addition, *the Commission* is *responsible for planning, drafting and proposing new European legislation, a process known as the 'right of initiative*'.[36]

It is important to note, however, that when *the General Guidelines for Cooperation between CEN, Cenelec and ETSI and the European Commission and the European Free Trade Association* were agreed in 2003, the EC agreed to *refrain from drawing up technical regulations in areas covered by mandates assigned to European standardisation organisations, unless this is necessary in the public interest.*[37] This arrangement took on greater significance in 2016, when the Court of Justice of the European Union ruled that harmonised standards form *part of EU law.*[38] (Despite this court ruling, European standardisation organisations still describe their standards as voluntary, and the European Commission's website states: *'The technical requirements set out in EU legislation are binding, whilst the use of harmonised standards is usually voluntary.'*)[39]

The Radio Spectrum **Policy Unit** within **the** European Commission's **Directorate-General for Communications Networks, Content and Technology** (CNECT.B.4) plays a leading role in the development of regional legislation for spectrum management. In addition to its responsibilities for technical harmonisation and promoting connectivity, it commissions independent studies on policy issues, monitors the effectiveness of spectrum authorisation processes in Member States and coordinates the EU's relations with the ITU. Sub-unit **CNECT.B.4.001** deals with wireless broadband connectivity.

The EC uses mandates to commission specialised EU technical agencies to work on issues that require clarification or resolution, in order to facilitate the implementation of European regulations or policies. Mandates relating to the use **of** spectrum and radio equipment are often issued by **the Radio Spectrum Committee (RSC**), which provides support and advice to the Commission, or by **the Radio Spectrum Policy Group (RSPG)**[40], which performs a similar function on less technical issues. Mandates and requests for standards identify the tasks to be carried out and propose a timetable for their completion.

The EC may also request the European Telecommunications Standards Institute (ETSI) to draw up harmonised standards for radio equipment in order to facilitate regional integration and the smooth functioning of the internal market. Within ETSI, the main responsibility lies with

---

[36] European Commission, "Planning and proposing law" – https://commission.europa.eu/law/law-making-process/planning-and-proposing-law_en

[37] *Official Journal* C 091, 16 April 2003, pages 0007–0011 – https://eur-lex.europa.eu/legal-content/EN/ALL/?uri=CELEX:52003XC0416(03)

[38] Court of Justice of the European Union, 'Judgment of the Court (Third Chamber) of 27 October 2016 in Case C-613/14: James Elliott Construction Limited v Irish Asphalt Limited', ECLI:EU:C:2016:821, paragraph 40 – link to the judgment. See also Kathrin Dingemann and Dr Matthias Kottmann, 'Legal Opinion on the European System of Harmonised Standards' (2020) – link to the document, which states in paragraph 4 of the executive summary that the European Commission may only request ETSI, CEN and CENELEC to draw up harmonised technical standards.

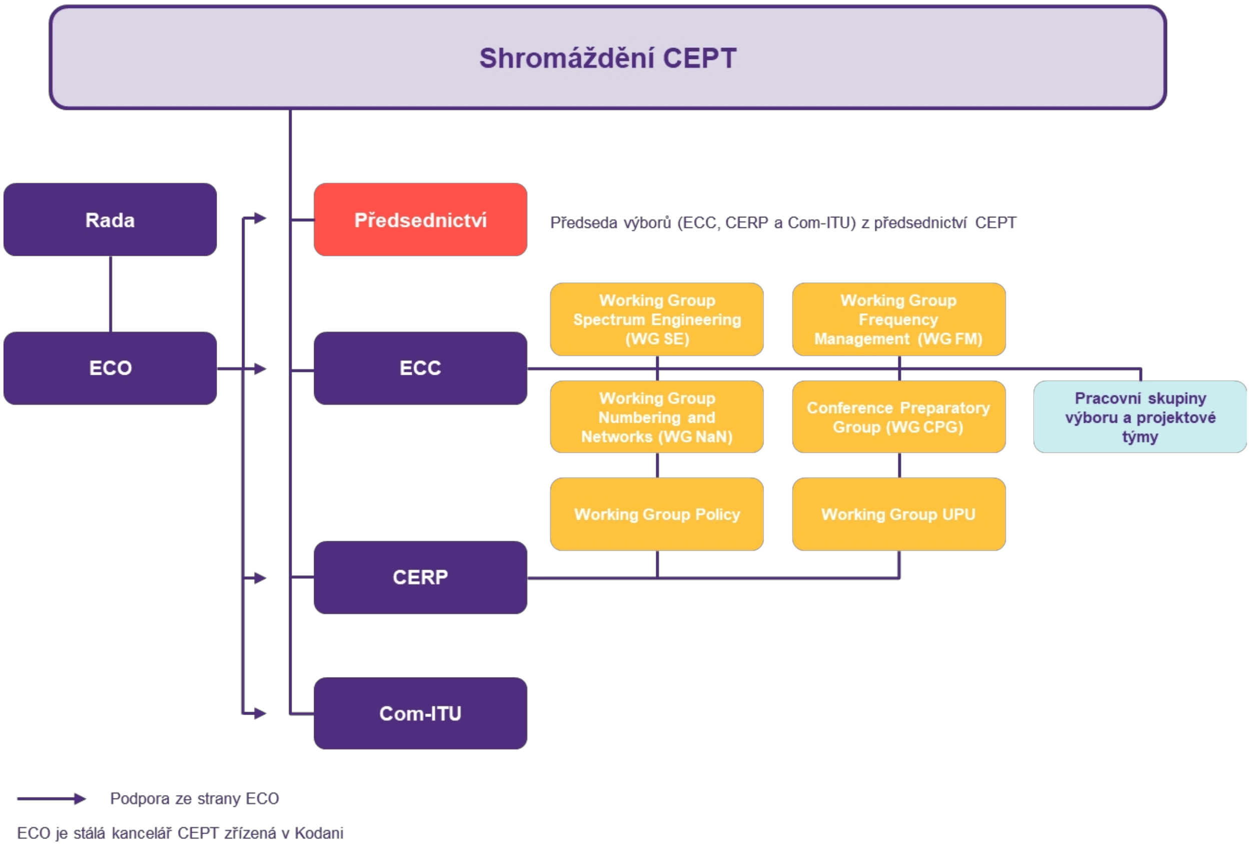
[39] European Commission, "Standards in Europe" – https://europa.eu/youreurope/business/product-requirements/standards/standards-in-europe/index_en.htm

[40]https://ctu.gov.cz/en/rspg

the development and maintenance of standards relating to the use of the radio spectrum by the Technical Committee on Electromagnetic Compatibility and Radio Spectrum Matters (ERM). The Technical Committee on Aviation (TC AERO) supports, in particular, European initiatives in the field of air traffic management, notably the Single European Sky.

The European Conference of Postal and Telecommunications Administrations (CEPT), with its many specialised working groups (WGs) and project teams (PTs), is the main European platform for technical cooperation specialising in the radio spectrum. The CEPT Electronic Communications Committee (ECC) brings together 46 countries (including non-EU Member States) with the aim of developing common policies and non-binding regulations. ECC members may request the CEPT to carry out compatibility studies and to define the parameters and conditions under which spectrum can be safely shared between different services. These requests, if accepted, become work items, similar to mandates from the European Commission.

Figure 4: CEPT organisational structure



Source: Own elaboration, based on CEPT (2012)[41]

The European Committee for Electrotechnical Standardisation (CENELEC) is an association of national electrotechnical committees from 34 European countries. As mentioned above, CENELEC is one of three standardisation organisations which the European Commission may request to develop harmonised technical standards for the region (the other two being ETSI and CEN). CENELEC and CEN have such close ties that they share a website, have jointly developed a long-term strategy and are led by the same Director-General (Elena Santiago Cid). CENELEC also has close ties with the International Electrotechnical Commission (IEC), and it is therefore not surprising that more than 72 per cent of the total 7,691 CENELEC standards are identical to IEC standards.

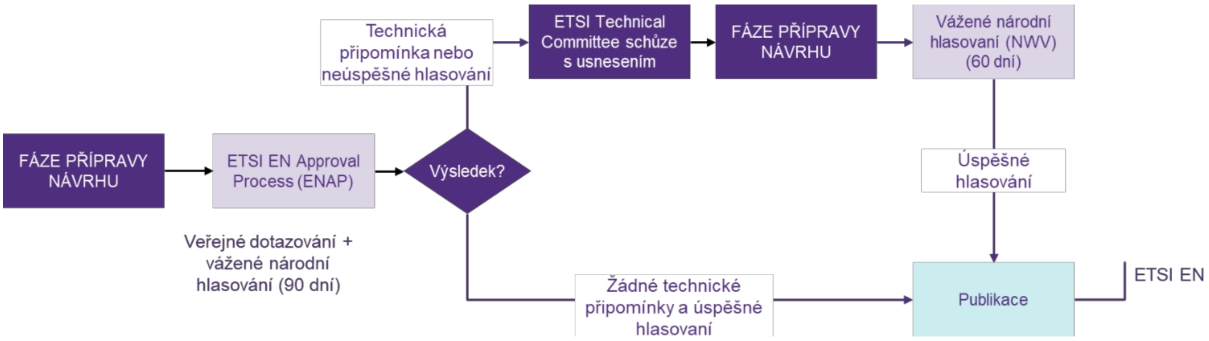
Any interested party may propose the development of a new standard, although most proposals come via a CENELEC or CEN member. 'Approximately 20 per cent of all European standards are developed on the basis of a standardisation request from the European Commission.'[42] If a proposal is accepted by the relevant technical body, standardisation work on the same subject at national level is suspended and the drafting process begins under the guidance of regional experts. Once finalised, the draft is submitted for public comment and voting in a process known as 'enquiry'. The consultation period lasts 90 days. If comments are received, they must be addressed, which may require some revision. In such cases, the revised draft is republished for public comment as part of

[41] http://www.cept.org/cept/cept-structure

[42] "Standards in Europe" – https://europa.eu/youreurope/business/product-requirements/standards/standards-in-europe/index_en.htm

a 60-day ‘re-circulation’ process. Member organisations of CEN or CENELEC then vote on the standard (votes are weighted according to population) and, if 100 per cent consensus is reached after a further 60 days, competing national standards are withdrawn and the harmonised standard is published, first by ETSI and subsequently by the national standardisation organisations that are members of CEN or CENELEC. Neither CENELEC nor CEN distribute or sell European standards. Instead, they are sold or distributed by the national technical committees that are members of CEN or CENELEC.

Figure 5: The process of developing harmonised European standards (EN)



Source: Own work, based on Hiertze and Max (2023)[43]

The European Committee for Standardisation (CEN), founded in 1961, brings together national standardisation bodies from 34 European countries. It has 1,533 working groups and 319 technical committees, which together have produced 16,672 European standards. The most prolific publisher of standards is CEN’s aeronautics committee, ASD-STAN (https://asd-stan.org/en). The ASD-STAN D07/WG02 working group is currently developing harmonised European standards for equipment installed in WAIC systems. ‘This includes defining minimum performance requirements and RF emission requirements for the integration of such equipment inside or in the vicinity of an aircraft.’[44]

Finally, mention should be made of the regional agreement on the coordination of radio frequencies to prevent cross-border interference between stations in the fixed and land mobile services: the Agreement on the ‘Harmonised Calculation Method’ (HCM).[45] The latest version of the Agreement was signed in 2022 by Belgium, the Czech Republic, France, Croatia, Italy, Liechtenstein, Lithuania, Luxembourg, Hungary, Germany, the Netherlands, Poland, Austria, Romania, Slovakia, Slovenia and Switzerland.

The HCM Agreement covers 19 frequency bands for the land mobile service (including 3400–3800 MHz) and 29 frequency bands for the fixed service (including 3600–4200 MHz).[46] It also proposes a preliminary coordination procedure for the roll-out of planned land mobile service networks.

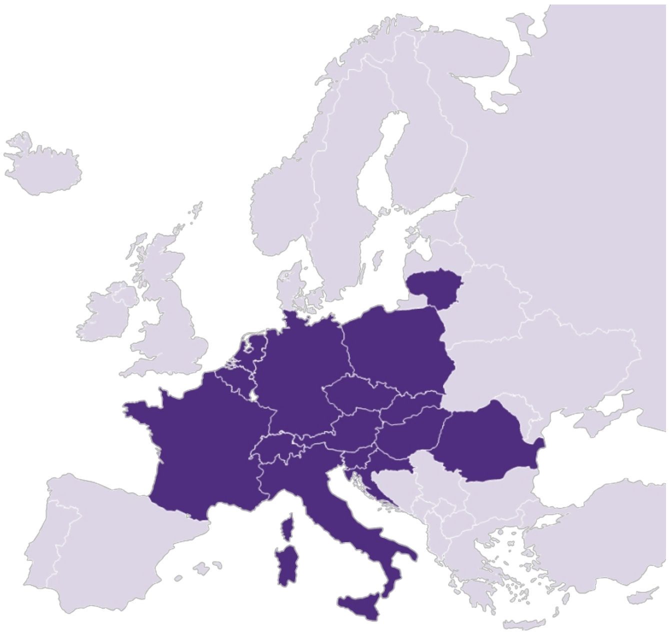
[43] Guido Hiertz & Sebastian Max, “European spectrum regulation and the harmonised market of the European Union – An overview,” IEEE 802.18-23/54r2 – https://mentor.ieee.org/802.18/dcn/23/18-23-0054-02-0000-european-spectrum-regulation-and-the-harmonised-market-of-the-european-union-an-overview.pdf

[44] ASD-STAN, *Work Programme for 2024 and Beyond* – https://cms.stan-shop.org/wp-content/uploads/2024/02/WORK-PROGRAMME-2024.pdf

[45] http://www.hcm-agreement.eu/http/englisch/verwaltung/index_europakarte.htm

[46] In the 3800–4200 MHz band, the HCM Agreement applies to the fixed service, but not to the land mobile service.

Figure 7: Map showing the signatories to the HCM Agreement marked in blue



Source: Own compilation, based on HCM Agreement Management (Bundesnetzagentur)[47]

Several important provisions of the agreement:

- Article 4.1: 'In the case of the land mobile service, the transmission frequency must be coordinated if the transmitter produces a field strength at the boundary of the territory of the administration concerned which, at a height of 10 m above ground level, exceeds the maximum permissible interference field strength as defined in Annex 1. Receiving frequencies must be coordinated if the receiver requires protection. It is strongly recommended that radio-relay links in the fixed service be coordinated if the shortest distance from the boundary of at least one station is less than or equal to the distance defined in Annex 11. All stations which may cause harmful interference to stations in another country or which require protection shall be coordinated regardless of distance."
- Article 4.2.3: "Preferential frequencies granted to an administration shall have priority over allocations to other administrations…"

4.2.1 Current use of the 3400–4200 MHz band in Europe[48]

4.2.1.1 Fixed Satellite Service (FSS)

Syncom 2, launched in 1963, was the first geostationary communications satellite. By matching its orbital period to the Earth's rotational speed, the satellite remained stationary in the sky as one end of a fixed point-to-point link relative to locations on the ground.

Unfortunately, the frequency range that was optimal for satellite relay – 1 to 10 GHz – was already heavily utilised by terrestrial fixed microwave networks. These competing demands for the same spectrum band led to an Extraordinary Administrative Radio Conference convened by the ITU in 1963:

> "With the technical feasibility of sharing between satellite and terrestrial systems as the primary consideration, and the economic advantages of satellites as a secondary factor, a sharing scheme was approved. Specifically, it was established that microwave radio-relay services, with their narrow beam parallel to the Earth's surface, and satellite services, with their transmission paths directed away from the Earth, can avoid harmful interference through the coordination of locations and defined parameters

[47] https://hcm.bundesnetzagentur.de/http/englisch/verwaltung/index_europakarte.htm

[48] Recommendation ERC 12-08 is accompanied by a table providing an overview of the use and restrictions on the use of the 3600–4200 MHz band in EU Member States – https://efis.cept.org/recommendationMatrixViewer.jsp?sectionRowId=3. Although this goes beyond the scope of this study, the 2700–3400 MHz band is allocated to radiodetermination services; the 2900–3400 MHz band is allocated to the radiolocation service (radar) for 'non-civil' purposes (i.e. for military purposes). The 3100–3300 MHz band is used by satellite Earth observation and space research services to determine the physical characteristics of the Earth's surface, oceans and atmosphere using radar and active sensors.

> of their systems. This was the first instance in which two different radiocommunication services were authorised to use shared operating frequencies simultaneously within a common band, setting an important precedent."[49]

The first satellites to transmit video served as intercontinental relays between terrestrial networks. Their transmissions were not intended for direct reception by the public. In 1967, however, the Soviet Union introduced a satellite system for transmitting television signals (Orbita, which also transmitted long-distance telephone calls and carried sensors for monitoring the Earth's environment). Orbita's television downlinks operated at frequencies between 3.4 and 4.1 GHz.[50] American amateur enthusiasts soon discovered that it was possible, using an outdoor parabolic dish, to tune in to signals from various satellites that were intended for onward transmission by cable television networks. Kits containing hard-to-find components were quickly superseded by ready-made products for the mass market, which fuelled public interest and demand for the legalisation of direct public access to satellite television broadcasts.

For a decade, the C-band was the preferred choice for both television programme distribution and telecommunications. According to Robert Matheson, the number of licensed downlinks peaked in 1988.[51]

> "Demand for expanded C-band capacity in the 3400–3700 MHz range... is on a downward trend, which is likely to continue into the future... Video distribution appears to be limited to a few national markets in Africa and to Russia, and is virtually absent in the Middle East... Even in Africa and Russia, 90 per cent of channels use only the upper part of the 100 MHz band 3400–3700 MHz... We have found little or no evidence that the extended C-band is being used on a significant scale, or at all, in CEPT countries, apart from a small group of well-identified and protected teleports... The relatively low utilisation rate of most of these satellites (in ITU Region 1), together with limited prospects for utilisation, does not justify their replacement or new programmes. The likelihood of investment in a new planned C-band satellite appears to be low...
>
> "As regards known operator plans, it is expected that approximately 70 per cent of the 54 satellites using extended/planned DL C-band frequencies and visible from R1 will not be in operation by 2030. It seems likely that many of them will not be replaced... The two main obstacles to the roll-out of new networks using the extended C-band are:
>
> - Preference is given to solutions in higher frequency bands (primarily the Ku and Ka bands) that enable higher data rates,
> - "A preference not to share with terrestrial networks and limited long-term visibility… for solutions based on the extended C-band spectrum."[52]

CEPT Report 088, which was adopted at the ECC plenary session in November 2024, states that:

> FSS ground stations in CEPT countries primarily used the 3600–3800 MHz and 3800–4200 MHz bands, rather than the lower 3400–3600 MHz band... CEPT recommended that regulatory authorities refrain from authorising new FSS stations in the 3400–3800 MHz band in areas designated for 5G and, instead, consider using higher bands above 3800 MHz for future FSS use.[53] As a result, a limited number of terrestrial FSS stations have been retained below the 3800 MHz band, whilst many stations have moved to the 3800–4200 MHz frequency band...
>
> CEPT is also examining the possibility of exempting small Internet of Things (IoT) terminals in the C-band and other frequency bands from individual licensing, which could lead to a need for a greater number of terrestrial stations in the 3.8–4.2 GHz band... Existing FSS ground stations in the 3800–4200 MHz band in Europe are limited in number and clearly identified in terms of location. It can also be expected that future new ground stations will be located in clearly defined

[49] Vernon T. Williams & Martin K. Collins, *The Radio Spectrum: International Allocation and Regulation*, US Naval Postgraduate School, Master's thesis (1979) – https://upload.wikimedia.org/wikipedia/commons/4/41/The_radio_spectrum_international_allocation_and_regulation_%28IA_radiospectrumint00will%29.pdf

[50] "Molniya 1/1," NSSDCA/COSPAR ID: 1965-030A, NASA Space Science Data Coordinated Archive – https://nssdc.gsfc.nasa.gov/nmc/spacecraft/display.action?id=1965-030A

[51] Robert J. Matheson, *Spectrum Usage for the Fixed Services,* NTIA Report 00-378 (2000) - https://its.ntia.gov/publications/download/TR-00-378.pdf

[52] Pacôme Révillon, Stéphane Chenard, et al., "The Use of Extended C Band, Planned C Band and the 7025–7075 MHz Band for Satellite Services: Key Findings," EuroConsult (2022) – https://www.euroconsult-ec.com/connectivity-expertise/download-extended-c-band-presentation

[53] Article 8 of the CTU's spectrum utilisation plan for 2700–4200 MHz states: "In view of the implementation of the Commission Decision, no new individual authorisations shall be granted for new terrestrial stations of the fixed-satellite service in the 3400–3800 MHz band." - https://ctu.gov.cz/plan-vyuziti-radioveho-spektra

> locations... Given that the 3800–4200 MHz band is the only remaining part of the C band for downlink communications, CEPT has assessed and proposed conditions for preserving this band for the long-term development of FSS...[54]

EuroConsult found that 37 per cent of 'operational downlink capacity' in the 3400–3700 MHz band is used for telecommunications, 17 per cent for television and 46 per cent is unused. These findings are based on a ten-day monitoring of 19 satellites which, in January 2022, were located more than 7 degrees above the horizon as viewed from a teleport near Munich in Germany.

An even more striking figure is that the actual utilised satellite capacity in the C-band has fallen to approximately 2 per cent of the total commercial satellite capacity serving ITU Region 1.

Researchers from the business sector are relatively consistent in their estimates of the FSS market, both currently and in the near future, although their assessments primarily reflect the growing dominance of services based on frequencies in the Ku and Ka bands (12–18 GHz and 27–40 GHz respectively) and the rise of broadband access via low Earth orbit (LEO) constellations. We have not come across any study estimating the monetary value of C-band satellite services in the EU.

- The IMARC Group states that "the global market for fixed satellite services (FSS) reached a value of USD 25.0 billion in 2023. The market is expected to reach USD 36.6 billion by 2032 and to grow at a compound annual growth rate (CAGR) of 4.19% between 2024 and 2032."[55]
- 360iResearch states that "the size of the satellite fixed services market was estimated at USD 21.65 billion in 2023 and is expected to reach USD 23.11 billion in 2024 and, with a compound annual growth rate of 6.83 per cent, to reach USD 34.41 billion by 2030..."[56]
- The Business Research Company states that the FSS market "will grow from USD 21.59 billion in 2023 to USD 22.96 billion in 2024… to USD 28.47 billion in 2028, at a compound annual growth rate (CAGR) of 5.5 per cent". "Growth over the forecast period can be attributed to rising demand for high-throughput satellites (HTS), the expansion of satellite broadband services, growing demand for mobility solutions, the growth of remote sensing applications, and the development of small satellite constellations..." [57]
- However, it appears that this growth is more likely to drive subscribers away from C-band services than to attract them.

Satellite dish owners regularly scan for available transponders and report their findings on various websites. We visited two of these websites and found that migration from the 3400–3700 MHz band has accelerated in the two years since the publication of the EuroConsult report:

Figure 8: Frequency ranges used by C-band satellites positioned above Central Europe

Orbital positions	Satellite name	Downlink frequency range (MHz)	Transponder content, areas served
2.9° E	Rascom QAF	3970–4147	Africa, Spain & France
3.0° E	Eutelsat 3B	3672 – 4170	Africa, raw feeds (unprocessed signals)
5.0° E	SES 5	3922 – 4111	BBC, VOA and African TV
10.0° E	Eutelsat 10B	3836 – 4039	African channels only
17.0° E	Amos 17	3846–4119	Africa, excluding direct-to-home services
20.0°	Arabsat 5C	3747–4194	Radio/TV in Africa/the Middle East
26.0° E	Badr 8	4080 – 4099	Africa

Sources: Lyngsat.com and Satbeams.com (October 2024)

[54] [Draft] *CEPT Report 088: On the shared use of 3800–4200 MHz by terrestrial wireless broadband systems providing local-area network connectivity (WBB LMP)* – https://cept.org/files/9522/Draft-CEPT-Report-088.docx

[55] IMARC Group, *Fixed Satellite Services (FSS) Market Report… 2024–2032* - https://www.imarcgroup.com/fixed-satellite-services-market

[56] 360iResearch, *Fixed Satellite Services Market by Service Type (Consumer Broadband, Enterprise & Government, Media & Broadcast), Vertical (Oil & Gas), Maritime – Global Forecast 2025–2030* – https://www.360iresearch.com/library/intelligence/fixed-satellite-services

[57] The Business Research Company, *Fixed Satellite Services Global Market Report 2024* - https://www.thebusinessresearchcompany.com/report/fixed-satellite-services-global-market-report

However, so as not to conclude that protecting the remaining FSS links in the C-band is unnecessary, we must bear in mind that the active frequencies reported by antenna owners are based on television signals, which are only part of the satellites' payload. EuroControl acknowledges this:

> The use of the extended and planned C-band for telecommunications applications is more difficult to quantify than for television… It appears there will be several hundred user terminals in Africa and a smaller number of devices in Europe. These devices appear to correspond exclusively or almost exclusively to older networks, as we have not identified any significant deployment of new networks in recent years. However, the available use cases confirm that, for telecommunications applications that rely on it, the C-band is usually the only viable option, primarily due to their need for high reliability... These are of critical importance to their operation, but rely on a small number of facilities in isolated locations, and it appears that this usage will decline as these satellites are decommissioned and their successors switch to other frequencies for connection to gateways. However, this process may be slow, as some of the satellites concerned may have a long service life... The C-band spectrum is valued because its physical properties allow for more reliable communication and wider coverage than is generally possible at higher frequencies.[58]

Based on findings from the 1960s, these frequencies are desirable for both space-based and terrestrial services. Fortunately, sharing of the band is possible, and CEPT has produced a technical manual for national administrations to facilitate coexistence between satellite and terrestrial stations in this band: *ECC Report 254*.[59]

This may not be relevant to the Czech Republic; however, the ITU points out that:

> The use of the 3 400–4 200 MHz band for FSS involves government use and international commitments within the framework of the WMO.[60] The WMO currently utilises this band – which is essential for civil aviation and weather, water, climate and environmental warnings – on only a few channels within the 3 600–3 800 MHz band.[61] The 3 400–4 200 MHz band is also used for telemetry, tracking and command (TT&C) purposes within the FSS allocation, primarily by FSS satellites operating in this band... It is for each administration to decide which stations within its territory it wishes to protect in accordance with the RR. The Regulations do not set out any criteria or procedures for all types of coordination required under Article 9 of the RR, for example between GSO FSS networks and between FSS and terrestrial networks, as to how such bilateral coordination should be carried out."[62]

4.2.1.2 Fixed Service (FS)

The Fixed Service is the oldest radio service, having evolved from wireless telegraphy. The first allocations to the Fixed Service were made at the World Radio Conference in 1912, which approved a US proposal that frequencies below 200 kHz be reserved for long-distance point-to-point communication.[63]

At the World Administrative Radio Conference in 1959, it was agreed to substantially increase the allocations for the Fixed Service in the microwave band to support the expansion of telephone and television networks. The growing demand for fixed wireless connections came from national telephone networks (for long-distance voice connections) and TV broadcasters (for the distribution of live and pre-recorded audiovisual programmes). In the last two decades, however, demand for new fixed links has come primarily from mobile networks, which use point-to-point microwave links to connect base stations to exchanges (backhaul). In France, for example, approximately 80 per cent of fixed-service link capacity is now occupied by mobile operators.[64] Private networks connecting company branches with high data volumes have also become more widespread. Although fibre-optic networks have also expanded, a complementary relationship has developed between optical fibres and microwave links, with microwaves serving as a backup for optical fibres in situations requiring high reliability (such as the management of electricity grids or rail systems).[65]

---

[58] Révillon, Chenard (EuroControl), op. cit.

[59] *ECC Report 254: Operational guidelines for spectrum sharing to support the implementation of the current ECC framework in the 3600–3800 MHz range* (2016) – https://docdb.cept.org/document/958; *Recommendation ITU-R F.1403-0: Power flux-density criteria in ITU-R Recommendations for the protection of systems in the fixed service in frequency bands shared with space stations of various space services* (1999) – https://www.itu.int/rec/R-REC-F.1403/recommendation.asp?lang=en&parent=R-REC-F.1403-0-199905-I

[60] World Meteorological Organisation

[61] This appears to be a reference to GEONETcast's Disaster Channel. This is supported by EUMETSAT and provides video alerts, information updates and meteorological data on major storms and environmental crises via associated broadcast channels available on Ku-band and C-band satellites. EUMETSAT Europe reports that it has over 3,000 registered users. See https://old.earthobservations.org/geonetcast.php

[62] ITU-R Report M.2109

[63] Williams and Collins, op. cit.

[64] *ECC Report 173: Fixed Service in Europe – Current use and future trends post 2022* (2023) – https://docdb.cept.org/document/281

[65] ETSI EN 302 217-3 V2.2.1 (2014-04): "Fixed Radio Systems; Characteristics and requirements for point-to-point equipment and antennas; Part 3: Equipment operating in frequency bands where both frequency-coordinated and uncoordinated deployment may be applied;

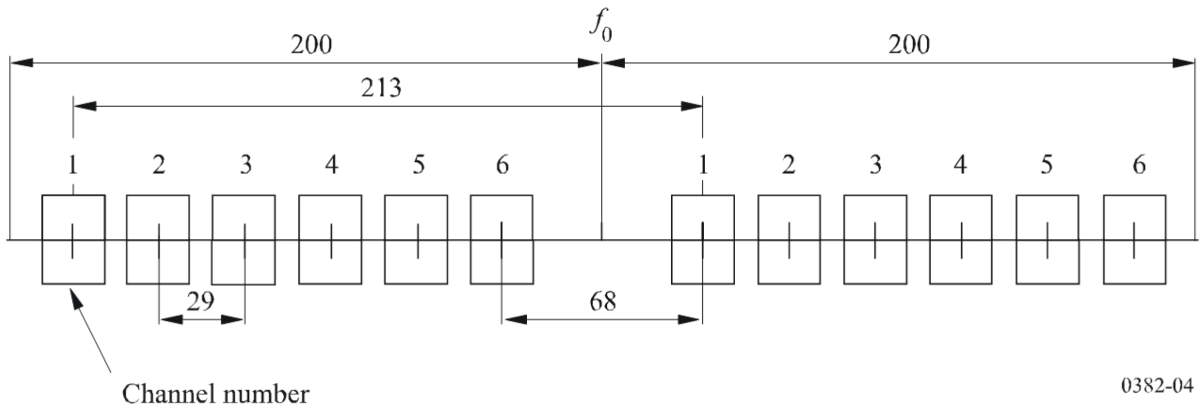
The recent increase in the deployment of fixed microwave networks has primarily concerned single-city frameworks, rather than connections between cities. The average link length has thus decreased, enabling the practical use of higher frequencies despite their more limited propagation range. (The main advantage of higher frequency bands is that wider channels are available in them, particularly above 15 GHz, which provides greater capacity per link.) According to *ECC Report 173*, ‘the number of active point-to-point links declared by the surveyed administrations rose from approximately 160,000 links reported in 1997 to approximately 740,000 declared in 2021.’[66] The vast majority of these links are bidirectional; only 1–2 per cent are unidirectional.

It is important to note, however, that the 3600–4200 MHz band did not contribute to the rapid increase in new point-to-point links. According to *ECC Report No. 173*, ‘the 3.6–4.2 GHz band has shown a sustained downward trend since 1997 and has now probably reached its minimum possible number of links. The links that are still in operation are predominantly long-distance links for telecommunications and broadcasting network infrastructure...’ The 4 GHz band now has the longest hops of all fixed microwave bands.

In the Czech Republic, according to the Czech Telecommunications Office (ČTÚ), “the operation of point-to-point fixed links in the 3600–3800 MHz band ceased in 2011.”[67] Nevertheless, the fixed service retains its priority status alongside the mobile service – presumably to enable the roll-out of MFCN.[68]

In the ČTÚ’s online database of individual authorisations, there are currently 47 active licences for fixed service frequencies in the 3800–4200 MHz band. It is assumed that most of these belong to České radiokomunikace. Each fixed service channel has a bandwidth of 29 MHz and is grouped into six FDD pairs. The band is harmonised in accordance with ITU-R Recommendation F.382-7:[69]

Figure 8: Channel arrangement for digital radio relay systems in the Czech 4 GHz fixed service band



Source: ITU-R Recommendation F.382-7

Twelve of the Czech Telecommunications Office’s (ČTÚ) fixed service licences will expire in 2025, fifty in 2026, eighteen in 2027, six in 2028 and eight in 2029. None of the licences extends their validity to 2030 or beyond. This would facilitate the introduction of a new fixed service authorisation regime at the start of the next decade, should the Czech Telecommunications Office (ČTÚ) decide that this is warranted.

A by-product of the break-up of national telephone monopolies in the 1990s was the stimulation of competition in the fixed-line sector, which manifested itself in pressure to seek new applications and markets for fixed-line services, for example in the case of contracts for the provision of backbone connectivity to support the expansion of mobile telephony and public internet access. The spirit of liberalisation, which brought an end to the monopolies of telecommunications companies, also led to the introduction of technology-neutral licences in many radio services, including fixed services. This subsequently enabled the emergence of new link configurations, such as point-to-

Harmonised EN covering the essential requirements of Article 3.2 of the R&TTE Directive’ – https://www.etsi.org/deliver/etsi_en/302200_302299/30221703/02.02.01_60/en_30221703v020201p.pdf

66 *ECC Report 173.* These figures, which reflect the trend in roll-out, do not include links established under block authorisations, as these do not usually require the reporting of new sites to the national regulator. Therefore, the figure given for 2021, however high it may be, is almost certainly an underestimate.

67 CTU, ‘Announcement of a tender procedure for the granting of rights to use radio frequencies for the provision of electronic communications networks in the 3600–3800 MHz frequency band’, CTU-1/2017-613 (March 2017) - https://ctu.gov.cz/sites/default/files/obsah/ctu/oznameni-ceskeho-telekomunikacniho-uradu-o-vyhlaseni-vyberoveho-rizeni-za-ucelem-udeleni-prav-k/obrazky/20170327-vyhlasenivyberovehorizeni.pdf

68 These services operate in accordance with the harmonised frequency arrangements and the least restrictive technical conditions set out in ECC/DEC/(11)06

69 ITU-R Recommendation F.382-7: “Radio-frequency channel arrangements for fixed wireless systems operating in the 2 and 4 GHz bands” (1997)

- https://www.itu.int/rec/R-REC-F.382/recommendation.asp?lang=en&parent=R-REC-F.382-7-199709-S. Note: This Recommendation was subsequently superseded by Recommendation F.382-8 (2006).

multipoint and, more recently, non-line-of-sight (NLOS) links in urban areas, for which lower frequency bands, such as the 4 GHz band, are particularly suitable. The shift from technology neutrality to service neutrality has opened the door to new applications, such as mobile-fixed communication networks (MFCN), fixed wireless access (FWA) networks and private cells. The 3600–3800 MHz band was already being used in some CEPT countries for P-MP in accordance with ERC/REC 12-08.[70] Licences for the fixed service in this band were most often technology-neutral, giving operators the freedom to explore new, potentially profitable applications.

In 1998, the 3400–3600 MHz frequency band was designated by the CEPT as the preferred frequency band for fixed wireless access networks.[71] However, the situation regarding FWA has developed differently:

> Although FWA is, in principle, well suited to serving any type of customer, from households to small businesses (SOHO/SME) and large corporations, an analysis of the current market situation shows that 'pure' FWA operators now have increasingly slim prospects of achieving profitable business models through serving households... prices have been driven down by competition and the emergence of efficient BWA in lower frequency bands, so] it has become very difficult for FWA to compete in the residential market due to the persistently high cost of CPE.
>
> Consequently, FWA networks in these higher bands are limited to deployment in market niches, and no real expansion is expected... Other bands used for FWA in several European countries are mostly those below 3 GHz (around 1.5 GHz and 2–2.7 GHz).
>
> With the increasing relaxation of regulation, and particularly in certain lower frequency bands (currently 3400–3600 MHz and 3600–3800 MHz), the FWA designation has been replaced by BWA, and in many CEPT countries the original authorisations for the use of FWA spectrum have been liberalised to reflect this new flexibility, without any change in the ownership of the authorisations.[72] The new BWA designation introduces regulatory flexibility to support fixed, portable and mobile services, and in many cases the access technology is derived from both fixed and mobile standardisation sources for the deployment of MFCNs. The 3400–3600 MHz and 3600–3800 MHz bands are the most widely used for BWA and are supported by harmonisation measures:

- EC Decision 2008/411/EC[73]
- Decision 2014/276/EU[74] …(harmonised ECC Decision (11)06[75]]) on the organisation of bands for MFCN use (including IMT)

This supplements the BWA framework with a specific harmonised frequency channel arrangement."[76]

The development of variants such as P-MP, BWA and FWA in fixed service bands has led some national regulatory authorities to reassess the most appropriate authorisation regime:

> '...individual licensing (allocating frequencies to each individual link...) remains the predominant method of allocation in most bands for which information is available. This is followed by block allocation, which, whilst not the dominant method, tends to be applied in most bands. In the 3.4–4.2 GHz band, block allocation is on a par with link-by-link allocation... It is assumed that the reason for this is the initial deployment of P-P links, which were later partially converted to potential P-MP applications."[77]

---

70 CEPT/ERC/Recommendation 12-08 E (Poděbrady 1997, Saariselkä 1998): 'Harmonised Radio Frequency Channel Arrangements and Block Allocations for Low and Medium Capacity Systems in the 3400 MHz to 3600 MHz Band' – https://docdb.cept.org/download/2407

71 See CEPT/ERC/Recommendation 14-03 E (Turku 1996, Poděbrady 1997): 'Harmonised Radio Frequency Channel Arrangements and Block Allocations for Low and Medium Capacity Systems in the Band 3400 MHz to 3600 MHz' – https://docdb.cept.org/download/2422; 'ERC/REC 13-04 of 25 September 1998 on preferred frequency bands for fixed wireless access in the frequency band between 3 and 29.5 GHz' (1998) – https://docdb.cept.org/download/2417.

72 The allocation of frequency blocks for FWA systems in the 3400–3800 MHz band was proposed in ITU-R Recommendation F.1488. The key difference between FWA and BWA is that BWA is not restricted to fixed installations. BWA encompasses fixed, nomadic and mobile networks.

73 "Commission Decision of 21 May 2008 on the harmonisation of the 3400–3800 MHz frequency band for terrestrial systems capable of providing electronic communications services in the Community" (2008/411/EC) - https://eur-lex.europa.eu/legal-content/EN/ALL/?uri=CELEX%3A32008D0411 Decision ECC (07)02 was also mentioned in this sentence from ECC Report 173, but this Decision was withdrawn in 2018.

74 "Commission Implementing Decision of 2 May 2014 amending Decision 2008/411/EC on the harmonisation of the 3400–3800 MHz frequency band for terrestrial systems capable of providing electronic communications services in the Community" (2014/276/EU) – https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=uriserv%3AOJ.L_.2014.139.01.0018.01.ENG

75 ECC Decision (11)06: "Harmonised frequency arrangements and least restrictive technical conditions (LRTC) for mobile/fixed communications networks (MFCN) operating in the 3400–3800 MHz band" (2011, 2018) – https://docdb.cept.org/download/1531

76 *ECC Report 173*.

77 Ibid.

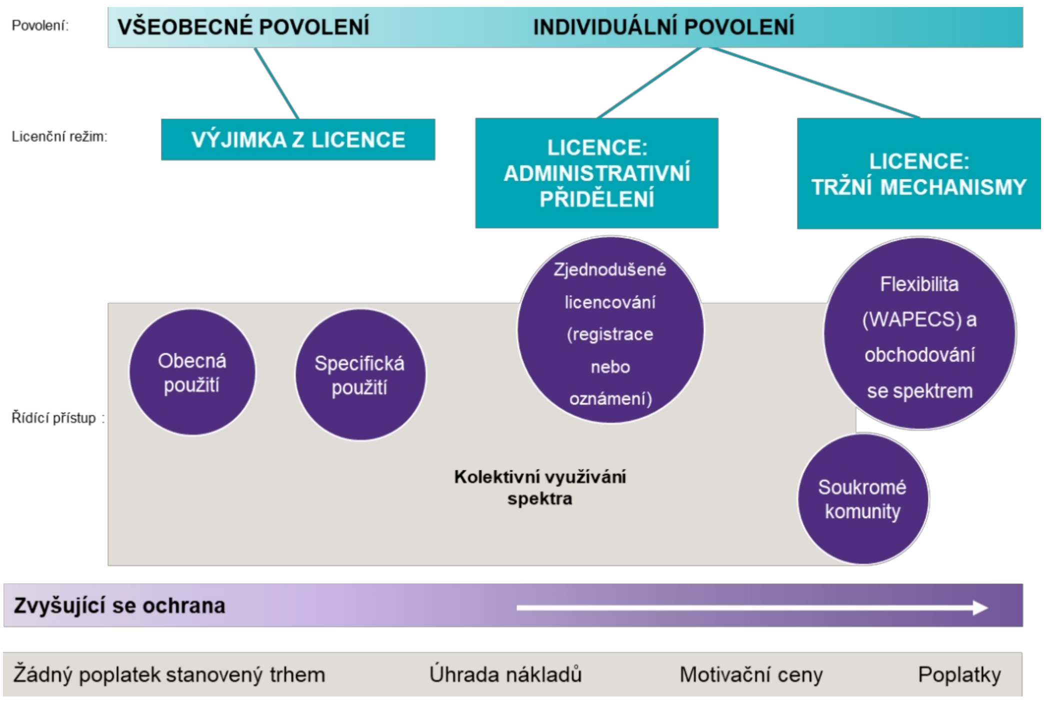
ECC Report 80 proposed a more flexible authorisation option, which gives licence holders greater responsibility for link planning and the coordination of local frequencies:

> The 'simplified licensing regime' combines licence-exempt use with protection for spectrum users. This model operates on a 'first come, first served', whereby the user notifies the regulator of the location and characteristics of the stations. A database of installed stations containing the relevant technical parameters (location, frequency, power, antenna, etc.) is publicly available and should therefore be consulted before installing new stations. If a transmitter can be installed without affecting already registered stations (i.e. without exceeding pre-defined interference criteria), the new station may be entered into the database. Furthermore, a mechanism is required to enable a new participant to challenge whether a station already recorded in the database is actually in use or not. New participants should be able to reach an agreement with existing users in the event that the interference criteria are exceeded."[78]

In subsequent correspondence following the introductory meeting on this study, it was stated that, whilst the CTO does not expect a significant number of applications for the deployment of new or upgraded P2P fixed-service links, it does not plan to restrict them. This raises the question: What authorisation procedure should be applied if a new or upgraded P2P link is proposed in an area with existing BWA/MFCN stations?

As mentioned above, the ČTÚ will have the option to introduce a new approach to licensing fixed services in this band from the start of 2030. Simplified licensing appears appropriate given that the number of active transmitters in this band – both on Earth and in space via FSS – is slowly declining. The risk of interference resulting from new registrations of fixed services appears to be manageable, and the most likely new applicants for registration are current users of the band who have experience in coordinating frequencies, sites and link routes. The onus will be on IMT/MFCN network operators to ensure they do not cause interference to existing services.

Figure 9: Licensing regimes in spectrum management and authorisation guidelines



Source: Own compilation, based on ECC Report 137[79] (2010)

4.2.1.3 Mobile services, IMT and MFCN

The first indication that changes might be forthcoming emerged at WRC-03, when item 1.4 of the WRC-07 agenda, concerning spectrum issues for future iterations of IMT, was approved. WRC-03 called on ITU-R to submit, in good time for WRC-07, the results of studies on

---

78 *ECC Report 80: Enhancing Harmonisation and Introducing Flexibility in the Spectrum Regulatory Framework* (March 2006) – https://docdb.cept.org/download/391

79 *ECC Report 137: Introducing Greater Flexibility in the Current Regulatory Structure with a View to Taking Forward Convergence and Harmonisation in the ECC* (January 2010) – https://docdb.cept.org/download/547

spectrum requirements and potential frequency bands suitable for future IMT networks. [80] This led to the publication in 2006 of ITU-R Report M.2079, which identified a number of candidate bands. As CITEL informed its member states: 'After four weeks and many hours of discussion on all candidate bands, WRC-07 concluded that it was not possible to designate any part of the C-band on a global basis for IMT systems.'[81] Nevertheless, dozens of regulatory authorities approved the addition of footnote 5.430A to the International Frequency Table, which designates the 3400–3600 MHz band for IMT. The Czech Republic was among them, along with 22 other EU Member States. Dozens of other countries added footnotes identifying IMT either in the 3400–3500 MHz or 3500–3600 MHz bands.

The RSPG's Strategic Plan for 5G in Europe, dated November 2016, "considers the 3400–3800 MHz band to be the primary band suitable for the roll-out of 5G-based services in Europe...[82] noting that this band is already harmonised for mobile networks...'. However, it was unclear whether 5G would meet the harmonised conditions. There were grounds for doubt. For example, in its review of C-band compatibility studies, LS telecom found that:

> 'The roll-out of (IMT/5G) in this band is much more complex than for previous fixed services if satellite reception is to be protected:
>
> - transmissions from mobile base stations have much higher power;
> - mobile base stations transmit in all directions, not just on a point-to-point basis;
> - user equipment can be located anywhere, making it almost impossible to control its proximity to satellite receivers"[83]

Following the publication of the RSPG plan, the Radio Spectrum Committee (RSC) therefore tasked CEPT, in cooperation with ETSI, with reviewing the harmonised technical conditions for the use of frequencies in the 3400–3800 MHz band, assessing their suitability for 5G networks and, where necessary, amending these conditions.[84] The results were published in ECC Report No 281[85] , which highlights several issues:

- 'There is a need to reorganise and defragment the band. The ECC is currently developing guidelines/best practices for administrations, which propose ways to facilitate the availability of the largest possible contiguous blocks of spectrum' [86]
- The existing Block Edge Mask (BEM) adequately protects stations operating below 3400 MHz and above 3800 MHz from out-of-band emissions from MFCN/IMT base stations that do not use active antenna systems, but a different BEM is required to protect stations from MFCN/IMT base stations using AAS.
- To prevent interference between synchronised MFCN base stations, it was necessary to set new out-of-block power limits.

Even before the RSPG plan was published (and before the changes recommended by the ECC were defined), the ČTÚ began preparing an auction for fifteen-year nationwide MFCN licences for the 3600–3800 MHz band. "This frequency band is not currently in use," noted the ČTÚ. "The operation of point-to-point fixed links in this band ceased in 2011, i.e. prior to the planned allocation of spectrum under this tender. None of the frequency allocations in this band have yet been issued."[87] Five 40 MHz blocks were therefore offered, with a starting price of 29 million CZK per block. The CTU ultimately raised 1.015 billion CZK (203 million CZK per block).

The EIRP limits within the block for base stations using frequencies in the 3600–3800 MHz band were set at '68 dBm/(5 MHz), with the exception of the lowest 5 MHz of each frequency segment..., where the output level is limited to +4 dBm/(5 MHz).' [88] If

---

[80] See Resolution 228 (rev. WRC-03).

[81] "WRC-07 Decisions and Next Steps for Protecting the Satellite C-band," *CITEL Electronic Bulletin*, No. 43 (January 2008) – https://www.oas.org/en/citel/infocitel/2008/enero/bandaC_i.asp

[82] RSPG, "Strategic Roadmap Towards 5G in Europe: Opinion on spectrum-related aspects for next-generation wireless systems (5G)" (RSPG16-032) – https://radio-spectrum-policy-group.ec.europa.eu/document/download/2d1c7750-4810-418e-8aa3-d58403b1a516_en?filename=RPSG16-032-Opinion_5G.pdf

[83] R. Womersley, *A review of 5G/Satellite compatibility studies in C-band,* LS telecom (2021) - https://www.lstelcom.com/fileadmin/content/lst/marketing/brochures/C-band_compatibility_report.pdf

[84] Radio Spectrum Committee, "Mandate to CEPT to develop harmonised technical conditions for spectrum use in support of the introduction of next-generation (5G) terrestrial wireless systems in the Union: Opinion of the RSC," RSCOM16-40rev3 (7 December 2016) - https://circabc.europa.eu/sd/a/448dc765-51de-4fc8-b6e0-56ed6a1d0bca/RSCOM16-40rev3%205G%20draft_mandate_C. The 3400–3800 MHz band was harmonised for MFCN by ECC Decision (11)06 in CEPT Member States and, in the EU, by Commission Decision 2008/411/EC, as amended.

[85] *ECC Report 281: Analysis of the suitability of the regulatory technical conditions for 5G MFCN operation in the 3400–3800 MHz band* (6 July 2018) – https://docdb.cept.org/download/3419

[86] Ibid

[87] Ibid

[88] "Invitation to Tender for the award of rights to use radio frequencies to provide an electronic communications network in the 3600–3800 MHz band" (27 March 2017) - http://www.ctu.cz/sites/default/files/obsah/ctu/oznameni-ceskeho-telekomunikacniho-uradu-o-vyhlaseni-vyberoveho-rizeni-za-ucelem-udeleni-prav-k/obrazky/20170327-vyhlasenivyberovehorizeni-en.pdf

The same licence holder controls neighbouring frequency blocks; the reduction of the output level to 5 MHz to limit interference outside the block does not apply between blocks with a common licence holder.

In November 2020, the Czech Telecommunications Office (ČTÚ) auctioned 12-year licences in the 3400–3600 MHz band for the roll-out of 5G networks. For two 20 MHz blocks (3400–3420 MHz[89] and 3420–3440 MHz), it was envisaged that the frequencies would be leased to enable the creation of private networks supporting Industry 4.0.[90] The starting price for these two blocks was CZK 110 million per block; for the other eight 20 MHz blocks, the starting price was CZK 140 million per block.[91] The CTU ultimately raised CZK 1.606 billion in the auction.

The auction winners undertook to refarm the 3400–3800 MHz frequency band with the aim of harmonising allocations and creating contiguous frequency blocks for individual operators. This commitment was fulfilled in July 2021 through changes to the allocated radio frequency ranges… The Radio Spectrum Utilisation Plan published in February 2022 set out the parameters for the uniform mutual synchronisation of TDD time frames, taking into account both existing 4G-LTE networks and newly built 5G networks, with a view to optimising the use of radio frequencies."[92]

TDD networks operating in the same area and using the same frequency band must be synchronised. Otherwise, network performance is reduced, connection speeds are lowered, and interference occurs between stations (both terminal and base stations). The GSMA recommends uniform synchronisation at national or even international level, as well as a consistent frame structure at national level.[93] Where synchronisation is not possible – for example, where co-existing networks use different technologies, or where a local/industrial cellular network requires specific parameters to support certain essential applications – output power limits, guard bands or greater separation distances may be necessary. Coordination is therefore an important factor in spectrum sharing between IMT and other radio services, as well as between national and local/industrial MFCN networks.

In January 2018, the RSPG issued its second opinion on 5G, in which it placed these issues in a broader context:

- Beamforming (a key 5G feature) may alter the calculation of the minimum separation distances required between stations in services and networks that share frequencies:
    a) Antenna beamforming technologies being developed for 5G will be used to improve the quality and throughput of links to individual end-users. Where possible, consideration should be given to whether beamforming technologies can also be used in a way that explicitly minimises radiation in specific directions, i.e. towards receiving stations of other services. If feasible, this, in conjunction with other technical approaches (e.g. database/geolocation technologies), could potentially be effective in mitigating interference with other services. This may allow 5G stations to be deployed closer to existing stations that are to be protected than would otherwise be the case. However, such functions would need to be implemented in beamforming algorithms and massive MIMO in a way that would allow operators to define emission limits in a given direction.
    b) It is important for standardisation bodies, such as 3GPP and ETSI, and for research programmes, such as 5G-PPP, to address these features. Where possible, manufacturers should incorporate them into the development of 5G equipment to facilitate greater spectrum sharing.
    c) Member States should take these potential technological developments into account when analysing the possibilities for spectrum sharing between 5G and existing users.
- 5G is designed to be more adaptable than previous generations of mobile technology and to serve a wider range of customer groups, such as industrial enterprises, PPDR, the Internet of Things, etc. Beamforming (a key feature of 5G) may alter the calculation of the minimum required separation distances between stations in services and networks that share frequencies:
    a) When granting authorisations, account should be taken of the fact that different categories of applications have different requirements... Member States will require flexibility regarding the combination of authorisation approaches. Alternative authorisation

---

[89] The amateur service has a secondary allocation in the 3400–3410 MHz band, which is governed by the conditions set out in Note CZ7 of the National Frequency Table and in Annex 1 to Decree No. 156/2005 Coll. (on the technical and operational conditions of the amateur radio service). Amateur stations in this band must not interfere with the operation of existing or future electronic communications networks, nor are they entitled to protection from such networks.

[90] CTU, "The Czech Telecommunications Office has auctioned frequencies in the 700 MHz and 3400–3600 MHz bands," press release (13 November 2020 – https://ctu.gov.cz/tiskova-zprava-cesky-telekomunikacni-urad-vydrazil-kmitocty-v-pasmech-700-mhz-3400-3600-mhz

[91] CTU, "Annex 3 to the Announcement of a tender procedure for the granting of rights to use radio frequencies for the provision of electronic communications networks in the 700 MHz and 3400–3600 MHz frequency bands; Auction Rules;" Text corrected for obvious errors, published on 21 September 2020 under ref. no. ČTÚ-38 426/2020-613/IV.vyř. - https://ctu.gov.cz/sites/default/files/obsah/ctu/oznameni-ceskeho-telekomunikacniho-uradu-o-vyhlaseni-vyberoveho-rizeni-za-ucelem-udeleni-prav-k/obrazky/20200921-priloha3czoprava.pdf

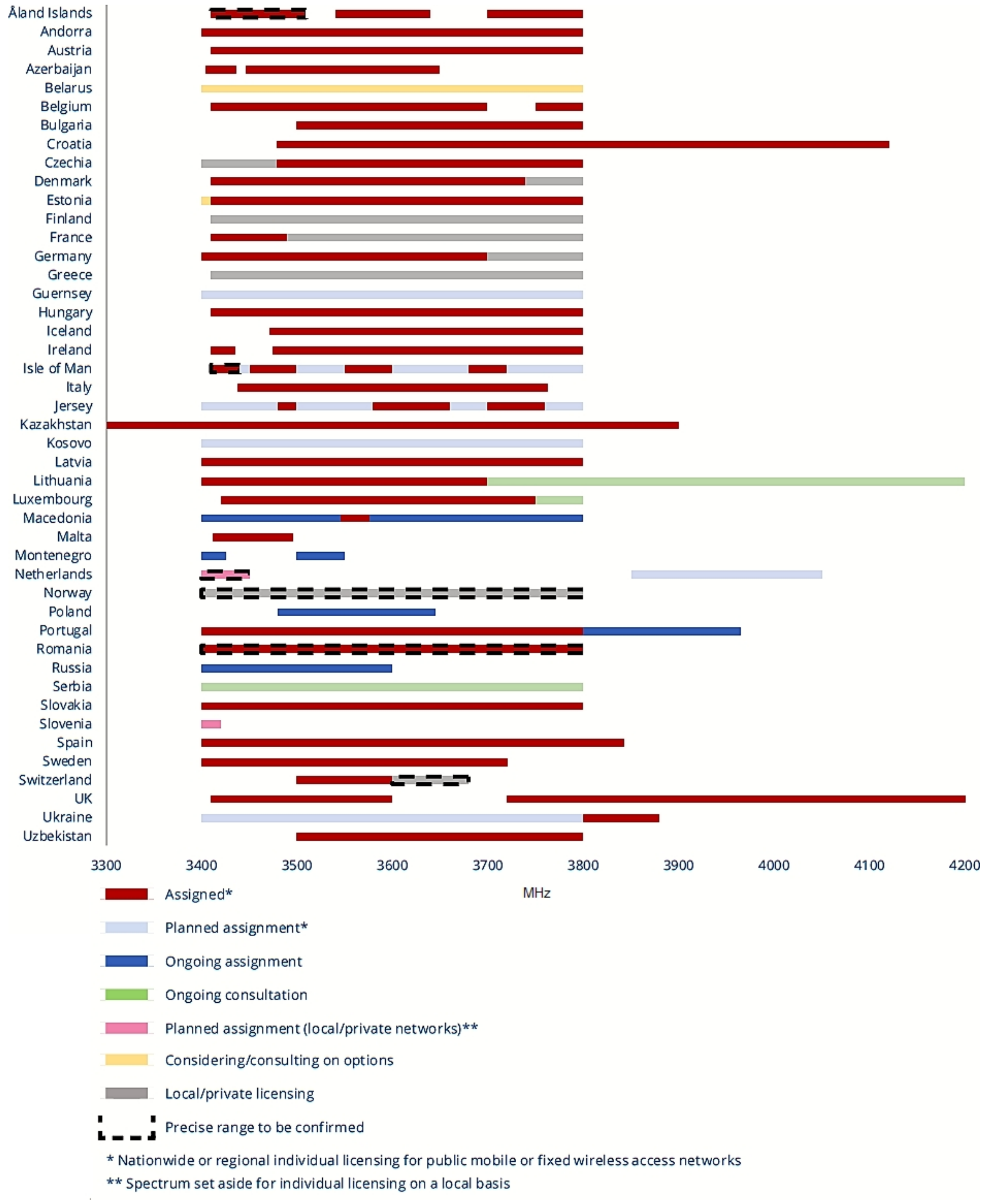
[92] CTU, "Radio Spectrum Management Strategy – Second Situation Report on the Status of Implementation Measures" [Radio Spectrum Management Strategy – Second Situation Report on the Status of Implementation Measures], June 2022 – https://ctu.gov.cz/sites/default/files/obsah/stranky/49264/soubory/druha_situacni_zprava_ve_zneni_projednanem_radou_ctu_v_srpnu_2022.p df

[93] GSMA, *5G TDD Synchronisation: Guidelines and Recommendations for the Coexistence of TDD Networks in the 3.5 GHz Range* (April 2020) – https://www.gsma.com/connectivity-for-good/spectrum/wp-content/uploads/2020/04/3.5-GHz-5G-TDD-Synchronisation.pdf

Approaches may include general authorisation regimes (licence exemptions), licensed shared use between different users, geographical sharing (including sub-national, regional and local-specific licences, including at local level directly for businesses) or more dynamic approaches to spectrum sharing over time and space, possibly utilising geolocation databases... In order to make optimal use of the spectrum, the industry should develop appropriate protocols to ensure coexistence between different 5G applications in general authorisation bands and at the boundaries of geographical licences.[94]

[94] "Strategic Spectrum Roadmap Towards 5G for Europe: RSPG Second Opinion on 5G Networks," RSPG18-005 FINAL (30 January 2018) – https://circabc.europa.eu/sd/a/fe1a3338-b751-43e3-9ed8-a5632f051d1f/rspg18-005final-2nd_opinion_on_5g.pdf

Figure 10: Allocation of IMT in the C-band in Europe and certain countries of the former CIS



Source: GSA (2024)[95]

[95] Global Mobile Suppliers Association, *GSA Snapshot: Spectrum Positions Used for Mobile Services* (June 2024) - https://gsacom.com/download.php?id=17360

Figure 11: European spectrum for industrial verticals

AUSTRIA Frequency band: 3400–3800 MHz Bandwidth: 390 MHz

In March 2019, an auction was held for regional 5G licences in the 3400–3800 MHz band. A portion of the spectrum remained unallocated, ranging from 10 MHz in two regions to 40–60 MHz in the other regions. In 2021, a consultation was held to ask the public whether these remaining channels should be allocated to industry verticals or to public mobile operators to expand their networks. Mobile operators were given priority.

BELGIUM Frequency band: 3800–3840 MHz, 3880–3960 MHz Bandwidth: 120 MHz

This information is taken from the "Decision of 19 December 2023 concerning local private networks in the 3800–4200 MHz band and the assignment of E.212 mobile network codes" (original in French and Flemish)[96] :

The regulatory authority BIPT offers licences for TDD mode with a bandwidth of 20 or 40 MHz for non-public IMT networks, with a maximum duration of 10 years. Each licence holder is allocated a maximum of 40 MHz, and licences are non-transferable. Annual spectrum usage fees amount to EUR 400/MHz/km² (amounts are adjusted for inflation in subsequent years).

'The licence holder may deploy any number of stations within the service area covered by their licence…. To prevent interference with public mobile networks, private LANs in the 3800–3860 MHz sub-band must use the DDDSU frame structure. As this frame structure may not be suitable in all situations, the BIPT does not, at this stage, intend to introduce the DDDSU frame… above 3860 MHz.

For unsynchronised outdoor networks, this decision sets an EIRP limit of 18 dBm/5 MHz with an antenna height limited to 10 m. This limit is identical to that used in the United Kingdom and Norway… For synchronised outdoor networks, this decision sets an EIRP limit of 30 dBm/5 MHz with an antenna height limited to 10 m, i.e. 12 dB higher than for non-synchronised networks. BIPT's calculations show that even with this 12 dB difference, the risk of interference is no greater than for non-synchronised networks.

For indoor networks, BIPT's compatibility calculations factor in a 12 dB attenuation due to signal penetration into the building… This 12 dB attenuation allows the EIRP to be increased by 6 dB whilst reducing the distance between two networks, thanks to a 6 dB margin for propagation losses. For unsynchronised indoor networks, this decision sets the EIRP limit at 24 dBm/5 MHz. For synchronised indoor networks, the BIPT considers that a limit of 30 dBm/5 MHz is sufficient to ensure coverage. This decision sets a limit (on total radiated power) of 28 dBm for terminals. This limit is the same as that applicable to terminals in the 3400–3800 MHz band.

Emission mask: The EIRP limits outside the allocated block for base stations are set out in the table below. Unless otherwise stated, the measurement bandwidth is 5 MHz. These limits are in accordance with the harmonised conditions of CEPT Report 088 (minimum technical requirements for WBB LMP in the 3800–4200 MHz band:

Frequency band	**EIRP limits for base stations**
0 to 5 MHz below and 0 to 5 MHz above the allocated block	maximum power minus 40 dB per antenna
3800–4200 MHz, excluding the allocated block and the frequencies 0 to 5 MHz below and 0 to 5 MHz above the maximum carrier power of the allocated block	minus 43 dB per antenna
Less than 3800 MHz	For networks using the DDDSU framework:

[96] https://www.bipt.be/operators/publication/decision-of-19-december-2023-concerning-local-private-networks-in-the-3800-4200-mhz-band-and-the-assignment-of-e.212-mobile-network-codes

	Maximum carrier power minus 43 dB per antenna For other networks: -43 dBm/MHz per antenna

Protection of other services: RTBF (Radio-Television Belgium) uses radio links in the 3800–4200 MHz band. To protect RTBF's radio links, the BIPT applies the same compatibility criteria as those laid down for international coordination in the HCM Agreement (Berlin, 8 September 2022), specifically a maximum permissible threshold reduction of 1 dB (corresponding to an I/N ratio of –5.9 dB). Ground stations: There are two sites in Belgium where ground stations using the 3800–4200 MHz band for reception are located: the site at Redu (European Space Agency headquarters) and the site at Gosselies. To protect ground stations, the BIPT uses as a protection criterion a limit on the power received by an isotropic antenna with a 20 % probability at a height of 15 m above ground level of –184 dB(W/4 kHz).[97] The BIPT calculates that, when the above-mentioned EIRP limits for base stations are applied, there is no risk of interference to radio altimeters.

International coordination: There is no agreement on cross-border coordination of boundaries for the 3800–4200 MHz band. If calculations show that the potential field generated at the border exceeds the limit of 41 dBµV/m/5 MHz at a height of 10 m above ground level at the border with a neighbouring country, BIPT will initiate coordination with that neighbouring country or, where appropriate, impose restrictions in the authorisation to ensure compliance with the 41 dBµV/m/5 MHz limit.

Compatibility between private local networks: Where relevant, the BIPT applies the technical conditions adopted in the United Kingdom and Norway for the 3800–4200 MHz band. In the United Kingdom and Norway, networks are not synchronised. The BIPT therefore applies the technical conditions adopted in the United Kingdom and Norway only to non-synchronised networks. CEPT Recommendation (15)01 proposes threshold values at the border between neighbouring countries for the 3400–3800 MHz band for both synchronised and non-synchronised networks. For unsynchronised networks, where interference between base stations predominates, this recommendation is less relevant, as it is based on public mobile networks with antenna heights much greater than the 10 m permitted for private local networks in the 3800–4200 MHz band. For synchronised networks (interference to terminals in network B caused by base stations in network A), the threshold level is 61 dBµV/m/5 MHz at a height of 3 m above ground level.[98] For non-synchronised networks (interference to Network B base stations caused by Network A base stations), the BIPT takes into account a noise factor of 13 dB and an I/N ratio of -4 dB when calculating compatibility. The threshold level is therefore 55 dBµV/m/5 MHz at a height of 10 m above ground level.

This decision may be revised once the European Commission's implementing decision laying down harmonised technical conditions for the 3800–4200 MHz band has been adopted.

CZECH REPUBLIC Frequency band: 3400–3600 MHz Bandwidth: 200 MHz

The auction for licences in the 3400–3600 MHz band concluded in November 2020. Two bidders (CentroNet and O2) were awarded 20 MHz blocks in the 3400–3440 MHz band, on the condition that the spectrum must be leased to industry verticals upon request. In 2023, CentroNet sold its licence to T-Mobile, whilst this obligation remained in place.

DENMARK Frequency band: 3740–3800 MHz Bandwidth: 60 MHz

TT-Network (a joint venture between Telenor and Telia in Denmark) was awarded a licence for the 3660–3800 MHz band at an auction in April 2021. The licence included an obligation (until 2025) to lease its frequencies to businesses and public institutions on a 'first come, first served' basis for the creation of local private networks serving exclusively the internal needs of the lessees on their premises. Leases are subject to strict technical rules designed to prevent interference with radars and public mobile networks operating on adjacent frequencies. Private networks must meet the same technical requirements as the main licence holder to ensure the coexistence of private networks with the public mobile network. The licensee shall ensure that the cumulative power flux density (PFD) from the licensee's private network at a distance of 500 metres beyond the boundary of the private network… does not exceed -5 dBm/m²/(5 MHz) at a height of 1.5 metres.

Standard contract for lease is available online at https://ens.dk/sites/ens.dk/files/Tele/annex_m_-_standard_contract_for_leasing_spectrum.pdf

[97] See *ECC Report 100: Compatibility studies in the 3400–3800 MHz band between broadband wireless access (BWA) systems and other services* (February 2007).

[98] The value proposed in CEPT Recommendation (15)01 for synchronised networks using non-preferential PCI for the 3400–3800 MHz band.

The annual fee is limited to a geographically proportional share (of Denmark's area), taking into account the number of frequencies covered by the contract, the amount paid for the licence at auction, and the annual fee for the use of the frequencies, which the licence holder pays to the regulatory authority.

FINLAND Frequency band: 2300–2320 MHz, 3410–3800 MHz Bandwidth: 410 MHz

Since 2020, local licences have been available for the 2300–2320 MHz and 24.25–25.1 GHz bands, enabling factories, ports, airports, shopping centres, power stations, mines, educational institutions, etc. to develop IMT or FWA networks for their own use. The 3410–3800 MHz band was allocated to mobile operators in October 2018, with an obligation to use or lease it.

FRANCE Frequency bands: 2575–2615 MHz, 3490–3800 MHz, 3800–4200 MHz Bandwidth: 340 MHz

In 2019, the regulator ARCEP decided to make local mobile licences available to private industrial entities in the 2575–2615 MHz band. From 2022, ARCEP has also authorised the use of the 3800–4000 MHz band for industry/vertical sector trials. The 3.6 GHz band, allocated to four mobile operators in 2020, requires licence holders to meet reasonable requests from economic operators (businesses, local authorities) for tailored network solutions with agreed coverage and performance levels or, if the operator prefers, to grant them local access to their frequencies via 'secondary' licences for a maximum of three years. This obligation came into force in 2024 and, at the end of 2024, will be supplemented by an obligation to develop the network in rural and industrial areas.

GERMANY Frequency band: 3700–3800 MHz Bandwidth: 100 MHz

The following information is taken from the regulatory agency BNetzA: "Administrative rules for spectrum assignments for local spectrum usages in the 3700–3800 MHz band" (15 May 2023)[99] -

According to BNetzA's findings, many manufacturers planned to deploy private networks that would be more powerful and secure than Wi-Fi. At the same time, however, complaints were received that mobile operators were unable to offer such networks. BNetzA has therefore reserved up to 100 MHz (in 10 MHz blocks) in the 3700–3800 MHz band for the direct allocation of frequencies to businesses, on a technology-neutral 'first come, first served' basis. Licences may be issued for up to 10 years, but their validity must not extend beyond the end of 2040. Spectrum usage fees are calculated annually according to the following formula:

$$\text{fee (EUR)} = 1000 + B \cdot t \cdot 5 \cdot (6 \cdot {}_{a1} + {}_{a2})$$

Where: 1,000 is the base amount in EUR

B is the bandwidth in MHz (from 10 MHz to 100

MHz) t is the allocation period in years

a is the area in square kilometres (km²) $_{a1}$ is the

built-up and transport area

$_{a2}$ represents other land types

The application window opened in November 2019. To date, every company that has applied for a licence has been granted one. The 'use it or lose it' – the network must be operational within one year of the licence being issued, otherwise the licence will be revoked. Applicants are required to sign a document confirming their technical expertise, financial standing and reliability.

BNetzA does not specify a maximum permitted field strength at the edge of the licensed area, but network operators must agree to negotiate with neighbouring network operators to resolve complaints regarding interference. Any written agreement regarding interference must be submitted to BNetzA. If

[99] https://www.bundesnetzagentur.de/SharedDocs/Downloads/EN/Areas/Telecommunications/Companies/TelecomRegulation/FrequencyManagement/FrequencyAssignment/LocalBroadband3,7GHz.pdf

no agreement can be reached, BNetzA may set a field strength limit of 32 dBµV/m/5 MHz at a height of 3 m at the boundary and beyond the allocated area (as specified in Recommendation ECC (15)01). No EIRP limits have been set for base stations within the block…

GREECE Frequency band: 3400–3410, 3410–3800 MHz Bandwidth: 400 MHz

RSPG: In Greece, most verticals are rolling out their own private networks based on MNO resources. Stand-alone private networks are managed by mobile operators.

LUXEMBOURG Frequency band: 3700–3800 MHz

Allocation rules were issued in March 2020 for local applications utilising the 3700–3800 MHz band.

NETHERLANDS Frequency band: 3400–3450, 3750–3800 MHz Bandwidth: 100 MHz

In a press release dated November 2023, the Dutch Ministry of Economic Affairs announced that licences for local private 5G networks would be available from 1 December 2023. Companies were already able to use the 1780–1785 MHz and 1875–1880 MHz bands without a licence, subject to the conditions set out in the "Regeling gebruik van frequentieruimte zonder vergunning en zonder meldingsplicht 2015" (Regulation on the use of frequency spectrum without a licence and without a notification requirement).[100] However, the 100 MHz available in the C-band supports much higher speeds. The Dutch government designates these channels as intended for 'on-premises networks', as they are intended solely for premises that a company or organisation owns or has the right to use. The bandwidth for which an application may be made is limited solely by availability in the planned coverage area. The standard licence validity period runs until 31 December 2040, with no possibility of extension.There is an obligation to cooperate with other licence holders, and no interference must be caused to other spectrum users. All on-premises networks have equal rights. The order in which they were activated does not confer priority – with the important exception that on-premises networks with licences issued before 2018 take precedence over later licences until
1 September 2026, when their licences expire. The Ministry's online network database indicates that there are currently 27 parcel networks in the Netherlands. Fixed antenna installations with a transmission power exceeding 10 dBW must also be registered in the national Antenna Register.[101] However, technical information on these networks appears to be lacking – no power limit, BEM, or details on whether synchronisation is required are specified. The application form states that bandwidths are available in multiples of 10 MHz and that TDD mode is mandatory; however, the drive for simplification has led to an ambiguous description of practical implementation.

NORWAY Frequency band: 3800–4200 MHz Bandwidth: 100 MHz

Information taken from the NKOM document "Regulation of local networks in 3.8–4.2 GHz", Version 02 (January 2023)[102]

Since 2022, the regulatory authority Nkom has been accepting applications from companies for 20, 40, 60 or 80 MHz blocks in the 3800–4200 MHz band to support low- and medium-power local networks serving geographically defined areas as a supplement to national mobile coverage. Low-power licences are granted as 'local licences' (one licence for any number of low-power stations, provided they are located within a circle with a radius of 50 m), whilst medium-power licences are granted as 'transmission licences' (one licence per base station). Low power means a maximum permitted EIRP spectral power density of 18 dBm/5 MHz for base stations. The maximum permitted antenna height for an outdoor low-power transmitter is 10 m. This table shows the maximum permitted EIRP values across the entire low-power band:

Bandwidth	EIRP	EIRP
20 MHz	24 dBm	0.25 W

[100] https://wetten.overheid.nl/BWBR0036378/2021-12-15

[101] https://antenneregister.nl/Html5Viewer/Index.html

[102] https://nkom.no/aktuelt/nkom-has-opened-3-8-4-2-ghz-for-local-area-5g-networks

40 MHz	27 dBm	0.50 W
60 MHz	29 dBm	0.6 W
80 MHz	30 dBm	1.01 W

Medium power refers to the maximum permitted EIRP power spectral density of 36 dBm/5 MHz for base stations. This table shows the maximum permitted EIRP across the entire band for medium power:

Bandwidth	**EIRP**	**EIRP**
20 MHz	42 dBm	16 W
40 MHz	45 dBm	32 W
60 MHz	47 dBm	48 W
80 MHz	48 dBm	64 W

Operators must specify the antenna gain for medium-power base stations in their licence application (the maximum permitted gain is 16 dBi). Medium-power base stations and their connected equipment are not permitted within 10 km of a town or city with a population of more than 10,000. For mobile and nomadic terminals connected to base stations, the TRP limit is 28 dBm (0.631 W); for fixed terminals, the limit is 28 dBm EIRP. All equipment in the network must be registered with Nkom. Requests for bandwidth exceeding 50 MHz must be justified in the application. Only 'stand-alone' networks are permitted – without interconnection or resource sharing with public mobile networks. Only equipment capable of tuning across the entire 3800–4200 MHz frequency band may be used, as Nkom may order transmitters to be retuned to resolve interference issues. Applicants are responsible for planning their own networks.

NKOM uses the following spectrum masks for compatibility calculations (transmission in the first table, reception in the following two):

Spectral mask for low- and medium-power transmission – for all bandwidths

Offset centre frequency (MHz)	**Gain (dB)**
–2.5 × BW	–53
–BW/2–10	–53
–BW/2–5	–53
–BW/2-5	–45

–BW/2	–45
–BW/2	0
0	0
BW/2	0
BW/2	–45
BW/2+5	–45
BW/2+5	–53
BW/2+10	–53
2.5 x BW	–53

Spectral mask for low- and medium-power reception – 20 MHz bandwidth

Offset centre frequency (MHz)	Gain at low power (dB)	Gain at medium power (dB)
–2.5 × BW	–54.1	–57.1
–BW/2–5	–54.1	–57.1
–BW/2-5	–45.1	–48.1
–BW/2	–45.1	–48.1
–BW/2	0	0
0	0	0
BW/2	0	0
BW/2	–45.1	–48.1
BW/2+5	–45.1	–48.1
BW/2+5	–54.1	–57.1
2.5 × BW	–54.1	–57.1

Spectral mask for low- and medium-power reception – bandwidths exceeding 20 MHz

Offset centre frequency (MHz)	Gain for low power (dB)	Gain for medium power (dB)
–2.5 × BW	–48.1	–51.1
–BW/2–5	–48.1	–51.1
–BW/2-5	–39.1	–42.1
–BW/2	–39.1	–42.1
–BW/2	0	0
0	0	0
BW/2	0	0
BW/2	–39.1	–42.1
BW/2+5	–39.1	–42.1
BW/2+5	–48.1	–51.1
2.5 × BW	–48.1	–51.1

Nkom carries out coexistence calculations between local networks and satellite ground stations, and may also restrict the siting of base stations near airports and heliports. As synchronisation with public mobile networks is not required, there is a guard band at frequencies 3800–3840 MHz. Non-synchronised outdoor medium-power base stations are restricted to the 3840–4000 MHz frequency band; synchronised base stations may use frequencies within the guard band. An assessment will also be carried out regarding coexistence with aviation altimeters operating above 4200 MHz and public mobile networks operating below 3800 MHz, to ensure their protection. The licence is valid for a maximum of 10 years. The annual fee depends on the bandwidth and power level. For low-power applications, annual fees are calculated on the basis of the licensed area. For medium-power applications, the fee is calculated on the basis of each base station.

This initiative began when nationwide licences were allocated for the entire 3,400–4,200 MHz band, rather than a partial allocation for local verticals and industrial entities. These rules are based on the UK's 'Shared Access Licence' (SAL) regime operated by the UK regulator Ofcom. The technology used is 5G; however, FWA operators have challenged this decision, stating that they prefer IEEE 802 equipment. The synchronisation requirement would make the use of IEEE equipment considerably more difficult. Other reported issues include obtaining the correct equipment, implementation costs and uncertainty regarding the future availability of spectrum.

POLAND **Frequency band: 3900–4200 MHz** **Bandwidth: 300 MHz**

The information in this box is taken mainly from the document “Sieci prywatne w paśmie 3,8–4,2 GHz już od wakacji” [Private networks in the 3.8–4.2 GHz band from the summer holidays onwards], dated 6 April 2023.[103]

The 3,800–3,900 MHz frequency band is reserved for local government bodies to meet their own needs (they may not use this band to provide communication services to other entities). From 2023, a single entity may apply for a licence to use part of the 3900–4200 MHz band in up to 20 ‘municipalities’. As this frequency band will also be used by other services, cooperation and mutual consideration are essential. Bandwidths for private networks are available in multiples of 10 MHz, up to a maximum of 100 MHz. Licences will be issued for low- or medium-power networks. To prevent interference with altimeters operating in the band above 4,200 MHz, medium-power transmitters may not be used outdoors in the 4,000–4,200 MHz band. If an entity uses the network exclusively for its own needs, the licence fee will be a one-off payment of 82 PLN (19 EUR). If it provides a public telecommunications service, the fee is 1,939 PLN (447 EUR). In addition, monthly spectrum usage fees are charged, which vary according to location and bandwidth, as summarised in this table:

Annual fees for the use of frequencies

Bandwidth	Rural municipality	Mixed urban-rural municipality	Urban municipality	Town with district status
10 MHz	100 PLN	250 PLN	1,250 PLN	2,500 PLN
20 MHz	200 PLN	500 PLN	2,500 PLN	5,000 PLN
30 MHz	300 PLN	750 PLN	3,750 PLN	7,500 PLN
40 MHz	400 PLN	1,000 PLN	5,000 PLN	10,000 PLN
50 MHz	500 PLN	1,250 PLN	6,250 PLN	12,500 PLN
60 MHz	600 PLN	1,500 PLN	7,500 PLN	15,000 PLN
70 MHz	700 PLN	1,750 PLN	8,750 PLN	17,500 PLN
80 MHz	800 PLN	2,000 PLN	10,000 PLN	20,000 PLN
90 MHz	900 PLN	2,250 PLN	11,250 PLN	22,500 PLN
100 MHz	1,000 PLN	2,500 PLN	12,500 PLN	25,000 PLN

The maximum permitted EIRP, depending on bandwidth, is almost the same as in Norway:

Bandwidth	Maximum EIRP for low power	Maximum EIRP for medium power

[103] https://uke.gov.pl/blog/sieci-prywatne-w-pasmie-3-8-4-2-ghz-juz-od-wakacji,77.html

10 MHz	21 dBm	39 dBm
20 MHz	24 dBm	42 dBm
30 MHz	26 dBm	44 dBm
40 MHz	27 dBm	45 dBm
50 MHz	28 dBm	46 dBm
60 MHz	29 dBm	47 dBm
70 MHz	29 dBm	48 dBm
80 MHz	30 dBm	49 dBm
90 MHz	31 dBm	49 dBm
100 MHz	31 dBm	49 dBm

SLOVAKIA Frequency band: 3600–3800 MHz Bandwidth: 200 MHz

Regional licences for broadband wireless access using LTE/4G were auctioned in October 2017 in 40 MHz blocks in the 3600–3800 MHz band. The licences, valid only until the end of 2024, were awarded to 16 bidders.[104] In May 2018, the regulator RÚ announced a tender for regional licences in the 10 GHz band for the provision of public fixed wireless access services. A pilot project for a non-public 5G network at the Technical University of Košice, reportedly the only one of its kind in the country, has been serving as a test environment for equipment since 2023.

SLOVENIA Frequency band: 3400–3420 Bandwidth: 20 MHz

PolicyTracker reported in March 2024 that the Slovenian regulator (AKOS) had allocated specific regional licences for 5G spectrum (3400–3420 MHz, 2300–2320 MHz and 2390–2400 MHz) to several local authorities, industrial enterprises and mobile network operators. Through this approach, AKOS is seeking to further strengthen the use of 5G in industry and local networks."[105]

SWEDEN Frequency band: 3720–3800 MHz Bandwidth: 80 MHz

Since November 2021, the Swedish regulator PTS has been accepting applications for local and regional 5G licences in the 3760–3800 MHz and 24.25–25.1 GHz bands. A spokesperson stated: "We have tried to ensure that the licences are small enough and attractive enough to ensure there are plenty of them, so that at this level you can effectively apply the 'first come, first served' principle… however, the very simple rules and very low fees have not generated much interest in these licences."[106] Sweden also permits local spectrum leasing within licensed blocks, provided that a mobile operator in the area has surplus spectrum and agrees to this arrangement. PTS has approved several larger leasing agreements; smaller agreements (fewer than 10 base stations) do not require regulatory approval. A third option is local spectrum sharing within a block licence. Block licences

104 5G Observatory https://5gobservatory.eu/national-5g-spectrum-assignment/

105 Regional 5G spectrum licences in Slovenia

106 Kelly Hill, "Private network spectrum strategy, Part 2: Sweden's PTS," *RCR Wireless News*, 22 November 2022 - https://www.rcrwireless.com/20221122/spectrum/private-network-spectrum-strategy-part-2-swedens-pts

In Sweden, licences are not exclusive. All block licences contain conditions allowing the regulator to introduce additional users into their licensed frequency bands, provided this does not interfere with the primary licence holder's service provision. However, a PTS spokesperson stated that, although this option has existed for many years, the regulator has not received a single request for sharing in the bands covered by block licences. Instead, vertical sectors have implemented their own private networks in the 3.6 GHz band.

SWITZERLAND Frequency band: 3400–3500 MHz Bandwidth: 100 MHz

This information is taken primarily from "Swiss Government implements spectrum plan for private 5G networks," *Mobile Europe,* 12 September 2023
- https://www.mobileeurope.co.uk/swiss-government-implements-spectrum-plan-for-private-5g-networks/

From 1 January 2024, the regulatory authority BAKOM will offer radio licences in the 3400–3500 MHz band for private 5G networks, with a minimum bandwidth of 10 MHz. The licence fee is 48 CHF/MHz/year, meaning the minimum fee will be 480 CHF per campus. Unlike other countries, the Swiss government has not opted for a per-square-kilometre charge, which means that, as things stand, the fee for a small business would be the same as for a large manufacturing plant or an airport.

To reduce the risk of interference, the maximum permitted power will be 6 W and the maximum permitted field strength at the campus boundary will be set individually for each licence. The technical and regulatory framework for these networks appears to still be under development (there is no further information on the BAKOM website apart from the licence application itself, which is even simpler than the Dutch one). It appears that the licence's duration has not yet been determined, and the applicant is not required to specify it in the application.

UNITED KINGDOM Frequency band: 1781.7–1785 MHz/1876.7–1880 MHz; 2390–2400 MHz; 3800–4200 MHz Bandwidth: 416.6 MHz

The information in this section is taken from the Ofcom document: "Enabling wireless innovation through local licensing: Shared access to spectrum supporting mobile technology," https://www.ofcom.org.uk/data/assets/pdf_file/0033/157884/enabling-wireless-innovation-through-local-licensing.pdf

Ofcom began accepting applications for shared licences in 2020 and continues to issue 20–70 new shared licences per month… more than 1,000 of these are for access to the 1.8 GHz band; more than 500 licences are for access to the 3.8–4.2 GHz band… Ofcom offers two types of shared licences: a low-power licence, which allows users to deploy multiple base stations within a circular area with a radius of 50 metres, or a medium-power licence for a single base station. The medium-power licence is generally available only in rural areas, but exceptions may be considered upon request. Ofcom allows entities other than mobile network operators to use spectrum licensed to MNOs that is not being used or is not planned for use in a given area for the next three years. This is subject to the condition that the new user does not cause interference (this type of use is likely to be restricted to remote areas). Shared Access Licences (SALs) were made available for the 1800 MHz, 2300 MHz and lower 26 GHz bands at the end of 2019; this option was subsequently extended to the 800 MHz, 900 MHz, 1400 MHz, 1900 MHz, 2100 MHz, 2600 MHz and 3400 MHz.

Source: Ericsson (2024)[107]

The RSPG's third opinion was published a year later. It provided a logical framework for considering the various needs of vertical sectors for network services, in order to clarify what types of spectrum allocation and authorisations might be appropriate. It does not cover all possible scenarios, but its analysis directly addresses one of the priority questions this report is intended to answer:

- Connectivity for vertical sectors could be provided by mobile operators, third-party providers or the vertical sectors themselves, either in harmonised EU bands (electronic communications services) or in spectrum set aside for vertical sectors.
- The RSPG recommends that Member States consider further spectrum utilisation solutions, including dedicated or shared spectrum for business/sectoral needs ('vertical sector needs'), which may not be met by mobile operators.
- The RSPG notes that, in addition to the above, technologically neutral, dedicated, harmonised EU spectrum may be required in response to certain EU public policy objectives that call, for example, for pan-European services for specific verticals. The RSPG recommends that these needs be assessed on a case-by-case basis...

[107] Finn Pedersen, Rowan Högman, et al., "5G spectrum for local industrial networks," Ericsson – https://www.ericsson.com/en/reports-and-papers/white-papers/5g-spectrum-for-local-industrial-networks

Figure 12: Meeting the needs of vertical sectors for network services

Connectivity provided via…	Connectivity provided via…		
	Mobile network operator (MNO)	Third-party solution provider	Vertical sector (user)
Regionally harmonised MFCN spectrum	Infrastructure-dependent vertical sectors requiring wide-area coverage can be served via a network segment / virtual private network		Application requirements are constantly evolving
			Smaller user groups, requiring mainly local coverage
Dedicated spectrum for vertical sectors	Service provision using sublet spectrum		Seeks full control over the network for reasons of data security, cost, flexibility when changing technologies, or for other reasons
		Needs not met by mobile network operators (MNOs)	

Source: Own analysis, based on RSPG (2019)

- Vertical sectors requiring dedicated spectrum: This encompasses two types of verticals. The first type is predominantly dependent on network infrastructure. Such verticals are capable of generating aggregated demand/needs vis-à-vis spectrum managers (particularly in terms of wide coverage). The second type comprises more fragmented and specialised users who usually require local coverage and typically use a private network, such as local areas for 'on-site' industry. These users may require dedicated spectrum for reasons of cost, security or a desire to have full control over the network. In both cases, the EU's harmonised technical conditions, which are suitable for mobile networks and provide economies of scale, are also suitable for these types of use
- Solutions provided by MNOs for vertical sectors: "Parts of the 5G network provide opportunities for virtual private networks, which potentially offer different service levels to different customer/business segments based on key performance indicators (KPIs) such as transmission speed, latency, availability and reliability... This may reduce the need for dedicated spectrum allocation for certain applications, particularly those requiring wide coverage (e.g. at national level for many Internet of Things applications, critical PPDR infrastructure, FRMCS, etc.).
- "Access to dedicated spectrum may be based on a specific licensing regime for verticals or on the trading or leasing of spectrum by operators. The need for dedicated spectrum for verticals varies from country to country and depends on the services that mobile operators are permitted to offer."
- This may also include hybrid solutions, such as verticals using their own private network as well as a mobile operator's network.[108]

Version 16 of the IMT standards was published by 3GPP in June 2020 and introduced the technology known as 5G. Unlike previous versions, 5G focused significantly on the needs of industrial automation, specialised applications and machine-to-machine communication (the Internet of Things). Improvements were made to support manufacturing processes, time-critical communications, 'vehicle-to-everything' and private networks (PNs). Version 17 was 'frozen' for further changes in early 2022 and added more features for vertical sectors, including a new IoT standard called NR-light. Version 18, finalised in mid-2024, included even more specifications focused on vertical sectors.

In 2021, the RSPG issued a brief opinion recommending that Member States review the potential use of the 3.8–4.2 GHz band for local vertical applications (i.e. low/medium power) whilst safeguarding terrestrial satellite stations and other

[108] "Strategic Spectrum Roadmap Towards 5G For Europe: RSPG Opinion on 5G implementation challenges (RSPG 3rd opinion on 5G)" RSPG19-007 FINAL (30 January 2019) – https://radio-spectrum-policy-group.ec.europa.eu/system/files/2023-01/RSPG19-007final-3rd_opinion_on_5G.pdf

existing applications and services.[109] In fact, many EU Member States had already reached the same conclusion. However, the RSPG's opinion spurred other countries into action. As this was a 'bottom-up' movement, however, the conditions for these local vertical networks were set without much coordination. This was an experiment designed to show which approaches work and which do not. Although this approach may have been well-intentioned, the result was stagnation in the development of equipment for 5G verticals due to inconsistencies in spectrum allocation and uncertainty regarding responsibility for site planning.

In December 2021, the European Commission's RSC issued this mandate:

> PT1_47: *Mandate to CEPT on technical conditions for the shared use of the 3.8–4.2 GHz frequency band for terrestrial wireless broadband systems providing local network connectivity in the Union*[110]
>
> Task 1: To investigate and assess the technical feasibility of the shared use of the 3.8–4.2 GHz frequency band by terrestrial wireless broadband systems providing local network connectivity (i.e. low/medium power). In this context, to consider sharing solutions, including innovative features, that will ensure:
>
> > a. the protection, future evolution and development of existing users sharing this band, in particular terrestrial satellite stations and fixed terrestrial links,
> >
> > b. coexistence of terrestrial wireless broadband systems providing local network connectivity and applications operating in adjacent bands, such as terrestrial systems providing wireless broadband electronic communications services in the 3.4–3.8 GHz frequency band and airborne radio altimeters in the 4.2–4.4 GHz band.
>
> Task 2: Taking into account the sharing solutions and the results of Task 1, where appropriate, to develop a harmonised frequency allocation and the least restrictive harmonised technical conditions for the shared use of the 3.8–4.2 GHz frequency band by terrestrial wireless broadband systems providing connectivity for local area networks. These harmonised technical conditions should prevent interference, protect relevant existing uses within the band and in adjacent bands, and facilitate cross-border coordination.
>
> On the basis of the results of studies on sharing within the 3.8–4.2 GHz frequency band and studies on coexistence with uses in adjacent bands, CEPT may, where necessary, guidance on appropriate receiver characteristics for radio equipment as part of the harmonised technical conditions and/or recommend that ETSI take the results of these studies into account when drafting the relevant harmonised standards.[111]

CEPT has assigned these tasks to Working Group PT1 and the new Working Group FM60,[112] which was set up specifically to study the shared use of the 3800–4200 MHz band. The Commission expressed particular interest in this work item producing harmonised conditions for coexistence that would be technology-neutral and '5G-ready'; however, the terms of reference for the studies themselves already envisaged technology-neutral conditions.[113] The Commission's mandate also called for proposals for 'innovative sharing arrangements', such as Licensed Shared Access.[114]

CEPT commenced work on these additional tasks in March 2022. Agreement was reached at the PT1 meeting in January 2024, when it was decided to amend work item PT1_40 so that the conclusions on the sensitivity of altimeters could be incorporated into the report on task PT1_47, Part 1b, which was still only in draft form under the title *ECC Report 362: on Compatibility between MFCN operating in 3400–3800 MHz and wireless broadband systems in low/medium power (WBB LMP) operating in the 3800–4200 MHz frequency band*

---

[109] "RSPG Opinion on Additional Spectrum Needs and Guidance on the Fast Rollout of Future Wireless Broadband Networks," RSPG21-024 FINAL (16 June 2021) – https://radio-spectrum-policy-group.ec.europa.eu/system/files/2023-01/RSPG21-024final_RSPG_Opinion_Additional_Spectrum_Needs.pdf

[110] https://ec.europa.eu/newsroom/dae/redirection/document/82230

[111] "EC Mandate 3.8–4.2 GHz" (16 December 2021) – https://cept.org/files/6813/Mandate%203_8-4_2GHz.pdf The contact person for this work item is Doriana Guiducci (doriana.guiducci@eco.cept.org).

[112] FM identifies the group as belonging to the Frequency Management cluster. Their online document archive can be found at https://www.cept.org/ecc/groups/ecc/wg-fm/fm-60/client/introduction.

[113] This seemingly contradictory guideline means that the recommended technical conditions should not require the use of equipment based on a specific technological standard. Rather, they should allow for the use of any equipment that meets general requirements, such as the Block Edge (BEM) spectral mask, selectivity, etc., but these requirements should be formulated in such a way as to permit the use of 5G technology.

[114] According to the RSPG, Licensed Shared Access is "a regulatory approach aimed at facilitating the deployment of radio communication systems operated by a limited number of licence holders under an individual licensing regime in a band that is already allocated, or is expected to be allocated, to one or more existing users… other users are permitted to use the spectrum (or part thereof) in accordance with the sharing rules included in their spectrum usage rights, thereby enabling all authorised users, including existing ones, to provide a certain level of quality of service (QoS)." "RSPG Opinion on Licensed Shared Access," RSPG13-538 – https://circabc.europa.eu/sd/d/3958ecef-c25e-4e4f-8e3b-469d1db6bc07/RSPG13-538_RSPG-Opinion-on-LSA%20.pdf

with Radio Altimeters (RA) operating in 4200–4400 MHz. This draft report was discussed and adopted at the ECC plenary meeting in November 2024. It is discussed in the following chapter of this report, which deals with altimeters. The report resulting from Task PT1_47, Part 2—*CEPT Report 088—is entitled: 'On the shared use of 3800–4200 MHz by terrestrial wireless broadband systems providing local-area network connectivity (WBB LMP)'*[(115)]and was also adopted at the CEPT/ECC meeting in November 2024.

The report on Task PT1_47, Part 1a, was completed earlier. It was approved by the ECC following a public consultation and published in June 2024 as *ECC Report 358: "In-band and adjacent bands sharing studies to assess the feasibility of the shared use of the 3.8–4.2 GHz frequency band by terrestrial wireless broadband systems providing local-area (i.e. low/medium power) network connectivity."*[116]

Although two of the reports were still at the draft stage in spring 2024, CEPT took further steps: in May 2024, *Recommendation ERC 12-08: "Harmonised radio frequency channel arrangements and block allocations for low, medium and high capacity systems in the 3600 MHz to 4200 MHz band"* was supplemented with new guidelines concerning national implementations of channel arrangements for the fixed service.[117] The findings from this document are set out below.

Draft ***ECC Decision (24)01: Harmonised technical conditions for the shared use of the 3.8–4.2 GHz frequency band by low/medium-power terrestrial wireless broadband systems (WBB LMP) providing local network connectivity.***[118] is now available online. The public consultation on this draft concluded in August. This draft was also discussed and adopted at the ECC plenary meeting in November 2024.

The remainder of this section consists mainly of extracts from the above-mentioned documents. It is recommended that these documents be studied in full, as they indicate the direction being taken by regionally harmonised conditions for 5G and IMT/MFCN local networks, together with expected national derogations. Some key points:

1) ECC Report 358: 'Study of sharing within the band and in adjacent bands to assess the feasibility of shared use of the 3.8–4.2 GHz frequency band by terrestrial wireless broadband systems providing local network connectivity (i.e. low/medium power)'

- This report contains studies of various coexistence conditions, including geographical and frequency separation, as well as a range of WBB LMP parameters for analysis (e.i.r.p., antenna height, antenna gain, transmission and reception masks, etc.). Both scenarios with and without AAS are considered.
- Two WBB LMP network technologies are analysed here: one based on 3GPP specifications and the other on DECT-2020 NR specifications. It is likely that 3GPP technologies will be deployed on a wider scale than DECT-2020 NR.
- One study highlighted the importance of real-world terrain data when assessing coexistence with fixed service (FS) stations. Terrain affects the propagation of radio signals, which may alter the minimum separation distances required between WBB LMPs and FS stations. Given the importance of terrain, the report concluded that it is not possible to define a uniform set of general technical conditions that would guarantee the protection of FS and FSS stations in all scenarios across the entire CEPT region. Instead, a case-by-case analysis is required, in conjunction with appropriate mitigation techniques, to ensure satisfactory coexistence.
- Due to the large separation distances that may be required, the protection of the fixed service (FS) cannot always be managed at national level alone, but may in some cases require cross-border coordination, as well as bilateral or even multilateral agreements between neighbouring countries.
- An analysis of operations within the same and neighbouring bands demonstrates the feasibility of unsynchronised WBB LMP operation in the 3.8–4.2 GHz frequency band, although coordination may be required in some cases. For example, coordination may be necessary for unsynchronised WBB LMP operation in the lower part of the 3.8–4.2 GHz band. Examples of coordination may include geographical or frequency separation, setting a maximum permitted power level (pfd) at the boundary of the WBB LMP licensed area, synchronised operation, semi-synchronised operation allowing only adjustments from DL to UL for the WBB LMP network compared with the MFCN framework, and/or the setting of maximum unwanted emission limits below 3.8 GHz depending on the location of the WBB LMP in relation to the MFCN.
- ECC Report 358 also contains no conclusions regarding the protection of radio altimeters using the 4200–4400 MHz band. This topic was reassigned to the group that prepared ECC Report 362, where it is analysed in detail.

2) (Draft) CEPT Report 088: On the shared use of the 3800–4200 MHz frequency band by terrestrial wireless broadband systems providing local network connectivity (WBB LMP) According to a report published on the CEPT website, the FM60 group meeting (16–19 September 2024) "considered the results of the public consultation on the draft *CEPT Report 88*. FM60 resolved the vast majority of comments; however, the FM Working Group will need to discuss the remaining unresolved issues before approving publication by the ECC. In particular, the question of whether, under specific circumstances, to allow local exceptions outside the harmonised technical conditions is to be considered

[115]https://cept.org/files/9522/Draft-CEPT-Report-088.docx

[116]https://docdb.cept.org/document/28615

[117]https://docdb.cept.org/document/821

[118]https://cept.org/files/9522/Draft-ECC-Decision-24-01.docx

by national authorities, or whether restrictions need to be imposed on medium-power base stations operated in the immediate vicinity of airport runways.

Unless otherwise stated, the texts cited in this section are taken from the draft CEPT Report 088, which was uploaded to the online archive of the 12th meeting of Group FM60 on 20 September 2024 and marked as 'final'.[119]

- The proposed harmonised technical conditions in this report are based on the results of technical studies in *ECC* Report *358* and the draft *ECC* Report 362… The proposed harmonised technical conditions for WBB LMP were drawn up on the assumption of an authorisation regime where the locations of the WBB LMP network or base stations are known. An authorisation regime where the location is unknown falls outside the scope of the harmonisation proposed in this report, as this situation may pose an interference risk to existing and new WBB ECS base stations below 3.8 GHz, fixed links and FSS earth stations, as well as between WBB LMP networks.
- As the draft ECC Decision (24)01 incorporates the technical conditions proposed in the draft CEPT Report 088, the specific quantitative details relating to these conditions are set out in our summary of Decision (24)01. In this section, explanations and notes from Report 088 are cited to provide context.
- **WBB LMP synchronisation:** Two WBB LMP network technologies were considered, one based on 3GPP technical specifications and the other on DECT-2020 NR technical specifications. Networks utilising these two technologies cannot synchronise with one another due to their differing operating principles. Synchronised operation of WBB LMP networks with MFCN below 3800 MHz is only possible for WBB LMP based on the 3GPP technical specifications. The results of the studies on these two technologies are presented separately.
- For studies based on 3GPP technology, the technical characteristics were based on the current ETSI technical specifications... For the purposes of the studies, the following base station power levels were defined for 3GPP WBB LMP:
  - Low power up to 31 dBm/100 MHz e.i.r.p.;
  - Medium power up to 51 dBm/100 MHz e.i.r.p.

  These power levels have also been adopted as part of the harmonised technical conditions within CEPT.

- The DECT-2020 NR parameters have been adopted from ETSI TS 103 636-2 v1.4[120] In studies relating to DECT-2020 NR, a maximum e.i.r.p. of 23 dBm was assumed for a channel bandwidth of 6.912 MHz…. The DECT-2020 NR specifications define only one set of parameters for all devices; that is, there is no distinction between 'base station' and 'end' devices. Devices in a DECT-2020 NR network may be regarded as a fixed radio terminal (RDFT) or a portable radio terminal (RDPT)… It should be noted that, for DECT-2020 NR, the technical specification mandates that all radio equipment in the network must use TPC, including fixed radio equipment…

- **Coexistence of WBB LMP and Fixed Satellite Service (FSS):** It is not possible to define general technical conditions that would guarantee the protection of FSS. To ensure the protection of current and future FSS deployments, each case must be carefully planned and analysed on a case-by-case basis, including consideration of appropriate mitigation techniques. Furthermore, given the large separation distances that may be required, the protection of FSS in the frequency band below 3.8 GHz cannot always be managed solely at national level, but may also require cross-border coordination on a case-by-case basis and bilateral or even multilateral agreements between neighbouring countries. CEPT intends to draw up guidelines to assist regulatory authorities in addressing coordination and planning both at national level and with neighbouring countries...
- Studies using real-world field data show FSS separation distances ranging from 5.3 to 17.2 km for low-power WBB stations and from 17.5 to 70 km for medium-power WBB stations. The results for DECT-2020 NR are consistent with the above separation distances at low power, assuming a transmitter power of 23 dBm When evaluation of the results according to the short-term protection criterion[121], it was found that the protection distance is up to 277 km (medium power, flat terrain and without assuming the attenuation of interfering signals).
- **Coexistence of WBB LMP and fixed service (FS):** For medium-power WBB LMP base stations, studies assuming flat terrain show that the required separation distances in the direction of the FS main lobe can reach up to 113 km. If, in flat terrain, a WBB MP BS is located within the side lobe of the FS receiving antenna, the required separation distance will be shorter (up to 69 km). The case studies carried out demonstrate how important it is to take actual terrain data into account, as the actual terrain can either significantly impede propagation or

[119] "TEMP14: FM60#12 drafting (final)" (20 September 2024) – https://api.cept.org/documents/fm-60/85214/temp14_draft-cept-report

[120] A more recent version of this standard has been published: ETSI TS 103 636-2 V1.5.1 (2024-03): "DECT-2020 New Radio (NR); "Part 2: Radio reception and transmission requirements; Release 1" – https://www.etsi.org/deliver/etsi_ts/103600_103699/10363602/01.05.01_60/ts_10363602v010501p.pdf. According to ETSI, an even newer standard for DECT-2020 (i.e. Release 2) is planned, "with enhanced functionality to better support new application scenarios."

[121] As defined in ITU-R Recommendation SF.1006, the 'short-term interference criterion' is I/N = −1.3 dB, which may be exceeded for up to 0.001667 % of the time (≈ 8.76 minutes per year). Based on ITU-R Recommendation S.1432, the 'long-term interference criterion' is I/N = −10 dB (DT/T = 10 %), which corresponds to cumulative interference from the co-primary allocation for 20 per cent of each month.

To facilitate... For DECT-2020 NR, studies indicate a required separation distance of 37 km if the antenna is located in the main lobe of the FS and interference is present at one end of the propagation path. In conclusion, it is not possible to define general technical conditions that would guarantee protection of the FS...

- **Coexistence of MFCN / WBB ECS in the band below 3.8 GHz:** “The 3.4–3.8 GHz band was harmonised for WBB ECS within CEPT by ECC Decision (11)06[122] and in the EU by Decision 2008/411/EC, as amended[123] and is recognised as the primary 5G band in Europe. It is essential that the WBB ECS service be adequately protected... The studies are primarily based on the assumption that there will be no synchronisation between WBB LMP networks in the 3.8–4.2 GHz frequency band and WBB ECS networks below 3.8 GHz. Adjacent-channel coexistence between synchronised WBB LMP networks based on 3GPP and WBB ECS is considered to be covered by ETSI technical specifications and is therefore not studied in this report. CEPT plans to draw up recommendations for regulatory authorities that would provide guidance on approaches to safeguarding coexistence with WBB ECS below 3.8 GHz. It may also be necessary to draw up relevant cross-border recommendations.
- **Coexistence with radio altimeters in the band above 4200 MHz:** The overall conclusion is that… coexistence between WBB LMPs in the 3.8–4.2 GHz band and radio altimeters operating at frequencies above 4.2 GHz is feasible. Only in certain exceptional cases near airports, where a medium-power base station is operated very close to the runway, may coordination be necessary to ensure the protection of radio altimeters
- **Harmonised technical conditions:** It has not been possible to define general technical conditions that would, in themselves, guarantee the protection of all established services. Careful planning and individual analysis are required, combined with consideration of appropriate mitigation techniques. In order to facilitate and maximise opportunities for the deployment of WBB LMPs and to address remaining coordination cases that may not be resolved by harmonised technical conditions, administrations may consider supplementing certain aspects of the use of the 3.8–4.2 GHz frequency band at national and/or local level with provisions such as synchronisation, pfd limits, separation distance and/or frequency separation requirements. CEPT intends to draw up appropriate recommendations to support administrations as necessary.”
    - **Exceptions by national administrations to the harmonised technical conditions:** With regard to power in the band (base stations), the harmonised technical conditions define e.i.r.p. limits for low-power and medium-power WBB LMP BSs. This does not preclude local exceptions outside the harmonised technical conditions, which may be considered by national regulatory authorities in certain circumstances...

- **GALILEO:** The VLBI Global Observing System (VGOS) network of stations is appropriately distributed worldwide; these are highly sensitive passive receivers, the number of which is expected to eventually reach around 40. Some VGOS observatories are located throughout Europe (including in Wettzell, Germany, approximately 20 km from the Czech border[124] . They form part of the European Galileo critical infrastructure project, which must be supported by all European countries. The initial frequency of these VGOS stations... is 3960.4 MHz (Block A) (see ITU-R Report RA.2507,[2][125] page 25). These observatories, which operate in spectral bands ranging from 2 to 14 GHz, do not currently have any radio-astronomical allocation in the 3.8–4.2 GHz band and therefore cannot claim protection against interference at international or European level. Regulatory authorities are nevertheless urged to take all feasible measures to protect the operation of these observatories from harmful interference.

---

[122] ECC Decision (11)06: “Harmonised frequency arrangements and least restrictive technical conditions (LRTC) for mobile/fixed communications networks (MFCN) operating in the 3400–3800 MHz band” – https://docdb.cept.org/download/1531

[123] 2008/411/EC: ‘Commission Decision of 21 May 2008 on the harmonisation of the 3400–3800 MHz frequency band for terrestrial systems capable of providing electronic communications services in the Community’ – https://eur-lex.europa.eu/legal-content/EN/ALL/?uri=CELEX%3A32008D0411

[124] The Wettzell station is home to two 13-metre parabolic antennas, located at 49º 08’ 38.1” N x 12º 52’ 39.4” E and 49º 08’ 36.4” N x 12º 52’ 41.6” E.

[125] Report ITU-R RA.2507-0: “Technical and operational characteristics of the existing and planned Geodetic Very Long Baseline Interferometry” (2022) – https://www.itu.int/dms_pub/itu-r/opb/rep/R-REP-RA.2507-2022-PDF-E.pdf

Figure 13: Wettzell radio telescope

Source: ITU-R Report R.A. 2507-08

Figure 14: Location of the Wettzell twin telescopes in Germany.

Source: Google Maps

3) ERC Recommendation 12-08: Harmonised radio channel arrangement and block allocation for low-, medium- and high-capacity systems in the 3600 MHz to 4200 MHz band. The aim of this Recommendation is to harmonise the channel arrangement and block allocation for point-to-point and point-to-multipoint systems sharing the 3600–4200 MHz band.

It notes that the current use of the 3600–4200 MHz band in most European countries is in accordance with ITU-R Recommendation F.635[126] and/or Recommendation F.382[127] ; (a) that ITU-R Recommendation F.635 specifies only a basic 10 MHz grid, without defining specific channel spacing or duplex spacing... and that ITU-R Recommendation F.635 specifies only a basic 10 MHz grid, without defining specific channel spacing or duplex spacing...

recommends:

1. that CEPT administrations which have the 3600–4200 MHz band available for the fixed

service should adopt a channel arrangement in accordance with:

“1) Annex A,

which is based on ITU-R Recommendation F.635 for the

3600–4200 MHz band with channel spacing of 30 or 15 MHz

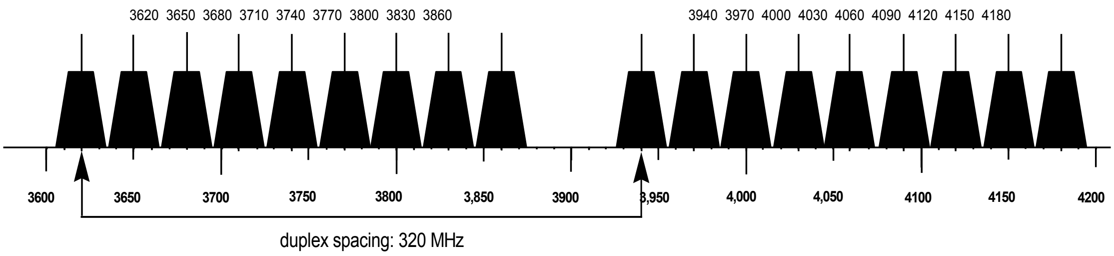
and a duplex spacing of 320 MHz;

or

“2) Annex B,

which is based on ITU-R Recommendation F.382 for the 3800–4200 MHz frequency range.

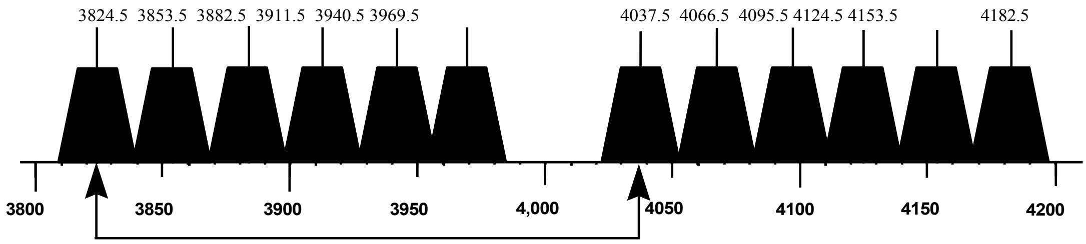
Figure 15: Channel arrangement set out in Annex A



[126] ITU-R Recommendation F.635-7 (02/2013): “Radio-frequency channel arrangements based on a homogeneous pattern for fixed wireless systems operating in the 4 GHz (3 400–4 200 MHz) band” – https://www.itu.int/dms_pubrec/itu-r/rec/f/R-REC-F.635-7-201302-I!!PDF-E.pdf

[127] ITU-R Recommendation F.382-8 (04/2006): “Radio-frequency channel arrangements for fixed wireless systems operating in the 2 and 4 GHz bands” – https://www.itu.int/dms_pubrec/itu-r/rec/f/R-REC-F.382-8-200604-I!!MSW-E.doc. The channel spacing recommended in the main text is 29 MHz, with the option of using interleaved channels with a spacing of 14 MHz. The annex sets out a further channel arrangement with a channel spacing of 28 MHz in the 3 700–4 200 MHz band. The notes also describe other arrangements used in certain countries.

Figure 16: Channel arrangements set out in Annex B



duplex spacing: 213 MHz

4) (Draft) ECC Decision (24)01

This Decision proposes harmonised technical conditions for the shared use of the 3.8–4.2 GHz band by existing services, with the addition of terrestrial wireless broadband systems providing local connectivity (WBB LMP). The Decision requires CEPT Member States to "designate the 3.8–4.2 GHz frequency band or parts thereof on a non-exclusive basis for the use of terrestrial wireless broadband systems providing local connectivity, i.e. low/medium power (WBB LMP). These systems should support innovation and the digital transformation of vertical industries, as well as wireless local connectivity serving both private (e.g. enterprise) and public (e.g. community) networks." The aim of this Decision is to define the least restrictive technical conditions harmonised at pan-European level, so that WBB LMP systems can utilise all or part of this frequency band — even though ECC Report 358 concluded that it is not possible to establish general conditions that would, in all situations, guarantee the protection of fixed service and satellite fixed service stations against interference from WBB LMP. Regulatory authorities may still need to intervene in specific cases where trouble-free coexistence cannot be guaranteed.
Therefore, in accordance with Decision (24)01

> , "CEPT shall draw up guidelines to ensure, on a case-by-case basis, the protection and future development of FSS receiving earth stations and terrestrial fixed links sharing the 3.8–4.2 GHz band with WBB LMPs, for the management of coexistence between WBB LMP networks and between WBB LMPs and MFCNs below 3.8 GHz… e.i.r.p. limits are defined for low- and medium-power WBB LMPs (base stations) as part of the harmonised technical conditions. This does not prevent national regulatory authorities from considering local exceptions in certain circumstances, subject to the following conditions:
>
> - in exceptional cases, this will be on a case-by-case basis;
> - coverage will be limited to the local area (no nationwide network);
> - protection of established services is ensured within the band, where appropriate, taking into account their long-term development, as well as in adjacent bands;
> - where necessary, coordination is finalised.

The draft Decision states that CEPT will draw up up to five Recommendations to assist regulators in implementing 'national measures' to address coexistence issues between:

- WBB LMPs and FSS (fixed-satellite service) earth stations;
- WBB LMPs and fixed-service links;
- WBB LMPs and MFCNs in the adjacent 3.4–3.8 GHz band;
- WBB LMPs and radio altimeters and wireless avionics communication systems in the adjacent 4.2–4.4 GHz band; and
- interfering WBB LMP networks.

Work on these Recommendations has been assigned to Group FM60, with a completion date of 31 October 2025. The scope of work is defined as 'National guidelines for the protection and facilitation of future development and evolution through coordination between WBB LMP and the following services:

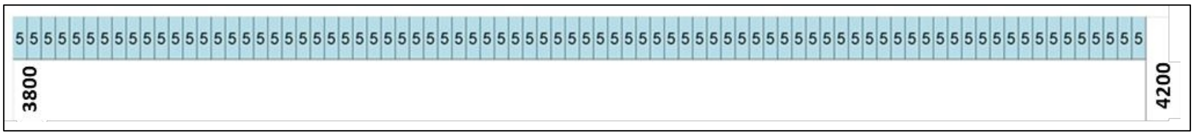
- FSS services in the same band
- FS services in the same band
- MCFN services in the adjacent band
- national WBB LMP network planning [128]

[128] CEPT, "Work Item FM60_02 details" – https://eccwp.cept.org/WI_Detail.aspx?wiid=835

ANNEX 1 The Decision sets out regionally harmonised technical conditions to ensure the compatibility of WBB LMP systems with other systems using the 3.8–4.2 GHz band: “The technical conditions defined in this Annex have been drawn up on the assumption that the locations of WBB LMP networks or base stations are known and that protection of MFCN below 3.8 GHz is ensured at national level through appropriate coordination. National coordination may be necessary to ensure coexistence with other WBB LMP networks. National and/or cross-border coordination may be required to protect existing FSS and FS systems.”

- **WBB LMP channel arrangement plan**: “The frequency arrangement is a TDD arrangement based on a 5 MHz block size, starting at the lower edge of the 3800 MHz band. To obtain wider channels, multiple adjacent 5 MHz blocks may be combined.”

Figure 17: Frequency allocation in the 3800–4200 MHz band



- **Non-AAS and AAS base stations:** Non-AAS (non-active antenna systems) refers to WBB LMP base station transmitters that use a passive antenna with a fixed radiation pattern... Non-AAS systems cannot respond to short-term changes in the radio environment. AAS refers to a WBB LMP base station and antenna system in which the amplitude and/or phase between antenna elements is continuously adjusted, resulting in an antenna pattern that changes in response to short-term changes in the radio environment. This precludes long-term beam shaping, such as a fixed electrical tilt downwards.
- **Block-level power limits for WBB LMP base stations: Coordination at national level may be necessary to protect MFCNs operating at frequencies below 3.8 GHz. Examples of coordination may include geographical/frequency separation, defining the maximum permitted power level (pfd) at the boundary of the licensed WBB LMP area, synchronised operation, a specific sub-case of semi-synchronised operation that permits only DL to UL modifications to the WBB LMP network relative to the MFCN network framework, and/or the definition of maximum unwanted emissions below 3.8 GHz depending on the location of the WBB LMP relative to the MFCN.**

Figure 18: Maximum e.i.r.p. per block per cell for 3GPP WBB LMP base stations operating in the 3.8–4.2 GHz band.

Power category	e.i.r.p. per cell (Note 1 and Note 2)
Low-power (LP) BS	≤ 24 dBm/channel for a bandwidth ≤ 20 MHz Otherwise ≤ 18 dBm/5 MHz
Medium-power (MP) BS	≤ 44 dBm/channel for a bandwidth ≤ 20 MHz; otherwise ≤ 38 dBm/5 MHz

Note 1: For a multi-sector site, the value ‘per cell’ corresponds to the value for one of these sectors.
Note 2: Higher e.i.r.p. limits may be applied at national level on a case-by-case basis, provided that protection is ensured for the fixed service (FS) and the fixed satellite service (FSS) in the band, as well as for MFCN below 3.8 GHz and radio altimeters above 4.2 GHz, taking into account their long-term development, including in neighbouring countries.

The text in Note 2 of the table above was added at the meeting of Working Group WG FM on 3–7 June 2024.[129] Its aim was to enable States to authorise operations with higher effective isotropic radiated power (e.i.r.p.) where this is feasible at national level. The status of this note, following a minor amendment, was confirmed by the ECC:

> “Higher e.i.r.p. levels may be authorised by national administrations in exceptional and duly justified cases, provided that protection of FS and FSS in the band, as well as MFCN below 3.8 GHz and radio altimeters above 4.2 GHz, is ensured, taking into account their long-term development, including in neighbouring countries. Coverage shall remain local (no nationwide network).”

Restricting national exemptions from harmonised power limits to cases that are ‘exceptional and duly justified’, and replacing this with a less restrictive ‘case-by-case’ approach, allows a greater number of networks to operate at power levels exceeding the harmonised limits. At the same time, the text recognises that FS, FSS, MFCN and radio altimeter services (including those in neighbouring countries) have the right to make more intensive use of their allocated bands in the future, which could limit the deployment of WBB LMPs or output power at present and cause uncertainty regarding the sustainability of the proposed power limits.

[129] See CEPT document FM(24)106, Annex 19: “Draft Technical conditions for WBB LMP in 3.8–4.2 GHz” – https://api.cept.org/documents/wg-fm/83911/fm-24-106annex19-_draft-technical-conditions-for-wbb-lmp-in-3_8-4_2-ghz.docx

The issue of the possibility of using higher power at national level was discussed again at the WG FM meeting on 14–18 October.

- **Unwanted emissions above 4200 MHz from WBB LMP base stations:** The following maximum levels of unwanted emissions above 4.2 GHz are defined. These levels are intended to protect the operation of radio altimeters in the band above 4.2 GHz.

Figure 19: Unwanted emissions from WBB LMP base stations in the band above 4,200 MHz.

Frequency band	Non-AAS LP BS e.i.r.p. limit (dBm/5 MHz per cell) (Note 1)	Non-AAS MP BS e.i.r.p. limit (dBm/5 MHz) per cell (Note 1)	AAS MP BS t.r.p. limit dBm/5 MHz per cell (Note 1)
4200–4205 MHz	3	11	1
4205–4210 MHz	-5	8	-3
4210–4240 MHz	-11	8	-3
Note 1: For a multi-sector site, the value per 'cell' corresponds to the value for one of these sectors.			

- A provisional cover page containing several specific questions for respondents to the public consultation was attached to draft Decision (24)01. A summary of the responses received was presented at the FM60 meeting on 16–18 September 2024,[130] including several instances of proposed responses from the group chair. The main points are as follows:

  "Some questions remain open and administrations as well as industry representatives are invited to provide their views as part of the public consultation.

  – **"Should the limits set out in the 4200–4240 MHz band for non-AAS BS be 'per cell' or 'per antenna', taking into account MIMO gain?**

    The United Kingdom's response: "Out-of-band limits should also be defined per cell… Any attempt to split this up into a per-antenna value would require an assumption to be made regarding the number of antennas per cell."

    Germany's response: "All limits should be given in e.i.r.p. per cell/sector… Recommended by the ECC: 'The expression "e.i.r.p. per cell/sector" should normally be used in future deliverables, as it represents the relevant parameters in terms of impact on the victim in compatibility studies'."

    France's response: "Limits for non-AAS MP BS should be per antenna."

    Orange's response: "The limits in the 4200–4240 MHz band were derived from the base station unwanted emission mask in ETSI TS 38.104/38.141 and ETSI EN 301 908, on a per-antenna basis. In Draft ECC Report 362, studies were drawn from ECC Dec (11)06, according to which the baseline unwanted power levels for non-AAS antennas are defined as 'per antenna' and not 'per cell'."

[130] See FM60(24)081: "Summary answers in PC cover letter CEPT Report 088" – https://api.cept.org/documents/fm-60/85045/fm60-24-081_summary-answers-in-pc-cover-letter-cept-report-088

The Chair of Group FM60 added this reference to *ECC Report 362* (Part 1, pages 49–50):

Figure 20: Power limit to be applied in the band above 4200 MHz for non-AAS and AAS type WBB LMP base stations

Frequency band (MHz)	Notation	e.i.r.p. limit in dBm/MHz per antenna	AAS TRP limit in dBm/MHz per cell (Note 1)
4200–4205	P_{OOB1} (dBm/MHz)	*e.i.r.p.* – 47 (Note 2)	TRP – 47 (Note 3)
4205–4210	P_{OOB2} (dBm/MHz)	*e.i.r.p.* – 50 (Note 2)	TRP – 50 (Note 3)
4210–4240	P_{OOB3} (dBm/MHz)	-9	-21

Note 1: For a multi-sector site, the value per 'cell' corresponds to the value for one of these sectors.
Note 2: *e.i.r.p.* is the maximum mean carrier power in dBm for a base station, measured as e.i.r.p. per carrier, interpreted as power per antenna.
Note 3: TRP is the maximum mean carrier power in dBm for a base station, measured as TRP on the carrier of the given cell.

– **"Is there a need to have specific limits for non-AAS LP BS, and why? Or are the limits for non-AAS MP BS sufficient for all non-AAS BS to protect radio altimeters above 4.2 GHz?**

All six commentators stated that there is no need to define LP limits, as the MP limits provide sufficient protection. The Chair of the FM60 group agreed with this.

– **"Is there a need to document in the regulatory framework the antenna gains (and MIMO gains) that were assumed for non-AAS BS, given that the limits for spurious emissions apply to the conducted power?**

Germany replied: "Yes. The BS antenna gain is relevant for the blocking scenario used in the compatibility studies."

BTG replied: "There is a need to document in the regulatory framework the antenna gains (and MIMO gains) that were assumed for non-AAS BS in order to avoid any ambiguity regarding the relationship between conducted power and e.i.r.p. levels."

France replied: "No. The TRP limit is considered for AAS base stations independently of the antenna gain. The same approach should be taken for non-AAS base stations."

The GSA replied: "Spurious emissions limits are based on conducted power; the assumption of non-AAS antenna gains will not be relevant. MIMO gains are not relevant for the same reason."

The United Kingdom and Orange replied in the negative for other reasons.

– **"Comments are also invited on limits applicable in the 4200–4240 MHz band for AAS MP BS, taking into account the assumptions in the studies."**

France replied: "The technical conditions for LMP BS should ensure that there is no need for any coordination around airfields. Consequently, consequence, an appropriate emission mask is required for WBB LMP BS.

Two options are proposed:

> “Option 1 (more restrictive mask): AAS configurations of up to 8x8
>
> are permitted without coordination around the airfield. “Option 2
>
> (less restrictive mask): AAS configurations of up to 4x4 are
>
> permitted without coordination around the airfield.”

Germany, GSA and Orange replied that the limits on unwanted emissions are sufficient. The United Kingdom and BTG had no further comments.

- **Requirements for WBB LMP terminals within a single block:**
  - All terminal stations: 28 dBm t.r.p. (including a 2 dB tolerance).
  - At national level, an e.i.r.p. limit may be set within a block for fixed terminal stations, provided that the protection of existing services and cross-border obligations are met.
  - Uplink power control is mandatory and must be enabled.

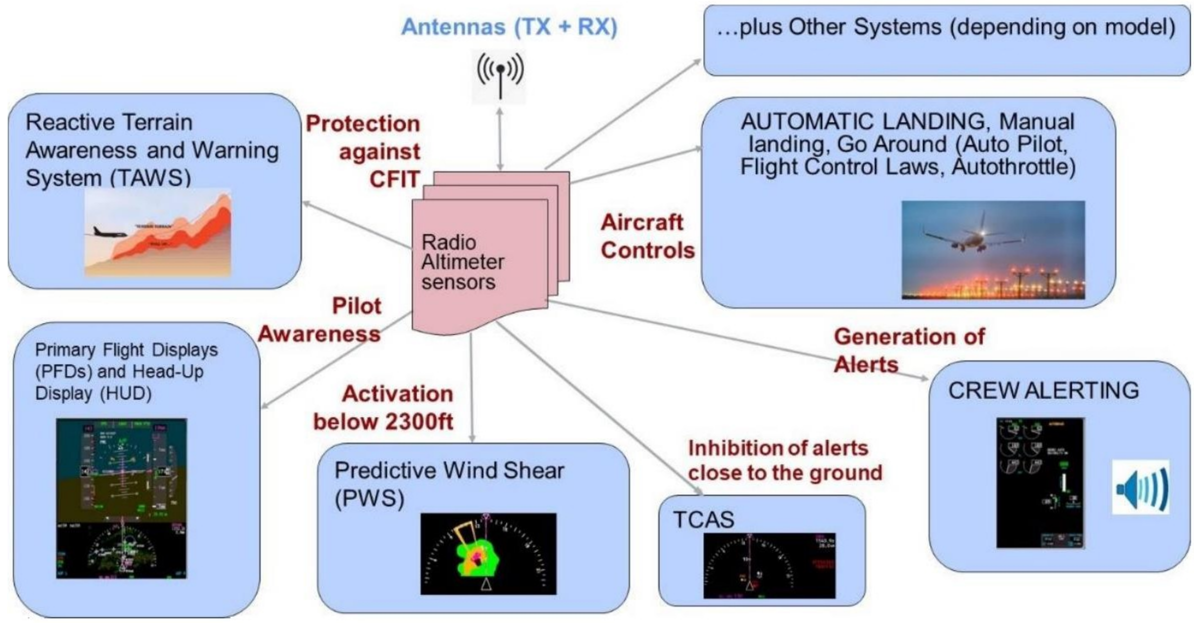
4.2.2 Current use of the 4200–4400 MHz band

4.2.2.1 Aeronautical Radionavigation Service: Altimeters

Altimeters are a type of radar that accurately measures an aircraft's altitude above the ground by transmitting probing signals towards the ground and measuring the delay and frequency shifts of the return signal, either from the ground surface itself or from ground-level transponders.[131]

> A radio altimeter operates in the 4.2–4.4 GHz frequency band. It is a mandatory critical safety system on aircraft, used to determine the aircraft's altitude above the ground and obstacles. The information it provides is essential for enabling safety-related air traffic control and navigation functions on all commercial aircraft, as well as on a wide range of other civil aircraft. Such functions and systems include terrain awareness, aircraft collision avoidance, wind shear detection, air traffic control and automatic landing functions. Unless properly mitigated, harmful interference with the radio altimeter's operation during any phase of flight may pose a serious safety risk to passengers, crew and people on the ground.[132]

Figure 21: Altimeters provide essential data for many aircraft systems.



Source: ICAO[133]

1) Global legal and regulatory framework

(a) International Telecommunication Union (ITU)

[131] ITU-R Recommendation M.2059 (2014): "Operational and technical characteristics and protection criteria of radio altimeters utilising the 4, ,200–4,400 MHz band" – https://www.itu.int/rec/R-REC-M.2059-0-201402-I/en

[132] Quoted from ICAO, *Guidance on safeguarding measures to protect radio altimeters from potential harmful interference from 5G cellular communications*, ICAO MID Doc 015 (May 2023) – https://www.icao.int/MID/MIDANPIRG/Documents/eDocuments/MID%20Doc%20015-%20%205G%20Guidance%20Material.pdf

[133] Op. cit.

Resolution 424,[134] adopted at WRC-15, amended the ITU Radio Regulations to permit in-flight avionics communications (WAIC) in the 4200–4400 MHz band, which had been reserved exclusively for the aeronautical radionavigation service for the use of altimeters, provided that WAIC does not 'cause harmful interference to altimeters or require protection against them'.

It is also worth noting that the report *of the International Telecommunication Union's Conference* Preparatory Meeting (CPM) for WRC-23 included the following information as background:

> 'As part of the preparations for WRC-15, ITU-R conducted studies on sharing and compatibility between aeronautical mobile/terrestrial mobile applications and potential IMT systems in the 4 400–4 990 MHz frequency band, which resulted in ITU-R PDN report M.[AERO-IMT.SHARING.C-BAND]... WRC-15 adopted RR No. 5.441B and designated the 4 800–4 990 MHz frequency band, or parts thereof, for use by administrations wishing to introduce IMT, and established, amongst other things, a pfd limit for IMT use in this frequency band as an additional measure to ensure the protection of AMS outside the territorial waters of coastal states... The pfd criterion, as set out in RR No. 441B, was established in accordance with RR No. 441B. 5.441B did not result from ITU-R studies during the preparation of WRC-15, but from discussions at WRC-15, as the aforementioned technical studies concluded that, for the shared-channel scenario, sharing between aeronautical mobile applications and IMT systems in the 4 400–4 990 MHz band was not practical. The pfd value of –155 dB(W/(m² – 1 MHz)) was derived on the basis of simplified assumptions during WRC-15. This pfd value was based on the deployment of small IMT cells indoors and one specific AMS system. WRC-19 attempted to review this criterion, but without a final outcome..." [135]

- RESOLUTION 256 (WRC 23): "Sharing and compatibility studies and development of technical conditions for the use of International Mobile Telecommunications (IMT) in the frequency bands 4 400–4 800 MHz, 7 125–8 400 MHz (or parts thereof), and 14.8–15.35 GHz for the terrestrial component of IMT." This resolution calls upon "the ITU Radiocommunication Sector to complete, by the World Radiocommunication Conference in 2027, ... studies on sharing and compatibility with the aim of ensuring the protection of services to which the frequency band is allocated on a priority basis..., without imposing further regulatory or technical restrictions on these services, or on services in adjacent bands, for the frequency bands: 4 400–4 800 MHz (and others), and calls on the World Radiocommunication Conference in 2027 to consider, on the basis of the results of the studies, the designation of the frequency bands: 4 400–4 800 MHz or parts thereof in Region 1 and Region 3... for the terrestrial component of IMT ([136]

The designation of these additional bands for IMT was subsequently adopted as *item 1.7* on the WRC-27 agenda.

- RESOLUTION 424 (REV.WRC-23): "Use of Wireless Avionics Intra-Communications in the 4 200–4 400 MHz frequency band… The World Radiocommunication Conference (Dubai, 2023) calls upon the International Civil Aviation Organisation to take into account the latest version of ITU-R Recommendation M.2085[137] when developing SARP (Standards and Recommended Practices) for WAIC[138]systems
- RESOLUTION 674 (WRC-23): "Studies on possible allocations to the Earth exploration-satellite service (passive)[139] in the 4 200–4 400 MHz and 8 400–8 500 MHz bands." ITU study groups should complete studies on sharing and compatibility by the World Radiocommunication Conference in 2027, with a view to determining the possibility... consider a new priority allocation in all regions for the EESS (passive) in the 4 200–4 400 MHz and 8 400–8 500 MHz frequency bands, without protection from existing services in these frequency bands and in adjacent bands[140]
- RESOLUTION 813 (WRC 23): "Agenda for the 2027 World Radiocommunication Conference." Several items already proposed relate to the 4 GHz band:

> "1.7 to consider studies on sharing and compatibility and to draw up technical conditions for the use of International Mobile Telecommunications (IMT) in the 4 400–4 800 MHz and 7 125–8 400 MHz frequency bands (or their

---

[134] Resolution 424 (WRC-15): "Use of Wireless Avionics Intra-Communications in the 4 200–4 400 MHz frequency band" – https://www.itu.int/dms_pub/itu-r/oth/0C/0A/R0C0A00000F00106PDFE.pdf. The change to the allocation was made in accordance with footnote 5.436.

[135] ITU, *Report of the CPM on technical, operational and regulatory/procedural matters to be considered by the World Radiocommunication Conference 2023*, p. 14 – https://www.itu.int/pub/R-ACT-CPM-2023

[136] ITU, *World Radiocommunication Conference 2023 (WRC-23): Final Acts* (2024) – https://www.itu.int/dms_pub/itu-r/opb/act/R-ACT-WRC.16-2024-PDF-E.pdf

[137] ITU-R Recommendation M.2085-0 (2015): "Technical conditions for the use of wireless avionics intra-communication systems operating in the aeronautical mobile (R) service in the 4 200–4 400 MHz frequency band" – https://www.itu.int/dms_pubrec/itu-r/rec/m/R-REC-M.2085-0-201509-I!!PDF-E.pdf

[138] ITU, *World Radiocommunication Conference 2023 (WRC-23): Final Acts* (2024) – https://www.itu.int/dms_pub/itu-r/opb/act/R-ACT-WRC.16-2024-PDF-E.pdf

[139] ITU, *Handbook: Earth Exploration-Satellite Service* (2011) - https://www.itu.int/dms_pub/itu-r/opb/hdb/R-HDB-56-2011-PDF-E.pdf; also ITU-R, "Recommendation RS.1624-0: "Sharing between the Earth exploration satellite (passive) and airborne altimeters in the aeronautical radionavigation service in the 4 200–4 400 MHz band" (2003) – https://www.itu.int/dms_pubrec/itu-r/rec/rs/R-REC-RS.1624-0-200305-I!!PDF-E.pdf

(parts) and 14.8–15.35 GHz, taking into account the existing priority services operating in these and adjacent frequency bands."

"1.19 to consider possible priority allocations in all regions for the Earth exploration-satellite (passive) service in the 4 200–4 400 MHz and 8 400–8 500 MHz frequency bands...".

- **"RR Footnote 5.436:** "The use of the 4 200–4 400 MHz frequency band by stations in the aeronautical mobile service (R) is reserved exclusively for in-flight wireless communication systems operating in accordance with recognised international aviation standards. This use must be in accordance with Resolution 424 (WRC-15)."
- **RR Footnote 5.437:** Passive sensing within the framework of Earth exploration-satellite and space research services may be permitted in the 4 200–4 400 MHz frequency band on a secondary basis. (WRC-15).
- **RR Footnote 5.438:** The use of the 4 200–4 400 MHz frequency band by the aeronautical radionavigation service is reserved exclusively for radio altimeters installed on board aircraft and for associated ground transponders. (WRC-15)[141] .

(b) Civil Aviation Organisation

(1) International Civil Aviation Organisation (ICAO)

Like telecommunications, civil aviation has developed into a global industry with a multi-layered legal and regulatory framework involving commercial and governmental bodies at national, regional and global levels. Like the ITU, the International Civil Aviation Organisation (ICAO) is a specialised agency of the United Nations, acting as a consensus-seeking policy forum, a standard-setter and an information centre for Member States and stakeholders on matters falling within its remit. ICAO's International Standards and Recommended Practices (SARPs) have a status comparable to that of the Radio Regulations.

Since its establishment in 1944, ICAO has worked closely with the ITU on the development of standards and procedures for the use of radiocommunications in civil aviation, as reliable access to the radio spectrum has long been recognised as essential for flight safety. The importance of radiocommunications in aviation is also recognised in the ITU Constitution, which states in Article 40:

> 'International telecommunication services shall have absolute priority for all telecommunications relating to the safety of life at sea, on land, in the air or in outer space...' [142]

Similarly, the Radio Regulations stipulate in Article 4.10:

> "ITU Member States recognise that the safety aspects of radionavigation and other safety services require special measures to ensure their protection against harmful interference; it is therefore essential to take this factor into account in the allocation and use of frequencies." [143]

The extent of the International Civil Aviation Organisation's (ICAO) involvement in setting global standards and regulations for radio equipment and its use in aviation is demonstrated by the size of Annex 10 to the Convention on International Civil Aviation (the ICAO Convention). This Annex, entitled 'Aeronautical Telecommunications', now comprises six volumes. ICAO also provides background material for ITU discussions concerning radio equipment and the use of frequencies in civil aviation and coordinates the allocation of frequencies in bands exclusively reserved for aeronautical services. It should be noted, however, that the COM lists published by ICAO have no legal status within the ITU. Nevertheless, there is a clear division of responsibilities between ICAO and the ITU, and coordination takes place with the aim of minimising inconsistencies and conflicts in decision-making and regulatory measures.

The ICAO Aeronautical Communications Panel has various specialised working groups. Working Group WG-F is responsible for spectrum management.[144] It prepares ICAO contributions to the World Radiocommunication Conferences (WRC) and coordinates ICAO's input at meetings of ITU Study Groups and regional telecommunications organisations. Working Group WG-T is responsible for technology. Among other things, it represents ICAO in a joint public-private project known as the Single European Sky ATM

---

141 *ITU Radio Regulations*, Chapter 2, Section IV: 'Table of Frequency Allocations', pages RR5-100 – RR5-102.

142 Article 40: "Priority of Telecommunications Concerning Safety of Life," ITU Constitution in *the Collection of the Basic Texts of the International Telecommunication Union adopted by the Plenipotentiary Conference, 2011 edition* – https://www.itu.int/dms_pub/itu-s/opb/conf/S-CONF-PLEN-2011-PDF-E.pdf

143 ITU, *Radio Regulations, 2024 edition* – https://www.itu.int/hub/publication/r-reg-rr-2024/

144 ICAO Frequency Spectrum Management Panel (FSMP) – https://www.icao.int/safety/fsmp/Pages/default.aspx).

Research[145] (SESAR, https:// https://www.sesarju.eu/), as a partner of the European Commission and EUROCONTROL. Together, they plan to integrate European airports, air-ground data links and air traffic management systems.

Before we focus on ICAO's role in the use of the 4200–4400 MHz band, it is necessary to introduce two further international aviation organisations.

(2) Radio Technical Commission for Aeronautics (RTCA)

The RTCA is a US-based organisation that develops technical performance standards for the global aviation industry and provides recommendations for use by government regulatory bodies.[146] It was founded in 1935 as an association and was re-incorporated in 1991 as a private non-profit organisation. Today, it defines itself as a 'standards development organisation' and a 'public-private partnership platform for building consensus amongst diverse, often competing interests' — much like 3GPP. Dozens of Special Committees (SCs) develop and publish RTCA standards, which may serve as a basis for regulations or for assessing compliance with regulations. The most relevant Special Committees in relation to the topics discussed here include:

- SC-234: Portable Electronic Devices (PEDS)
- SC-236: Standards for Wireless Avionics Communications within the Aircraft (WAIC)
- SC-239: Short-Range Altimeters
- SC-242: Spectrum Compatibility
- SC-243: Quality assurance for the development of airborne electronic hardware (AEH)

The following RTCA standards are particularly relevant to this study:

- DO-155: "Minimum Performance Standards – Airborne Low-Range Radar Altimeters (published 1 November 1974, but still in force): "standards and test procedures for those characteristics of airborne low-range radar altimeters that are essential for their operation in applications for measuring height above terrain for the purpose of obstacle avoidance and landing. Co-ordinated with EUROCAE." (Note: After 50 years, an updated version, DO-155A, is scheduled for publication by the end of 2024.)
- DO-378A: "MASPS for Coexistence of Wireless Avionics Intra-Communication Systems within 4200–4400 MHz" (published 23 July 2022): "EUROCAE and RTCA have defined this Minimum Aviation System Performance Standard (MASPS), which applies to wireless avionics intra-aircraft communication (WAIC) systems utilising the 4 200–4 400 MHz frequency band allocated by the World Radiocommunication Conference (WRC) in 2015. The key criteria for the WRC allocation of the band were (i) coexistence between WAIC systems and (ii) coexistence between WAIC systems and radio altimeters (RA), both on board neighbouring aircraft. These MASPS define two performance requirements (PRs) that ensure WAIC systems meet the above-mentioned coexistence criteria. The first PR specifies the spectral power flux density that may be radiated by WAIC systems on board an aircraft. The second PR specifies the tolerance of WAIC systems to radio-frequency (RF) emissions from RA and WAIC systems on neighbouring aircraft. Both PRs were developed in accordance with ITU-R documentation and validated through significant work by the Aerospace Vehicle Systems Institute (AVSI), EUROCAE and RTCA, with the aim of identifying and characterising the worst-case conditions that may occur during the normal operation of the global aircraft fleet. Revision A is consistent with the intended content of the ICAO SARP for WAIC systems."
- RR-001: "Survey of Radio Frequency (RF) Performance Standards for Aeronautical RF Systems" (published 28 November 2023): "This report summarises the results of the 2022/2023 survey conducted jointly by the RTCA-242 Special Committee and the EUROCAE-124 Working Group (SC-242/WG-124) on applicable standards published by RTCA and EUROCAE for radio frequency (RF) performance, which can be used for spectrum compatibility analysis with external systems…"

(3) The Institute for Aerospace Systems (AVSI)

AVSI is a cooperative research environment comprising major airlines and government organisations that collaborate with the academic community to address issues common to its members. AVSI provides a predefined framework for collaborative research, enabling members to save resources by sharing costs and to tackle problems beyond the scope of a single organisation.[147] Two of its projects are particularly relevant:

- AFE 76s1 – Wireless Avionics: The Wireless Avionics Intra-Communication (WAIC) project addresses common challenges associated with wireless avionics and works to secure the necessary spectrum allocation at the WRC. The project has provided the ITU-R with working documents forming the basis for an agenda item at WRC-15 to secure a specific spectrum allocation meeting the needs of WAIC systems… The WAIC project has its own website at waic.avsi.aero.

[146] https://my.rtca.org/

[147] https://avsi.aero/

- AFE 76s2 – Out-of-band interference to radio altimeters: Members of the aviation industry have suggested that it is essential to obtain data characterising the potential effects of IMT operations on radio altimeters (RA) operating in the adjacent frequency band (4200–4400 MHz). The potential loss of RA accuracy due to IMT interference is a safety concern, particularly in the vicinity of airports where aircraft are in the landing phase. Empirical data quantifying the extent of the problem must be provided to the relevant regulatory authorities to ensure that they can maintain the continued safe operation of aircraft.[148]

According to AFE 76s2, "most altimeters used in commercial airliners are frequency-modulated continuous-wave (FMCW) devices with a typical pulse bandwidth (chirp bandwidth) of around 100–180 MHz, centred at 4300 MHz."[149] Large commercial aircraft often have up to three altimeters with different centre frequencies and pulse durations, mounted on the underside of the fuselage, which ensures high reliability, mutual redundancy and the ability to compare and average measurements.

Figure 22: Aircraft with two altimeters

Source: Moniem-Tech[150]

2) Regional legal and regulatory framework

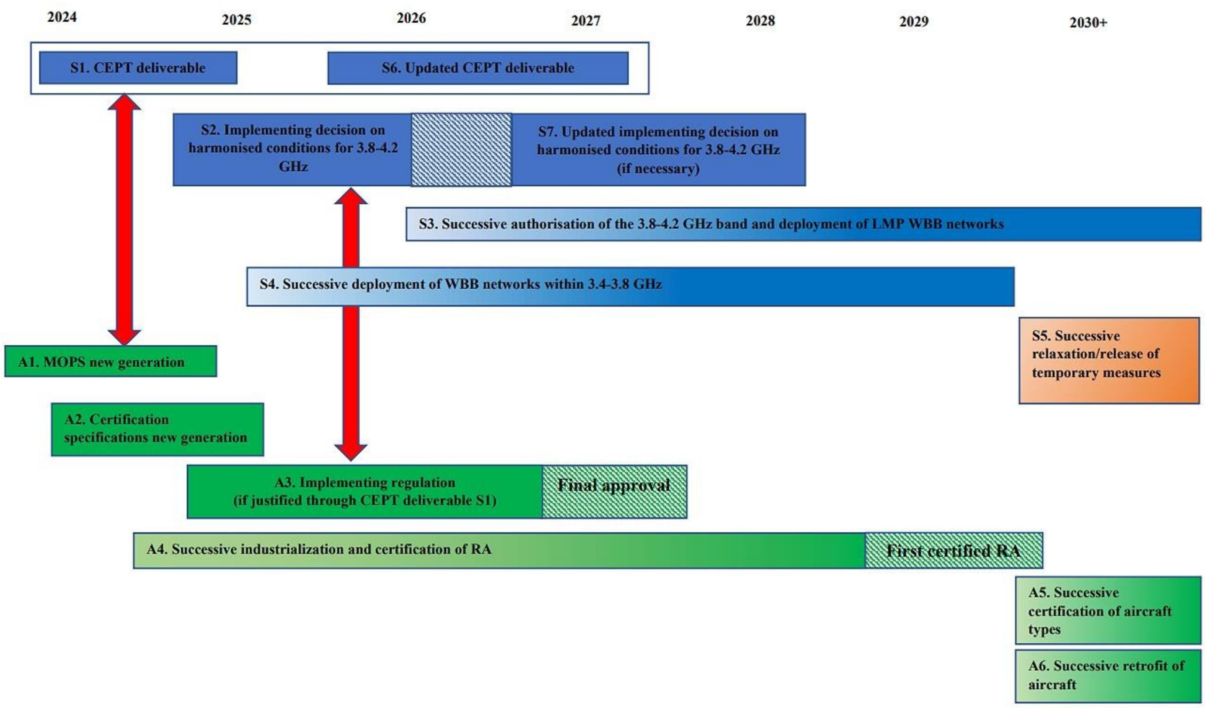
---

[148] https://avsi.aero/projects/current-projects/rf-interference-with-radar-altimeters/

[149] "AVSI Publishes Report Cataloging Out-of-Band Interference to Radar Altimeters" (6 December 2021) – https://avsi.aero/afe76s2-report/. AVSI's statement that "most altimeters used in commercial airliners are frequency-modulated continuous wave" contradicts a survey conducted in 2022 at three airports in the US state of Washington, which was reported to the FAA: "Our 25-day field testing at three airports in Washington shows that 66 per cent of radio altimeters use PULSE technology..." FAA-2022-1647- 0046_attachment_1 - https://downloads.regulations.gov/FAA-2022-1647-0046/attachment_1.pdf

[150] Moniem-Tech, "Summary of 5G Interference with Aviation Safety in the US," (2022) - https://moniem-tech.com/2022/01/20/summary-of-the-5g-interfering-with-aviation-safety-in-the-us/

Figure 23: ‘EU Roadmap’ timeline: IMT/altimeter coexistence (Gantt chart)



Source: European Commission (2024)[151]

In January 2021, in response to the fact that some EU Member States had begun to introduce measures to protect altimeters near airports in response to the roll-out of 5G networks in the Commission-supported ‘pioneering’ 3400–3800 GHz band — measures which were not necessarily consistent with one another — eight members of the ECC[152] submitted a proposal for a work item to the ECC PT1 project team, which deals with matters relating to IMT technologies, including 5G. Following approval by the ECC, this work item became known as PT1_40: ‘Radio altimeters.’ Its aim was to assess the susceptibility of already deployed radio altimeters to interference and to analyse the aviation industry’s remedial measures.

Scope: To assess the sensitivity of deployed RA receivers operating in the 4200–4400 MHz band, taking into account all civil aviation initiatives to improve RA receivers, in order to examine the following compatibility scenarios:

1) Unwanted emissions from MFCNs operating in the 3400–3800 MHz band and WBB LMPs operating in the 3800–4200 MHz band into the 4200–4400 MHz radio altimeter band

2) The impact of interference to radio altimeters from 3400–3800 MHz in-band emissions from MFCNs and 3800–4200 MHz in-band emissions from WBB LMPs

Start date 05-03-2021

Target date 08-11-2024

Public consultation 28 June 2024

Output: ECC Report

151 Commission Staff Working Document on Services: “EU Roadmap for Ensuring Safe Coexistence between Mobile Networks and Aircraft Radio Altimeters within the Frequency Range 3.4–4.4 GHz in the Union” (18 April 2024) - https://circabc.europa.eu/sd/a/9e35cb97-0cac-422a-959e-b1b920a26dfc/EU%20Roadmap_WBB-RA_Coexistence_v1.pdf

152 Belgium, France, Germany, Greece, Latvia, the Netherlands, Portugal, Sweden

Comments: General agreement that realistic scenarios and parameters for RA and MFCN AAS are required before compatibility studies can begin.

Based on the results of the study, consider the need for any future steps, e.g. improving the RA's sensitivity to interference, particularly with regard to blocking characteristics.

It should be noted that radio altimeters are used worldwide and, once installed, remain in service for many years. Therefore, the development of future MOPS (Minimum Operational Performance Standards) for RA should take a forward-looking approach and should also take into account the various 5G MFCN deployments that already exist in frequency bands below 4.2 GHz and above 4.4 GHz, both in Europe and globally."[153]

Two further, lesser-known regional organisations are worth mentioning due to their specific interest in the 4 GHz band. The European Organisation for Civil Aviation Equipment (EUROCAE), founded in 1963, is a non-profit platform for the development of aviation standards, similar to RTCA and AVSI.[154] Its 450 members include service providers, regulatory authorities, research institutes, aviation experts and international organisations. Its standards are designed to "promote international harmonisation and global interoperability and contribute significantly to the safety, efficiency and environmental sustainability of the global aviation system."[155] Like other organisations of this type, EUROCAE has a large number of specialised working groups. Those relevant to the topics covered in this report include:

- WG-31 – Electromagnetic Risks. This working group primarily deals with electromagnetic compatibility and the effects of lightning on aviation equipment.
- WG-96 – Wireless On-Board Avionics Networks. It is currently addressing the coexistence of WAIC systems and altimeters in the 4200–4400 MHz band. Its outputs include:
    - ED-260A – MASPS for the coexistence of in-flight wireless avionics communications in the 4 200–4 400 MHz band (published in June 2022)
    - ED-319 – MOPS for the Wireless Avionics Intra-Communication System (still under consultation)
- WG-119 – Radio altimeters. "To ensure the compatibility of current and future radar altimeters (RA) with the radio frequency spectrum allocated for 5G telecommunications, work has commenced within WG-119, in collaboration with RTCA SC-239, to develop the ED-30A/DO-155A radar altimeter MOPS. From the fourth quarter of 2022, a new document, ED-310 Standard Guidelines on Radar Altimeter Interference Suppression and Tolerance, was opened for consultation to provide specifications to RA suppliers and prevent constant RA upgrades in an undefined environment. A revision of MOPS ED-30A/DO-155A, intended for a new generation of radio altimeter receivers, is scheduled for the end of 2024."[156]

    - "The updated MOPS addresses the RA's resilience to the current and planned future radio frequency environment. This future radio frequency environment… addresses all of the following types of interference simultaneously:

        • Interference at the edges of the RA band (3800–4400 MHz) and (4400–5000 MHz), including anticipated future modulations and signal strengths

        • Interference within the RA band (4200–4400 MHz), including: other RA interference on board the aircraft, other RA systems off the aircraft, WAIC systems and any other systems in the RA band located outside the aircraft's on-board systems, WAIC systems and any other RA systems located on board the aircraft

        • Interference outside the RA band which could potentially have an indirect effect on the RA due to the following factors: signal level, modulation, potential harmonics, weakness of the RA antenna (sensitivity), potential weakness in the RA design (resonance)…

    - 'Last but not least, the RA is designed to meet the highest safety requirements. Consequently, particular attention should also be paid to the definition of appropriate margins…'
    - The current ED-30 and DO-155 are not technically identical; one of the aims of this revision is to harmonise these documents and produce technically identical documents (ED-30A/DO-155A)…

---

[153] "Draft new WI – radio altimeters," ECC PT1(21)086_Annex VIII-12 - https://api.cept.org/documents/ecc-pt1/62871/ecc-pt1-21-086_annex-viii-12_draft-new-wi-radio-altimeters

[154] As this chapter shows, there are many organisations in Europe working in parallel to develop standards for avionics. To reduce duplication of effort and conflicts in their work, ASD-STAN and EUROCAE signed a Memorandum of Cooperation in July 2024. See "EUROCAE and ASD-STAN Forge Cooperation to Enhance European Aerospace Standards", 4 July 2024 – https://www.eurocae.net/news/posts/2024/july/eurocae-and-asd-stan-forge-cooperation-to-enhance-european-aerospace-standards/

[155] https://www.eurocae.net/

[156] EUROCAE, *Technical Work Programme*, *2024 Edition* – https://eurocae.net/media/2209/twp-2024.pdf

- WG-124/SC-242 – Spectrum Compatibility, a joint committee with RTCA SC-242, 'intended to support other working groups developing standards with spectrum-related aspects... The guidance document, due to be published in 2025, should also provide information to a wider audience, including non-aviation sectors, on the radio frequency performance required to meet existing aviation performance standards (e.g. availability, reliability, continuity, latency, etc.) for life-safety functions. The guidance will be based on the development of two EUROCAE Reports (ERs), the first of which is 'Overview of Radio Frequency (RF) Performance Standards for Aviation RF Systems'. This ER is intended to serve as a reference for non-aviation spectrum stakeholders, to support effective and successful discussions with the aviation industry, and to inform civil aviation authorities and ICAO, whilst the second ER, 'Report on Aviation Radio Frequency Systems, their Regulatory Framework and Operational Considerations', will serve as a reference for a wider audience, including aviation system developers, as well as stakeholders outside the aviation sector. As such, it will support effective and successful discussions with the aviation industry and regulatory authorities in future ITU study cycles. It is anticipated that the outputs will be referenced by EASA, other CAAs, ICAO and, where applicable, national/international spectrum regulators...[157]

The European Aviation Safety Agency (EASA), established in 2002, certifies aircraft, components and equipment for safe operation, establishes 'airworthiness' rules and issues licences for crews, airports and air traffic control services.[158] Its responsibilities are growing as the European air traffic management system becomes increasingly integrated, with the Agency taking on duties that previously fell to national airspace regulators.

EASA's certification of equipment, personnel, services and airworthiness is based on tests of compliance with European Technical Standards (ETSOs). ECC Report 362 states that "radio altimeters used on EASA-certified aircraft must comply with the European Technical Standard ETSO-C87A[159] , which defines the certification test procedures and the minimum performance required of the equipment. Similarly, in May 2024, EASA updated its Certification Memorandum 'Guidance to Certify an Aircraft as PED Tolerant'[160] by adding references to industry standards for 5G and Wi-Fi 6e, which had emerged since the memorandum's publication in 2017, as well as a reference to "intentional emissions in the vicinity of the frequency bands of aviation radio receivers, such as radio altimeters… Previous versions of EUROCAE ED-130, RTCA DO-307 and RTCA DO-294C do not contain guidance on assessing the effects of emissions from 5G PEDs on radio altimeters."

In a subsequent section, EASA states that "whenever possible, ETSOs are… equivalent to the corresponding FAA TSO standards…"[161] This emphasises the importance of the technical standards set by the FAA. However, the FAA's response to interference with altimeters caused by 5G signals may be an exception, as EASA does not regard the US as a model for Europe in this specific case. "At this stage, no risk of hazardous interference has been identified in Europe. EASA acknowledges the FAA's assessment regarding the increased risk specific to the US resulting from the implementation of potentially higher 5G ground station emissions,"[162] as well as the much smaller frequency spacing between aviation and MFCN allocations. ECC Report 362 cautions, however, that these differences should not be regarded as permanent.

---

157 EUROCAE, *Technical Work Programme*, *Edition 2024* – https://eurocae.net/media/2209/twp-2024.pdf

158 Although EASA might be perceived as a regional branch of ICAO, ICAO itself has its regional office for Europe and the North Atlantic in Paris, France. (email:icaoeurnat@icao.int , tel: +33 1 46 41 85 85, website: http://www.icao.int/EURNAT/

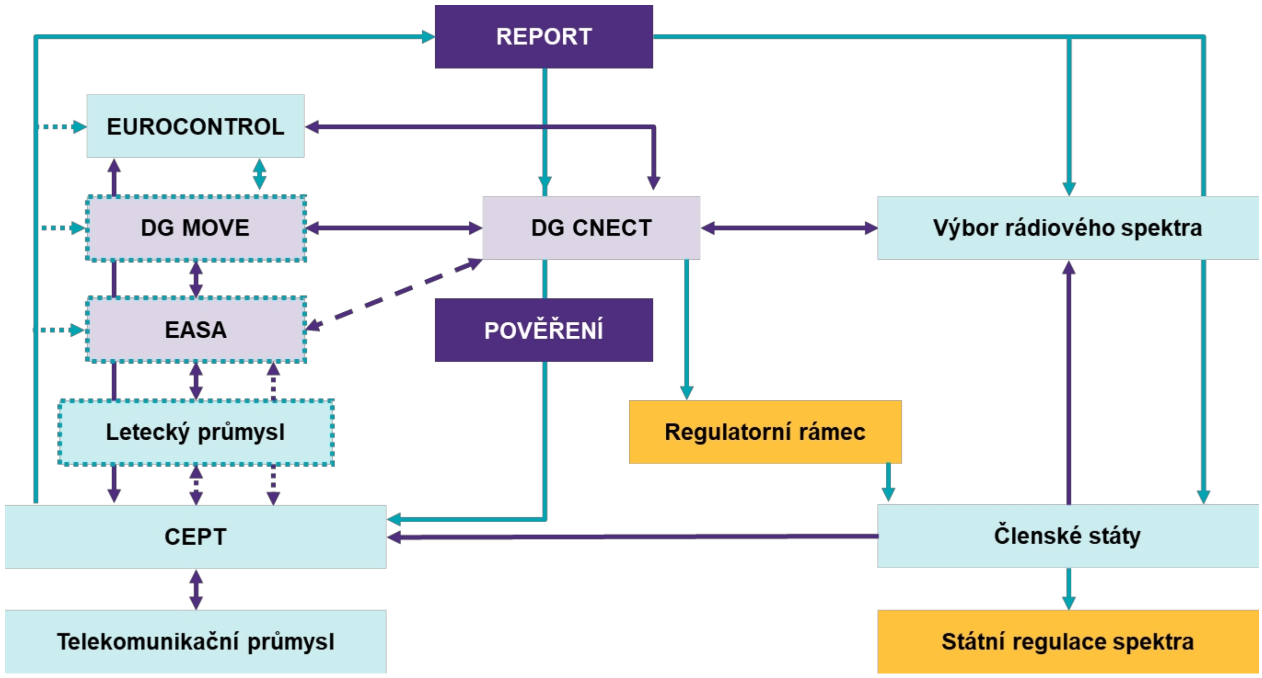
159 https://www.easa.europa.eu/download/etso/ETSO-C87a_CS-ETSO_8.pdf

160 EASA, "FINAL UPDATE to Certification Memorandum ref. CM-ES-003 Issue 02 on 'Guidance to certify an aircraft as PED Tolerant' (2017)," (2024) - https://www.easa.europa.eu/en/downloads/139882/en

161 EASA, "Explanatory Note to Decision 2013/012/R" – https://www.easa.europa.eu/en/downloads/1991/en

162 EASA, "Safety Information Bulletin," SIB 2021-16 (17 November 2021) - https://ad.easa.europa.eu/blob/EASA_SIB_2021_16.pdf/SIB_2021-16_1

Figure 24: Policy-making environment for aeronautical radio communications in Europe



Source: Author's own compilation, based on EASA[163]

The first indication of potential problems with interference to altimeter operation emerged at WRC-07, when dozens of administrations supported the addition of footnote 5.430A to the International Frequency Allocation Table, which designates the 3400–3600 MHz band for IMT. (Among them was the Czech Republic, along with 22 other EU Member States.) Dozens of other countries added footnotes identifying IMT in either the 3400–3500 MHz or 3500–3600 MHz bands. Although IMT was still at least 600 MHz away from the 4200–4400 MHz band, it was clear that IMT was likely to gain access to frequencies closer to the aeronautical mobile/radionavigation service bands within a few years.

Given that item 1.1 of the agenda for WRC-15 was 'to consider the priority allocation of additional spectrum for mobile services and the identification of further frequency bands for International Mobile Telecommunications (IMT)', ICAO prepared preliminary studies for consideration at the conference[164] and has commenced the development of new SARPs for altimeters and WAICs.

In 2018, the US Federal Communications Commission (FCC) announced that it was considering making part or all of the 3700–4200 MHz band, which is reserved for fixed and satellite-fixed services, available for 5G networks.[165] This has also inspired other countries to consider similar measures and has raised concerns within the aviation industry that this could lead to widespread interference affecting the altimeter/WAIC band.

During preparations for the first auction of 5G licences in the C-band in the US in 2021, the AVSI organisation conducted laboratory tests in which currently available radio altimeters were exposed to signals simulating 5G base station transmissions. The test results were summarised in *the AFE 76s2 Report: Effect of Out-of-Band Interference Signals on Radio Altimeters* (4 February 2020). The main finding was:

> "The protection criteria for radio altimeters (RAs) set out in Recommendation [ITU-R] M.2059-0 provide the only existing guidance for changes in the radio frequency environment within and in the vicinity of the 4200–4400 MHz frequency band. The data presented here, to a large extent

---

[163] "5G Update" (4 January 2024) – https://www.iata.org/contentassets/047eae4355824577a2060ac745110215/easa-5g_updated_4_jan_2024.pdf

[164] ICAO, "Preliminary Study into Radio Altimeter Adjacent Band Compatibility," ACP-WG-F30/WP-14 (2014) - https://www.icao.int/safety/acp/ACPWGF/ACP-WG-F-30/ACP-WGF30-WP14%20Radio%20Altimeter%20Adjacent%20Bands%20Compatibility%20Study%20with%20IMT-FINAL%20Rev1.docx; and ICAO, "Potential Level of Interference from IMT Systems on Adjacent Band Radio Altimeters," ACP-WGF30/WP-17 (2014) – https://www.icao.int/safety/acp/ACPWGF/ACP-WG-F-30/ACP-WGF30-WP17_radio%20altimeter%20analysis.doc

[165] US FCC, "Order and Notice of Proposed Rulemaking – GN Docket No. 18-122" (issued 13 July 2018) - https://docs.fcc.gov/public/attachments/FCC-18-91A1.pdf

> "These measurements confirm these criteria for the 3700–4200 MHz band and can be used to develop future rules and operational characteristics for new allocations in this frequency band."[166]

With the support of the AVSI report, in June 2020 ICAO sent a statement of cooperation to the CEPT ECC, in which it drew attention to the absence of specific limits for unwanted emissions from IMT base stations into the 4200–4400 MHz frequency band.

> "Commission Implementing Decision (EU) 2019/235 of 24 January 2019 amending Decision 2008/411/EC as regards the update of the relevant technical conditions applicable to the 3400–3800 MHz frequency band[167] , defines the basic power limits below 3400 MHz and above 3800 MHz. In the absence of other information, this Decision proposes that, within the 4200–4400 MHz frequency band, the EIRP limit per antenna be defined as -2 dBm/5 MHz (-9 dBm/MHz) for systems with non-active antennas (non-AAS) and the total radiated power (TRP) limit per cell be defined as
> -14 dBm/5 MHz (-21 dBm/MHz) per cell for active antenna systems (AAS). When using an AAS with an assumed maximum antenna gain of 26 dBi, the EIRP limit would reach +5 dBm/MHz… Preliminary studies using the operational and technical characteristics set out in ITU-R Recommendation M.2059 show that, when applying the above-mentioned out-of-band emission limits:
>
> - a separation of more than 27 km is required for AAS (applying a 6 dB safety margin; for information purposes: more than 13 km without applying any safety margin); and
> - for non-AAS, a distance of more than 5.5 km is required (applying a 6 dB safety margin; for information purposes: more than 2.7 km without applying any safety margin).: [168]

Shortly afterwards, the RTCA SC-239 working group established a task force tasked with assessing the potential impact of out-of-band emissions from 5G networks on radio altimeters. The FAA commissioned this working group to produce 'An assessment of the impact of C-band mobile telecommunications interference on the operation of short-range radar altimeters.' [169] Considering the worst-case scenarios, the resulting report stated that there could be:

> "a major risk that 5G telecommunications systems in the 3.7–3.98 GHz band will cause harmful interference to radio altimeters on all types of civil aircraft, including commercial airliners, business, regional and general aviation aircraft, and both transport and general aviation helicopters. The results of the study clearly show that this risk is widespread and could lead to … catastrophic failures resulting in multiple fatal accidents unless appropriate mitigation measures are taken. The extent of RF interference is summarised in a worst-case scenario where the safe interference limit for radio altimeters is exceeded by expected 5G signals in the 3.7–3.98 GHz band: 14 dB for commercial airliners..., 48 dB for aircraft in commercial, regional and general aviation... and 45 dB for helicopters..."

The RTCA report was heavily criticised by representatives of the mobile industry and organisations such as the GSMA:

> "The original RTCA study presented a set of assumptions based on highly pessimistic, overly conservative and theoretical operational scenarios which, taken together, would not occur in real-world radio network deployments. As a result, the aviation industry is seeking protection from 5G networks for a small number of poorly designed and obsolete devices based on outdated standards from the 1970s."[170]

Further testing of altimeters has shown that the aviation industry's performance standards (in force since 1974) lack minimum requirements for the altimeters' resistance to interference – presumably because the surrounding spectrum was relatively unused – until the advent of IMT.

---

166 RTCA Paper No. 274-20/PMC-2073 – https://www.rtca.org/wp-content/uploads/2020/10/SC-239-5G-Interference-Assessment-Report_274-20-PMC-2073_accepted_changes.pdf

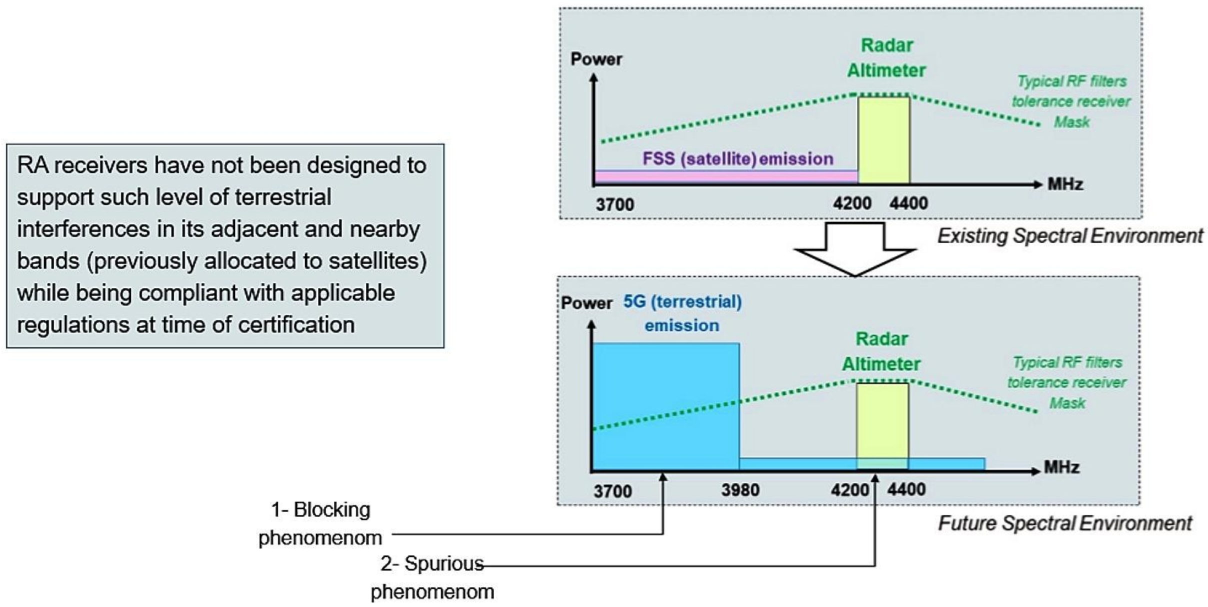
167 https://eur-lex.europa.eu/eli/dec_impl/2019/235/oj

168 ICAO, "Liaison Statement to ECC on 5G emissions and Radio Altimeters in the 4200–4400 MHz frequency band," ECC(20)INFO 06 (24 June 2020) – https://cept.org/Documents/ecc/59495/ecc-20-info-06_liaison-statement-from-icao-to-ecc

169 RTCA Paper No. 274-20/PMC-2073 (7 October 2020) – https://www.rtca.org/wp-content/uploads/2020/10/SC-239-5G-Interference-Assessment-Report_274-20-PMC-2073_accepted_changes.pdf

170 GSMA, *5G and Aviation Altimeters: Co-existence with IMT in the 3.3–4.2 GHz and 4.8–4.99 GHz Bands,* (2023) – https://www.gsma.com/connectivity-for-good/spectrum/wp-content/uploads/2023/05/5G-and-Aviation-Altimeters.pdf

Figure 25: Changed spectral environment for avionics and altimeters



Source: M. Utsunomiya (ICAO, 2023)[171]

Consequently, ITU-R Recommendation M.2059-0 (2014) identified a wide range of sensitivity levels, overload thresholds and interference tolerance masks among existing altimeter models. It also noted that “the front end of a radio altimeter generally has moderate selectivity (gradual RF-filter roll-off). Consequently, the radio altimeter is susceptible to interference both within its operational swept bandwidth and outside this bandwidth.” To address this issue, ITU-R M.2059 recommended the use of RF filters in altimeters with frequency-dependent attenuation characteristics, as shown in the following table:

Figure 26: Recommended RF selectivity for radio altimeters

Interference frequency (MHz)	RF filter attenuation (dB)
≤ 4,200	Attenuation of 24 dB per octave, with a maximum of 40 dB
4,200	0
4,300	0
4,400	0
≥ 4,400	Attenuation of 24 dB per octave, with a maximum of 40 dB

Source: ITU-R Recommendation M.2059-0 (2014)

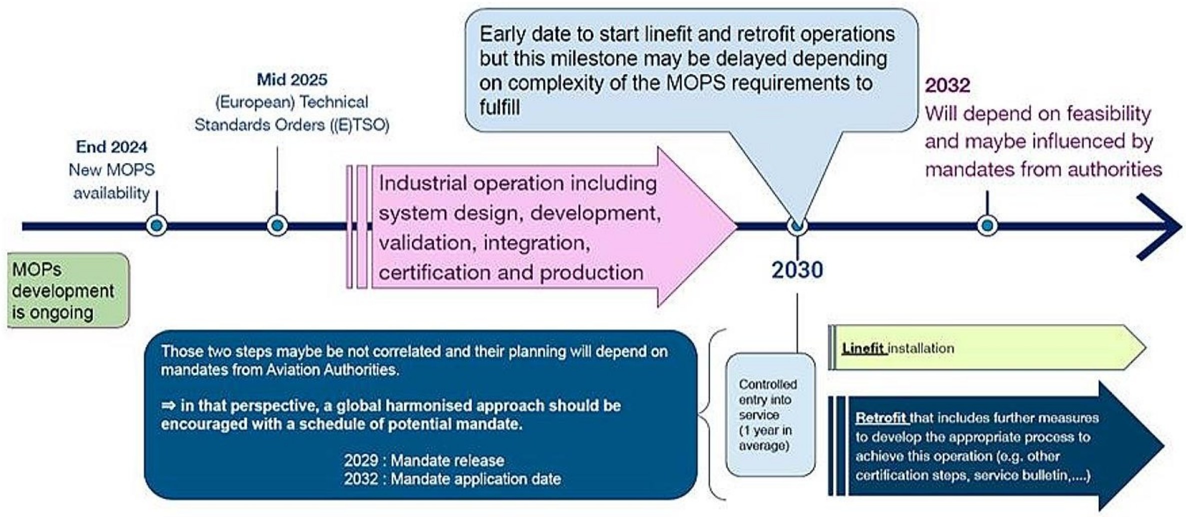
The document also noted that a loss of sufficient receiver sensitivity may lead to the reporting of incorrect altitude readings when an in-band interference signal causes the signal-to-noise ratio to exceed –6 dB within the altimeter’s IF bandwidth. Unlike out-of-band signals, RF energy from in-band interference cannot be filtered out, and because the transmission power of altimeters is limited (typically to 1–2 watts to prevent direct leakage into a nearby altimeter receiver), the receivers must be highly sensitive. For this reason, increasing the altimeters’ interference tolerance whilst maintaining their functionality is challenging. Furthermore, altimeters cannot be modified without invalidating their safety certification, so the only ‘quick fix’ was to restrict the roll-out

[171] Mie Utsunomiya, “Potential Safety Concerns due to Interference from 5G to Aeronautical Radio Altimeters,” preparatory workshop for WRC-23, Cairo, Egypt, 28–29 August 2023 – https://www.icao.int/MID/Documents/2023/WRC-23%20and%20FSMP-SG17/FSMP-WG17-WRC23WrkShp41_Rev%20ICAO-Potential%20Safety%20Concerns%20due%20to%20Interference%20from%205G_Radio%20Altimeters.pdf

of IMT/WBB transmitters into adjacent frequency bands and/or to keep them at a sufficient distance from airports. The FCC has done both, and other national regulatory authorities have followed suit, adopting various sets of ‘ad hoc’ restrictions.[172] The facts highlighted in ITU-R M.2059
— that altimeters are designed for up to 30 years’ operation and vary significantly in their technical parameters — have made it difficult to reach a consensus on new harmonised standards for interference management. However, the need for such standards is clear, as the majority of flights are international and diverse local measures can lead to uncertainty amongst pilots as to whether the altimeter reading is accurate or, conversely, distorted by interference.

Given the scale and potential impact of the problem, many organisations are involved in addressing it, and as a result, a globally acceptable solution is emerging slowly. ITU-R M.2059-0 recognised that ‘the airworthiness certification of radio altimeters is a lengthy and costly process’. However, in 2016, the ICAO Frequency Spectrum Management Panel agreed to add new standards for altimeters to its annexes. Eight years later, however, this has still not happened.[173] Final approval of the new Minimum Operational and Performance Standards (MOPS) document is not expected until the end of 2024, with the new Standards and Recommended Practices (SARPs) document to follow in 2032 and implementation expected ‘around 2034’.[174] Once the new standards are available, the existing studies carried out by the ITU, CEPT and national authorities will need to be revalidated; however, no tightening of harmonisation for LMPs in the 3.8–4.2 GHz band is anticipated from 2024.

Figure 27: Expected timetable for the development of new ICAO/RTCA/EUROCAE/ETSI minimum operational and performance standards for altimeters



Source: ICCAIA

Figure 6. Expected timeline necessary for ICAO SARPs and RTCA/EUROCAE compliant radio altimeters
(Image reproduced by kind permission of ICCAIA)

Source: ICAO Circular 360

The following comments are speculative, but ICAO’s slow response may be due to a reluctance to act or a tactic to put pressure on others to help speed up the process by contributing to the costs of mitigation measures. As one representative of the International Air Transport Association (IATA) put it:

---

[172] ICAO *Circular 360* (see further note)

[173] However, ICAO has issued a number of interim guidance documents. For the latest version, see *Circular 360: Guidance on Safeguarding Measures to Protect Radio Altimeters from Potential Harmful Interference,* https://elibrary.icao.int/reader/471867/&returnUrl%3DaHR0cHM6Ly9lbGlicmFyeS5pY2FvLmludC9leHBsb3JlO3NlYXJjaFRleHQ9NUclMjBpbnRlcmZlcmVuY2U7c2VhcmNoU2NvcGU9MjtwaHJhc2VNYXRjaD0wO21haW5TZWFyY2g9MQ%3D%3D?productType=eBook

[174] ICAO, “Non-Final Work in Progress: ICAO Position for the International Telecommunication Union (ITU) World Radiocommunication Conference 2027 (WRC-27)” - https://www.icao.int/safety/FSMP/MeetingDocs/FSMP%20WG18/Flimsy%20-%20Copy/FSMP-WG18-Flimsy01R3_Draft%20ICAO%20Position%20for%20WRC-27.docx

> "Airlines did not cause this situation. They are the victims of poor government planning and coordination. The industry's concerns regarding 5G, expressed for many years in the relevant forums, have been ignored and overlooked. Half-measures have been imposed on airlines, which are required to implement them at their own expense and with little insight into their long-term viability… These investments will yield no gains in operational efficiency. Moreover, they are merely a temporary reprieve. Under current scenarios, airlines will have to retrofit most of their aircraft twice within just five years. And with standards for the second retrofit yet to be developed, we could easily face the same supply chain problems in 2028 that we are grappling with today. This is clearly unfair and uneconomical. We need a more rational approach that does not place the entire burden of resolving this unfortunate situation on the aviation industry."[175]

This statement raises two important questions: How many altimeters actually need to be replaced or upgraded? And how much would that cost?

According to Oliver Wyman, the total number of commercial aircraft worldwide will be 28,398 in 2024.[176] Discussions within the ICAO suggest that approximately 20,000 of these are equipped with altimeters using the 4200–4400 MHz frequency band.[177] In its report to the FAA, the International Air Transport Association stated that retrofitting aircraft worldwide with altimeters would cost up to USD 637 million (approximately USD 22,431 per aircraft).[178]

Conversely, in 2022, the FAA stated that two models of altimeters, which are used in approximately 45 per cent of commercial aircraft registered in the US, were already sufficiently resistant to 5G interference, meaning that they did not need to be replaced or upgraded.[179] For the remaining aircraft, Airworthiness Directive 2023-10-02 set a deadline of 1 February 2024 for compliance with the new FAA rules, which require interference-resistant altimeters, as summarised below. Many airlines requested an extension of the deadline, but the FAA refused, stating:

> "The FAA has reviewed the 1 February 2024 deadline in light of the latest data on radio altimeter fitment and has determined that an extension is not warranted. The only aircraft… that are not expected to be fitted by 1 February 2024 are approximately 164 commercial-category aircraft fitted with older radio altimeters that are not supported by the aircraft manufacturers (original equipment manufacturers) or the radio altimeter manufacturers. Operators of these aircraft will have to make a commercial decision to fit newer models of radio altimeters or to withdraw these aircraft from service… Aircraft without upgraded radio altimeters will be able to operate at any airport, but will not be permitted to fly in reduced visibility… The FAA and its international civil aviation partners plan to expedite the approval of radio altimeters… The FAA has used measures such as an approved list of models (supplementary type certificates) to assist with the retrofitting…
>
> The FAA estimates that this airworthiness directive affects approximately 1,000 aircraft registered in the US.
>
> As at the date of publication of this airworthiness directive, there are approximately 8,000 aircraft in the US register in the commercial and regional aircraft categories... The FAA roughly estimates that nearly 7,000 aircraft on the US register have already been fitted or are being retrofitted to address radio altimeter interference tolerance and therefore will not need to take any action to comply with this AD... The FAA estimates that approximately 180 aeroplanes will require replacement of the radio altimeter and 820 aeroplanes will require the addition of radio altimeter filters to comply with the modification requirement. As such, the FAA estimates the following costs for compliance with this AD, totalling US$35,152,000 for the US fleet.[180]

---

175 Statement by Nick Careen, IATA's Senior Vice-President for Operations, Safety and Security, quoted in "IATA welcomes agreement to extend 5G mitigations," Aerospace Global News (4 May 2023) – https://aerospaceglobalnews.com/news/iata-welcomes-telcos-agreement-to-extend-5g-mitigations/

176 Oliver Wyman, *Global Fleet and MRO Market Forecast*, *2024–2034* – https://www.oliverwyman.com/content/dam/oliver-wyman/v2/publications/2024/feb/OliverWyman-Global-Fleet-and-MRO-Market-Forecast-2024-2034.pdf

177 See, for example, Laurent Azoulai (ICCAIA), "Radioaltimeter permanent functioning," FSMP-WG/19-WP/17, 19th) Working Group meeting of ICAO's Frequency Spectrum Management Panel (July 2024) – https://www.icao.int/safety/FSMP/MeetingDocs/FSMP%20WG19/WP/FSMP-WG19-WP17_Radioaltimeter%20permanent%20functioning%20submitted.docx

178 IATA's comments on FAA Docket 2022-1647 https://www.regulations.gov/comment/FAA-2022-1647-0040 They are right to criticise the FAA's cost estimate for failing to include aircraft that already complied with the new altimeter regulations, although they overstate the difference in the cost estimate by ignoring the fact that 45 per cent of aircraft did not need to modify their equipment.

179 Andrew Curran, "FAA Okays Almost Half of US Passenger Jets Ahead Of 5G Rollout," *Simple Flying*, 17 January 2022 – https://simpleflying.com/faa-clears-planes-5g-rollout/

180 FAA, *AD Final Rules – 2 October 2023*, published in the [US] Federal Register, Volume 88, Number 102 (26 May 2023), pages 34065–34081] - https://drs.faa.gov/browse/excelExternalWindow/FR-ADFRAWD-2023-11371-0000000000.0001

Cost estimate

Action	Labour costs	Component costs	Product costs	US operators' costs
Aircraft manual (amendments up to 30 June 2023)	One hour's labour = 85 USD	0	USD 85	USD 85,000 for 1,000 aircraft
Aircraft Manual (amendments after 30 June 2023)	One hour's work = 85 USD	0	USD 85	USD 85,000 for 1,000 aircraft
Modification (replacement of radio altimeter)			Up to 80,000 USD (includes parts and labour)	Up to 14,400,000 USD for 180 aircraft.[181]
Modification (filter replacement)	24 hours' labour x 85 USD = 2,040 USD per filter	USD 8,000 per filter	10,040 USD per filter	Up to 20,582,000 USD for 820 aircraft with 2 or 3 filters per aircraft

Source: FAA (op. cit.)

This slowness on the part of the FCC is particularly striking given that the US government ordered domestic aircraft to be rapidly fitted with 5G-resistant altimeters, a requirement which was fully met at the start of this year.

Another factor worth mentioning is that, although interference with altimeters during landing could have catastrophic consequences, this has not occurred, despite warnings from the aviation industry. In January this year, EASA, the European Aviation Safety Agency, stated:

- 'No confirmed instances of 5G interference with radio altimeters have been reported to EASA. No evidence of 5G interference has been found.'[182]

As regards the domestic situation:

> The Czech Republic has published the results of an on-board RA test carried out on a new IMT BTS installed at an airport. Two different types of aeroplanes and two types of helicopters were used. The base station operated at a frequency of 3.7 GHz. The results showed that no abnormal RA behaviour was detected."[183]

The situation in the US is very different. The main difference is that the MFCN band in Europe currently ends at 3800 MHz. In the US, it ends at 3980 MHz. The guard band in the US is 20 MHz, whilst in Europe it is currently 400 MHz. Furthermore, the maximum permitted e.i.r.p. for 5G transmitters in the 3700–3980 MHz band in rural areas of the US is 3280 W/MHz. "This limit applies to the total power of all antenna elements in any given sector of a base station." [184] In Europe, the maximum in-block e.i.r.p. in the 3400–3800 MHz band is approximately 1585 W/MHz.

The difference was striking:

> "On 19 January 2022, 5G systems were switched on. Almost immediately, complaints began to pour into NASA…
>
> According to an analysis by *IEEE Spectrum* of reports submitted via NASA's Aviation Safety Reporting System (ASRS), there was a significant increase in the number of complaints regarding malfunctioning and failing radio altimeters following the launch of high-speed 5G wireless networks earlier this year…

---

[181] Note: The FAA's calculation assumes only one altimeter replacement per aircraft. It is possible that the affected aircraft have only one altimeter, but most large aircraft have two or three altimeters. The FAA provides no explanation for its assumption. If one quarter have two altimeters and one quarter have three altimeters, the total replacement cost would be US$25,200,000, bringing the total cost for the fleet to US$45,952,000.

[182] EASA, '5G Update' (4 January 2024) – https://www.iata.org/contentassets/047eae4355824577a2060ac745110215/easa-5g_updated_4_jan_2024.pdf

[183] GSMA, *5G and Aviation Altimeters: Co-existence with IMT in 3.3–4.2 GHz and 4.8–4.99 GHz* (May 2023) - https://www.gsma.com/connectivity-for-good/spectrum/wp-content/uploads/2023/05/5G-and-Aviation-Altimeters.pdf

[184] *US Code of Federal Regulations*, "Title 47—Telecommunications; Chapter 1—Federal Communications Commission; Subchapter B—Common Carrier Services; Part 27—Miscellaneous Wireless Communications Services; Sub-part C—Technical Standards; §27.50 Power limits and duty cycle" – https://www.law.cornell.edu/cfr/text/47/27.50

In January this year, altimeter faults were simultaneously recorded on at least three flights over Tennessee, which, according to one of the pilots, “made it impossible to maintain the assigned altitude.” One aircraft completely lost its autopilot and was reportedly met by fire engines upon landing.

In February, a commercial aircraft experienced erratic low-altitude warnings whilst approaching Louis Armstrong International Airport in New Orleans, whilst flying below 1,000 feet. “These erroneous warnings would have been extremely confusing in a more challenging environment, such as low visibility, icing, etc.,” the pilot wrote later.

In March 2022, a commercial aircraft landing on autopilot at Los Angeles International Airport suddenly began an aggressive descent just 100 feet above the ground. “I took control of the aircraft, raised the nose and landed,” said the pilot.
“It was a very alarming autopilot failure. Under [different] conditions, it could have caused a crash.”[185]

Brandon Vigliarolo pointed out that even if nothing adverse actually happens, false alarms have a negative impact: “The agency (FAA) is concerned that repeated false warnings, which it believes ‘will occur more frequently as telecoms companies continue to roll out 5G services in the C-band’, reduce flight crews’ sensitivity to genuine emergency situations.” [186]

As mentioned above, an important new standard (DO-155A – ‘Minimum Performance Standards – Short-Range Airborne Radar Altimeters’) is expected to be available by the end of 2024. ICAO has already issued *Circular 360: Guidance on protective measures to safeguard radio altimeters against potentially harmful interference*[187] *(2024)*.

A resolution to the part of the dispute concerning the standards is therefore not expected in the foreseeable future. However, the costs of replacing or retrofitting altimeters that are not 5G-resistant remain an obstacle, even though the recovery in airlines’ revenues following the COVID-19 pandemic has been strong enough that the industry appears capable of financing this migration. It may be more a case of a reluctance to bear the full costs. Nevertheless, airlines are unequivocally demanding compensation from the mobile communications sector, although outside the US the sense of urgency is lower.

(a) ECC Report 362, Part 1: “Compatibility between mobile or fixed communications networks (MFCN) operating in the 3400–3800 MHz band and low/medium-power wireless broadband systems (WBB LMP) operating in the 3800–4200 MHz band with radio altimeters (RA) operating in the 4200–4400 MHz band”

The results of numerous simulations of the coexistence of radio altimeters and fixed/mobile networks with various parameters deployed in different frequency bands and with different assumptions regarding the radio altimeters’ tolerance to interference – which led to varying estimates of the distances required for safe operation – form the subject of this comprehensive report (260 pages).

However, a press release on the CEPT website dated 16 September 2024 states that PT1 has completed its work on the compatibility of radio altimeters with MFCN and LMP WBB in adjacent spectrum: “PT1 has addressed all comments from the public consultation on the draft ECC 362 report.[188] This document will be submitted to the next ECC meeting[189] for approval prior to publication. A liaison statement has been sent to inform FM60 regarding their work on finalising the draft CEPT 88 report on WBB LMP in the 3.8–4.2 GHz band. PT1 has also prepared a brief summary to facilitate reading of the draft ECC report.”[190]

As the documents discussed and produced at CEPT meetings are publicly available online, the latest drafts of ECC Report 362 can be found in the file folders from the most recent PT1 meeting (9–13 September 2024) rather than in the final document approved by the ECC. The text quoted in the following paragraph is taken from a file entitled ‘ECC Report Altimeters Part 1) out with edits in ExecSum,’ [191] dated 13 September 2024 and labelled ‘Latest version.’

---

[185] Mark Harris, “How 5G’s Rollout Rattled Hundreds of Pilots,” *IEEE Spectrum* (13 October 2022) – https://spectrum.ieee.org/faa-5g

[186] Brandon Vigliarolo, “FAA sets 2024 deadline for preventing 5G crash landings,” The Register, 10 January 2023 – https://www.theregister.com/2023/01/10/faa_2024_altimeter_deadline/

[187] https://elibrary.icao.int/reader/471867/&returnUrl%3DaHR0cHM6Ly9lbGlicmFyeS5pY2FvLmludC9leHBsb3JlO3NlYXJjaFRleHQ9NUclMjBpbnRlcmZlcmVuY2U7c2VhcmNoU2NvcGU9MjtwaHJhc2VNYXRjaD0wO21haW5TZWFyY2g9MQ%3D%3D?productType=eBook

[188] See “Table of resolution of comments on draft ECC Report 362_rev1” (DG RA TEMP 05R1) – https://api.cept.org/documents/ecc-pt1/84987/dg-ra-temp-05r1_table-of-resolution-of-comments-on-draft-ecc-report-362_rev1

[189] 65th ECC Plenary Meeting: 5–8 November 2024 in Vienna.

[190] “PT1#79 Completed the Work on Compatibility [sic] with Radio Altimeters” (16 September 2024) – https://www.cept.org/ecc/groups/ecc/ecc-pt1/news/pt179-completed-the-work-on-compability-with-radio-altimeters

[191] https://api.cept.org/documents/ecc-pt1/85100/swg-a-temp-01r1_-ecc-report-altimeters-part-1-out-with-edits-in-exsum. The word ‘out’ in the file name could indicate that this version is an output from the draft preparation process.

- From the executive summary:

  'The studies in this ECC report are based on measurements for several models of radio altimeters, with interference tolerance thresholds (ITT) derived from published AVSI reports… The ITT values of different radio altimeter models vary by many dB… It was difficult to reach unanimous agreement on the parameters of radio altimeters…

  Based on the above-mentioned parameters of radio altimeters, as well as typical parameters of base stations with the main antenna beam directed towards or below the horizon, this report draws the following conclusions for the modelled approach scenario (Instrument Landing System).'

  For MFCNs operating in the 3400–3800 MHz frequency band and radio altimeters in the 4200–4400 MHz band

  Differences in radio altimeter parameters between parameter set 1 and parameter set 2 (see Section 5.3) and differences in the modelled scenarios lead to different conclusions...

  In summary, the results show:

  All studies of unwanted emissions (see ERC Recommendation 74-01) falling within the 4200–4400 MHz band from an MFCN operating in the 3400–3800 MHz frequency band show sufficient margins, including at least the 6 dB safety margin specified by ICAO;

  - A study of potential interference with a radio altimeter receiver:

    – using the parameters and assumptions from ITT parameter set 1 and the radiation characteristics of the RA antenna (including tilt of up to ±15 degrees) for MFCN macro-base stations operating in the 3400–3800 MHz band with the main beam directed towards or below the horizon (basic assumptions) show sufficient margins, including at least a 6 dB safety margin in accordance with ICAO;

    – when using the radiation patterns of ITT antennas and radio altimeters from parameter set 2, and in cases where MFCN parameters deviate from Annex 1 (sensitivity analysis – e.g. 0° mechanical tilt), there are situations where the ITT on the radio altimeter is exceeded;

    – when extending Parameter Set 2 (e.g. applying ITT values for altitudes of 200 feet below 200 feet) and where the MFCN parameters deviate from Annex 1 (sensitivity analysis – e.g. extended range of electric steering beyond standard settings, etc.), there are other situations where the ITT on the radio altimeter is exceeded… "demonstrate sufficient margins, including at least a 6 dB safety margin in accordance with ICAO;

  "For low- to medium-power wideband wireless (WBB LMP) in the 3800–4200 MHz band (based on 3GPP and DECT-2020 NR) and for radio altimeters in the 4200–4400 MHz band.

  For the 3800–4100 MHz frequency band:

  - All studies show sufficient margins for spurious emissions and interference with radio altimeters, including a safety margin of at least 6 dB, as recommended by the International Civil Aviation Organisation (ICAO).

  For the 4100–4200 MHz frequency band:

  - For WBB LMP base stations without AAS, all studies show sufficient margins for unwanted emissions and interference with radio altimeters, including a safety margin of at least 6 dB in accordance with ICAO.

  For WBB LMP base stations with AAS:

  - The 6 dB safety margin in accordance with ICAO is always met when taking into account the obstruction of radio altimeters (WBB LMP AAS emissions in the band);

  - Studies on the protection of radio altimeters at altitudes of 200 and 1,000 feet (base case) show sufficient margins for spurious emissions and interference with radio altimeters, including at least a 6 dB safety margin in accordance with ICAO;

- A study applying ITT values for an altitude of 200 feet below 200 feet (sensitivity analysis) shows that, for spurious emissions from the WBB LMP in the 4200–4400 MHz band, base stations with 4x4 and 8x8 AAS (without sub-arrays) near the runway threshold may lead to situations where the 6 dB safety margin specified by ICAO is exceeded by 13 dB (assuming a block edge mask derived from ETSI TS 138 104). The same study shows that the 6 dB safety margin is fully met for base station locations more than 1,200 m from the runway threshold or 40 m to the side, or for all base station locations with emission levels in the 4,200–4,240 MHz band…"

Several participants in the public consultation on the draft ECC 362 report noted that higher e.i.r.p. values are used in the deployment of MFCN in Europe than those assumed in the ITU studies, which means that these studies may not accurately reflect the situation in this region. In other words, C-band MFCN base stations in Europe radiate at higher power levels than those for which the currently deployed altimeters were designed. (However, as many experts have already pointed out elsewhere, the power limits for C-band IMT base stations are currently significantly higher in the US than in Europe, and the frequencies available for IMT in the US are also closer to the 4200–4400 MHz band than in Europe. Both of these differences could narrow in the future.

Once long-term MOPS are available (by the end of 2024?)[192], existing studies will be reassessed and updated where necessary. This may take the form of a separate study with a different timetable to the current work item schedule, or a new work item (WI).

Table 28: Out-of-band emission limits for WBB LMPs (non-AAS) providing local network connectivity in the 3.8–4.2 GHz band, derived from ECC Decision (11)06.

Frequency offset	Maximum mean *e.i.r.p.* density
3795–3800 MHz, 4200–4205 MHz	(P_{max} – 40) dBm / 5 MHz *e.i.r.p.* per antenna
3790–3795 MHz, 4205–4210 MHz	(P_{max} – 43) dBm / 5 MHz *e.i.r.p.* per antenna
3760–3790 MHz, 4210–4240 MHz	(P_{max} – 43) dBm / 5 MHz *e.i.r.p.* per antenna
below 3760 MHz / above 4240 MHz	-2 dBm / 5 MHz *e.i.r.p.* per antenna
Note: Pmax is the maximum mean carrier power of the station in dBm for a base station, measured as equivalent isotropic radiated power (e.i.r.p.) per carrier, derived for the antenna.	

Source: (Draft) ECC Report 362, Part 1

b) Aeronautical mobile service: Wireless avionics communications within the aircraft (WAIC)

Wireless in-aircraft avionics communication (WAIC) systems provide radio communication links over relatively short distances between two or more stations integrated into a single aircraft or installed on a single aircraft to support safe operations. WAIC systems do not provide radio communication between the aircraft and the ground, or with another aircraft or satellite. They offer alternatives to hard-wired installations, introduced to reduce aircraft costs and weight, to ensure flexibility in the placement and routing of signals between end points of a link, or to deliver data to or from moving parts that cannot be fixed to the wiring harness. WRC-15 adopted rules allowing WAIS to use the 4200–4400 MHz band, which had previously been allocated exclusively to radio altimeters.

The ITU expects ICAO to establish rules ensuring that systems mounted on or within an aircraft do not interfere with one another. The ITU is addressing the issue of systems in one aircraft interfering with systems in another aircraft, which can occur at airports when aircraft are parked side by side or when one aircraft is taking off or landing whilst another is taxiing nearby. This could also occur in the air, between aircraft that are vertically separated by the minimum required distance of 300 m.

---

[192] The Radio Technical Commission for Aeronautics (RTCA) is preparing a document entitled 'Minimum Operational Performance Standards (MOPS) for Low Range Radar Altimeters' (DO-155A). The document is expected to be finalised by the end of 2024. See also 'EUROCAE ED-310 / RTCA DO-399: Standard Document containing guidelines for the suppression and tolerance of interference by radar altimeters', which requires a significant improvement in the ability of altimeters to suppress interference from sources within the band, beyond what is specified in ITU-R Recommendation M.2059.

Resolution 424 states that both WAIC and radio altimeters use the 4200–4400 MHz frequency band. Both access the entire bandwidth simultaneously, so interference between them is a very real possibility. [193] The resolution, as mentioned above, cites ITU-R Recommendation M.2085, the purpose of which is to set limits on the e.i.r.p. density generated by WAIC systems outside the aircraft, in order to prevent interference with radio altimeters on nearby aircraft (the aircraft fuselage provides sufficient protection against high-frequency emissions from WAIC systems inside the aircraft). Recommendation M.2085 states that the maximum e.i.r.p. should not exceed 5 dBm/MHz for 'high data rate' out-of-aircraft WAIC applications or 6 dBm/MHz for 'low data rate' out-of-aircraft WAIC applications. ITU-R Recommendation M.2067-0[194]defines 'low data rate' WAIC applications as those with a data rate of less than 10 kbit/s and 'high data rate' WAIC applications as those with a data rate of more than 10 kbit/s. The maximum transmit power for 'low data rate' applications is 10 mW, whilst the maximum transmit power for 'high data rate' applications is 50 mW.

ITU-R Report M.2283-0[195] provides examples of various types of external 'high-data-rate' WAIC applications: voice data transmission for communication with the cockpit crew, external video display for safe taxiing, and 'sensors for monitoring structural health using, for example, ultrasonic technologies or accelerometers'. A large commercial aircraft may have up to 65 external high-speed data links, although only one may be transmitting at any given time. In addition to 'low-data-rate' WAIC applications, these include ice detectors, feedback on landing gear position to ensure control and deployment, tyre pressure sensors, tyre and brake temperature sensors, engine power sensors, etc. A large passenger aircraft may have up to 400 external low-data-rate WAIC links, although only one may be transmitting at any one time. Despite the large number of links, ICAO defines a 'WAIC system… as the totality of all WAIC components on board the same aircraft, so that a single aircraft contains only one WAIC system.' [196]

A study cited in ITU-R Report M.2319-0 noted that where omnidirectional antennas are used for WAIC systems outside the aircraft, "radio frequency emissions… upwards will exceed the protection criteria for fixed services, Earth exploration satellite services (passive) and radio altimeters in the frequency band. Therefore, the following diagram and accompanying table derive and summarise the maximum tolerable values of radiated power by angle caused by WAIC:

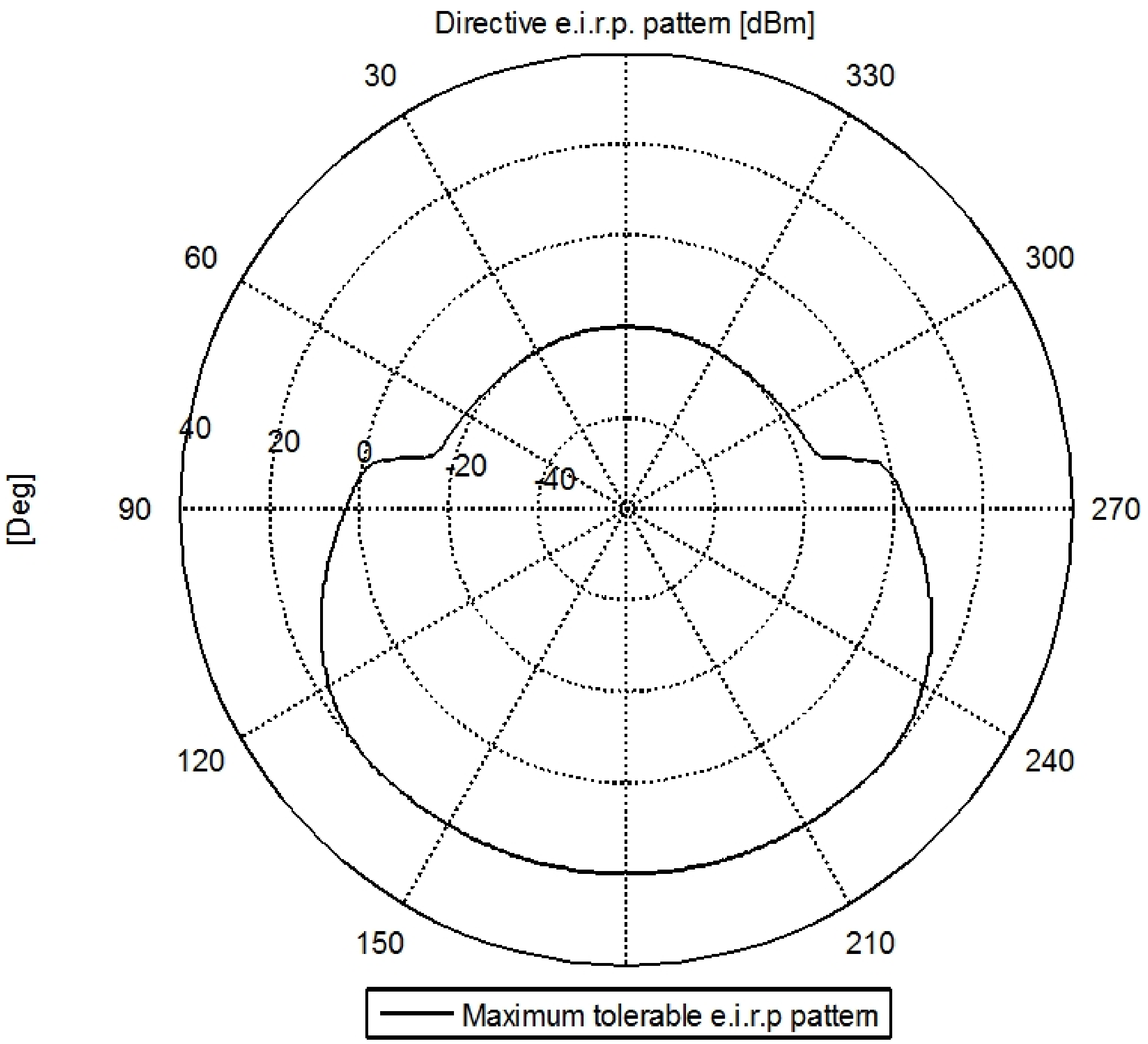
[193] According to ITU-R Recommendation M.2059-0, 'radio altimeters require a bandwidth of 196 MHz', whilst ITU-R Recommendation M.2283-0 estimates that WAIC systems require between 145 and 185 MHz.

[194] ITU-R Recommendation M.2067-0 (2015): "Technical characteristics and protection criteria for Wireless Avionics IntraCommunication systems" - https://www.itu.int/dms_pubrec/itu-r/rec/m/R-REC-M.2067-0-201502-I!!PDF-E.pdf

[195] "Technical characteristics and spectrum requirements of Wireless Avionics Intra-Communications systems to support their safe operation" (2013) - https://www.itu.int/dms_pub/itu-r/opb/rep/R-REP-M.2283-2013-PDF-E.pdf

[196] "Proposed Modifications to Annex 10 Volume V to the Convention on International Civil Aviation," FSMP.3.WP.03, Annex 1 - https://www.icao.int/safety/FSMP/MeetingDocs/FSMP-3/Report/FSMP.3.WP.03%20YELLOW%20COVER%20REPORT.pdf

Figure 29: Maximum tolerable values of radiated power at different frequencies as a function of angle, based on WAIC



Maximum reference values for EIRP as a function of angle

Parameter	Value											Units
Angle	>120	90	75	69	35	0	325	291	285	270	<240	**degrees**
e.i.r.p.	20	3	-2	-15	-17	-20	-17	-15	-2	3	20	**dBm**

However, when discussing this option, the ICAO WAIC Standards Correspondence Group stated in 2020 that 'e.i.r.p. could seriously affect the viability of the band for WAIC applications.' [197] ITU-R Report M.2319 appears to have recognised that directional antennas may not be the best solution, as it identified other ways to bring external WAIC systems into compliance with the recommended emission limits:

[197] David Redman, "Report of the WAIC SARPS Correspondence Group," presented at the 10th Working Session of the ICAO Spectrum Management Panel (14 August 2020) -https://www.icao.int/safety/FSMP/MeetingDocs/FSMP%20WG10/WP/FSMP-WG10-WP20_WAIC%20SARPS%20CG.doc

- reduce the transmission power of the systems;
- reduce the maximum distance between the WAIC transmitter and its intended receiver;
- position the transmitter on the underside of the aircraft to take advantage of the vertical shielding effect of the fuselage.

However, there are growing concerns about interference with WAIC's internal systems caused by passengers' portable electronic devices (PEDs) on board, particularly if frequencies approaching 4200–4400 MHz are allocated for IMT and airlines expand their in-flight mobile connectivity services for passengers. Reports of harmful interference – primarily from mobile phones, but also from laptops, tablets and other PEDs – affecting sensors, displays and control circuits have been recorded for decades.[198] This table summarises the current specifications for WAIC receivers with regard to interference. These parameters may be updated to deal more effectively with the continuing proliferation of PEDs or to compensate for changes in WAIC transmitter power limits or antenna directivity.

Figure 3: Technical characteristics of existing WAIC receivers

Receiver characteristics	Low-data-rate systems	High-data-rate systems
Protection criteria (I/S)	-9 dB	-14 dB
Minimum out-of-band interference	-10 dB	-10 dB
Overload protection level - Front-end overload protection level*	-30 dBm	-30 dBm

* The power of incident interference must be less than –30 dBm across the entire allocated frequency range to ensure sufficient operational linearity.

Source: ITU-R Recommendation M.2319-0 (2014)

Although the table above is taken from an ITU Recommendation, it will be the responsibility of ICAO and RTCA to review these standards in response to changes in the radio frequency environment. In fact, the ICAO Frequency Spectrum Management Panel approved a new draft SARP in September 2022. This sets out the minimum radio frequency characteristics required to prevent interference between WAICs and radio altimeters. 'The expected date of applicability for the proposed amendments to the ICAO Convention is November 2025. The Standards and Recommended Practices (SARPs) for WAIC will be included in Chapter 4 of Annex 10, Volume V, under a new Section 4.5 dealing with the 4200–4400 MHz frequency band. This section will also cover the SARPs for radar altimeters once these standards have been finalised." [199]

Here are extracts from the new (but not yet formally approved) draft SARP for WAIC:

> "4.5.2.6.2 The total aggregate radiated power of all WAIC transmitters on board an aircraft must not exceed an equivalent isotropically radiated power of –20 dBm, assuming that the point source is located at the geometric centre of the aircraft.
>
> "4.5.2.6.3 The total occupied bandwidth must be maintained entirely within the allocated frequency band of 4200–4400 MHz, including any compensations such as the Doppler effect or frequency tolerance. The occupied bandwidth is defined as the bandwidth over which 99 per cent of the signal energy falls between the lower and upper frequency limits...
>
> "4.5.2.6.4 The required bandwidth (NB) of a WAIC transmitter shall be calculated in accordance with Annex 1 to the Radio Regulations.
>
> "4.5.2.6.5 The boundary between the out-of-band region and the region of unwanted emissions shall be determined in accordance with Appendix 1 to Annex 3 of the Radio Regulations. The required attenuation of the average power of any unwanted emissions relative to the total average power P must satisfy or exceed the following conditions:
>
> - 50% NB < f < 150% NB: A linear increase (in dB) from 24 dB to 35 dB within a reference frequency band width of 4 kHz (Note 1)
> - 150% NB < f < start of the unwanted emission region: 35 dB within the reference frequency band width of 4 kHz (Note 1)

198 Elden Ross, *Personal Electronic Devices and their Interference with Aircraft Systems,* NASA/CR-2001-210866 (2001) – https://ntrs.nasa.gov/api/citations/20010066904/downloads/20010066904.pdf

199 ICAO, "Connecting the World", presented at the 12th meeting of the CNS MIDANPIRG sub-group, held on 2–4 May 2023 - https://www.icao.int/MID/Documents/2023/MIDAMC%20and%20CNS/CNS%20SG12-PPT4.pdf

- Spurious emission domain: 56 + 10 log(P) or 40 dB, whichever is less stringent, measured in an RBW of 1 MHz (Note 2)

  Note 1: Reference bandwidth of 4 kHz in the out-of-band emission region in accordance with Appendix 11 of ITU-R Recommendation SM.1541-6. The parameter f is the frequency offset from the centre frequency of the transmitted signal.

  Note 2: Reference bandwidth of 1 MHz within the out-of-band emission region in accordance with Annex 3, paragraph 7, of the Radio Regulations, and attenuation requirements for low-power radio equipment in accordance with Annex 3, paragraph 13, of the Radio Regulations.

4.5.2.7 WAIC receiver immunity to out-of-band interference

Immunity of the WAIC receiver to out-of-band interference *Note: These requirements apply to WAIC equipment and define the radio frequency environment in which WAIC equipment must meet performance requirements, without taking into account any constraints caused by its installation.*

4.5.2.7.1 Receivers must tolerate interference from sources operating outside the 4200–4400 MHz frequency band, where the total combined radiated power falling within the 4200–4400 MHz frequency band, as measured at the receiver, does not exceed a power spectral density of –120 dBm/MHz.

4.5.2.7.2 Receivers must tolerate interference from sources operating outside the 4200–4400 MHz frequency band, where the total combined power, as measured at the receiver, does not exceed –20 dBm.[200]

[200] ICAO, "Proposed Amendment to the International Standards and Recommended Practices, *Aeronautical Telecommunications* Annex 10 Volume 5—Aeronautical Radio Frequency Spectrum Utilisation, Convention on International Civil Aviation, ATTACHMENT A to State letter AN 7/66.1.1-23/47 – https://www.atcguild.in/iwen/IWEN2323/ICAO/047e.pdf

UNOFFICIAL MACHINE TRANSLATION

Grant Thornton

www.grantthornton.cz