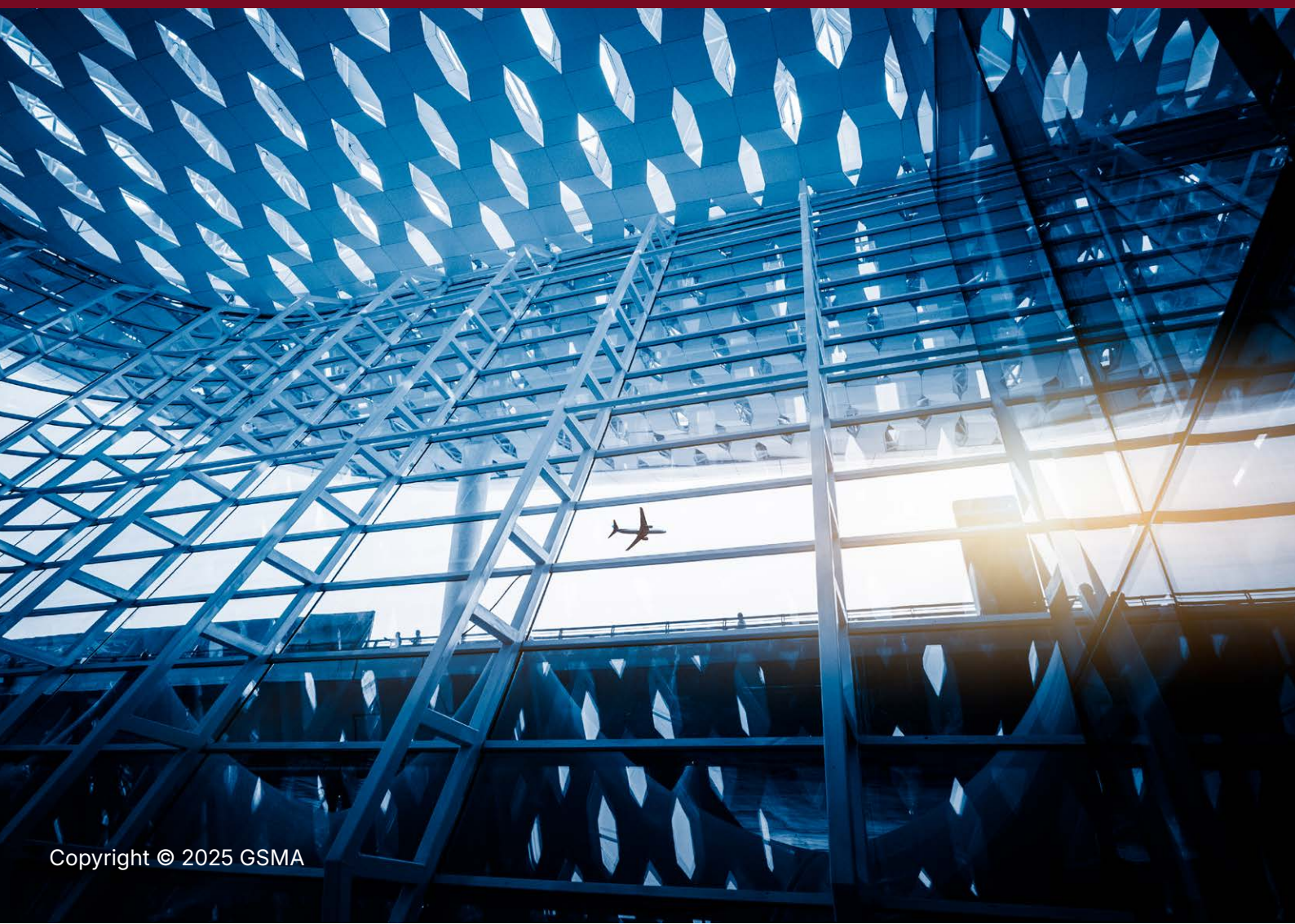


5G and Radio Altimeters Coexistence in 3.3-4.2 GHz

October 2025



GSMA

The GSMA is a global organisation unifying the mobile ecosystem to discover, develop and deliver innovation foundational to positive business environments and societal change. Our vision is to unlock the full power of connectivity so that people, industry and society thrive. Representing mobile operators and organisations across the mobile ecosystem and adjacent industries, the GSMA delivers for its members across three broad pillars: Connectivity for Good, Industry Services and Solutions and Outreach. This activity includes advancing policy, tackling today's biggest societal challenges, underpinning the technology and interoperability that make mobile work and providing the world's largest platform to convene the mobile ecosystem at the MWC and M360 series of events.

We invite you to find out more at [**www.gsma.com**](http://www.gsma.com)

Follow the GSMA on Twitter/X: @GSMA

Contents

Background	3
Spectrum aspects	5
Sharing spectrum	6
5G networks and altimeter spectrum	6
Aviation concerns	7
Background to the debate with aviation	8
Safe functioning of altimeters	8
5G operation and regulation	9
Tests around the world	10
5G operation and restrictions in the 3.5 GHz range	11
Compatibility studies	13
ECC Report 362	14
EU roadmap for ensuring safe coexistence between mobile networks and aircraft radio altimeters	15
Mobile industry considerations	15

Background



Today, live 5G networks in over 90 countries are using spectrum in 3.3-4.2 GHz (the 3.5 GHz range). More than 60% of 5G network launches have used this band so far, adding up to around 260 networks and further auction plans are expected in the years to come.¹

The relationship between aircraft altimeters in the 4.2-4.4 GHz band and 5G in 3.5 GHz has been closely studied. This has occurred both before and after global media reaction to concerns from the aviation industry that these altimeters could be impacted by 5G networks operating in the 3.5 GHz range. Since the media storm in late 2021 to early 2022, government studies across the world have carried out detailed examination of the safe operation of the two neighbouring services.

Collaboration between the aviation and mobile industries has also been taking place to reach improvements in radio altimeter equipment to support removal of temporary restrictive measures in the limited number of countries that implemented them.

There have been no reported instances of interference from 5G to radio altimeters. This is further reinforced by the fact that even in high-density aviation markets such as Europe, Japan, and South Korea, where 5G base stations are deployed extremely close to airports, regulators have confirmed no harmful interference.

The 3.5 GHz range has been under consideration, development and deployment for mobile services for nearly 25 years. It has also been studied at the International Telecommunication Union (ITU) and by national governments during this period and, more recently, the relationship between altimeters and 5G has been intensely scrutinised both nationally and by regional organisations such as CEPT.

Coexistence between different radiocommunication services is at the foundation of sound radio spectrum management to ensure that citizens derive the maximum benefit from this resource. The 3.5 GHz range is no exception, where the coexistence between 5G networks and aviation in adjacent frequencies is imperative.

The 3.5 GHz or '5G pioneer band' was the first used for 5G network trials and deployments. The harmonisation of 3.3-3.8 GHz for IMT, carried out over several World Radiocommunication Conference (WRC) cycles, was concluded at WRC-23.² 5G has also been safely operating in the upper 3.5 GHz range in spectrum between 3.8-4.1 GHz.

¹ [Spectrum Navigator](#), GSMAi, Q2 2025.

² [Outcomes of the World Radiocommunication Conference](#), ITU, 2023.

Spectrum aspects





Sharing spectrum

5G is an IMT technology and as such the way it uses spectrum is harmonised and coordinated by the ITU. The ITU's Radio Regulations stipulate how IMT can share spectrum with other radio systems and define technical and regulatory conditions for their operation.³

IMT technologies sit adjacent to or near adjacent to, and in some cases share spectrum with, a number of other services including satellites, Wi-Fi, aeronautical, military, radio astronomy, Earth exploration, deep space exploration and other applications and radio services. Ensuring that spectrum is shared in the most efficient manner helps all users of those services.

5G is the most spectrum efficient mobile technology to date. It makes use of advanced network technologies such as multi-antenna processing, beamforming, active antenna systems (AAS), massive MIMO, and various interference mitigation techniques that in combination enable very high frequency reuse.⁴ These technologies direct signals more precisely, reducing interference into adjacent areas and bands improving coexistence. 5G networks are engineered with strict out-of-band emission masks, helping them operate next to other sensitive services like satellite, radio astronomy, broadcast or aircraft altimeters.

5G networks and altimeter spectrum

The 3.5 GHz range is the most widely used for 5G and the lower part at 3.3-3.8 GHz has been harmonised over multiple WRC cycles between 2007 and 2023. While most 5G networks currently use the 3.3-3.8 GHz range, a number of macro-cell networks are live in the upper 3.8-4.1 GHz part. Some networks also use spectrum near adjacent to the upper end of the radio altimeter band in 4.5-4.9 GHz.

Aeronautical radionavigation is intended for the benefit and safe operation of aircraft and operates in various frequency bands. The 4.2-4.4 GHz frequency band is allocated to the aeronautical radionavigation service on a primary basis, and it is reserved for the operation of radio altimeters, which are used on aircraft to determine their height.

³ [Radio Regulations](#), ITU, 2024.

⁴ [Recommendation M.2150-2](#), ITU, 2023.

Aviation concerns



Background to the debate with aviation

The possibility of interference to radio altimeters from 5G networks was raised in 2020 through a white paper by the US aviation industry group Radio Technical Commission for Aeronautics (RTCA). Prior to this, the US FCC examined the use of 3.5 GHz by 5G over the course of four years, including submissions by the aviation industry, and found that the technical rules adopted for 5G in 3.5 GHz service “are sufficient to protect aeronautical services in the 4.2-4.4 GHz band”.⁵

The first RTCA study was published in October 2020 and filed with the FCC immediately after that.⁶ RTCA did not give detailed, non-aggregated deployment information on individual radio altimeter models currently being used and only some anonymised information was provided publicly by RTCA's research partner in late 2021. The US telecommunications industry offered clear rebuttal of the findings of this at the time (and has continued to do so since its publication).

RTCA's paper was subsequently raised more widely within the US government later in 2021 and led to significant media attention. To ensure 5G networks launched smoothly, the US mobile network operators (MNOs) voluntarily agreed to first delay the launch of the 3.7-3.8 GHz band, and then a set of temporary, voluntary, precautionary operational measures around certain airports.

The original RTCA study represented a set of assumptions based on highly pessimistic, overprotective and theoretical operational scenarios that together would not occur in live radio network implementations. As a result, the aviation industry wished to claim extreme protection from 5G networks for a handful of poorly designed and obsolete altimeter models built on outdated standards from the 1970s. Those models are not designed to adequately reject signals emanating from outside of the altimeter frequencies authorized for aeronautical radionavigation. Altimeter equipment designed against such an outdated standard should not be in use in today's radio-frequency environment. For example, existing high-power radar systems up to 3.7 GHz, which have operated worldwide for decades, would significantly disrupt or damage the front-end components of such a hypothetical receiver altimeter device.

A considerable amount of coordinated work and progress has been made among mobile and aviation industries since these initial reports, and has led to the cessation of some unilateral projects in exchange for wider collaborative efforts.⁷ The RTCA and the European Organisation for Civil Aviation Electronics (EUROCAE) are working on Radar Altimeter Minimum Operation Performance Standard (MOPS).⁸ The new MOPS will set standards for radio altimeters for many years into the future. It is important that these specifications will enable better coexistence between radio altimeters and other users of spectrum in neighbouring bands.

Safe functioning of altimeters

3.5 GHz spectrum is being widely used by 5G networks in more than 90 countries. To date, no instances of interference to radio altimeters have been reported as a result of these 5G operations. The safe operation of altimeters is critical, and the international mobile and the aviation communities have been working in good faith to address any concerns. Such interaction will enable the aviation industry to ascertain where, if necessary, it will need to replace old and obsolete altimeter equipment with those that have adequate filtering capabilities.

Altimeters are integral to aircraft safety and as such, building appropriate margins into their protection is important. The aviation industry gave clear information on technical parameters for radio altimeters as part of the WRC-15 agenda item which included the study of wireless avionics intra-communication systems (WAIC).

5 [Report and Order -Expanding Flexible Use of the 3.7 to 4.2 GHz Band](#), FCC, 2020.

6 [Assessment of C-Band Mobile Telecommunications Interference Impact on Low Range Radar Altimeter Operations](#), RTCA, 2020.

7 The RTCA started a process to build the DO-399/ED-310 'Standard Guidance Document on Radar Altimeter RF Interference Rejection and Tolerance' but later notified that the document is no longer planned for completion in favour of its work on next generation altimeter MOPS.

8 [Advancing Industry Standards: SC-239/WG-119 Aligns to Meet Evolving Radar Altimeter Needs](#), RTCA, 2025.

5G operation and regulation





Tests around the world

Several countries have performed tests to identify possible interference from IMT operations to radio altimeters. France published results of a trial on Gendarmerie helicopters using a Base Station (BS) at 3640-3710 MHz configured to a worst-case scenario of 78 dBm EIRP. The helicopters flew around the high-power BS in test loops trying to simulate interference. No disturbances were observed.

Another case from Norway, outlines a set of tests done at Bergen-Flesland airport (BGO) with a 3.7-3.8 GHz BS. It concludes: "The tests were carried out with a wide range of aircrafts representative for aircrafts landing at Norwegian airports". The results showed no abnormalities on the radio altimeters.

The US performed four phases of testing: lab setting, in-flight joint test and evaluation, collection of altimeters power levels, and characterisation of radiation patterns with emissions of 5G BS at 3.3-3.6 GHz, 3.7-3.98 GHz and 3.3-3.98 GHz.

In the report released, it was concluded that the "low level of unwanted 5G emissions within the radalt (Radio Altimeter) spectrum band reduces the potential for a 5G-to-radalt harmful interference scenario which would be due to 5G unwanted emissions on radalt receiver frequencies". Additionally, given the measurement-based observations, if "any EMC (electromagnetic compatibility) problem exists between 5G transmitters and adjacent-band radalt receivers, the technical solution to such a problem might be the installation or retrofitting of more-effective RF power-rejection filters on radalt receivers for frequencies below 4200 MHz".⁹ See also the FAA's Airworthiness Directive (described in the following section) regarding replacing obsolete equipment.

Other countries and their regulatory bodies, such as Canada, performed verification processes and test deployments which included a public consultation and produced a list of protected runways.¹⁰

The Czech Republic published the results of a radio altimeters test (onboard) near a new IMT BS installed at an airport. They used two different types of planes and two types of Helicopters. The BS operated at 3.7 GHz. Results did not detect any abnormal functioning of radio altimeters.

⁹ [Measurements of 5G New Radio Spectral and Spatial Power Emissions for Radar Altimeter Interference Analysis](#), NTIA, 2022.

¹⁰ [Civil Aviation Safety Alert \(CASA\) No. 2024-05](#), Transport Canada, 2024.

5G operation and restrictions in the 3.5 GHz range

To date, 93 countries have deployed 5G networks using spectrum in 3.3-4.2 GHz (the 3.5 GHz range). Some countries have assigned frequencies for 5G operations above 3.8 GHz as shown in Table 1:

Table 1:
Countries with 5G live networks above 3800 MHz

Country	Spectrum assigned (MHz) – (not necessarily contiguous)	
	Start	End
Japan	3400	4100
Saudi Arabia	3400	4000
Australia	3600	4000
United States	3450	3980
Chile	3500	3900
Uzbekistan (Republic of)	3500	3900
Vietnam	3700	3900
Canada	3450	3900

Most countries using 5G in the band 3.3-4.2 GHz do so without extra restrictions and there has been no impact to date on radio altimeters used for commercial aircraft. A few countries have implemented additional or provisional measures out of an abundance of caution:

- Japan applies a set of restrictions in close proximity to airport landing strips in the 4-4.1 GHz and 4.4-4.5 GHz bands but does not restrict 3.6-4 GHz which is also used for 5G.
- France and Belgium applied a set of measures for airports in 3.4-3.8 GHz. However, Belgium has withdrawn its restrictions.
- US operators adopted voluntary commitments in 3.7-3.98 GHz on a temporary basis from 2023 to 2028 with a mid-term check in 2026.¹¹ Also, the Federal Aviation Administration (FAA) set up a coexistence plan and an online resource detailing its own work to give additional clarity on the functioning of radio altimeters. The FAA issued an Airworthiness Directive (AD) which would “mandate that transport category airplanes used in scheduled passenger or cargo flight operations have 5G C-Band-tolerant radio altimeters or install an acceptable radio frequency filter”. US airlines upgraded their equipment by the end of June 2023.¹²
- Canada applies 5G mitigation measures including exclusion zones in the band 3.45-3.9 GHz, these will be maintained until 2026. Also, Transport Canada remarked in their latest mandate that “all (aviation) operators are strongly encouraged to retrofit their aircraft to meet radio altimeter tolerance requirements”.¹³
- Brazil applied temporary precautionary measures around airports in 3.3-3.7 GHz. These measures, except for downtilting, were withdrawn in November 2023.¹⁴
- Australia decided to apply provisional precautionary measures in airports and power limits for 5G operations in 3.7-4.0 GHz until 2026. However, air operators “need to upgrade radalts that do not meet minimum performance level before the interim period ends”.¹⁵
- Colombia applies precautionary measures around airport runways, which may be adjusted once the aviation authority confirms that air operations use 5G-tolerant radio altimeters.¹⁶
- India decided to apply precautionary restrictions in 2022. An update was made in 2025 noting that those “have been agreed as an interim measure till the upgradation or retrofitting of radio altimeters”.¹⁷

¹¹ [Filing - Expanding Flexible Use of the 3.7-4.2 GHz Band](#), FCC, 2023.

¹² [5G and Aviation Safety](#), FAA, 2023.

¹³ [Clarification on RadAlt Retrofit Mandate - Civil Aviation Safety Alert \(CASA\) No. 2025-05](#), Transport Canada, 2024.

¹⁴ [Act n° 14704](#), ANATEL, 2023.

¹⁵ [5G and aviation services in Australia](#), ACMA 2023.

¹⁶ [Despliegue 5G - Documentos de Interés](#), MinTIC, 2024.

¹⁷ Safety measures regarding C band radio altimeter vs. 5G/ IMT, DoT India, 2025.

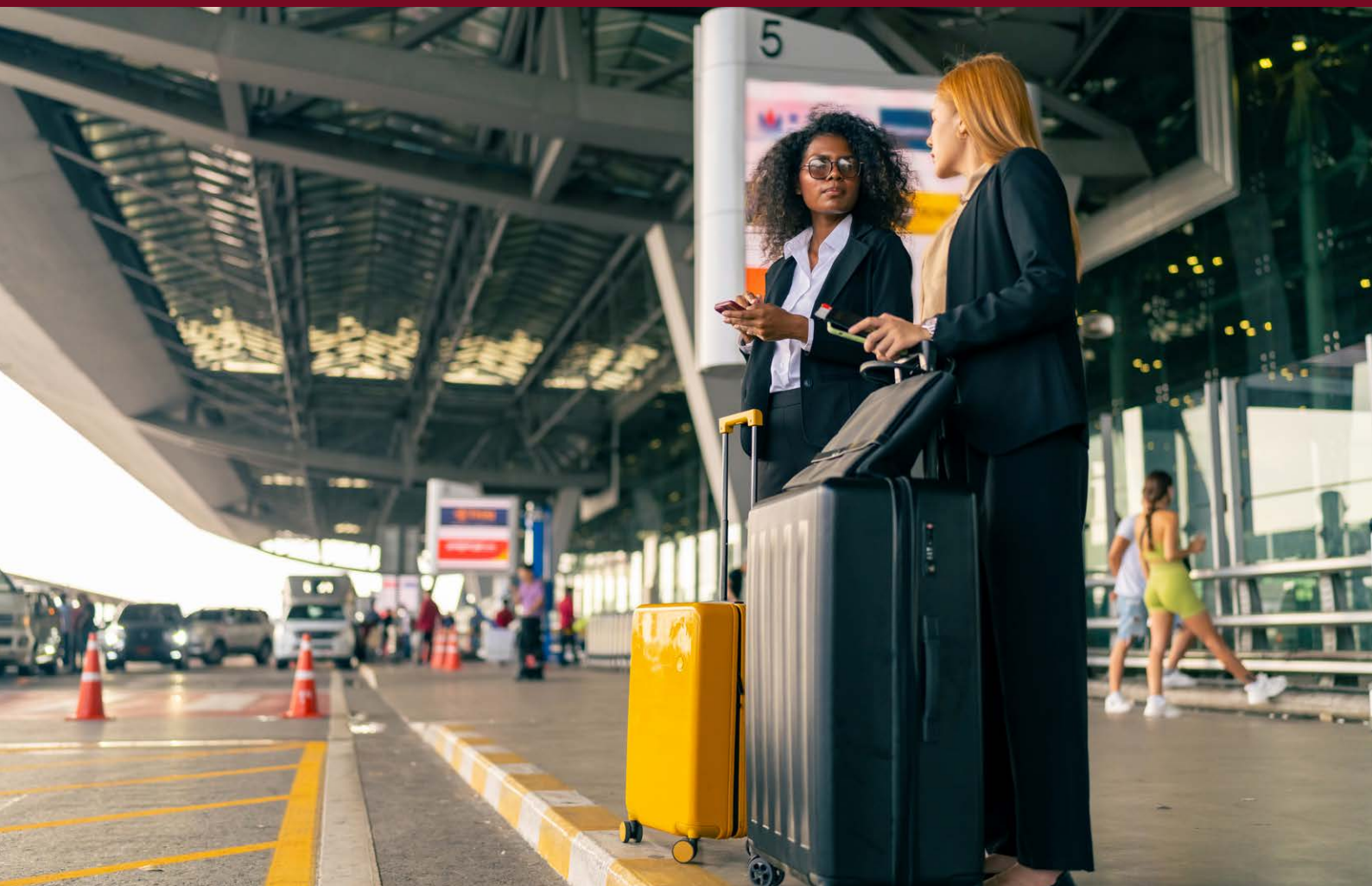


Table 2 provides an overview of operational restrictions known to GSMA, including voluntary measures such as those in the US. Protection zones adjacent to airport runways may vary in configuration, and the data presented is intended as an approximate reference.

Table 2:
Countries with 5G operation restrictions in 3.3-4.1 GHz

Country	Frequency range restricted (MHz)	Protection zones around airports' runways - EIRP limits	Antenna tilt
Australia	3700-4000	Exclusion zone (2570×1440m) - No operation permitted Restricted zone (5630×510m) - 62 dBm/MHz	Below the horizon
Canada	3450-3900	Exclusion zone (1590×756m) - No operation permitted Protection zone low-power (2464×1216m) - 52 dBm/MHz Protection zone mid-power (3170×447m) - 55 dBm/MHz Protection zone higher-power (3740×1082m) - 61 dBm/MHz	Below the horizon
Colombia	3300-3700	Security area (150×150m) - No operation permitted Protection area (910×910m) - 22,3 dBm/MHz Restraint area (2100×910m) - 43 dBm/MHz	Below the horizon
Czech Republic	3600-3800	Safety zone (2100×910m) - No operation permitted Precaution zone (6100×400m) - 55 dBm/MHz	Below the horizon
France	3400-3800	Safety zone (2100×910m) - No operation permitted Precaution zone (6100×400m) - 55 dBm/MHz	Below the horizon
India	3300-3670	Zone 1 (1635×445m) - 38 dBm/MHz Zone 2 (2100×910m) - 50 dBm/MHz Zone 3 (2640×1450m) - 58 dBm/MHz Zone 4 (4000×1450m) - 59 dBm/MHz	Below the horizon
Japan	4000-4100 & 4500-4600	Protection area (1000×200m) - No operation permitted	NA
Saudi Arabia	3800-4000	Exclusion zone (2000×2000m) - No operation permitted Protection zone (6000×6000m) - 45 dBm/MHz	Below the horizon
United States	3700-3980	Coordination zone 1 (914×914m) - No operation permitted Coordination zone 2 (4630×2037m) - 51 dBm/MHz Coordination zone 3 (5556 ×2963m) - 62 dBm/MHz	Limits on skyward radiation

Compatibility Studies



ECC report 362

ECC Report 362, published in November 2024, includes studies of compatibility of radio altimeters (RAs) operating in the 4.2-4.4 GHz band with public 5G mobile networks (referred to as MFCN in CEPT documentation) operating in the 3.4-3.8 GHz band. The studies considered both the effect of blocking of RA receivers by 5G base station transmissions in the adjacent frequency bands, and the effect of unwanted emissions from 5G base stations falling in the 4.2-4.4 GHz band used by radio altimeters.¹⁸

The radio altimeter parameters used in ECC Report 362 are based on measurements for several different RA models of User Category UC1, with Interference Tolerance Thresholds (ITTs) derived from published AVSI Reports for heights of 200 and 1000 feet.¹⁹ 'Parameter Set 1' contains data on a variety of radio altimeter models and is considered by the European Aviation Safety Authority (EASA) -and most CEPT administrations- to be representative of the radio altimeters currently installed on aircraft operating in Europe.²⁰

The European Union Aviation Safety Agency (EASA) has publicly stated that they "consider Parameter Set 1 sufficiently representative of the radio altimeters currently installed in the fleet of aircraft operating in EU airspace for the determination whether any regulatory action would be required to ensure safety". Also, on the potential risk of interference from 5G ground stations "EASA has not identified conclusive evidence of an unsafe condition due to 5G interference on aircraft radio altimeters in EU airspace".²¹

For 5G networks (MFCN) operating in the 3.4-3.8 GHz band, the results of all studies for unwanted emissions show sufficient margins (covering at least the 6 dB ICAO safety margin). Studies of potential blocking of RA receivers using Parameter Set 1 also show sufficient margins (covering at least the 6 dB safety margin).

The vast majority of countries in Europe are not planning any restrictions for MFCN in addition to those from the general airport Obstacle Limitation Surface, the function of which is to avoid having physical objects in places where aircraft are landing.²²



¹⁸ [ECC Report 362](#), CEPT, 2024.

¹⁹ User Category UC1 refers to types of radio altimeters that are used on larger commercial fixed-wing aircraft.

²⁰ EASA has publicly stated that they "consider Parameter Set 1 sufficiently representative of the radio altimeters currently installed in the fleet of aircraft operating in EU airspace for the determination whether any regulatory action would be required to ensure safety".

²¹ [Safety Information Bulletin](#), EASA, 2023.

²² Obstacle Limitation Surface is a 'surface' above the area surrounding a runway where no 'obstacles' are allowed to penetrate, to protect the safety of aircraft taking off and landing on the runway, defines a 3-dimensional area where no structures (including mobile base stations) are allowed to be constructed (irrespective of any limitations due to RAs).

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

The European Commission has produced a detailed roadmap within an official document including technical, standardisation, regulatory, and deployment activities for both the aviation and telecommunications sectors aimed at establishing key milestones to ensure the safe coexistence of mobile networks and aircraft radio altimeters.

The roadmap looks for a coordinated approach of mobile networks in the 3.4-3.8 GHz band (primary 5G pioneer band), low/medium power (LMP) networks in the 3.8-4.2 GHz band and radio altimeters in 4.2-4.4 GHz. It was developed with input from EU Member States, industry workshops and groups such as EASA, CEPT, EUROCAE and RTCA. The current document is the second version of the roadmap, and some milestones have been delayed. Key activities include:

- An aviation assessment of CEPT studies was completed. Based on ECC Report 362, EASA concluded that there is no justification for a fleet-wide retrofit mandate (Q1 2025).
- An EU Implementing Decision on the harmonised use of the 3.8-4.2 GHz band for LMP networks and ECC guidance in Q4 2025.
- Publishing MOPS (Minimum Operational Performance Standards) for the new generation of radio altimeters, now expected in Q1 2027 (a delayed date).
- Consequent delays in specification and certification of new radio altimeters, with "aircraft equipage with new RA" now not expected until "2030 +".
- EASA has committed to undertake "continuous monitoring of 5G related occurrences and issuance of mandatory action on specific aircraft types or radio altimeters and/or the issuance of non-mandatory guidance" if any incompatibility issue is identified.²³

Mobile industry considerations

ECC Report 362 contains studies of coexistence between radio altimeters and mobile networks in 3.4-3.8 GHz. Within 3.8-4.2 GHz, it is also possible to use high power macro networks across wide areas of a country without interference to altimeters. The frequency range 3980-4200 MHz is also being considered for future IMT auctions in the US. It may be necessary to undertake local coordination and network planning for coexistence around certain airports. Any potential coordination zone for this will depend on local factors, such as the size of the runway, surrounding terrain, position and height of base stations, antenna downtilt, etc.

Findings from additional mobile industry studies, such as those conducted by the Cellular Telecommunication Industry Association (CTIA) in the United States, indicate that "Considering real-world factors, most if not all RAs perform sufficiently well today without modification" and "If necessary, retrofit lower-performing RA installations, and/or design next generation RAs, with custom filters".²⁴

²³ [EU Roadmap WBB-RA Coexistence, European Commission, 2025.](#)

²⁴ [Radio Altimeter Test Report and Coexistence Study, CTIA, 2024.](#)

