International Civil Aviation Organization

SIXTH MEETING OF SPECTRUM REVIEW WORKING GROUP (SRWG/6)

Video Teleconference, 1 – 3 March 2022

Agenda Item 7: State and Regional Updates

5G INTERFERENCE TO AIRCRAFT RADIO ALTIMETERS

(Presented by IATA and The Civil Aviation Authority of Thailand)

SUMMARY

The radio altimeter is the only mandatory sensor onboard aircraft, capable of providing a direct measurement of the clearance height above terrain and obstacles. It sources information that is the main enabler of several safety-critical aircraft functions and systems.

C-band 5G telecommunications systems operating without proper mitigations in the frequency bands adjacent to aircraft radio altimeters have the potential to cause harmful interference to radio altimeters on all types of civil aircraft during any phase of flight - most critically during approach and landing phases. Such interference poses a serious safety risk to aircraft, passengers and crew onboard, and people on the ground.

This paper discusses recent lessons learned concerning the deployment of 5G telecommunication networks and outlines recommendations to mitigate the potential risks to flight safety by 5G deployments.

1. INTRODUCTION

1.1 Critical Roles of Radio (Radar) altimeter onboard aircraft

1.1.1 The radio altimeter is a mandatory safety-critical aircraft system. It is used to determine an aircraft's height above terrain and obstacles. Globally, operating at 4.2-4.4 GHz frequency range, these altimeters are deployed on all types of commercial and general aviation aircraft including helicopters. This altimeter system input is utilized by aircraft systems at or below 2500ft altitude Above Ground Level (AGL).

1.1.2 The information provided by the altimeter is used in many automated landing and collision avoidance systems. Undetected failure of this sensor can therefore lead to catastrophic results whilst false alerts have the potential to undermine trust in the avionics systems.

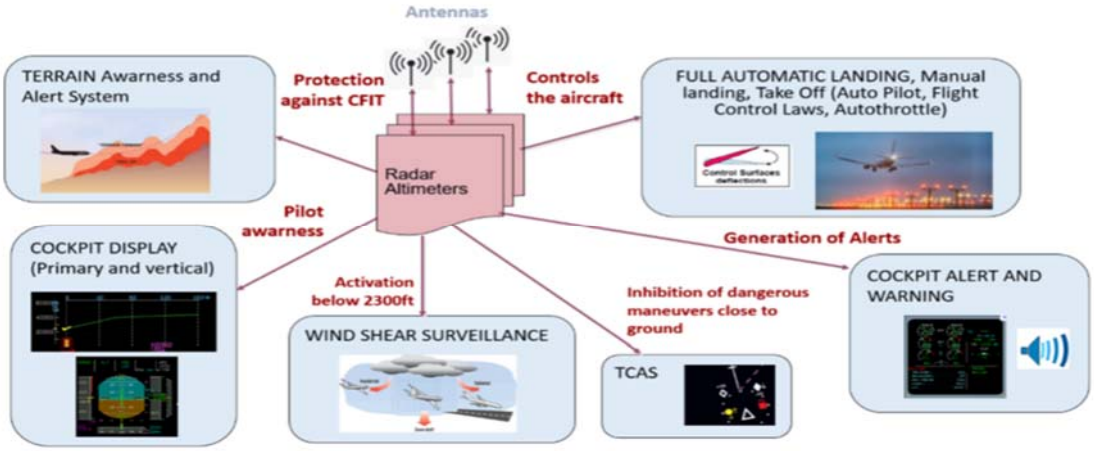

Figure 1: Functions of Aircraft Radio Altimeters

1.1.3 Interference to Radio Altimeter (RA) operations can potentially affect various equipment and systems onboard an aircraft, including

- Autoland functions particularly in low visibility auto approach operation,
- Class A Terrain Awareness Warning Systems (TAWS-A) including Enhanced Ground Proximity Warning Systems (EGPWS)
- Traffic Alert and Collision Avoidance Systems (TCAS II)
- Take-off guidance systems
- Flight Director and Flight Control, including Automatic Flight Guidance and Control Systems (AFGCS) and Primary Flight Display of height above ground
- Tail strike prevention systems
- Windshear detection systems
- Envelope Protection Systems
- Altitude safety call outs/alerts
- Auto-throttle and Thrust reversers
- Stick pusher / stick shaker
- Engine and wing anti-ice systems

1.2 Global summary of 5G deployment proposals

1.2.1 Globally, auctions/proposals for 5G spectrum are being planned/conducted in various countries. Fig. 2 summarizes some of the global 5G deployment proposals being considered (as at the time of writing).

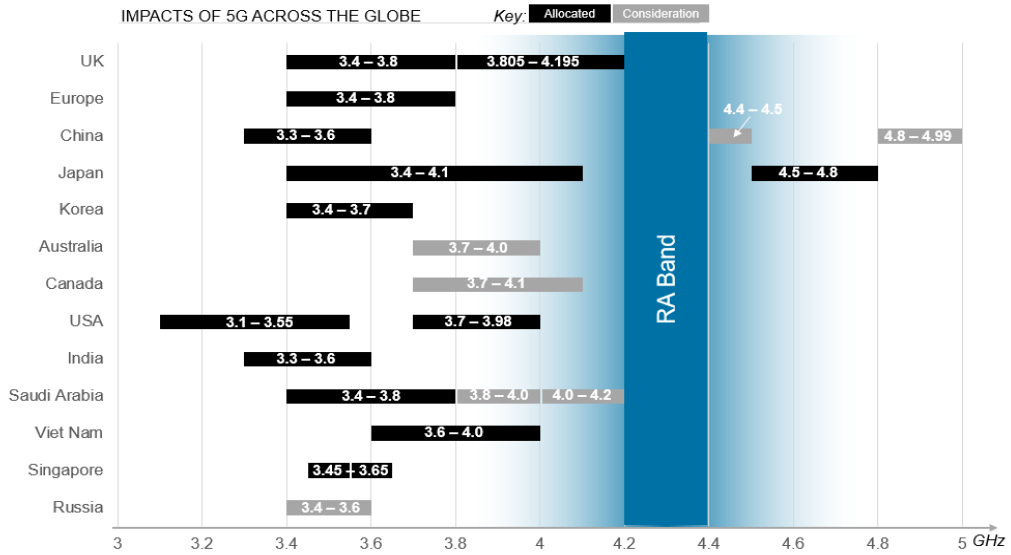

Figure 2: 5G implementations/proposals across the globe

1.2.2 Within each State, decisions regarding spectrum allocation rest fully with each national telecommunication regulator. Adding to the complexity, 5G deployment proposals and associated conditions vary technically from one country to another. The differences can be in terms of which spectrum will be considered for 5G; where the 5G transmitter can be located; and/or the maximum transmitting power the 5G base station can use.

2. DISCUSSION

2.1 **Safety Concerns:** The collective global aviation community has formally recognized and expressed safety concerns arising from the potentially harmful interference to radio altimeters (4.2-4.4 GHz) deployed on all types of civil aircraft that could result from the deployment of 5G telecommunications systems in the adjacent frequency band (3.7–3.98 GHz). Without appropriate mitigation, this harmful interference poses a risk to aviation operations across all ICAO regions, including APAC.

Below are some of the concerns expressed:

2.1.1 **ICAO** — In ICAO State Letter SP 74/1-21/22 dated 25 March 2021 (ref Appendix-A), the ICAO Secretary General notes that *harmful interference to the function of the radio altimeter during any phase of flight may pose a serious safety risk to passengers, crew and people on the ground" and encourages "Administration[s] to consider as a priority, public and aviation safety when deciding how to enable cellular broadband/5G services in radio frequency bands near the bands used by radio altimeters*.

This was followed up by a State Letter dated 25th January 2022 (ref Appendix-B) from the ICAO NACC Regional Director urging States in the NACC region to carry out evaluations of their operations, especially at international airports, to assess the impact that the implementation of 5G technology may have on operational safety.

2.1.2 **IATA and IFALPA** — In a problem statement endorsed by the ICAO Flight Operations Panel, IATA and IFALPA jointly stated that *the radar altimeter is one of the most critical components to an aircraft's operations; and the only sensor onboard an aircraft providing a direct measurement of the aircraft's clearance over the terrain or other obstacles. This information is the most critical information in many automated landing and collision avoidance systems. Undetected failure of this sensor can*

therefore lead to catastrophic results; and false alarms have the potential to undermine trust in the avionics systems.

2.1.3 **RTCA —** Results presented in the recent Radio Technical Commission for Aeronautics (RTCA) paper 'Assessment of C-Band Mobile Telecommunications Interference Impact on Low Range Radar' revealed *a major risk of harmful interference to radar altimeters on all types of civil and commercial aircraft caused by 5G telecommunications systems in the 3.7–3.98 GHz band in a broad range of operational scenarios. This risk is widespread and has the potential for broad impacts to aviation operations, including the possibility of catastrophic failures leading to multiple fatalities. Further, this risk cannot be adequately mitigated by the aviation industry acting alone.*

2.1.4 **FAA —** The FAA stated in its Safety Alert for Operators 21007 dated December 23, 2021 (SAFO 21007) and entitled 'Risk of Potential Adverse Effects on Radio Altimeters when Operating in the Presence of 5G C-Band Interference', that:

> *a wide range of other automated safety systems rely on radio altimeter data whose proper function may also be affected. Anomalous (missing or erroneous) radio altimeter inputs could cause these other systems to operate in an unexpected way during any phase of flight – most critically during takeoff, approach, and landing phases. These anomalous inputs may not be detected by the pilot in time to maintain continued safe flight and landings.*

The SAFO was followed by Special Airworthiness Information Bulletin (SAIB: AIR-21-18R1) detailing the same concerns.

2.1.4.1 Further, the FAA issued **Airworthiness Directive (AD 2021-23-12)** for commercial operators and AD 2021-23-13 for helicopter operators because the agency determined an unsafe condition exists or could develop in transport and commuter category airplanes with a radio altimeter as part of their type design.

The ADs required revising the limitations section of the existing AFM on or before 4 January 2022 to incorporate limitations prohibiting certain operations requiring radio altimeter data when in the presence of 5G C-Band wireless broadband signals as identified by NOTAM.

For air transport aircraft, these limitations concerned Instrument Landing System (ILS) Instrument Approach Procedures (IAP) SA CAT I, SA CAT II, CAT II, and CAT III; Required Navigation Performance (RNP) Procedures with Authorization Required (AR), RNP AR IAP; use of Enhanced Flight Vision System (EFVS) to touchdown; Manual Flight Control Guidance System operations to landing/head-up display (HUD) to touchdown operation and Automatic Landing operations. These limitations could prevent dispatch of flights to certain locations with low visibility and could also result in flight diversions.

2.1.4.2 Additionally, FAA issued addition ADs which contain operational and performance limitations to specific aircraft types. These ADs include AD 2022-02-16, AD 2022-03-05, AD 2022-03-20 and Continued Airworthiness Notification CAN-2022-01.

2.1.5 **Other State Aviation Regulators** – In addition to the United States FAA, other States' aviation regulators including those of Australia, Canada, France, South Africa, Thailand, and the United Arab Emirates have issued similar safety notices and/or ADs recognizing the need to address the safety risk.

2.2 Risk Mitigation Strategies and Next Steps

2.2.1 The ICAO High-Level Conference on COVID-19 (HLCC) recommendation for mitigating the risk of 5G implementation to safety-critical radio altimeter functions notes:

That States:

a) consider, as a priority, public and aviation safety when deciding how to enable cellular broadband/5G services;

b) consult with aviation safety regulators, subject matter experts and airspace users, to provide all necessary considerations and regulatory measures to ensure that incumbent aviation systems and services are free from harmful interference; and

That ICAO:

c) continue coordinated aviation efforts, particularly at the International Telecommunication Union (ITU), to protect radio frequency spectrum used by aeronautical safety systems.

2.2.2 As a minimum, some actions and regulatory measures need to be taken and put in place to safeguard the use of radio altimeters. Some States have set an example by cooperating with 5G network providers with regards to provision of location information for their stations, as well as details of the transmission characteristics (e.g., antenna radiation patterns, power levels) required.

The measures adopted include:

a) Adequate Buffer Zones: limiting the installation of 5G stations within 2-3 km of the approach ends of runways; declaring 'no-go zones' in the vicinity of airports; establishing permanent buffer zone safeguards.
b) Restricting Transmission Characteristics: limiting 5G transmission power and the angle of antennas, i.e., low power transmission around airports with a downward-looking radiation pattern for 5G transmitting station masts.
c) Timely Assessment: conducting timely surveillance and test flights to proactively ascertain the actual levels of 5G transmissions and potential harmful interference effects.

Figure 3: Examples of Risk Mitigation strategies

2.2.3 The following examples describes specific mitigations that various States through their telecommunication regulators have put in place to support safe deployment of 5G telecommunications in C-band:

- In **Japan**, the macro cell power levels are only 4% of that permitted in the United States and the small cell power levels are less than 1% of that permitted in the United States.
- In **Europe**, the spectrum is in the 3.4GHz to 3.8GHz range, a significant difference. The power levels permitted in most of Europe are 23% less than those permitted in the United States.

- **Australia's** 5G operates even farther away from the radio frequency band used by radio altimeters. The power levels permitted in Australia are 76% lower than those allowed in the United States.
- **Canada** introduced exclusion zones on an interim basis. 5G C-band antennas also have a national down-tilt requirement.

2.2.1 While the aviation community understands the economic importance of making spectrum available to support next generation commercial telecommunication systems, we insist that maintaining current safety levels for aircraft, passengers and flight crews must be States'/governments' highest priority.

Before deciding on spectrum allocation for 5G or conducting spectrum auctions for 5G particularly in C-band, States should ensure that every frequency allocation/assignment is comprehensively studied and is well proven not to adversely impact aviation safety and efficiency.

Robust testing in coordination with aviation safety regulators and aviation subject matter experts is critically important in providing necessary information.

Failures to mutually and positively engage in interagency and inter-industry dialogue between aviation and telecommunication regulators and stakeholders have resulted in increasing safety risks for aviation, flight cancellations and operational interruptions and uncertainties for airlines – negatively affecting passenger and cargo flows.

States must therefore provide necessary leadership and act as a fair facilitator to ensure open and positive information sharing between the two industries and national aviation and telecommunication regulators, so that mutually agreed conditions and measures for safe co-existence between aviation and 5G can be established and codified in appropriate national laws and regulations.

3. Action by the meeting

3.1 The meeting is invited to:

a) Review and acknowledge the safety concerns and potential operational impacts of 5G telecommunication system deployment, and in this regard:

I. Consider incorporating "C-Band mobile telecommunications interference impact on aviation operations" into the TORs of the SRWG;
II. Request ICAO APAC office to consider issuing a State letter to the region's States in a similar manner to the NACC letter referenced in section 2; and
III. As detailed in section 2.2, consider adopting actions taken by some States to mitigate 5G interference and suggest additional actions as necessary and appropriate.

b) Request ANSPs and aviation safety regulators to brief relevant government and telecommunication regulatory/management agencies about the potential impact of 5G deployment on aviation safety, and propose necessary provisions for the spectrum auctioning/allotting process that will ensure the radio altimeter frequency is free from harmful interference at and around airports.

c) Discuss and consider the draft conclusion below:

<table>
<tr><td colspan="3">Draft Conclusion SRWG/6/X - 5G Interference to Aircraft Radio Altimeters</td></tr>
<tr><td colspan="2">What: In line with Article 4.10 of the International Telecommunication Union (ITU) Radio Regulation; prior to allotting / auctioning the C-band spectrum that can cause interference to the aircraft radio altimeters (that operate in the 4.2 to 4.4 GHz range); States are urged to:
Carry out evaluations of operations, especially around international airports, to assess the impact that the implementation of 5G technology in C-band may have on operational safety, in order to maintain current levels of safety for aircraft, passengers and flight crews and to ensure uninterrupted flight operations; and to make suitable provisions for:
- Adequate buffer zones around airports and runways;
- Sufficient spectrum separation between 5G C-band deployments and 4.2-4.4 GHz frequency band used by existing radio altimeters
- Restricting transmission characteristics, including antenna patterns and maximum power limit, to ensure safeguarding of potential interference to aircraft radio altimeters.</td><td>Expected impact:
☒ Political / Global
☐ Inter-regional
☐ Economic
☐ Environmental
☒ Ops/Technical</td></tr>
<tr><td>Why: To safeguard functioning of aircraft radio altimeter from potential interference due to 5G signals</td><td colspan="2">Follow-up: ☒Required from States</td></tr>
<tr><td>When: 3-Feb-22</td><td colspan="2">Status: Draft to be adopted by PIRG</td></tr>
<tr><td colspan="3">Who: ☒Sub-groups ☒APAC States ☐ICAO APAC RO ☐ICAO HQ ☐Other: XXXX</td></tr>
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Tel.: +1 514-954-8219 ext. 7130

25 March 2021

Ref.: SP 74/1-21/22

Subject: Potential safety concerns regarding interference to radio altimeters

Action required: As indicated in paragraph 5

Sir/Madam,

1. I have the honour to bring your attention to an ongoing initiative by the International Civil Aviation Organization (ICAO) to ensure continued public and aviation safety.

2. During recent meetings of ICAO experts, concerns about interference to radio altimeters on-board aircraft have been raised. A number of administrations are currently considering or have already begun deploying new cellular broadband technologies (such as 5G) in the frequency bands close to the radio altimeter's frequencies of operation (4.2-4.4 GHz), a critical aviation safety system. The international aviation industry has noted with concern that these broadband technologies may cause harmful interference to radio altimeters.

3. The radio altimeter[1] is a mandated critical aircraft safety system used to determine an aircraft's height above terrain. Its information is essential to enable several safety related flight operations and navigation functions on all commercial aircraft as well as a wide range of other civil aircraft. Such functions and systems include terrain awareness, aircraft collision avoidance, wind shear detection, flight controls, and functions to automatically land an aircraft. If not properly mitigated[2], harmful interference to the function of the radio altimeter during any phase of flight may pose a serious safety risk to passengers, crew and people on the ground.

4. ICAO has received studies from several States and organizations regarding the interference potential to radio altimeters[3]. These studies generally conclude that some radio altimeters will be impacted

[1] In some aviation publications it is also known as the radar altimeter or Low Range Radar Altimeter.

[2] General guidance on Interference Protection Considerations can be found in Chapter 9 of the *Handbook on Radio Frequency Spectrum Requirements for Civil Aviation – ICAO spectrum strategy, policy statements and related information* (Doc 9718, Volume I)

[3] Report by RTCA – https://www.icao.int/safety/FSMP/MeetingDocs/FSMP%20WG11/IP/FSMP-WG11-IP07_RTCA_Report.docx

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if high power cellular systems are implemented near the frequency band used by radio altimeters. Several States have already implemented temporary technical, regulatory and operational mitigations on new 5G systems in order to protect radio altimeters while more permanent solutions are being devised[4].

5. I encourage you and your Administration to consider as a priority, public and aviation safety when deciding how to enable cellular broadband/5G services in radio frequency bands near the bands used by radio altimeters.

Accept, Sir/Madam, the assurances of my highest consideration.

Fang Liu
Secretary General

[3] Report of Australian national study (*IP03 WG/10 meeting – ACMA options consultation meeting*) – https://www.icao.int/safety/FSMP/MeetingDocs/FSMP%20WG11/WP/FSMP-WG11-WP13_Status%20on%20replanning%20the%203700-4200%20MHz%20band%20in%20Australia.doc

[3] Report of Japanese national study and mitigations - https://www.icao.int/safety/FSMP/MeetingDocs/FSMP%20WG11/WP/FSMP-WG11-WP30_5GJapan.docx

[3] Report of UK CAA study – https://www.icao.int/safety/FSMP/MeetingDocs/FSMP%20WG11/WP/FSMP-WG11-WP27_Mobile%20vs%20Radalt%20REv.1.docx

[3] Report of French national mitigations - https://www.icao.int/safety/FSMP/MeetingDocs/FSMP%20WG11/IP/FSMP-WG11-IP03_5G%20vs%20RA%20Actions%20taken%20in%20France%20to%20mitigate%20interference_r1.doc

[4] For example, ICAO has been informed of longer-term work being initiated by several aviation standard-making organizations to update radio altimeter standards. Part of that update will include improved tolerance of interference.

When replying please quote:
Ref.: NT- N1–3; NT-NE24–4 — **E.OSG-NACC91959** 25 January 2022

To: States, Territories and International Organizations

Subject: **Potential safety concerns regarding interference to radio altimeters**

Action Required: **To note and carry out suitable actions to mitigate safety concerns**

Dear Sir/Madam,

During the NAM/CAR/SAM Workshop on the ICAO Position for the International Telecommunication Union (ITU) World Radiocommunication Conference (2023) (WRC-23) held online in October 2021, said position for the protection of aeronautical frequencies that must be supported by all States to ensure that the frequencies necessary for civil aviation operations are available and protected for use was presented.

The event also addressed the issue of "Potential safety concerns regarding interference to radio altimeters". These potential problems are due to the implementation of 5G technology worldwide. Radio altimeters operate in the 4.2-4.4GHz frequency, they are sensors on board aircraft which provide a direct measurement of the free height of the aircraft above the ground or other obstacles.

There is a high 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 and regional transport aircraft, and transport and general aviation helicopters. If not properly mitigated, this risk has the potential to cause wide-ranging impacts to aviation operations as 5G telecommunications are being deployed alongside the 4.2-4.4 GHz frequency band.

During the aforementioned workshop, States were urged to carry out evaluations of their operations, especially at international airports, to assess the impact that the implementation of 5G technology may have on operational safety. The event report can be consulted at the following link: https://www.icao.int/NACC/Pages/meetings-2021-cmr23.aspx

Due to the aforementioned, States are invited to consider this issue promptly, carry out the corresponding analyses of their operations, work together with telecommunications companies and airlines to develop, as soon as possible, the necessary mitigation mechanisms to avoid a decrease in safety.

.../2

The ICAO State Letter 21/22, "Potential Safety Concerns Regarding Interference to Radio Altimeters" is **attached.**

If you have further questions and need more details on this topic, you may contact Mrs. Mayda Avila (mavila@icao.int), Communications, Navigation and Surveillance (CNS) Regional Officer and/or Mr. Gabriel Gutierrez (ggutierrez@icao.int), Assistant.

Accept, Sir/Madam, the assurances of my highest consideration.

Melvin Cintron
Regional Director
North American, Central American and
Caribbean (NACC) Regional Office

Enclosure: *As indicated*

N:\NE - External Relations\NE 24-4 - Relations with ITU-UIT-WRC\Correspondence\NACC91959CNS-STATES-PotentialConcernRadioaltimeters5G.docx / GGS

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ATTACHMENT

2021-01-19 LJ

Radio Altimeter and 5G issues

Ref: ICAO SL 21/22, "*Potential safety concerns regarding interference to radio altimeters*", issued 25 March 2021 – and references contained therein.

1. Radio Altimeters (RA) are a mandated critical aircraft safety system used to determine an aircraft's height above terrain. The technical performance of the RA, including receive mask and interference resilience, is currently not standardized by ICAO. There are currently no applicable industry standards either describing those characteristics.

2. The RA operate at 4200-4400 MHz, in a portion of a frequency range often designated as the "C-band". The frequency bands adjacent to the RA band, have traditionally been "quiet" until the recent 5G rollout in the "C-band". The adjacent bands were previously mainly used for downlinks from geostationary satellites.

3. The information from the RA is an essential enabler for several safety related flight operations and navigation functions on all commercial aircraft as well as a wide range of other civil aircraft. Functions include terrain awareness, aircraft collision avoidance, wind shear detection and flight controls, functions to automatically land an aircraft including auto throttle and thrust reversers.

4. If not properly mitigated, harmful interference from 5G will pose a serious safety risk. Safety net systems subject to interference by 5G such as the ground proximity warning system will become unreliable. These systems were introduced to avoid accidents based on lessons learned from previous ones. The unreliability of these systems defeats their purpose and poses a serious safety risk. Additionally, if the mitigations taken will result in operation of RA being prohibited at certain airports, then this would infer the necessary shutdown of those airports during foul weather (i.e. Instrument Flight Rules) conditions, which in turn could lead to widespread disruptions.

5. Studies from several States and organizations indicate the potential for harmful interference to RA if high powered base stations are implemented near the frequency band used by the RA and at distances close to airports/runways.

6. Industry studies cataloging the interference susceptibility of various RA types are still ongoing. While some RA typically used in helicopters, general aviation and business aircraft appear to be more vulnerable to interference, other RA, more often found in commercial aircraft appear to be less susceptible to potential interference from 5G.

7. The 5G rollout strategies in different States are different in terms of key parameters such as how close the frequency band used is to the RA frequency band and the total transmitting power of the base stations. Hence the mitigatory strategies taken will need to be tailored to each specific situation.

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8. The current situation in the United States is not directly comparable to that of the current rollout taking place within some European States, in that the "typical" 5G base stations being rolled out in the United States operate in a frequency band closer to the RA band and may transmit at power levels which are up to an order of magnitude higher. The Federal Aviation Administration (FAA) of the United States has issued a Safety Alert for Operators and Airworthiness Directives on the issue.

9. ICAO and industry standards are under development for the "future" RA, focusing especially on the interference environment. This however will be a longer-term solution.

10. To estimate the scope of potential RA replacements required, "one major air transport manufacturer representing approximately half of air transport sector, reports approximately 15,000 airplanes in service. There are three groups of altimeters operating on those airplanes, roughly representing three generations of RA equipment. All three groups were included in RA testing for the Radio Technical Commission for Aeronautics (RTCA) 2020 report. One group is represented by the RTCA 2020 report interference threshold and represents roughly 3000 airplanes. A second group performs somewhat better and is operating on 7000 airplanes. Finally, the third group is significantly more robust on the remaining 5000 airplanes. If only the most robust group of altimeters can meet the updated standard, then 10,000 aircraft will need to replace altimeters at an estimated cost of several billion dollars." (Ref FSMP WG/12, 4-15 Oct 2021, WP/17 – presented by the International Coordinating Council of Aerospace Industries Associations - ICCAIA)

11. Several States have already implemented temporary technical, regulatory and operational mitigations on new 5G systems in order to protect the RA while more permanent solutions are being devised.

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