ELEVENTH MEETING OF THE REGIONAL AVIATION SAFETY GROUP - ASIA AND PACIFIC REGIONS (RASG-APAC/11)

(Video Teleconference, 25-26 November 2021 at 10:00-13:00 hrs. Bangkok Time, UTC+7)

Agenda Item 4: ICAO / Member State / Industry Presentations

POTENTIAL IMPACTS FROM 5G IMPLEMENTATION ON AIRCRAFT RADIO ALTIMETERS – OUTCOMES FROM CNS SG/25 MEETING

(Presented by the Secretariat)

SUMMARY

This paper presents the discussion in the 25th Meeting of the Communications, Navigation and Surveillance Sub-group of APANPIRG (CNS SG/25) and its contributory bodies about 5G implementation and potential impacts on aircraft radio altimeters.

1. INTRODUCTION

1.1 The concerns about potential interference to radio altimeters onboard aircraft due to implementation of new cellular broadband technologies, such as 5G, in the frequency bands close to the radio altimeter's frequencies of operation have been identified in several ICAO global meetings.

1.2 The radio altimeter is a mandated critical aircraft safety system used to determine an aircraft's height above terrain. Critical functions and systems that rely on radio altimeters include terrain awareness, aircraft collision avoidance, wind shear detection, and automatic landing, etc.

1.3 While such interference was reported mainly in USA and Europe, the ICAO APAC Office was informed through the ICAO Frequency Spectrum Management Panel (FSMP) and presented to the ITU Regional Radiocommunication Seminar 2020 for Asia & Pacific in October 2020.

1.4 In APAC, the Spectrum Review Working Group (SRWG), a contributory body of the Communications, Navigation and Surveillance Sub-group of APANPIRG (CNS SG) held its Fifth Meeting (SRWG/5) from 15 to 17 March 2021. The report and papers of SRWG/5 are available at:
https://www.icao.int/APAC/Meetings/Pages/2020-SRWG5.aspx.

1.5 The 25th Meeting of CNS SG (CNS SG/25) held from 18 to 22 October 2021 reviewed the outcomes of SRWG/5 and made further elaborations on the issue, including the State Letter issued by ICAO Headquarters on 25 March 2021 to address potential safety concerns regarding interference to radio altimeters. The report and papers of CNS SG/25 are available at:
https://www.icao.int/APAC/Meetings/Pages/2021-CNS-SG-25.aspx

2. DISCUSSION

2.1 The concerns about potential interference to radio altimeters onboard aircraft due to implementation of new cellular broadband technologies, including 5G, in the frequency bands close to the radio altimeter's frequencies of operation have been identified in several ICAO global meetings. The issue has been one of the major discussion items of the ICAO FSMP.

2.2 IATA and IFALPA issued a *Problem statement - 5G interference with radio (radar) altimeter frequency band* in November 2020 which was endorsed by the 7th Meeting of ICAO Flight Operations Panel (FLTOPSP/7) stating that "The (radio) altimeter is one of the most critical components to an aircraft's operations; and the only sensor on-board an aircraft providing a direct measurement of the aircraft's clearance over the terrain or other obstacles. This information is the most critical 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", and the Statement suggested certain mitigation measures based on experience from France and other States. The Statement is provided in **Appendix A** to this paper.

2.3 In SRWG/5, France presented WP/08 on the *Actions Taken in France to Mitigate Interference into The Radio Altimeters Systems from 5G/MFCN in the band 3.4-3.8 GHz*. The paper mentioned that in June 2020, ICAO Headquarters was brought the attention by the FSMP members a Liaison Statement [1]informing the Electronics Communication Committee (ECC) about the issue of potential interference to aeronautical Radio Altimeters operating in the 4.2 – 4.4 GHz frequency band, caused by International Mobile Telecommunications (IMT) systems currently operating or planned to operate in the frequency band 3.4 – 3.8 GHz in Europe. The RTCA Report SC-239[2] published in October 2020 raised another risk from MFCN (5G in the band 3.7-3.98 GHz) into some radio altimeters, confirming the risk of harmful interference to radio altimeters. DGAC (French Civil Aviation) and the French Aeronautical and Space Industries Group (GIFAS) considered that there is a need to have a more thorough assessment of the risk of 5G interference in the frequency band 3.4-3.8 GHz. Taking into account the additional concerns expressed by DGAC on the basis of the RTCA Report, some immediate measures have been defined in France until the issue can be more thoroughly studied.

2.4 Three immediate preliminary measures have been implemented as phase one risk mitigation since November 2020 for the protection of radio altimeters. It included that 5G operators must implement only downward tilt, and they must take measures to avoid grating lobes as far as practicable, and special protection zones applied to all IFR aerodromes and some helicopter platforms. Details of these three measures were explained in the paper. In phase two risk mitigation from February 2021, it was decided to limit applications of mitigation techniques only to the airport with runway CAT II or/and CAT III, also to heliports identified. The negative tilt remains applicable to all base stations until practical tests showing there is no risk for them. DGAC established an OPS directive or safety information for the attention of French companies flying abroad. EASA, EUROCONTROL and DGAC will collaborate together on this topic. A virtual workshop "5G – Potential interference on Low Range Radio Altimeters" was organized on 25 February 2021. Besides, as a further step in phase two mitigation, DGAC plan to attend PT1 and EASA Workshop. In collaboration with the ANFR, Airbus, mobile operators and DGAC, flight tests are under study to measure and record the 5G signal received at the aircraft level. The European Radio Regulators agreed to establish a draft Working Item that calls for compatibility studies between 5G in the 3.4 – 3.8 GHz frequency range with radio altimeters in the 4.2 – 4.4 GHz frequency band.

2.5 In SRWG/5, Boeing Australia also presented IP/03 on *Protection of interference to radio altimeters from 5G applications in the Asia-pacific.* The paper mentioned the protection actions taken in APAC and other States as examples. Australian spectrum regulators proposed their re-planning of the 3.7 – 4.2 GHz frequency range. EASA published a Continuation Airworthiness Review Item (CARI) 'Investigation into vulnerability of Radio Altimeter to interference from 5G Telecommunications Base Stations.' The New Zealand Civil Aviation Authority released a safety message to operators on 17 November 2020 'Do not use 5G devices inflight if you have a radar altimeter'. The Canadian regulator, Innovation, Science and Economic Development (ISED) proposes

[1] https://www.icao.int/safety/FSMP/MeetingDocs/FSMP%20WG10/WP/FSMP-WG10-WP13-Annex%202%20-%20ECC_PT1_66th_meeting%20-%20ICAO%20Input%20on%20Radioaltimeters%20vs%205G.docx

[2] RTCA, "Assessment of C-Band Mobile Telecommunications Interference on Low Range Radar Altimeter Operations," RTCA Paper No. 258-20/SC239-006 (rel. Sept. 18, 2020). Available from: https://www.rtca.org/wp-content/uploads/2020/10/SC-239-5G-Interference-Assessment-Report_274-20-PMC-2073_accepted_changes.pdf

to allow terrestrial 5G up to 3.98 GHz and then apply a 220 MHz separation band to protect radio altimeters. The General Civil Aviation Authority (GCAA), United Arab Emirates (UAE) published Safety Alert 2021-01, Requirements to mitigate 5G Interference Operational Risks. Boeing Stated that it is a global issue and consequently necessary to address this risk for the Asia-Pacific region. Boeing asked the cooperation of ICAO Asia-Pacific administrations in the dissemination of the information to support airworthiness authorities and inform operators with respect to the impact of this issue. ICAO regional administrations are encouraged to work with respective national spectrum regulators to build awareness, recommend temporary precautionary mitigation measures and collaborate with 5G operators to share technical characteristics and consider adoption of temporary limitations. ICAO APAC Regional Office was requested to take necessary follow up action at the regional level, to support CAAs working with State's spectrum regulators to avoid future safety issues on radio altimeter due to 5G implementation.

2.6 On 25 March 2021, ICAO Headquarters issued a state letter with the **Subject**: *Potential safety concerns regarding interference to radio altimeters (Ref.: SP 74/1-21/22)*, the Member States and Administrations are encouraged 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. The state letter is provided in **Appendix B** to this paper.

2.7 In CNS SG/25, Australia presented IP/12 on the *status of activity in Australia to address the potential impact of deployment of wireless broadband services in the 3.4 to 4.0 GHz band on Aviation safety*. The meeting was informed that Australia through Australian Communications & Media Authority (ACMA) is consulting with stakeholders on the re-planning the use of Spectrum in the 3.7 – 4.0 GHz bands for principally the deployment of wireless broadband (WBB) services including 5G. Australian aviation stakeholders with the representation of Civil Aviation Safety Authority, Airservices Australia, Department of Defence, NSW Police, Qantas Airways, Virgin Australia and Boeing Australia have an informal radio altimeter coordination group (RA-CG) to provide the considered and coordinated views of Australian aviation stakeholders and made ACMA aware of potential impacts to the safety of operation of radio altimeter and associated aircraft systems with reference to international studies and mitigations.

2.8 Hong Kong China shared their experience and the established mechanism in handling potential interference to radio altimeters caused by 5G implementation. They have notified relevant aircraft operators through the issuance of "Flight Operations Notice" in April 2021 and has requested their vigilance on the possible interference on radio altimeter during any phase of flight, and report any relevant anomalies to the Civil Aviation Department of Hong Kong China. Moreover, a working group, with members of CAD, Airport Authority Hong Kong and Office of the Communications Authority, has been established to keep in view of the situation as well as to coordinate the implementation of 5G at the Hong Kong International Airport.

2.9 To alleviate the discussion on the issue during CNS SG/25, the ICAO Secretariat presented IP/06 on *5G Implementation and Potential Impacts on Aircraft Radio Altimeters summarizing* the discussion from SRWG/5 and the background in APAC.

2.10 CNS Section of ICAO APAC Regional Office has received ZERO report on such interference in radio altimeter from the Member States or IATA so far. However, the CNS SG/25 agreed that Member States would keep an eye on monitoring the impact of 5G on radio altimeters in their States/Administration with reference to the safety and frequency spectrum issues. In parallel, it was advised that Member States CAA and airworthiness office may collect all relevant information and past issues reported, if any, and inform RASG-APAC in case of any significant concern. The issues related to frequency spectrum may be brought to the attention of CNS section of the ICAO APAC Office for further coordination with RASG-APAC and ICAO Headquarters.

2.11 For reference, detailed discussions on the issue of potential interference to radio altimeter due to implementation of new cellular broadband technologies could be found on the FSMP website at https://www.icao.int/safety/FSMP/Pages/default.aspx, in particular, meeting materials and reports from FSMP WG/11 and WG/12 meetings.

3. ACTION BY THE MEETING

3.1 The Meeting is invited to:

a) note with concern on the information in this paper and in the **Appendix A and Appendix B**;

b) report to the relevant contributory bodies of the ICAO RASG-APAC in a timely manner for events on interference to radio altimeters; and

c) discuss any relevant matter as appropriate.

— — — — — — — —

Problem statement - 5G interference with radio (radar) altimeter frequency band

Reference

Problem statement and industry response to the ICAO FLTOPSP/7 information paper IP03 "5G frequency interference" and agenda item 5.4 "5G interference"

Introduction

Radio (radar) altimeters (RA), operating at 4.2-4.4 GHz, are the only sensors onboard a civil aircraft which provide a direct measurement of the clearance height of the aircraft over the terrain or other obstacles (i.e. the Above Ground Level - AGL - information).

The RA systems' input is required and used by many aircraft systems when AGL is below 2500 ft. Any failures or interruptions of these sensors can therefore lead to incidents with catastrophic outcome, potentially resulting in multiple fatalities. The radar altimeters also play a crucial role in providing situational awareness to the flight crew. The measurements from the radar altimeters are also used by Automatic Flight Guidance and Control Systems (AFGCS) during instrument approaches, and to control the display of information from other systems, such as Predictive Wind Shear (PWS), the Engine-Indicating and Crew-Alerting System (EICAS), and Electronic Centralized Aircraft Monitoring (ECAM) systems, to the flight crew.

There is a major risk that 5G telecommunications systems in the adjacent frequency bands to radio altimeters, including 3.7–3.98 GHz, will cause harmful interference to radio altimeters on all types of civil aircraft—including commercial transport airplanes; business, regional, and general aviation airplanes; and both transport and general aviation helicopters. If there is no proper mitigation, this risk has the potential for broad impacts to aviation operations in the United States as well as in other regions where the 5G network is being implemented close to the 4.2-4.4 GHz frequency band.

An example listed further below shows, that the identified risk has materialized during certain airline operations impacted by similar interference.

List of potential equipment failures

Interference to RA operations can affect:

1. **Autoland functions**:
   This is particularly critical in low visibility auto approach like Cat II or III conditions. Pilots cannot conduct CAT II and III approaches if RA is malfunctioning.

2. **EICAS/ECAM:**
   Nuisance and potentially misleading warnings after take-off or during approach which will distract crew from their tasks at hand. This will lead to deterioration of operational safety levels.

3. **False or missing GPWS alert:**
   Anywhere in proximity to ground, this could inhibit some functionalities of the TAWS (Terrain Alerting Warning System) reactive modes which would remove a safety net in case against CFIT (Controlled Flight Into Terrain).
   Additional distractions for crews from tasks at hand, – "too low gear" and "too low flaps", "don't sink"," terrain and pull up warning" and other alerts.
   A big concern is GPWS not triggering an alert when it should have done so, because of interference which can result in CFIT event!

4. **Unreliable instrument Indications:**
   This could contribute to an increased number of hard landings because of errors in automatic altitude indications and voice announcements.

5. **Abnormal behaviours in Automatic Flight Systems:**
   a. Autoland system
   b. Flight Control Laws (e.g. failure to transition to Flare law resulting in a higher than expected pitch on the flare; Retard function, etc.)
   c. Auto-throttle automatic stall protection.
   d. Auto Speed-brake deployment

Most low-visibility operations are predicated on aircraft reaching decision-height (DH) which is determined using radio altimeter While the USA does permit some Cat II approaches with barometric DH; the EU does not. All Cat III approach procedures and consequent auto-land are predicated on RA-provided DH. In particular, the flare logic is completely dependent on input from the radio altimeter. Consequently, any disruption to the signal close to the ground could easily cause a crash.

For approach and landing operations which are flown with auto-throttle engaged, erroneous commands could cause the auto-thrust to retard the power too early, which could result in low energy state close to the ground. That is particularly concerning for Airbus aircraft which do not have moving thrust levers.

EGPWS is predicated on use of radio altimeter. Erroneous information could either cause false pull-up warnings, which is undesirable, or no warning when one would otherwise be required, which could be catastrophic. Similarly, Predictive Wind-Shear (PWS) detection also uses RA input. The PWS will only provide guidance up to a certain height above an airfield, so incorrect information could result in wrong PWS commands.

Likewise, TCAS Resolution Advisories are inhibited below 900 feet AAL. Since the normalised rate of TCAS Resolution Advisories is an order of magnitude higher in the USA than anywhere else in the world, failure of the TCAS Resolution Advisories logic would result in an increase in the possibility of mid-air collision.

Example of an actual autopilot failure due to radio altimeter frequency interference

During the “iron dome” activations near Tel Aviv airport, one airline experienced several radar altimeter interference events which resulted in either inappropriate activations of EGPWS terrain warnings or an autopilot landing flare manoeuvre being erroneously activated at around 1500 feet above ground level. Had the flight crews not disengaged the autopilot and taken control of the aircraft manually during the erroneous activation of the autopilot flare manoeuvre at these altitudes, there would have been a high probability of the loss of the aircraft due to having insufficient altitude to recover from the resulting stall.

Even though this example was caused by jamming devices, it is nevertheless very possible that similar impacts on aircraft could be observed when the failures were caused by other interference sources. Ultimately, the onboard equipment reacts the same, no matter what the source of the interference is.

Example of actual erroneous indications of a radio altimeter due to 2- and 3G stations

A presentation provided to the ICAO Frequency Spectrum Management panel contained an example where a 2G and 3G radio station located directly under the final approach part caused erroneous Radar Altimeter indications of approximately 1000 ft. (Source: ICAO FSMP WG/11 IP/06)

Mitigations:

As a minimum, some actions and regulatory measures need to be taken and put in place in order to safeguard the use of Radar Altimeters. France, and other States, have set an example by

> limiting the installation of 5G stations within 2 km of the approach ends of runways

> prescribing a downward-looking radiation pattern for 5G transmitting stations in general

> considering surveillance and test flights in order to ascertain the actual levels of 5G transmissions and potential harmful interference effects

For such efforts to be effective, transparency and cooperation from 5G network operators 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) will be required. It is our IATA and IFALPA position that 5G Telecom providers should be required to provide accurate and comprehensive information to the aviation authorities to enable them to assure safety of air navigation.

Conclusion:

Radio altimeters are deployed on tens of thousands of commercial and general aviation aircraft as well as helicopters worldwide. The 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.

International Civil Aviation Organization | Organisation de l'aviation civile internationale | Organización de Aviación Civil Internacional | Международная организация гражданской авиации | منظمة الطيران المدني الدولي | 国际民用航空组织

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

999 Robert-Bourassa Boulevard
Montréal, Quebec
Canada H3C 5H7
Tel.: +1 514-954-8219
Fax: +1 514-954-6077
Email: icaohq@icao.int
www.icao.int

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 (*IP 03 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.