Agenda Item 5: MIDANPIRG Work Programme
5.8 CNS

Protecting Radio Altimeter Operations Electromagnetic Compatibility (EMC) related to 5G

Presented by Saudi Arabia

The purpose of this presentation/paper is to share information on the deployment of 5G services and related safety concern that was subject of ICAO State Letter inviting States 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 action by the meeting is given in the last slide of this presentation.

Radio Altimeter

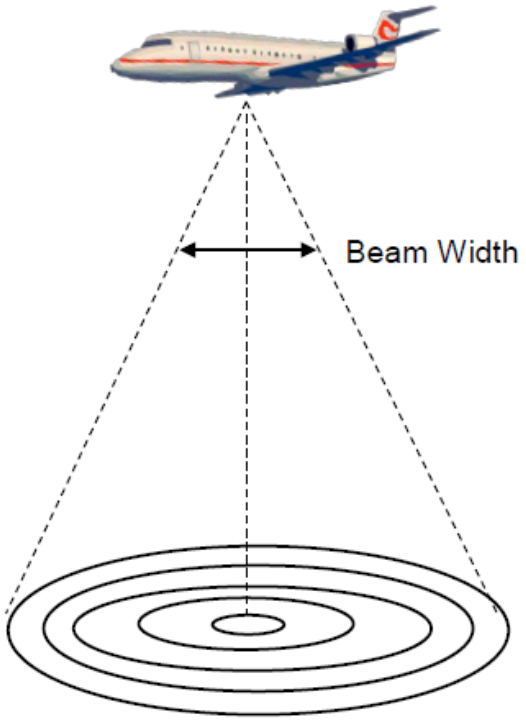
- The band 4 200-4 400 MHz (4.2-4.4 GHz) is currently allocated to the aeronautical radionavigation service (ARNS) and is reserved exclusively for radio altimeters installed onboard aircraft and for the associated transponders on the ground by Radio Regulations footnote No. 5.438.

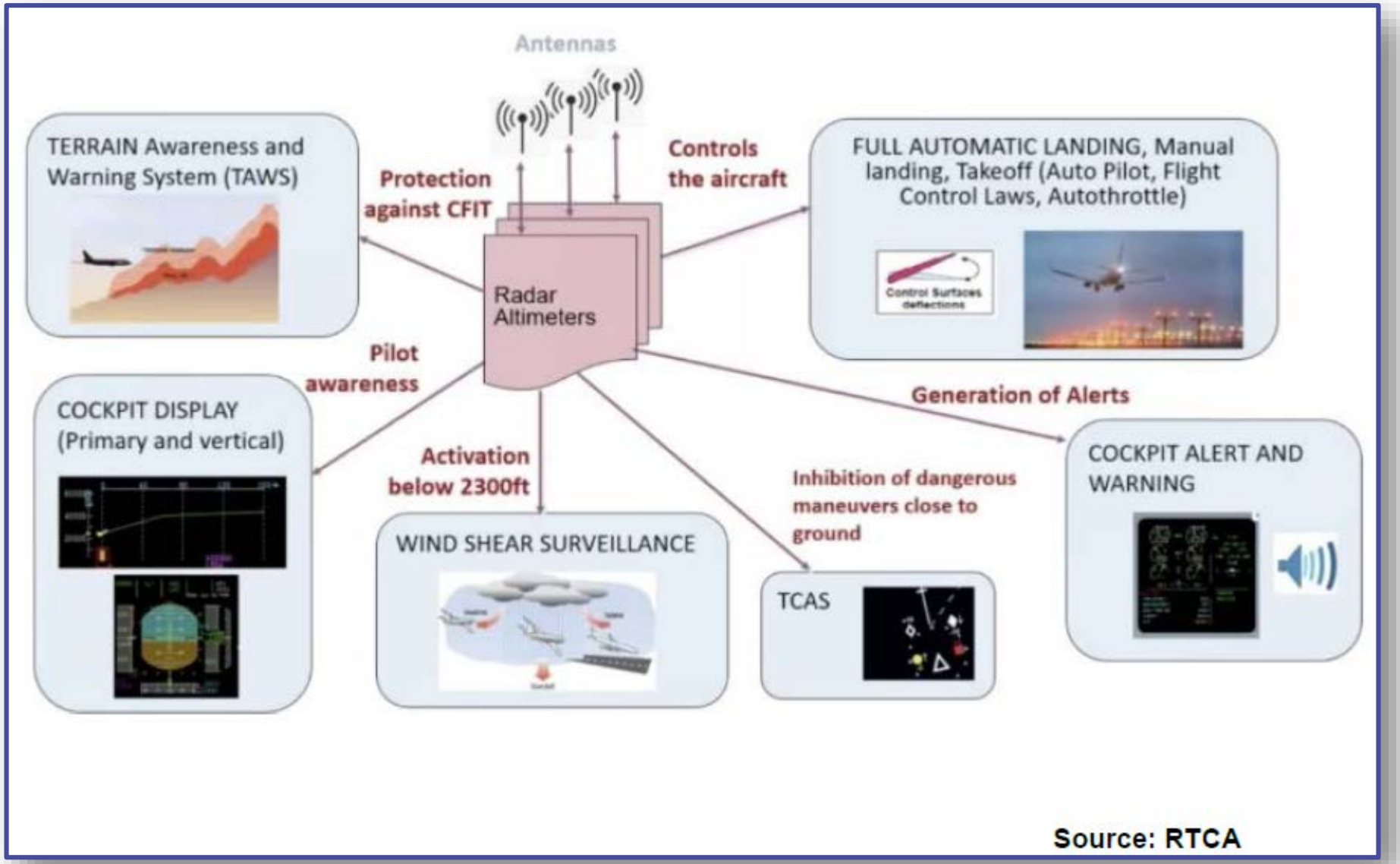
- The basic function of a radio altimeter is to provide accurate height measurements above the Earth surface of 0.9 meters (3 feet) or more with a high degree of accuracy and integrity during the approach, landing, and climb phases of aircraft operation representing a wide variety of reflectivity regardless of the Earth surface.

- The elevation readings are transmitted to a pilot's visual display and to several automatic safety components. **Radio altimeters provide an essential informational component of the automatic flight control system for approach and landing, ground proximity warning system, terrain awareness and warning system, flight management guidance computer, flight control systems, electronic centralized aircraft monitoring.**

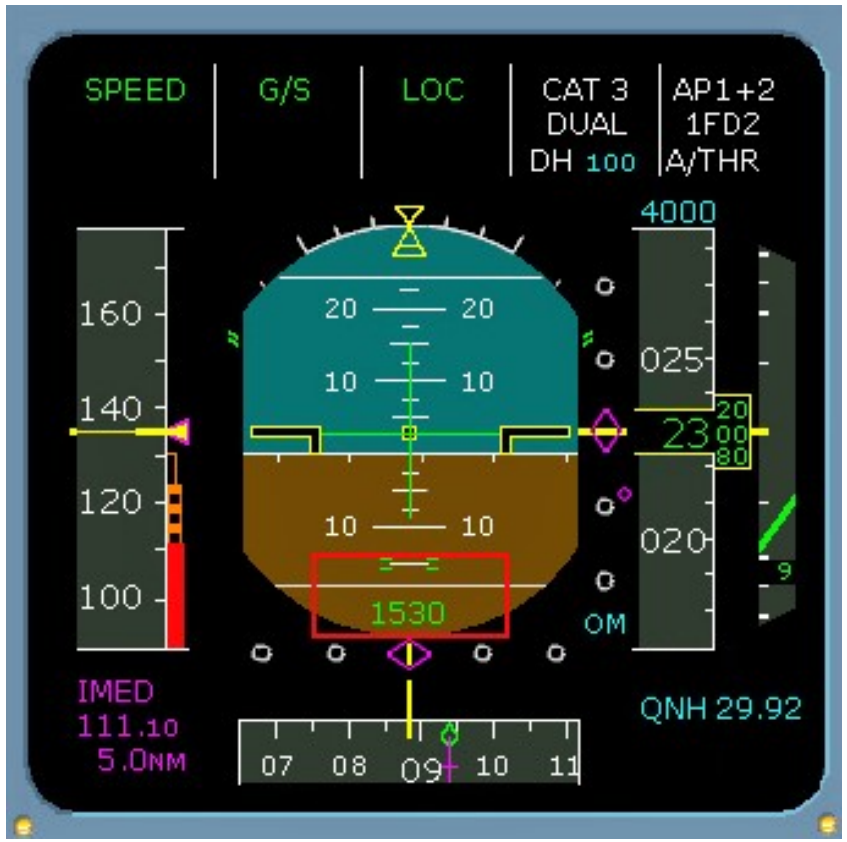
- RADALT determines the particular altitude in which the aircraft can safely land and as an input to the terrain awareness warning system (TAWS), which gives a "pull up" warning at a predetermined altitude and closure rate; and as an input to the collision avoidance equipment and weather radar (predictive wind shear system), auto-throttle (navigation), and flight controls (autopilot).

Radar Altimeters Measure Height *Above Ground Level* (AGL) and Feed into a Number of Safety Critical Systems





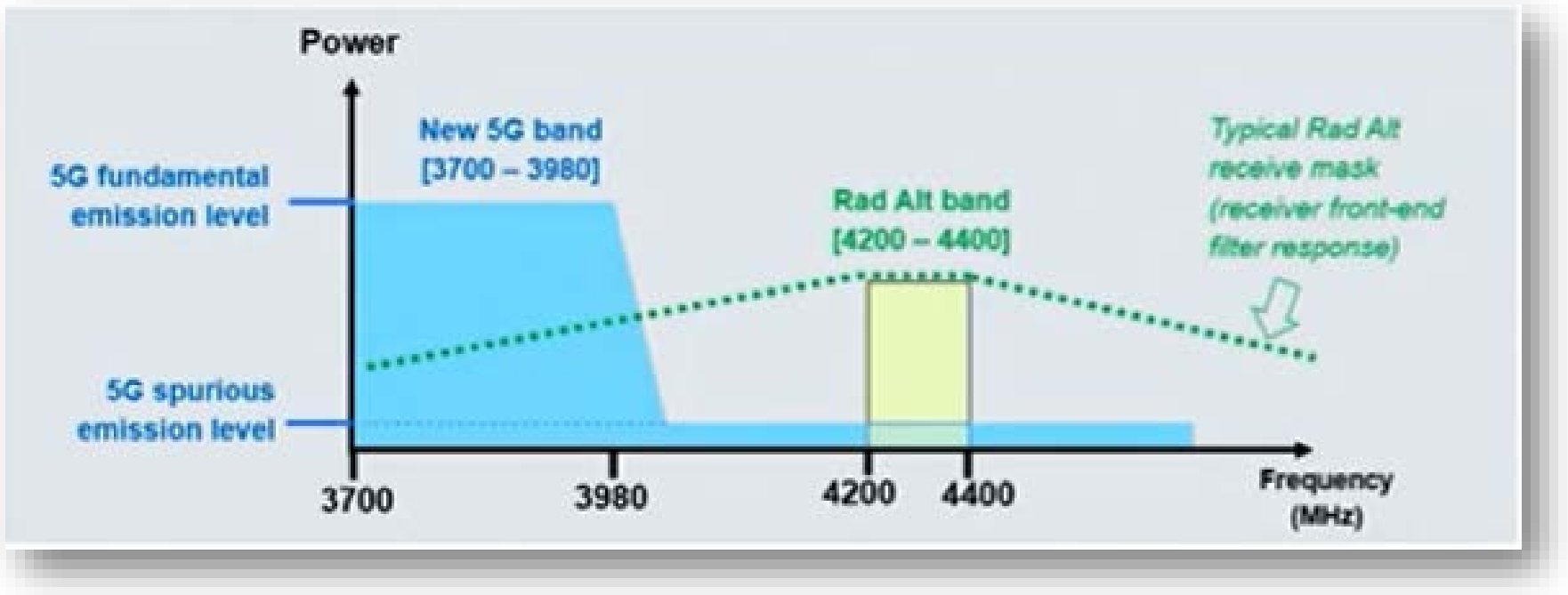
Radio Altimeter Operations



- Use during approach and landing
- Determination of Decision Height for all Low Visibility OPS (DH < 200ft);
  - Primary Flight Display Indication.
  - Audio announcement,
  - Used for landing flare manoeuvre in Automatic Flight Control System
- Integral Part of GPWS.
- ACAS Integration (Descent advisory)
- Current ICAO Requirements (Annex 14)
  - Radio altimeter Operating area
  - Pre-threshold terrain profile
  - Criteria & guidance in AWO Manual (Doc 9365) and PANS OPS (8168)

Potential Interference with 5G deployments

Cont'd



- From RTCA Paper No. 258-20/SC239-006, Assessment of C-Band Mobile Telecommunications Interference Impact on Low Range Radar Altimeter Operations.
- 5G network may include Telecom company-internal network to complement WIFI network: Could be directly underneath aircraft final approaches.
- International Telecommunications Union recommendations (ITU-R M.2059) define protection criteria for Radio Altimeters.

International Telecommunications Union recommendations

Protection criteria

- Any compatibility analysis between radio altimeters and other systems must utilize protection criteria for the maximum acceptable degradation for a radio altimeter. There are three primary electromagnetic interference coupling mechanisms between radio altimeters and interfering signals from other transmitters: receiver overload, desensitization, and false altitude generation. Also, both out-of-band and in-band interference can affect a radio altimeter performance.

International Telecommunications Union recommendations Cont'd

Operational and technical characteristics and protection criteria of radio altimeters utilizing the band 4 200-4 400 MHz

(2014)

Scope

This Recommendation describes the technical and operational characteristics, and protection criteria of radio altimeters used in the aeronautical radionavigation service.

The ITU Radiocommunication Assembly,

considering

a) that radio altimeters are an essential component of aeronautical safety-of-life systems, including precision approach, landing, ground proximity and collision avoidance systems;

b) that radio altimeter systems operate in the aeronautical radionavigation service;

c) that radio altimeters have been fitted for decades to all types of aircraft;

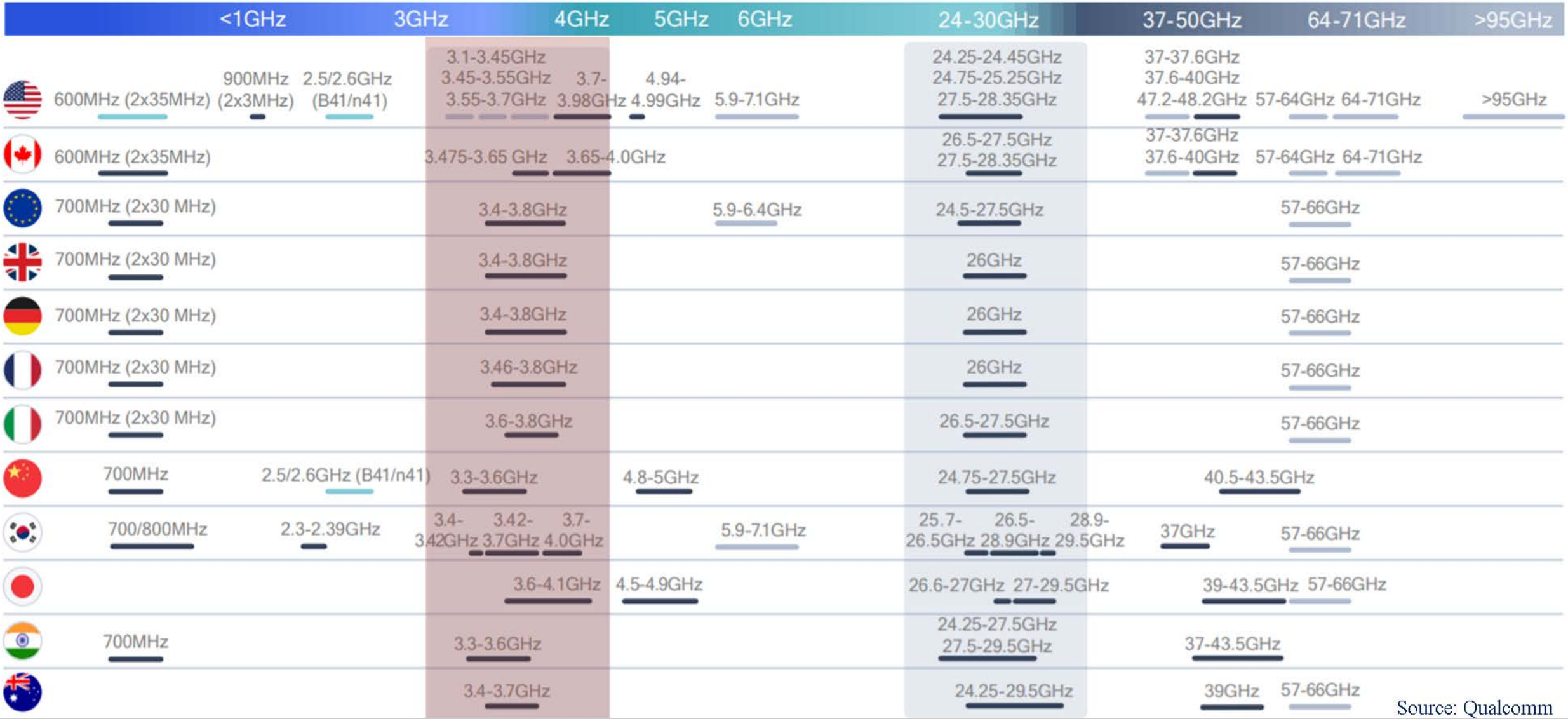
d) that radio altimeters are operational during and must operate without harmful interference for the entire flight;

If an aircraft loses or receives erroneous radio altimeter data, several consequences can occur depending upon the aircraft type, airport landing requirements or classification, and weather. Loss of radio altimeter data will disable the autopilot resulting in the pilot and co-pilot manually flying and landing the aircraft. Some airport categories or certain weather conditions would prohibit the landing of some types of aircraft without altimeter data. If only one radio altimeter is operational, then the height above ground when the decision to land the aircraft is made must be adjusted to a higher altitude. If visibility is poor, then the aircraft might be forced to wait until the weather gets better or land at a different airport. If the radio altimeter signal receives harmful interference during the final stages of landing, then a hazardous or catastrophic situation could occur. At best, the flight crew workload increases significantly; at worst the aircraft, crew and passengers are placed in a catastrophic situation.

It should be understood then that any interference that is unpredictable and that can mix with the linear FM waveform, thereby causing the radio altimeter to mistake the mixed signal as terrain has the potential to cause a radio altimeter to report a false altitude.

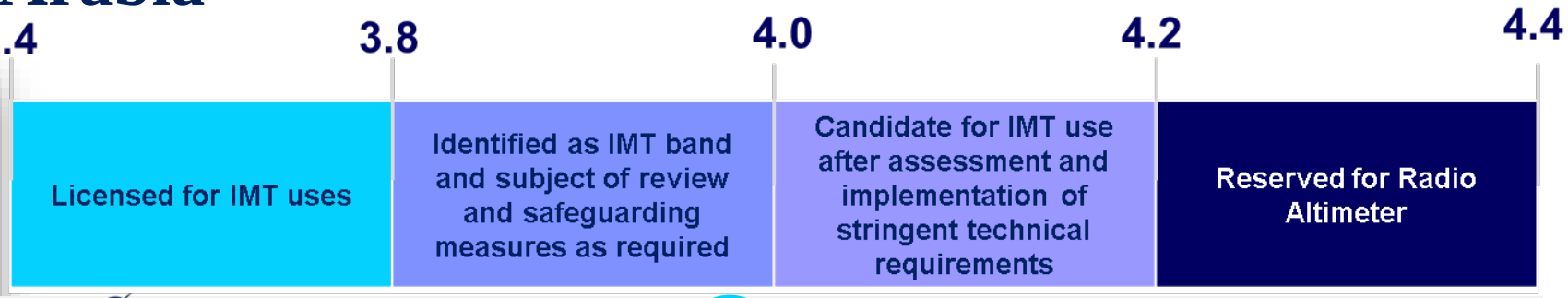
The fact that all radio altimeter antennas are necessarily pointed at the Earth's surface makes the system vulnerable to all possible interference sources illuminated during approach. The altimeter antennas, due to their location on an aircraft, do not have the benefit of being shielded or screened from many of the possible interference sources on the Earth's surface. Instead it can virtually "see" all possible radiation sources as they escape buildings and via direct transmission from devices operating outside of any structure.

Global snapshot of allocated/targeted 5G Spectrum



Source: Qualcomm

5G deployment in Saudi Arabia



BOEING CITC AIRBUS

Saudi Communications and Information Technology Commission (CITC) conducts consultation and workshop with aircraft manufactures in February 2021to take views and comments on the impact of 5G deployment on RADALT. The outcome can be summarized as follows:

- There is a potential of interference between 5G transmissions and RADALT for the bands that are close to 4.0-4.2 GHz
- There is a recommendation from the manufactures to avoid any identification to IMT 5G uses in the band 4.0-4.2 GHz
- The allocation in the band 3.8-4.0 GHz must be subject to protection criteria, technical and operational requirements considering the performance of RADALT to avoid any harmful interferences, which may include but not limited to (separation distance, antenna height and tilt or power).

5G deployment in Saudi Arabia

Cont'd

Joint committee for the coordination and management of aeronautical frequency spectrum.

- Members of the National Spectrum Coordination Committee (NSCC)
- Last meeting held on 24 January 2022 reserved to 5G deployment
- Coordination for the deployment of 5G Ground Stations located near the airports.
- Setting a protection criteria within Q1-2022 to protect the RADALT from any harmful interference due to 5G network deployment.
- Sharing of information on the last global and regional developments related to 5G issues and concerns.

Close monitoring of ICAO activities related to Compatibility between 5G and RADALT

- Attending ANC talks held on 22 February 2021 through Saudi Arabia Commissioner.
- Sharing of the ICAO State letter SP 74/1-21 dated on 25 March 2021 with CITC
- Provides a presentation titled Protecting Radio Altimeter Operations - Electro magnetic Compatibility (EMC) Aspects related to 5G to the Second meeting of the Frequency Management Working Group (FM WG/2) held on 7 June 2021. The meeting recommended to set TF on the compatibility between 5G and RADALT.
- GACA issues the Advisory Circular Number 091-01 dated on 6 January 2022 - Undesired Impact of 5G Networks on Airborne Radio Altimeters. This circular recommends precautionary flight operational measures to minimize the potential impact of 5G on radio altimeters.

5G Demonstration for CITC

From 17.01.2022 to 07.02.2022

- Flights over specific routes (busy ATS routes) and sites to identify any impact on the RADALT
- Monitoring of the impact on other flights and reporting to all concerned parties
- Recording of the flight trajectories and cross-check with the sitting of 5G Ground Stations.
- Overflight of areas where multiple 5G ground stations are deployed.
- Performing multiple approaches to check the impact of 5G on RADALT
- Performing visual and straight-in approaches with various combination to assess and monitor the behavior of RADALT.
- Performing various take-off and missed-approach considering the frequencies of RWY in Use.

There is no impact recorded or reported on RADALT during the Demonstration.

Potential impact on Continued Airworthiness

Safety and Operational impact

Anywhere close to terrain

- Could inhibit some functionalities of the TAWS reactive modes which would remove a safety net related to protection from CFIT (Controlled flight into terrain

Impact of 5G stations that are located too close to airports

- Could induce hard landing (manual and auto flare below 50ft)
- Risk of Go around as landing criteria are affected/not met
- Diversion: No possibility to land in low visibility conditions
- Spurious/false message in the cockpit, RA display
- RADALT use is supplemental and provides low altitude warning which is especially useful at night and poor weather conditions

RTCA

- Assessment of C-Band Mobile Telecommunications Interference Impact on Low Range Radar Altimeter Operations (RTCA Paper No. 274-20/PMC-2073)
- RTCA Special Committee 239 is:
  - Collecting information on all RF emission sources (including 5G) in the RADALT adjacent band from worldwide stakeholders (including regulators, telecom industry groups, etc.)
  - Developing a "RF Interference Worldwide Threat Definition" Useful for deriving interference tolerance requirements for new equipment and determining the compatibility of existing equipment
- EUROCAE WG119 / RTCA SC239 are working on new RADALT MOPS (Due fall 2022)

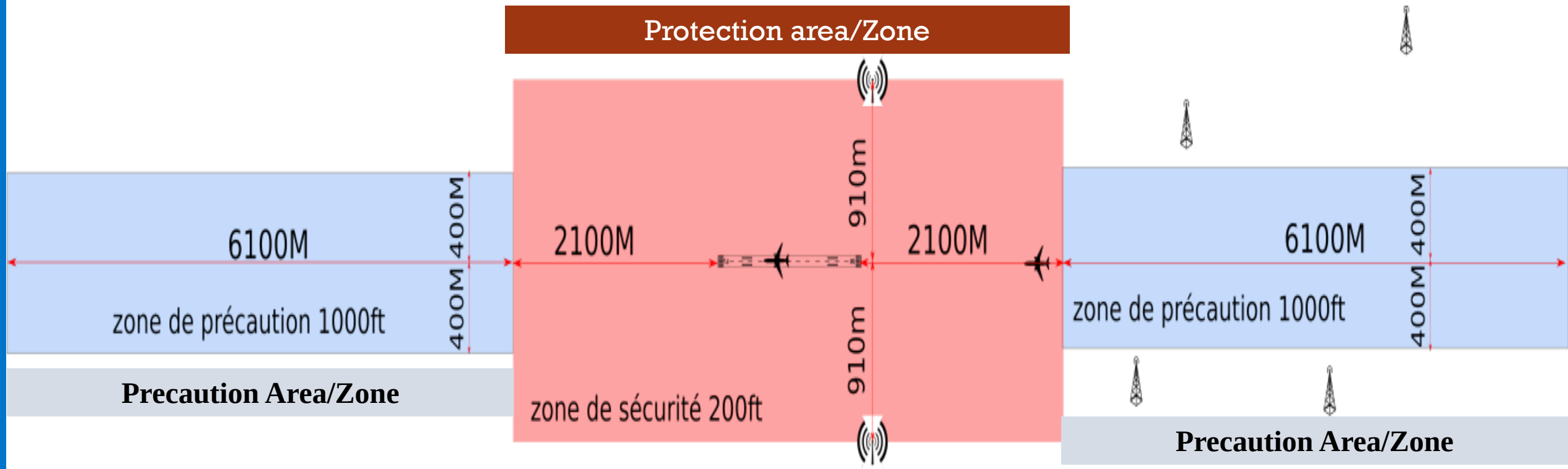
FAA Website on 5G: https://www.faa.gov/5g

- On December 9, 2021, FAA issued two ADs (transport category airplanes and helicopters) prohibiting certain operations in the presence of 5G (3.7-3.98 GHz C-Band) emissions.
- Special Airworthiness Information Bulletin (SAIB) AIR-21-18R1, issued on December 23, 2021.
- Safety Alert for Operators (SAFO) 21007
- Notices to Air Missions (NOTAMs) (FAA terminology) were issued to limit the impact of the AD to areas and airports where 5G C-Band will be deployed.

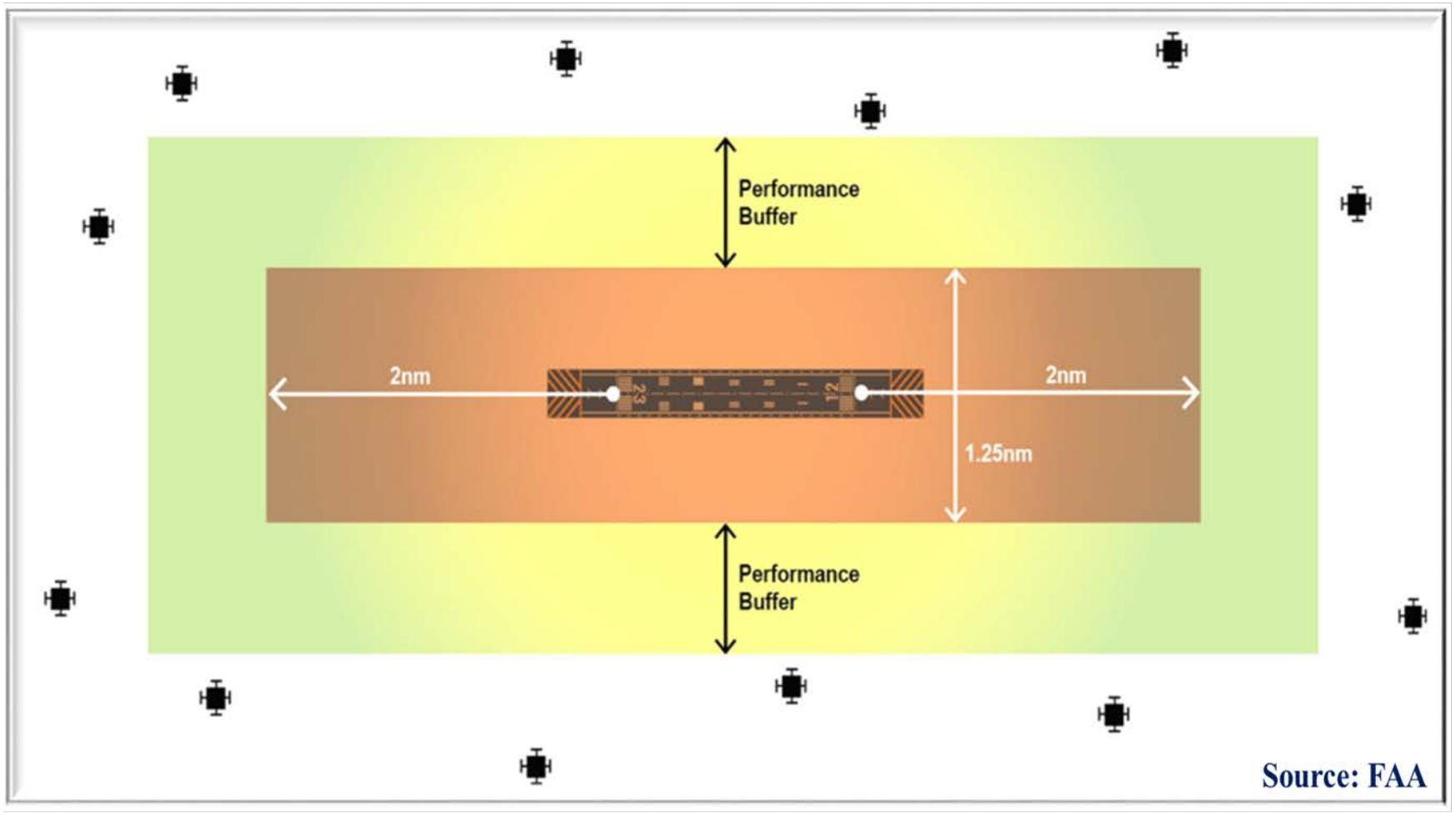
EASA European Union Aviation Safety Agency

- EASA issued a Continued Airworthiness Review Item (CARI) to aircraft and equipment manufacturers to collect data on RADALT and any observed interference.
- Safety Information Bulletin Operations issued on 17 December 2021, Subject: Operations to aerodromes located in United States with potential risk of interference from 5G ground stations (as published through aerodrome NOTAMs).
- Set up EASA / EUROCONTROL Coordination
- EASA has not been able to determine the presence of an unsafe condition but continues to closely coordinate with the affected design approval holders before deciding if mandatory action is warranted.

Measures taken by French DGAC



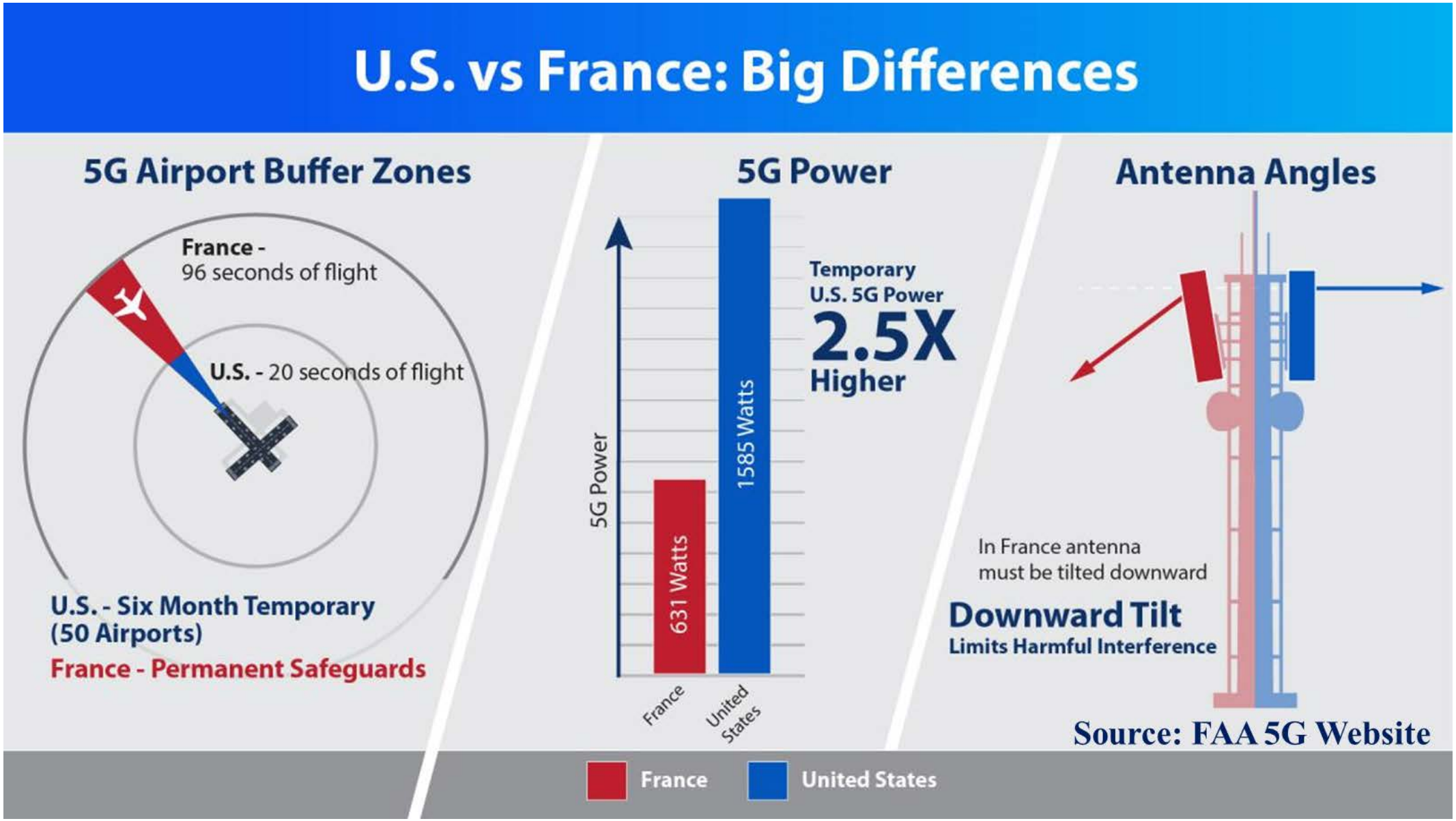
FAA safeguarding measures: Runway Safety Zone with Performance Buffer



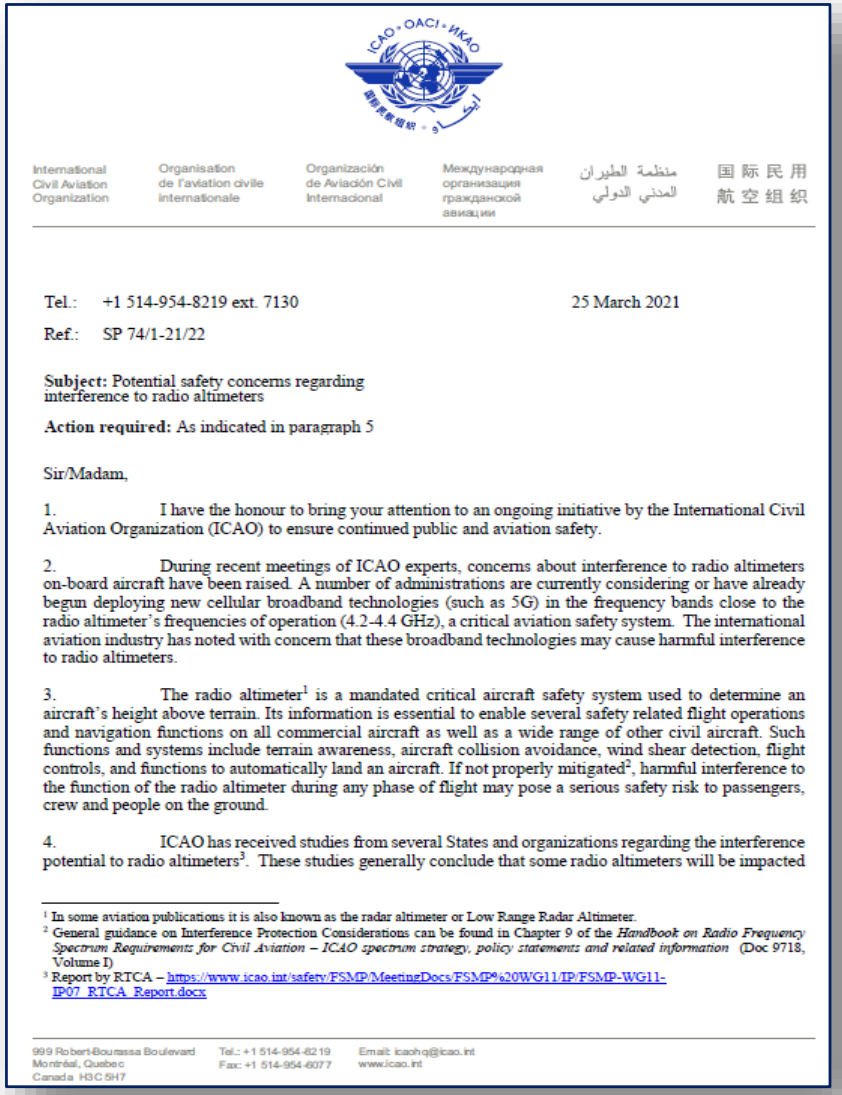
Runway Safety Zone (RSZ) – FAA's determination of the safety area around a runway. The safety area is defined as the area where unreliable Radio Altimeter function can lead to a catastrophic outcome. Acceptance criteria: The Radio Altimeter must function accurately and reliably in 100% of the RSZ.

Performance Buffer (PB) – FAA AMOCs are issued based on the performance capabilities of the Radio Altimeter. The current method is to determine the minimum distance away from a 5G antenna the aircraft needs to be to meet the acceptance criteria for the RSZ. This is described as a radius from a 5G antenna.

FAA vs DGAC France: Differences between Safeguarding Measures



Potential Safety concerns regarding interference to radio altimeters



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

ICAO State letter dated on 25 March 2021

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

- Invite States 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.

Discussion and summary on actions taken by States & Regional Organization

- Technical expert working groups in ICAO, ITU, CEPT, RTCA, EUROCAE are working on detailed assessment of the impact of 5 G on RADALT and development of MOPS
  - 5G is a key factor of the “digital economy”
  - 5G providers and industry will not support any mitigation/measures related to the relocation of 5G stations
- RADALT is one of aviation’s most safety critical systems
  - Radio frequency (RF) filtering needs to be improved. It will take time (development of Standards and equipment)
  - Safe operations depend on effective aerodrome safeguarding of the RF environment.
- Actions taken by Specialized agencies
  - EASA: Issued a Continued Airworthiness Review Item (CARI) to aircraft and equipment manufacturers to collect data on RADALT and any observed interference
  - RTCA: Issue a report on major risk that 5G telecommunications system will cause harmful interference to RADALT of all types of civil aircraft and will continue to conduct comprehensive data-driven analysis to identify solutions

Typical action plan for managing compatibility between 5G and RADALT

- Coordination with National Authority for Telecommunications to identify all 5G Stations deployed or planned to be deployed around the aerodromes
- Collection of data on 5G Ground Stations characteristics (Location, Operating frequency, Antenna array and height, antenna downtilt angle, Transmit power, backhaul connections).
- Mapping/plotting the locations of 5G stations deployed around the Aerodromes and sharing information on 5G potential interference with all stakeholders including the national committee/organization dealing with aviation spectrum
- Issue a circular to aircraft operators (AOs):
  - on 5G potential interference on radio altimeters and invite the operators to closely monitor any interference on RADALT and immediately report any occurrence to Civil Aviation Authority
  - Considering international best practices protection criteria and safeguarding measures applied around the aerodromes (e.g FAA and French DGCA)
  - to conduct Safety risk assessment on 5G potential interference during aircraft operations and identify proper mitigations. (e.g. restrictions on low visibility operations).

- Make sure that the RADALT is protected against any harmful interference prior to the deployment of 5G in the band 3.8 – 4.0 Ghz around the airports.
- Monitor the activities of International working groups on 5G potential interference and keep the aircraft operators aware of the outcome.
- Planning of aircraft retrofit based on approval airworthiness directives related to RADALT.

Guidance material on the deployment of 5G around aerodromes

- Considering the on-going development related to 5G and the safeguarding measures adopted at regional and global levels, it is necessary to set guidance material on concrete actions and steps to protect the aircraft operations from any 5G potential interference associated with the deployment of ground infrastructure to enable cellular broadband/5G services in radio frequency bands near the bands used by radio altimeters. The meeting may consider to adopt the following decision:

- ***DRAFT MIDANPIRG DECISION 19/XX: Guidance material on 5G Safeguarding measures around the aerodromes***

  That:

  a) CNS SG coordinate with ATM SG and other SGs to develops 5G Safeguarding measures around the aerodromes to protect RADLAT from any 5G interference;

  b) ICAO MID Office ensure that 5G Safeguarding measures is consolidated with the relevant guidance material that will be developed .

Why	*To develop MID Guidance material on the compatibility between 5G and radio altimeters and the protection of aircraft operations considering the deployment of 5G around the aerodromes*
What	*Guidance material*
Who	*CNS SG in coordination with other MIDANPIRG SGs*
When	2022

Action by the meeting:

The meeting is invited to:

a) Take note of the information provided in this presentation.

b) Invite States to share information on their practices to mitigate 5G potential interference that may impact the radio altimeters during aircraft operations.

c) Review and discuss the proposal for decision to task CNS SG coordinate with ATM SG to develops 5G Safeguarding measures around the aerodromes to protect RADALT from any interference.