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INTERNATIONAL CIVIL AVIATION ORGANIZATION

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Potential Safety Concerns due to Interference from 5G to Aeronautical Radio Altimeters

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ICAO Workshop on Frequency Finder

Bangkok, Thailand | 09-13 October 2023

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State Letter

issued in March 2021

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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

Problem Statement

issued by IATA and IFALPA

IATA IFALPA

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:

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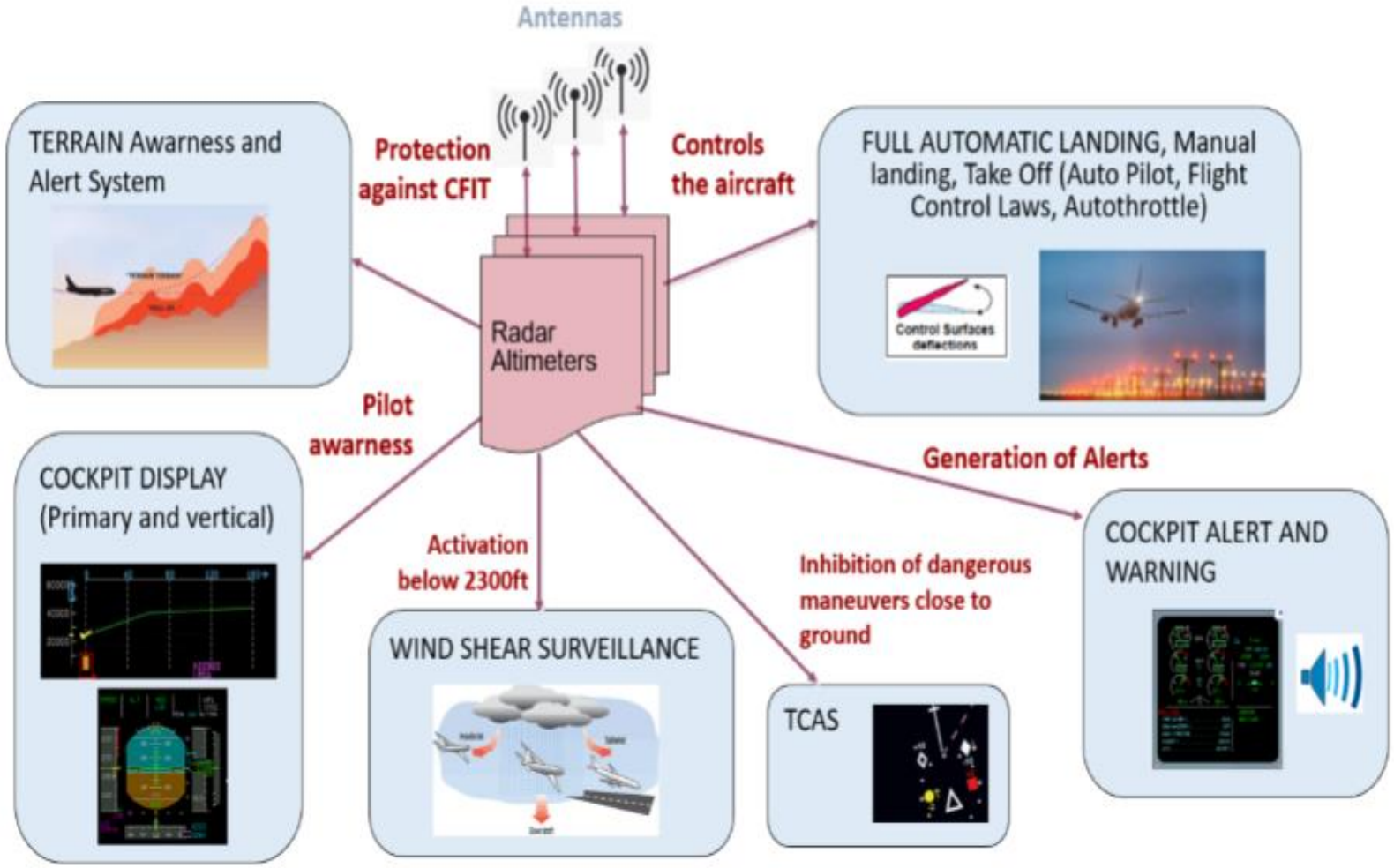
Critical Roles of Aircraft Radio Altimeters



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Some history:

The ITU Radio Regulations in 1947

Bands adjacent to the Radio Altimeter band already allocated to the Mobile service.

However in practice, until recently, with the advent of Satellite links and until recently, these bands were mainly used for Satellite Downlink

2 700–2 900 (200)	Aero-nautical radio-navigation 108)			
2 900–3 300 (400)	Radio-navigation 109) 110)			
3 300–3 900 (600)		3 300–3 900 (600) *a*) Fixed *b*) Mobile *c*) Radio-navigation	3 300–3 500 (200) Amateur 3 500–3 900 (400) *a*) Fixed *b*) Mobile	3 300–3 900 (600) *a*) Amateur *b*) Fixed *c*) Mobile *d*) Radio-navigation
3 900–4 200 (300)	*a*) Fixed *b*) Mobile			
4 200–4 400 (200)	Aero-nautical radio-navigation 111)			
4 400–5 000 (600)	*a*) Fixed *b*) Mobile			
5 000–5 250 (250)	Aero-nautical radio-navigation			

Present:

The ITU Radio Regulations as a result of the latest WRC (rev 2020)

Allocation to services		
Region 1	**Region 2**	**Region 3**
3 600-4 200 FIXED FIXED-SATELLITE (space-to-Earth) Mobile	**3 600-3 700** FIXED FIXED-SATELLITE (space-to-Earth) MOBILE except aeronautical mobile 5.434 Radiolocation 5.433	**3 600-3 700** FIXED FIXED-SATELLITE (space-to-Earth) MOBILE except aeronautical mobile Radiolocation 5.435
	3 700-4 200 FIXED FIXED-SATELLITE (space-to-Earth) MOBILE except aeronautical mobile	
4 200-4 400	AERONAUTICAL MOBILE (R) 5.436 AERONAUTICAL RADIONAVIGATION 5.438 5.437 5.439 5.440	
4 400-4 500	FIXED MOBILE 5.440A	
4 500-4 800	FIXED FIXED-SATELLITE (space-to-Earth) 5.441 MOBILE 5.440A	

Not much change.

Fixed Satellite Service allocations added in 1970s approx.

Mobile bands below 3700 MHz identified for IMT in 2007/2012, through country footnotes.

Current rollout of 5G not related to the ITU WRC-23 agenda

Brief Summary of Telecom & 5G

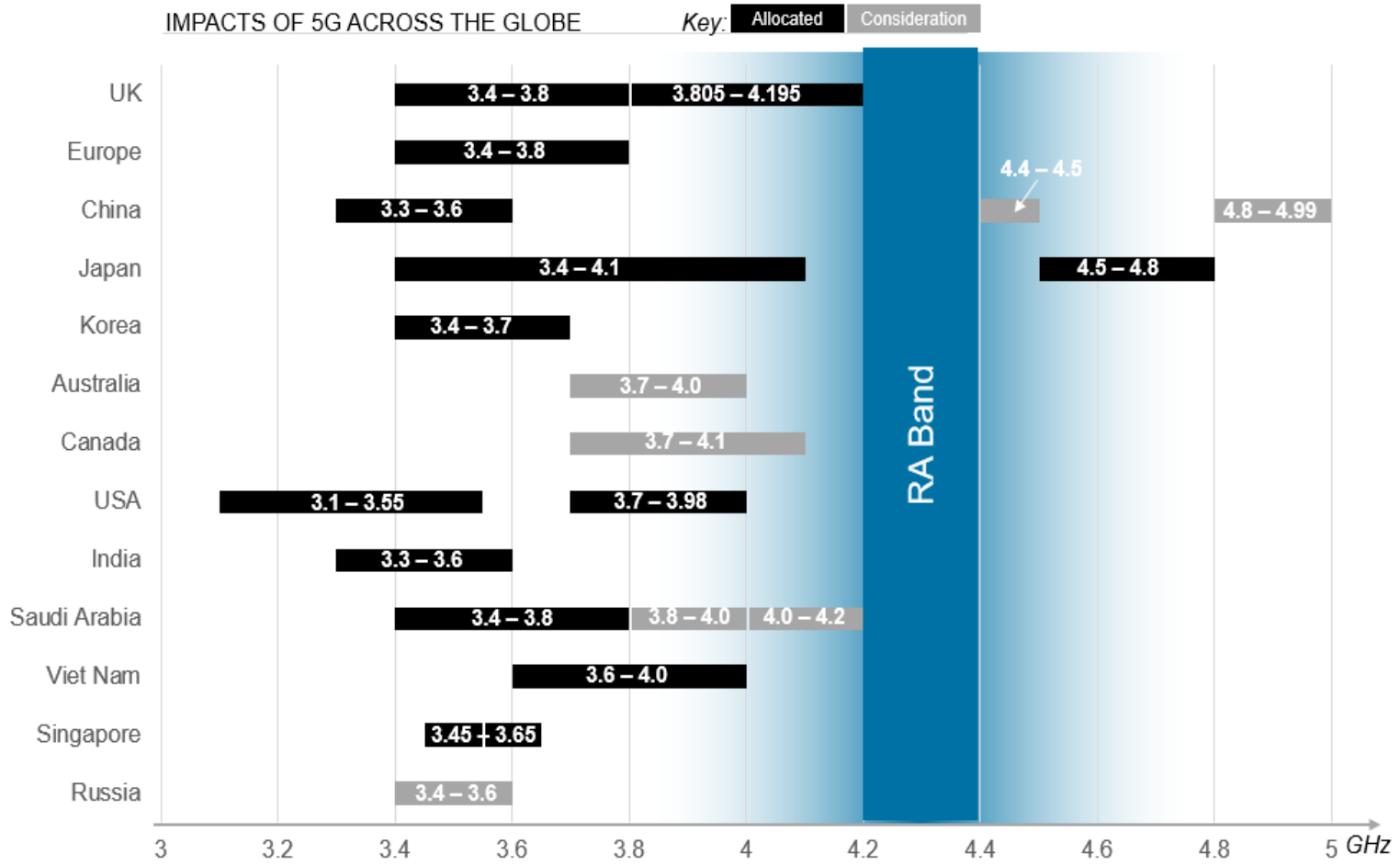
Telecom Industry (GSMA figures)	Aviation Industry (IATA figures)
$USD 3.9 trillion or **4.6%** of world GDP (2018)	$USD 899 billion or **1%** of world GDP (2019)
14 million direct jobs (2018)	2.9 million jobs (2019)

ITU - "[5G is] *an opportunity for policy-makers to empower citizens and businesses.*

5G will play a key role in supporting governments and policy-makers in transforming their cities into smart cities, allowing citizens and communities to realize and participate in the socio-economic benefits delivered by an advanced, data-intensive, digital economy."

- Deployments of **5G needs frequency spectrum – a very limited and finite natural resource**
- In the recent 5G spectrum auction, the Telecommunication Industry spent **US$80+ billion** to obtain a **10-year lease** of spectrum from the US government.
- Immense political and **economic pressure** often **overwhelmed aviation safety** arguments.

5G Proposals Across the Globe



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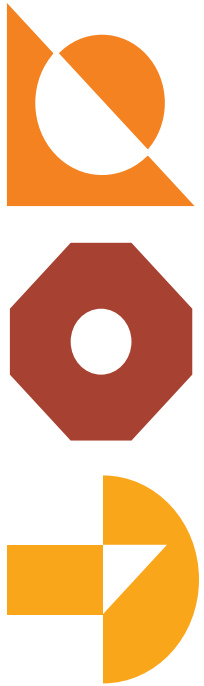
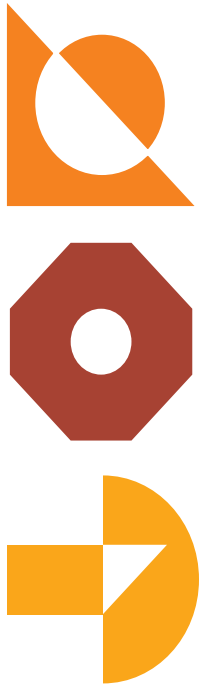
A Serious Aviation Safety Risk



Potential for Catastrophic Consequence

- ICAO SL 21/22 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."*
- *"if not properly mitigated, 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."* (ICAO)
- *undetected failure of the radio altimeter can lead to catastrophic results for people on board the aircraft and on the ground; and false alarms have the potential to undermine trust in the avionics systems.* (IATA & IFALPA)
- Similar concerns expressed formally by ICCAIA, RTCA, US Secretary of Transport…

If not mitigated, then a huge step backwards…



- **Limitation/Suspension of precision approach and landing capabilities** – This limitation/suspension will reduce airlines access to airports in low-visibility conditions.
- **Limitation/Suspension of night operations**, particularly for airports with challenging terrain – The radio altimeter is critical for the terrain awareness and warning system which is mandatory for all air transport aircraft.
- **Issue of State regulations mandating retrofits and re-certification** of aircraft radio altimeters and other related functions.

Using the US 5G proposal as a reference, Airbus approximates that, without mitigations, **11,000 altimeters** on its own commercial aircraft are potentially impacted by 5G interference. It is anticipated that the number represents just under **half of all altimeters** on commercial aircraft globally.

Typical Radio Altimeter Failures with Specific Operational Impacts

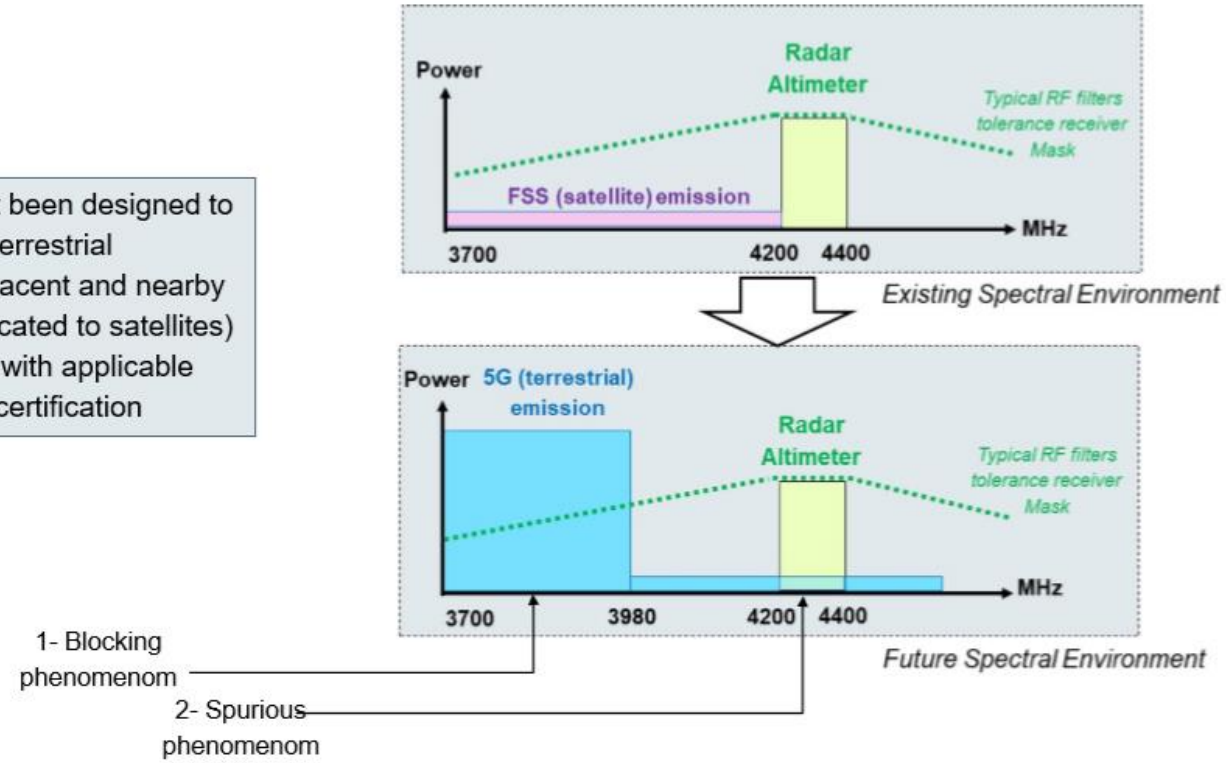
Note.-The operational impacts listed in this table are not exhaustive.

Radio Altimeter Failure	Operational Impact	Flight Phase	Severity
Undetected Erroneous Altitude	Just prior to touchdown, the aircraft performs a flare maneuver to avoid a hard landing. The flare may be performed manually by the flight crew, using auditory callouts of radio altimeter readings, if sufficient visibility is available. In low-visibility conditions, the flare may be controlled by an auto-land function. Erroneous radio altimeter readings in either case can result in the potential for CFIT with little or no time for the flight crew to react.	Landing – Flare	Catastrophic
Undetected Erroneous Altitude	Erroneous input to the AFGCS affects aircraft attitude commands and altitude, as well as flight control protection mechanisms	All Phases of Flight	Catastrophic
Unanticipated NCD	Undetected loss of PWS display to flight crew, preventing awareness of wind shear impact to vertical profile in front of the aircraft	Landing	Hazardous/Severe Major
Unanticipated NCD	Undetected loss of TCAS/ACAS inhibition near the ground, leading to potential erroneous descent advisory alert and associated possibility of CFIT in low-visibility conditions	Approach, Landing, Takeoff	Hazardous/Severe Major
Undetected Erroneous Altitude	Erroneous triggering of TAWS reactive terrain avoidance maneuver, forcing mandatory response from flight crew and leading to potential traffic conflicts in surrounding airspace	Approach, Landing, Takeoff	Major
Unanticipated NCD	Aircraft landing guidance flight control laws violated leading to unnecessary missed approach and go-around, jeopardizing safety of surrounding airspace	Approach, Landing	Major
Unanticipated NCD	Loss of capability to perform approach and landing in low-visibility conditions (Category II/III approach), leading to unnecessary diversion and jeopardizing safety of surrounding airspace	Approach, Landing	Hazardous/Severe Major
Unanticipated NCD	Loss of capability to warn flight crew in case of excessive aircraft descent rate or excessive terrain closure rate (TAWS Mode 1 and 2 alert protection not active)	All Phases of Flight	Major
Unanticipated NCD	Loss of capability to warn flight crew of potentially dangerous loss of height after takeoff (TAWS Mode 3 alert protection not active)	Takeoff, Go-around	Major
Unanticipated NCD	Loss of capability to warn flight crew of potentially dangerous aircraft configuration—e.g. landing gear, slats, flaps—based on height above terrain (TAWS Mode 4 alert protection not active)	Landing	Major
Unanticipated NCD	Loss of capability to warn flight crew that aircraft is dangerously below glide path during precision instrument approach (TAWS Mode 5 alert protection not active)	Landing	Major

Source: ICAO MID Draft Guidance on Safeguarding measures to protect Radio Altimeter from potential harmful interference from Cellular 5G Communications

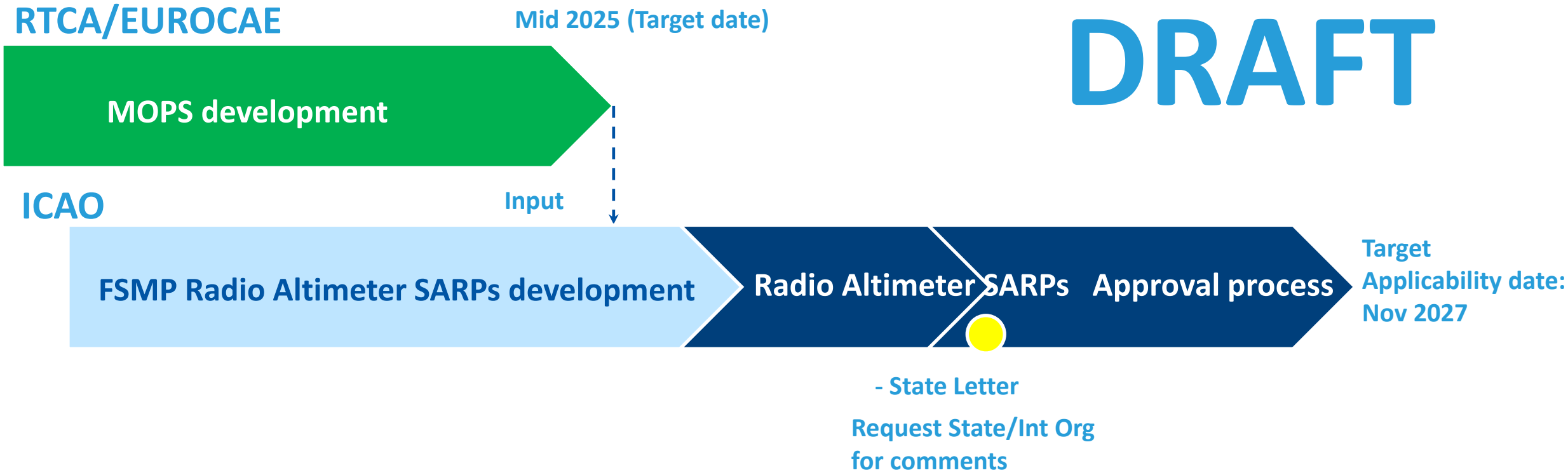
On-going Long-Term Actions

RA receivers have not been designed to support such level of terrestrial interferences in its adjacent and nearby bands (previously allocated to satellites) while being compliant with applicable regulations at time of certification



- New RTCA/EUROCAE MOPS expected end of 2022.
- ICAO FSMP task agreed in 2016 to include the new equipment standards into the ICAO Annexes and to assist with coordination with ITU for appropriate legal protections for future radio altimeters. This task will be progressed and finalized asap, dependent on the work being performed within RTCA/EUROCAE.

Radio Altimeter SARPs Development Schedule



Sequential General Steps

Note.- does not reflect proportional time flows

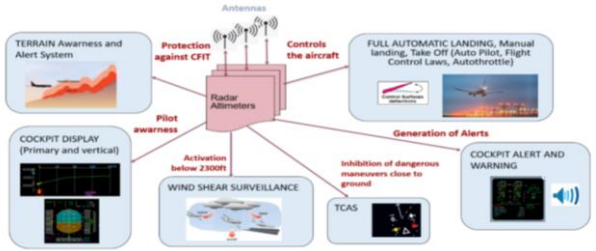
Up to 10 years in duration (typical)

- *Publication of the new MOPS and SARPs does not immediately eliminate the risk of harmful interference for currently deployed radio altimeters…..*
- *Need to acknowledge that a realistic timeline necessary for ICAO SARPs and RTCA/EUROCAE DO-155A/ED-30A compliant radio altimeters to be put into worldwide service includes a sequence of necessary activities and milestones extending over multiple years….*

Assembly 41st Session
(27 Sep to 7 Oct 2022)
WPs related to Spectrum

Assembly 41st Session (icao.int)

Item 30: Aviation Safety and Air Navigation Policy



Spectrum (WRC and 5G/Radio Altimeter): A hot topic related to CNS!

WPs related to Spectrum and 5G.		
A41-WP/80 TE/11	STRENGTHENING PROTECTIONS FOR AVIATION SAFETY SYSTEMS FROM HARMFUL INTERFERENCE	
A41-WP/227 TE/78	SAFEGUARDING MEASURES TO PROTECT RADIO ALTIMETER FROM POTENTIAL HARMFUL INTERFERENCE	
A41-WP/266 TE/99	COLOMBIAN CIVIL AVIATION AUTHORITY'S ENDORSEMENT OF THE ICAO POSITION ON RELATED MATTERS TO BE CONSIDERED AT THE WORLD RADIOCOMMUNICATION CONFERENCE (2023) (WRC-23) OF THE INTERNATIONAL TELECOMMUNICATION UNION (ITU)	

Also, Information papers provided by Brazil (A41-WP/536), Oman (A41-WP/410) and United States (A41-WP/561) were noted

A41 Outcome related to ICAO policy on radio frequency spectrum matter

The Technical Commission

- **Requested ICAO and its Member States to continue taking necessary measures and efforts to ensure that radio altimeters and other aeronautical systems are free from harmful interference, including implementation of mitigation measures, sharing of best practices, as well as development of relevant provisions and guidance.**

- **Recognizing the criticality of radio frequency spectrum, encouraged States and regions to actively participate in spectrum defense activities and to endorse the ICAO position for the ITU WRC-23. (State letter E 3/5-21/37).**

A41 adopted a Resolution A41-7: Support of the ICAO policy on radio frequency spectrum matters, which enhances Assembly Resolution A38-6 adding the following statement in the new resolution.

> *2. Urges Member States to consider, as a priority, public and aviation safety when deciding how to enable new or additional services, and to consult with aviation safety regulators, subject matter experts and airspace users, to provide all necessary considerations and to establish regulatory measures to ensure that incumbent aviation systems and services are free from harmful interference.*

Planned ICAO Circular in 2023:

Guidance on Safeguarding Measures to Protect Radio Altimeters from Potential Harmful interference from C-Band IMT Communications

(The unedited version of the Circular will be available on ICAO-NET by end of 2023)

See: FSMP WG/16 WP/02 Attachment,
available for download at FSMP website

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References and links

- ICAO State Letter 21/22: https://www.icao.int/MID/Documents/2021/FM%20WG2/74-1e.pdf

the SL includes several useful links, including Report by RTCA and reports of several national studies and mitigations.

- A41 Assembly: https://www.icao.int/Meetings/a41/Pages/default.aspx
- A better presentation on the actual Radio Altimeter and its use: https://www.icao.int/NACC/Documents/Meetings/2018/RPG/RPGITUWRC2019-P08.pdf

- Frequency Spectrum Management Panel, Working Group/12 (4-15 October 2021)

1. WP/17 "ICCAIA updates on Industry Assessment of 5G Cellular Compatibility with Radio Altimeters" https://www.icao.int/safety/FSMP/MeetingDocs/FSMP%20WG12/WP/FSMP-WG12-WP17_ICCAIA_5GLRRA%20Input.docx
2. IP/03 "Status on replanning the 3700-4200 MHz band in Australia" https://www.icao.int/safety/FSMP/MeetingDocs/FSMP%20WG12/IP/FSMP-WG12-IP05_Status%20on%20replanning%20the%203700–4200%20MHz%20band%20in%20Australia.docx
3. IP/07, ENRI Japan, "*Interference Susceptibility Evaluations of Pulsed Radio Altimeters Due to 5G Mobile Base Station Signal*" *https://www.icao.int/safety/FSMP/MeetingDocs/FSMP%20WG12/IP/FSMP-WG12-IP07_Interference%20Susceptibility%20Evaluations%20of%20Pulsed%20Radio%20Altimeters%20Due%20to%205G%20Mobile%20Base%20Station%20Signal_rev1.pptx*

- IP/12 "Brazil 5G auction" https://www.icao.int/safety/FSMP/MeetingDocs/FSMP%20WG12/IP/FSMP-WG12-IP12%20-%20Brazil%205G%20Auction.pdf

- Frequency Spectrum Management Panel, Working Group/16 (15 – 24 Feb 2023)

1. *IP/06 "*National efforts to implement broadband mobile near 4200-4400 MHz - Report from correspondence group on radio altimeters (CG-RA) " https://www.icao.int/safety/FSMP/MeetingDocs/FSMP%20WG16/IP/FSMP-WG16-IP06_CG-RA%20Report%20Feb%202023%20V1.0.docx

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Thank You!

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