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(NACC/WG/11)**

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**Agenda Item 3: Presentation of the progress of the action plans of the NACC/WG Task Forces
and the progress in the regional work**

Update on United States Regulation and Guidance for Radio Altimeters

(Presented by United States)

EXECUTIVE SUMMARY	
This paper shares updates related to final FAA requirements and guidance for interference tolerant radio altimeter systems.	
<i>Strategic Objectives:</i>	• Every Flight is Safe and Secure
<i>References:</i>	• ICAO Frequency Spectrum Management Panel (FSMP) Twenty First Working Group Meeting IP06R1

1. Introduction

1.1 On July 3rd, 2025, a congressional mandate was passed requiring the United States Federal Communications Commission (FCC) to auction at least 100 MHz in the upper C-band (3.98 – 4.2 GHz) for terrestrial wireless flexible use by July 4th, 2027. This band is directly adjacent to the 4.2-4.4 GHz band, which has a primary allocation to the aeronautical radionavigation service in the United States, and is reserved exclusively for airborne radio altimeters (RA). The Federal Aviation Administration (FAA) began aligning rulemaking timelines with the FCC to support aviation by defining the required actions and applicability. To ensure safe, efficient, and reliable aviation operations in the presence of interference signals in the upper C-band, the FAA proposed new regulations for all aircraft with RAs and compatibility conditions for adjacent band users. The FAA published the final regulations on July 31, 2026 and the FCC adopted a Report and Order for final Upper C-band technical rules on July 22, 2026. This paper provides an overview of the final FAA rule

2. Background

2.1 RAs measure aircraft height above terrain and obstacles using low-power signals in the 4.2 – 4.4 GHz frequency band, which is reserved exclusively for radio altimeters installed on board aircraft world-wide. Accurate RA data is critical for pilots as well as integrated aircraft automation, navigation,

and safety systems. Historically, radio frequency interference (RFI) was not a problem for RAs because receiver filtering was sufficient to reject interference from relatively low power transmitters in adjacent spectrum bands as well as unwanted emissions into 4.2 – 4.4 GHz. In 2021, the RFI environment in frequencies below the 4.2– 4.4 GHz band substantially changed in the United States when wireless providers began offering services that are below, and near to, the RA band (i.e., 3.7 – 3.98 GHz) . Laboratory testing, as developed in RTCA, Inc. Special Committee 239 (SC-239), demonstrated the interference susceptibility of operational RA models to the wireless 5G waveform that would be used in the lower C-band. The compatibility analysis demonstrated that relatively large separation distances were required between RAs and 5G transmitters to provide enough attenuation to not interfere with the RA.

2.2 With the auction of lower C-band licenses to wireless services and service rules set by the FCC, RAs would be susceptible to interference from high-power signals in the neighboring spectrum bands and unwanted (spurious) emissions from those wireless base stations into the 4.2 – 4.4 GHz band, which could result in loss or erroneous altitude readings if not properly mitigated, once the 5G base stations began transmitting. Anomalous RA output to downstream applications can cause aircraft to maneuver in an unsafe manner at low altitude or prevent collision avoidance technology from functioning properly. The pilot might not be able to detect the error or adjust the flight path in time to maintain continued safe flight and landing resulting in catastrophic outcomes.

2.3 Due to this unsafe condition, the FAA issued airworthiness directives (ADs) to require lower C-band interference tolerant RA equipment or restrict certain operations for aircraft that posed the highest safety risk. In response, the aviation industry provided RA retrofit solutions for these aircraft and the wireless industry accepted voluntary constraints in addition to countless other onerous processes and procedures by both industries to maintain safe coexistence.

3. Problem Statement

3.1 For continued allocation of frequency spectrum near the 4.2 – 4.4 GHz band, mandatory and long-term solutions must be achieved for the aviation and wireless industries through appropriate frequency band separation that no longer relies on burdensome constraints to aviation and wireless operations to return all aircraft in the National Airspace (NAS) to the same level of safety and functionality provided prior to 2021.

4. Current Limitations

4.1 As part of working with RA manufacturers to assess this new interference environment, each provided any test data available for existing Airworthiness Directive (lower C-band) interference compliant RAs. This data showed auctioning additional spectrum higher in frequency than 3.98 GHz (even a single additional 20 MHz channel), to high-power wireless would be problematic for existing RAs which are minimally compliant with the ADs. Additionally, data showed that nearly 55% of the fleet (including large transport airplane operators) are not equipped with the minimally compliant RAs. Without additional retrofits to address this new upper C-band interference environment, the FAA would need to prohibit operations in a significant portion of the fleet causing substantial operational and economic impacts and disruption to the NAS and flying public from flight delays, cancellations, and groundings. Table 1 summarizes the achievable performance of the existing lower C-band interference tolerant RAs, broken down by specific frequency ranges within the upper C-band. Performance above 4.2 – 4.4 GHz band is provided specifically for this audience. The power flux-density (PFD) indicates the minimum interference

tolerance at 500 feet height above ground level (HAGL) and below, measured as a root mean square (RMS) in decibel-watts per square meter per MHz (dBW/m²/MHz).

Table 1 - RA Interference Tolerance Performance in the Upper C-band

Frequency range (MHz)	Power flux-density, RMS (dBW/m² /MHz), 0-500 feet HAGL
$3980 < f < 4100$	-40
$4100 \leq f < 4200$	-67
4200 to 4400	-105
$4400 < f < 4500$	-56
$4500 \leq f \leq 4600$	-49

5. Future (Next Generation) RA Performance

5.1 SC-239/EUROCAE WG-119 is developing Minimum Operational Performance Standards (MOPS) for the next generation RA systems to guarantee the robustness against existing and planned in-band and out-of-band interference threats. The joint committee has completed a draft of the MOPS that is undergoing validation, which involves testing and analysis with prototype designs to ensure that the requirements are both achievable and sufficient to meet the industry's needs.

5.2 The draft MOPS included an interference tolerance mask (ITM) that informed the FAA proposed interference tolerance requirement (i.e., § 91.220(b)) and provided the RA parameters for the FAA safety and compatibility analysis. These new RA will be able to withstand interference from adjacent spectrum band users including high-power wireless within 40-60 MHz of 4.2 – 4.4 GHz band without constraints on aviation or wireless operations. The ITM is defined at the system level, i.e. the power flux density (PFD) at the RA antenna face which accounts for both RA antenna and transceiver interference rejection capabilities with the lowest tolerance capability within the 4.2 – 4.4 GHz band (constant PFD) and monotonically increasing tolerance capability as the frequency/spectrum channels extend away from the band edges, achieving maximum tolerance 60-70 MHz (and beyond) from the band edges.

5.3 These new RAs are maximally interference tolerant while continuing to provide highly accurate altitude readings for pilots and integrated aircraft safety systems. In light of the FAA's statutory mandate to maintain the safety of all aircraft in the NAS, the FAA is not requiring changes to the intended function or performance requirements of RA systems. The published regulation defines an interference environment within which the intended RA system functions, performance is achieved, and continued operational safety is maintained.

5.4 14 CFR § 91.220(b) specifies that necessary RA interference tolerance addresses the lower and upper C-band but also addresses a broader range of frequencies surrounding the 4.2 – 4.4 GHz band (3 – 5.6 GHz). Table 2 shows the RA system interference tolerance requirement applicable to different frequency ranges from an altitude of 0 - 500 HAGL. The interference environment is specified as a PFD at the surface of the aircraft antenna, measured as RMS in dBW/m²/MHz. Figure 1 illustrates the interference environment defined in Table 2

Table 2 – Next Generation RA Performance

Frequency range (MHz)	Power flux-density, RMS (dBW/m² /MHz), 0-500 feet HAGL
$3000 \leq f < 4000$	9.5
$4000 \leq f < 4100$	9.5
$4100 \leq f < 4150$	9.5
$4150 \leq f < 4160$	6.5
$4160 \leq f < 4170$	-1
$4170 \leq f < 4180$	-7
$4180 \leq f < 4190$	-17
$4190 \leq f < 4200$	-34
$4200 \leq f < 4400$	-82
$4400 < f \leq 4410$	-33
$4410 < f \leq 4430$	-21
$4430 < f \leq 4440$	-8
$4440 < f \leq 4450$	-1
$4450 < f \leq 4460$	6.5
$4460 < f \leq 4500$	9.5
$4500 < f \leq 4600$	9.5
$4600 < f \leq 5600$	9.5

6. Safety and Compatibility Analysis

6.1 The purpose of the FAA safety and compatibility analysis was to ensure the safe operation of RAs and integrated systems, support efficient (i.e., no constraints or coordination needed) high-power wireless spectrum allocation to the greatest extent, and help to identify channel bands appropriate for other low-power services. Based on this analysis, RA systems compliant with § 91.220 will support reallocating more than the required 100 MHz of additional spectrum for high-power wireless without coordination and operating constraints (i.e., 65 dBm/MHz EIRP up to 4.16 GHz). The contextualization formula used to demonstrate this is:

$$\text{PFD (in dBW/m}^2\text{/MHz)} = \text{EIRP(per polarization, in dBm/MHz)} - 30 - 10 \cdot \log_{10}(4 \cdot \pi) - 20 \cdot \log_{10}(\text{MSD (in meters)}) + \text{SAFETY MARGIN}$$

PFD = power flux density at the RA antenna surface, in dBW/m²/MHz.

EIRP = effective isotropic radiated power from wireless emitter, in dBm/MHz.

MSD = minimum separation distance between wireless emitter and RA antenna, in meters.

6.2 As long as the calculated PFD meets the ITM, then the RA is fully tolerant without any additional coordination or constraints needed, since the ITM reflects the maximum safely tolerable environment. Therefore, the ITM levels of +9.5 dBW/m²/MHz up to 4150 MHz, with a 35 ft. (10.67 m) MSD, can tolerate up to 65 dBm/MHz per polarization (or 68 dBm/MHz total EIRP for dual-pol emitters, like wireless base stations). Further, the ITM level of +6.5 dBW/m²/MHz from 4150–4160 MHz can tolerate up to 62 dBm/MHz per polarization (or 65 dBm/MHz total EIRP for dual-pol emitters). There would be no need for an EIRP elevation mask to limit the emissions downwards/towards the horizon. The emissions could occur at this limit in any direction as it is written in the current 3.7–3.98 GHz FCC Report and Order (R&O).

6.3 The 35-foot MSD has a basis in regulation for one engine out take-off clearance requirements and is applicable to a broader range of aircraft operating under both normal and abnormal conditions. The 3 dB reduction in the received power is a characteristic of broadband wireless antennas, which have orthogonal cross polarized elements with the power split equally between them. A 6 dB safety margin above the expected interference environment is applied to account for unknown internal or external issues to the RA system that could impact the safe operation of the RA which requires high levels of availability, continuity, and integrity due to catastrophic risks if there is failure. This safety margin is aligned with the ICAO recommendation in Doc 9718, the Handbook on Radio Frequency Spectrum Requirements for Civil Aviation, which specifies that a safety margin of 6 - 10 dB is to be applied for aeronautical safety systems. Since the FAA is actively working with spectrum regulators and users to ensure compatibility, a minimum safety margin is applied.

6.4 RA systems must continue to operate while withstanding the aggregate interference from all emissions sources into the 4.2 – 4.4 GHz band, including, but not limited to, the interference from lower and upper C-Band wireless transmissions. The in-band PFD of -82 dBW/m²/MHz can tolerate up to -33 dBm/MHz spurious EIRP per polarization (or -30 dBm/MHz total EIRP for dual-pol emitters) from wireless transmitters. The equation below outlines the contextualization formula used and the parameters that are applied to determine in-band compatibility.

$$\text{PFD (in dBW/m}^2\text{/MHz)} = \text{EIRP (per polarization, in dBm/MHz)} - 30 - 10 \cdot \log_{10}(4 \cdot \pi) - 20 \cdot \log_{10}(\text{MSD (in meters)}) + \text{SAFETY MARGIN} + \text{AGGREGATION}$$

6.5 The additional aggregation factor is based on cell towers which have multiple systems housed on the same tower. An upper limit of three base stations is assumed, with the effective aggregate interference of all other base stations and mobile units no greater than that of a single base station at the MSD. This limiting case has an aggregate interference that is 6 dB higher than a single base station.

6.6 RA performance requirements for operations above 500 feet HAGL are not specifically addressed in the published rule because FCC technical rules for upper c-band licensees restricts the 5G antenna height limit to no greater than 450 ft. above ground level. Also, up to 500 ft. is the most critical/highest risk considering interference that prevents the RA system from operating normally is less likely above this height, and the consequence is also reduced, as there is more time to recover after interference. This also represents the constraining scenario for the RA equipment considering the other conditions of the rule (MSD, EIRP up to 4.16 GHz, etc.). If there is compatibility at 500 ft., then there is also compatibility at aircraft altitudes above this because interference signals get weaker at a faster rate than the interference tolerance decreases. This is supported by the draft MOPS and best achievable approach to defining the ITM levels and RA characteristics and limitations with respect to providing maximum interference tolerance while maintaining intended function and supporting the aircraft installation. These characteristics and limitations include receiver sensitivity as a function of altitude with respect to in-band and near-band interference tolerance (as sensitivity increases with altitude, interference tolerance decreases) and receiver selectivity and power handling capability with respect to out-of-band interference tolerance where increasing power may approach permanent damage limits for the receiver front-end components or arcing inside of the receiver bandpass filter affecting the performance. Balancing these factors, the highest possible altitude at which the maximum interference level could be sustained is 500 ft. This also helps to maximize and simplify spectrum compatibility and analyses.

7. Conditions For Future Spectrum Compatibility

7.1 The FAA published regulation is a companion to the FCC proposal to expand wireless services in the C-band (3.7 – 4.2 GHz) in the contiguous United States. The FCC technical rules are in line with the FAA up to 4.16 GHz (180 MHz) allocation for high-power wireless or less based on a variety of factors outside of the control of the FAA or aviation industry. The FAA requirements are defined based on maximum interference tolerance (best-achievable) RA capability, rather than tailored to a fixed RFI environment. Compatibility was designed to provide the largest possible number of 20 MHz sub-blocks, as close to 4.2 GHz as possible, with the highest possible EIRP in each block, and the fewest deployment/operational constraints as possible. For future RAs, full spectrum compatibility is achievable, with EIRP limits only, for all current and planned wireless implementations to within 40 MHz of the 4.2–4.4 GHz band (as long as unwanted emissions are compatible with RA in-band tolerance levels). There is no need for direct coordination, emitter deployment limitations, etc.

8. RA System Retrofit Equipment, Installation, Testing, and Certification

8.1 The FAA has developed Advisory Circular (AC) 20-199, Installation of an Airborne Low-Range Radio Altimeter System, to provide guidance for the installation approval and means of compliance with the proposed interference requirement (i.e., § 91.220(b)). Although RTCA SC-239/EUROCAE WG-119 have completed a draft of the MOPS for next generation RA systems, the requirements are currently being validated. Therefore, the AC addresses an ITM only solution which allows type certificate (TC) applicants (including amended type certificate (ATC) and supplemental type certificate (STC)) to meet the RFI interference criteria in the AC while retaining the existing TSO-C87(), Airborne Low-Range Radio Altimeter, performance and testing basis as an acceptable means of compliance.

8.2 The AC also addresses re-use of existing antennas, which is expected to support the RA transceiver for compliance to the maximum interference tolerance capability while maintaining the intended function of the RA system for most retrofit installations. Note that based on trade-off analysis, there is a limit to the total interference rejection that is achievable without compromising accuracy and due to a variety of factors, interference rejection is more appropriately addressed in the RA transceiver. A flat maximum antenna gain is used to bound data on existing airplane installations and provides minimal performance risk allowing for variations in production, installation conditions and constraints, installed performance, and antenna lifespan. It also provides minimal compatibility risk considering aircraft operations and maneuvers, and the angle of interference into the RA system allowable per regulations and requirements. The AC also provides RFI injection test setup and testing consistent with the MOPS. For installation approval, an applicant is required to demonstrate that any modification to the aircraft meets the FAA's airworthiness regulations for TC (including ATC and STC). The extent of the design, analysis and testing of the installed equipment can vary significantly on the change impact to the aircraft integration. The FAA assumes that the installation can rely heavily on, and be done in parallel with, the equipment compliance demonstration when the only change to the radio altimeter system is to swap the old transceiver with a new transceiver with better filtering. The change impact also bounds the scope of the AC guidance that should be considered during the retrofit installation.

9. Timelines

9.1 The FAA regulation requires all aircraft equipped with RA operating under Part 121 and those aircraft with RA operating under Part 129 with 30 or more passenger seats or a payload capacity of

more than 7,500 pounds to comply in the lower 48 contiguous United States and District of Columbia by December 30, 2030.

9.2 By October 31, 2034, all other Part 129 operators, as well as Part 125, 133, 135, 136, 137, 194 must comply with the rule.

10. International Considerations

10.1 As airspace rule changes affect all aircraft, regardless of country of registration, the FAA is providing this information for awareness on the published rulemaking for RA interference tolerance in the United States.

11. Suggested Actions

11.1 The Meeting is invited to take note of the information provided in this information paper