[4910-13-P]

DEPARTMENT OF TRANSPORTATION

Federal Aviation Administration

14 CFR Parts 91, 121, and 129

[Docket No.: FAA-2025-5666; Notice No. 26-02]

RIN 2120-AM21

Requirements for Interference-Tolerant Radio Altimeter Systems

AGENCY: Federal Aviation Administration (FAA), Department of Transportation (DOT).

ACTION: Notice of proposed rulemaking (NPRM).

SUMMARY: In July 2025, President Trump signed the One Big Beautiful Bill Act. Section 40002 of that law re-institutes the Federal Communications Commission's general auction authority and specifically directs the Commission to complete a system of competitive bidding for not less than 100 megahertz in the 3.98-4.2 gigahertz band (Upper C-band). To ensure safe, efficient, and reliable aviation operations in the presence of wireless signals in the Upper C-band, the Federal Aviation Administration is proposing new regulations that would require all radio altimeters to meet specific minimum performance requirements. These new radio altimeters must withstand interference from wireless signals in neighboring spectrum bands and continue to provide accurate altitude readings to both pilots and integrated aircraft safety systems. The minimum interference tolerance requirements proposed in this rule reflect the best achievable interference rejection using current technology without compromising radio altimeter system performance. These regulations would require all aircraft equipped with radio altimeters operating under part 121 and those aircraft with radio altimeters operating under part 129 with 30 or more passenger seats or a payload capacity of more than 7,500 pounds to comply with the minimum performance requirements by the date

the Federal Communications Commission authorizes wireless services in the Upper C-band. All other aircraft equipped with radio altimeters would be required to comply with the same minimum performance requirements two years later. This proposed rule is a companion to the Federal Communications Commission's NPRM to expand the ecosystem for next-generation wireless services in the 3.7-4.2 gigahertz band by making as much as 180, and at least 100, megahertz of the Upper C-band available for terrestrial wireless flexible use via a system of competitive bidding.

DATES: Send comments on or before [INSERT DATE 60 DAYS AFTER DATE OF PUBLICATION IN THE FEDERAL REGISTER].

ADDRESSES: Send comments identified by docket number FAA-2025-5666 using any of the following methods:

- *Federal eRulemaking Portal*: Go to www.regulations.gov and follow the online instructions for sending your comments electronically.
- *Mail*: Send comments to Docket Operations, M-30; U.S. Department of Transportation (DOT), 1200 New Jersey Avenue, SE, Room W12-140, West Building Ground Floor, Washington, D.C. 20590-0001.
- *Hand Delivery or Courier*: Take comments to Docket Operations in Room W12-140 of the West Building Ground Floor at 1200 New Jersey Avenue, SE, Washington, D.C. 20590 between 9 a.m. and 5 p.m., Monday through Friday, except Federal holidays.
- *Fax*: Fax comments to Docket Operations at (202) 493-2251.

Privacy: In accordance with 5 U.S.C. 553(c), DOT solicits comments from the public to better inform its rulemaking process. DOT posts these comments, without edit, including any personal information the commenter provides, to www.regulations.gov, as described in the system of records notice (DOT/ALL-14 FDMS), which can be reviewed at www.dot.gov/privacy.

Docket: Background documents or comments received may be read at www.regulations.gov at any time. Follow the online instructions for accessing the docket or go to the Docket Operations in Room W12-140 of the West Building Ground Floor at 1200 New Jersey Avenue, SE, Washington, D.C. 20590 between 9 a.m. and 5 p.m., Monday through Friday, except Federal holidays.

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SUPPLEMENTARY INFORMATION:

List of Abbreviations and Acronyms Frequently Used in This Document

AC – Advisory Circular
AD – Airworthiness Directive
ADS-B – Automatic Dependent Surveillance – Broadcast
AGL – Above Ground Level
AIP – Aeronautical Information Publication
AMOC – Alternative Method of Compliance
BLS – Bureau of Labor Statistics
CAA – Civil Aviation Authority
CAT – Category (CAT II, CAT III)
C-band – 3.7-4.2 GHz frequency band
CBI – Confidential Business Information
CFIT – Controlled Flight Into Terrain
CFR – Code of Federal Regulations
CMA – C-band Mitigation Airport
CPI-U – Consumer Price Index for All Urban Consumers
dB – Decibel
dBm – Decibel-milliwatts
dBm/MHz – Decibel-milliwatts per megahertz
dBW/m2/MHz – Decibel-watts per square meter per megahertz
DOT – Department of Transportation
EA – Environmental Assessment
EFVS – Enhanced Flight Vision Systems
EGPWS – Enhanced Ground Proximity Warning System
EIRP – Effective Isotropic Radiated Power
EIS – Environmental Impact Statement
E.O. – Executive Order
EUROCAE – European Organisation for Civil Aviation Equipment
FAA – Federal Aviation Administration
FCC – Federal Communications Commission
FOIA – Freedom of Information Act

FR – Federal Register
GA – General Aviation
GHz – Gigahertz
GPS – Global Positioning System
GPWS – Ground Proximity Warning System
HAA – Helicopter Air Ambulance
HTAWS – Helicopter Terrain Awareness and Warning System
IBA – International Bureau of Aviation
ICAO – International Civil Aviation Organization
IRFA – Initial Regulatory Flexibility Analysis
ITM – Interference Tolerance Mask
Lower C-band – 3.70-3.98 GHz frequency band
MHz – Megahertz
MOPS – Minimum Operating Performance Standards
MPS – Minimum Performance Standards
MSD – Minimum Separation Distance
NAICS – North American Industrial Classification System
NAS – National Airspace System
NM – Nautical Mile
NOI – Notice of Inquiry
NOTAM – Notice to Airmen
NPRM – Notice of Proposed Rulemaking
NVG – Night Vision Goggles
OCS – Obstacle Clearance Surface
OEM – Original Equipment Manufacturer
OMB – Office of Management and Budget
PFD – Power Flux Density
R&O – Report and Order
RA – Radio Altimeter (also known as Radar Altimeter)
RA Band – 4.2-4.4 GHz frequency band
RF – Radio Frequency
RFA – Regulatory Flexibility Act
RFI – Radio Frequency Interference
RIA – Regulatory Impact Analysis
RMS – Root Mean Square
SA CAT – Special Authorization Category (SA CAT I, SA CAT II)
SBA – Small Business Administration
SC-239 – RTCA Special Committee 239
TAWS – Terrain Awareness and Warning System
TCAS – Traffic Collision Avoidance System
TD – Touchdown
TSO – Technical Standard Order
UAS – Unmanned Aircraft Systems
UMRA – Unfunded Mandates Reform Act of 1995
Upper C-band – 3.98-4.2 GHz frequency band
VSL – Value of a Statistical Life
WG-119 – EUROCAE Working Group 119

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I. Executive Summary

A. Overview of Proposed Rule

Federal Aviation Administration (FAA) is proposing new regulations that would require all radio (also known as radar) altimeter (RA) systems[1] on aircraft operating under title 14 of the Code of Federal Regulations (14 CFR) part 91 in the airspace of the 48 contiguous United States and the District of Columbia to meet minimum performance requirements necessary to withstand interference from wireless services in at least 100 megahertz (MHz) of the 3.98-4.2 gigahertz (GHz) frequency band (Upper C-band), which is immediately adjacent to the RA frequency band. FAA is proposing two compliance dates. RA systems on aircraft operating under 14 CFR part 121, and on aircraft operating under 14 CFR part 129 with 30 or more passenger seats or a payload capacity of more than 7,500 pounds, would be required to meet the new minimum performance requirements by the date the Federal Communications Commission's (FCC) Report and Order (R&O) authorizes wireless service in the Upper C-band. All RA systems on other aircraft operating under part 91 in the airspace of the 48 contiguous United States and the District of Columbia would be required to meet the new minimum performance requirements two years after the date FCC authorizes wireless service in the Upper C-band. As discussed in the proposal, FAA expects the initial RA performance deadline will be achievable between 2029 and 2032, based on a variety of factors. The proposed timeline for this retrofit is intended to reflect the urgency of expanding next-generation wireless services in accomplishing the equipment development and retrofit with acceptable schedule risk. The final RA system performance deadlines, within the proposed timeframe, will be informed by the comments to this proposal. These new

regulations would require the installation of new or upgraded RA systems for all aircraft currently equipped with RA operating under part 121; the majority of aircraft operating under parts 91 subpart K, 125, 129, 135, and 194; and a minority of general aviation (GA) aircraft operating under part 91. Aircraft that are not currently equipped with an RA would not need to replace or upgrade their RA system.

B. Statement of the Problem

RAs measure an aircraft's height above terrain and obstacles using low-powered signals in the 4.2-4.4 GHz frequency band (RA band). Wireless signals in the neighboring spectrum bands may interfere with RA systems and cause inaccurate altitude readings. New RA systems must be able to withstand interference from higher-powered wireless signals in neighboring spectrum bands and spurious emissions from those wireless base stations into the RA band, and continue to provide accurate altitude readings. Accurate RA data is critical for pilots as well as integrated automation, navigation, and safety systems, including autoland, rotorcraft automation modes, and systems that alert pilots of immediate hazards such as terrain, windshear, and traffic. This is particularly critical when the pilot cannot see the runway in low-visibility conditions. Anomalous RA inputs to these systems may cause the aircraft to maneuver in an unexpected or hazardous manner at a very low altitude during the final stages of approach and landing or may prevent collision alerting technology from functioning properly. The pilot might not be able to detect the error or adjust the flight path in time to maintain safe flight and landing, which could result in catastrophic outcomes, including aircraft accidents that may be fatal.

FCC issued a Notice of Inquiry (NOI)[2] in February 2025 to signal its intent to auction spectrum for more intensive use in the Upper C-band, which is immediately adjacent to the RA band. This NOI also sought comments on whether to adopt service rules similar to those in the 3.7-3.98 GHz band (Lower C-band). The One Big Beautiful

Bill Act of 2025, Public Law 119-21,[3] signed on July 4, 2025, requires FCC to auction at least 100 MHz in the Upper C-band by July 4, 2027. Pursuant to this requirement, FCC has proposed to further expand the ecosystem for next-generation wireless services in the 3.7-4.2 GHz band (C-band) by making as much as 180, and at least 100, megahertz of the Upper C-band available for terrestrial wireless flexible use via a system of competitive bidding.[4]

FAA expects future wireless services in the Upper C-band aligned with service rules in the Lower C-band to cause interference to current RA systems. Existing RA systems are not compatible with this envisioned use, and airworthiness directives (AD) issued by FAA in 2023 are insufficient to address the unsafe condition that will result from wireless services in the Upper C-band. In addition, existing RA systems are currently operating with reduced capabilities. Several ADs currently restrict operations to resolve the unsafe conditions caused by wireless services in the Lower C-band. Voluntary measures were adopted by the wireless service providers to minimize the national economic impact of restrictions by coordinating the power level of wireless services in the Lower C-band and ensuring airport access for air carriers at major airports.[5] The voluntary commitments sunset on January 1, 2028, unless extended or reduced by mutual agreement, and long-term compatibility between Lower C-band wireless services and RA systems has not been resolved beyond that date. In addition to the unsafe conditions that have been addressed through ADs, safety-enhancing systems such as Traffic Collision Avoidance Systems (TCAS) and Terrain Awareness and Warning Systems (TAWS) may not operate reliably in close proximity to the Lower or Upper C-band wireless base stations.

A single retrofit of RA systems can address long-term compatibility with wireless in both the Lower and Upper C-band. The aviation industry has been developing standards for next-generation RA systems for several years. A joint industry committee,

RTCA, Inc Special Committee 239 (SC-239)[6] and the European Organisation for Civil Aviation Equipment (EUROCAE) Working Group 119 (WG-119),[7] is developing an industry standard to define the maximum safely tolerable radio frequency interference (RFI) environment for RA systems. This avionics standard is scheduled for publication in early 2027. The wireless and aviation industries are also engaged in ongoing discussions about how to promote effective coexistence between RA systems and new terrestrial wireless services in the Upper C-band.[8]

FAA is proposing new regulations that would require all aircraft operating under part 91 in the airspace of the 48 contiguous United States and the District of Columbia and equipped with RAs to upgrade to RA systems that meet minimum interference tolerance requirements that reflect the best achievable interference rejection using current technology and without compromising the RA system performance. These new RA systems must provide accurate altitude readings to pilots and integrated safety systems in the presence of the defined interference environment. The goal of these proposed regulations is to minimize the impact on the safety, efficiency, and reliability of aviation operations as a result of the Presidential[9] and Congressional goals of increased wireless and broadband access for the American people.

C. Summary of the Costs and Benefits

RA systems are integral to aviation safety by providing altitude information directly to pilots and to safety systems that need accurate information to function properly. Besides the importance of pilots having accurate height over terrain information in low visibility conditions, RA data is vital for the proper functioning of safety systems such as TCAS, TAWS, and other aircraft-specific functions, which historically have reduced the risk of airline crashes in the United States significantly.[10] Upgrading to new interference-tolerant RA systems would allow RAs and their dependent safety systems to

continue to play their important role in ensuring safe aircraft operations in the National Airspace System (NAS).

FAA is proposing two compliance dates for RA retrofits. FAA considered several factors in proposing a staggered compliance schedule, including the role the operations play in the economy, expected level of safety, and the expected availability of RA units. The initial RA performance deadline would apply to all aircraft equipped with an RA operating under part 121 and aircraft equipped with an RA operating under part 129 with 30 or more passenger seats or a payload capacity of more than 7,500 pounds. FAA would require an earlier compliance date for part 121 and 129 operations because they constitute flights by the major domestic and international airlines and affect the majority of the flying public, have the highest public expectation of safety, and are the most critical to the national economy.

Any other aircraft operating in the airspace of the 48 contiguous United States and the District of Columbia equipped with an RA would have two additional years from the first compliance date to retrofit with an RA system that meets the proposed performance requirement. As necessary, FAA would supersede the current ADs to impose operating limitations on the use of RAs that do not meet the proposed performance requirements until such time as the RA system is replaced. The superseding ADs would address operators who have upgraded to a Lower C-band interference-tolerant RA, but do not upgrade to an RA system compliant with the proposed rule prior to the initial compliance date (see section IV-H).

In order to properly evaluate a regulation, agencies must measure its costs and benefits against a baseline. Office of Management and Budget (OMB) Circular A-4 defines the “no action” baseline as “the best assessment of the way the world would look absent the proposed action.” FAA considers the primary baseline for this analysis to be a no action baseline, in which FAA assumes FCC completes the auction required by Public

Law 119-21 and the voluntary commitments of the wireless service providers lapse. Under this scenario, FAA would have to react to the interference to prohibit all operations of certain aircraft makes and models, as well as prohibit low-visibility operations in all aircraft, causing significant operational impacts. Aircraft owners would need to replace their RA systems to achieve compatibility with the new spectrum environment. The inherent costs of delays, cancellations, and groundings resulting from re-imposing AD operational prohibitions under this no action baseline can be negated by the cost of retrofitting the RA system in compliance with proposed performance standards.

FAA also considers an alternative pre-C-band utilization baseline, in which FAA does not account for the inherent costs of delays, cancellations, and groundings resulting from AD operational prohibitions that would be necessary due to the proposed Upper C-band auction or expiration of the voluntary wireless commitments. Relative to this baseline, FAA estimates the total undiscounted cost to retrofit with interference-tolerant RA units is $4.49 billion, or $424 million annualized at a 7 percent discount rate over 20 years,[11] as shown in Table 1.

Table 1: Cost of RA Retrofit Relative to Pre-C-band Utilization Baseline

(millions of 2025$)

CFR Operational Part	Undiscounted Total Cost	Annualized Costs[1]	
		3% Discount Rate	7% Discount Rate
Part 91	$1,589	$107	$150
Part 121	$1,363	$92	$129
Part 129	$891	$60	$84
Part 135	$651	$44	$61

Total	$4,494	$302	$424
Notes: Columns may not sum due to rounding 1. Costs are annualized over a 20-year period, estimated to be the average remaining service life for current fleet aircraft.			

II. Authority for This Rulemaking

FAA's authority to issue rules on aviation safety is found in Title 49 of the United States Code. Subtitle I, Section 106 describes the authority of the FAA Administrator. Subtitle VII, Aviation Programs, describes in more detail the scope of FAA's authority. This rulemaking is promulgated under the authority described in 49 U.S.C. 106(f), which establishes the authority of the Administrator to promulgate and revise regulations and rules related to aviation safety. This rulemaking is also issued under the authority described in Subtitle VII, Part A, Subpart III, Section 44701: General requirements. Under that section, FAA is charged with prescribing regulations promoting safe flight of civil aircraft in air commerce by prescribing regulations for practices, methods, and procedures the Administrator finds necessary for safety in air commerce.

This regulation is within the scope of this authority. This proposed rule will ensure continued safety after completion of FCC's auction of at least 100 MHz of spectrum in the band immediately adjacent to the RA spectrum band, which Public Law 119-21 requires to be completed by July 4, 2027. The requirement for an RA system retrofit is necessary due to FCC's anticipated auction and is also needed to support continued safety with respect to Lower C-band wireless services.

III. Background

Aircraft rely on RA systems to measure height above terrain and obstacles in all phases of flight. The RA provides this information to the pilot and to the aircraft's interconnected navigation and safety systems to support functions such as low-visibility

approaches and landings, terrain awareness and alerting, wind shear detection and recovery, aircraft collision avoidance, automated rotorcraft systems, and other flight control systems. The safety and efficiency of flight depend heavily on RAs providing accurate inputs to these systems. For example, automatic and manual flight guidance systems on airplanes rely on RA data to facilitate low-visibility operations such as autoland and guidance provided for manual landing using a Head Up Display to touchdown (TD) when conducting Category (CAT) II, CAT III, Special Authorization (SA) CAT I, SA CAT II or Enhanced Flight Vision Systems (EFVS) to TD operations. These inputs determine when and where the pilot or automation system flares for landing (i.e., raising the aircraft's nose just before touchdown to smooth touchdown), when power reductions are made for landing, and when other control inputs are made. On helicopters, automatic and/or manual flight guidance systems rely on accurate RA height data to facilitate low-visibility operations such as Category A and Category B takeoff operations.

Accurate RA readings are critical for all of these applications. Inaccurate altitude information from an RA experiencing signal interference from higher-powered wireless services in neighboring frequency bands may give the pilot a false sense of the aircraft's position in the air and can cause missing or erroneous (anomalous) RA inputs to navigation and safety systems, potentially resulting in catastrophic consequences. For example, automated safety systems reading erroneous altitude information can cause the aircraft to make unexpected or hazardous maneuvers during the final stages of approach and landing, or prevent ground collision alerting technology from functioning properly. Importantly, the pilot might not be able to detect the error or adjust the flight path in time to maintain safe flight and landing, which could result in an accident with fatalities or injuries.

RA systems work by emitting and then detecting low-powered signals returning from the ground or other obstacles, similar to how radar works. The 4.2-4.4 GHz frequency band (RA band) is allocated for RA operational use in the U.S. and worldwide. Before 2020, satellite operators and other low-powered sources used the neighboring frequency bands, and their low-power signals in-band and out-of-band did not interfere with RAs. This changed when the Lower C-band was reallocated to permit high-powered commercial wireless services.[12] Though FCC limits apply differently for terrestrial and satellite-based services, as a comparison, previous low-powered satellite services were limited such that their signals were no greater than roughly -99 decibel-milliwatts (dBm) per MHz (dBm/MHz) at the Earth's surface, where current Lower C-band wireless base stations can transmit up to 65 dBm/MHz. This significant increase in signal power can interfere with the RA's ability to receive the low-power signal reflected off the ground or other obstacles. As a result, the RA can register incorrect data (or no data at all) unless the RA system can block or otherwise filter out this interference from neighboring spectrum bands and their unwanted emissions into the RA band.

In April 2020, RTCA formed a "5G Task Force," including members from RTCA, FAA, aircraft and radio altimeter manufacturers, EUROCAE, industry organizations, and operators, to perform "a quantitative evaluation of radar altimeter performance regarding RF interference from expected 5G emissions in the 3.7-3.98 GHz band, as well as a detailed assessment of the risk of such interference occurring and impacting aviation safety"[13] that concludes there is a major risk that C-band signals can cause harmful interference to RA on all types of aircraft. The report further concludes that the likelihood and severity of radio frequency interference increases for operations at lower altitudes. That interference could cause the RA to either become inoperable or present misleading information, as well as affect associated systems on civil aircraft.

In late 2021, to address the unsafe conditions caused by interference from wireless services in the Lower C-band, FAA issued ADs prohibiting certain transport and commuter category airplane[14] and rotorcraft operations[15] that require RA data. FAA also issued airplane model-specific ADs[16] with additional restrictions to address unique safety issues for those airplanes. The FAA risk assessment for these ADs included consideration of the RTCA report, public comments to the RTCA report, and analyses from RA and aircraft manufacturers in support of the safety risk determination. The analyses FAA considered were consistent with RTCA's conclusions pertaining to RA interference from C-Band emissions. Some aircraft could not operate safely at all unless equipped with RA systems that are sufficiently resilient to potential spectrum interference. While the ADs addressed the unsafe conditions, the safety enhancements provided by RA systems have been compromised where an RA experiences interference. On January 19, 2022, FAA began tracking and analyzing reports of potential interference affecting RAs and integrated safety systems. As of August 19, 2025, FAA has received 659 reports of potential C-band interference, and 493 of these reports were associated with RAs or related systems. FAA has completed analysis of 625 of these reports and identified 118 events where all other potential sources were eliminated as likely causes and were potentially caused by C-band interference. Most of these 118 events consist of RA display errors, including erroneous altitude data, and/or nuisance alerts from integrated safety systems dependent on RA data to function properly. The quantity and details of reports received to date reflect the current spectrum environment defined by the wireless voluntary commitments and mitigations imposed by ADs to address the highest-risk operations. These reports demonstrate that wireless signals disrupt radar altimeters as predicted.

In January 2022, Verizon and AT&T (the first licensees to begin next-generation wireless services in the Lower C-band) agreed to limit wireless base station deployments

and coordinate power levels around certain airports with FAA until July 1, 2023. The 2022 voluntary agreement provided the aviation industry time to find a solution to address the immediate, critical issue of increased risk of RA interference: to quickly develop, produce, and install modified RA systems that were tolerant to interference caused by Lower C-band signals. FAA worked collaboratively with RA and airframe manufacturers throughout 2022 to develop the aviation safety case that would allow a steady deployment of Lower C-band wireless base stations while avoiding unsafe conditions and preventing significant disruptions for aviation operations. Other types of operations and safety enhancements such as TAWS, which is intended to provide ground warning away from airports, have been disrupted by the current wireless deployment in the Lower C-band.

FAA conducted a series of flight tests in 2022, with cooperation from AT&T and Verizon, to measure real-world Lower C-band signal levels in an airspace. Each set of flights had unique goals and objectives, with each flight furthering FAA's understanding of how to measure C-band signals through an airspace. Lessons learned from each flight were incrementally incorporated into subsequent flights to improve measurement fidelity and accuracy. Flight locations were chosen strategically to extract maximal value based on the objectives and goals for each flight. Coordination with AT&T and Verizon preceded the flights to ensure FAA properly understood the wireless base station deployments relevant to each location. Technical interchanges between FAA, AT&T, and Verizon engineers helped to ensure the measurement procedures and equipment were properly suited for making accurate Lower C-band signal measurements from an aircraft. After each flight, measurement data and engineering analysis reports were shared with the associated wireless service provider to maximize transparency. While the primary objectives of each flight varied, FAA collected evidence during those flights showing ambient levels of fundamental Lower C-band signals that exceeded the interference

tolerance of RA systems in use at the time. Both the raw and processed data associated with each of these flights were shared with AT&T and Verizon. The flight tests measured the signal present at the aircraft at multiple locations within the airspace and were not intended to observe real-world effects of Lower C-band signals on the performance of any specific RA or the test aircraft's equipped RA. These flights provided empirical evidence that it was possible for an airborne aircraft to experience Lower C-band signal levels that exceed the performance tolerance of unmodified RA equipment.

As of July 1, 2023, Verizon, AT&T, and the other 19 wireless service license holders[17] voluntarily committed to coordinate power levels and limit emissions into the RA band to minimize the disruption to air carrier operations until January 1, 2028.[18] FAA replaced its initial ADs with a second set of ADs to address the unsafe condition in the operating environment after July 1, 2023. AD 2023-10-02[19] requires transport and commuter category airplanes to have a Lower C-band interference-tolerant RA suitable for the spectrum environment defined in the voluntary agreement to conduct certain low-visibility landings, and AD 2023-11-07[20] contains similar requirements for rotorcraft. In addition, all airplanes operating under 14 CFR part 121 must have a Lower C-band interference-tolerant RA (or otherwise have an FAA-approved alternative method of compliance). FAA also replaced the existing airplane model-specific ADs with updated ADs,[21] and issued others where appropriate,[22] with additional restrictions to address issues affecting those specific airplanes. With the implementation of the 2023 ADs and other limitations relevant to part 129 foreign air carriers, the RAs on over 7,500 aircraft were modified to meet the Lower C-band tolerance that was prescribed. Some operators upgraded their RAs by adding supplemental filters, while other operators replaced their RA with one more resilient to potential interference in the Lower C-band.

When publishing these ADs, FAA noted they were an interim action until a new technical standard order (TSO) for RAs is established to incorporate new Minimum

Operating Performance Standards (MOPS) that were in development. Currently, in accordance with the provisions in the ADs, FAA determines whether an RA is interference tolerant based on compatibility with the power limits in the voluntary agreements with the Lower C-band license holders, which temporarily reduces emissions through January 2028. However, these ADs do not address future next-generation wireless services in the Upper C-band and do not provide a long-term resolution that would ensure safety in the presence of Lower C-band wireless services.

A new industry standard for RA systems is being developed jointly by U.S. and European consensus bodies through RTCA SC-239[23] and EUROCAE WG-119.[24] In 2020, RTCA/EUROCAE began developing a MOPS for RA systems that can tolerate interference from signals in neighboring spectrum bands. This joint industry committee has developed a draft standard, which is being validated through testing to ensure the proposed performance is achievable. Once the standard is validated, it will undergo a final public comment period and is planned for publication in March 2027. FAA has requested the committee publish the standard by June 2026, if possible, to align with FAA's anticipated timeline for publication of a final rule. The wireless and aviation industries are also engaged in ongoing discussions about how to promote effective coexistence between RA systems and new terrestrial wireless services in the Upper C-band.[25]

When the RTCA standard is complete, FAA anticipates recognizing the industry standard with new TSOs, which will provide a means for obtaining an FAA design and production approval for compliant equipment to facilitate aircraft equipage under this proposed rule. FAA will ensure that the TSOs conform to the interference tolerance mask (ITM) requirements in the final rule; any difference in the ITM of the industry standard will be corrected to conform to the FAA final rule by the implementing TSOs.

IV. Discussion of the Proposal

A. Broadband Objective to Meet Projected Spectrum Demand, Spur Economic Growth, and Advance American Security Interests

The 3.7-4.2 GHz band (C-band) is an ideal band for many next-generation advanced wireless services, including 5G, due to its desirable coverage, capacity, and propagation characteristics. As a result of previous efforts to expand access to the 3.7-3.98 GHz band, wireless operators have extensively deployed 5G throughout the continental United States, bringing enhanced services and increased connectivity to countless communities, including many in rural, remote, and underserved areas. Making additional spectrum available in the 3.98-4.2 GHz frequency range will expand on the success of these prior efforts to help meet projected demand for advanced wireless services, spur economic growth, and advance American security interests.

FCC issued an NOI in February 2025 to signal its intent to auction spectrum for next-generation wireless services in the Upper C-band, which is immediately adjacent to the RA band. While the Upper C-band presents a unique opportunity for commercial wireless expansion, it is even closer to the RA band than the current Lower C-band wireless services and poses a risk of increased interference with RAs and critical aviation systems dependent on the RA for accurate altitude data. FCC issued an NPRM to expand the ecosystem for next generation wireless services in the C-band by making as much as 180, and at least 100, MHz of the Upper C-band available for terrestrial wireless flexible use via a system of competitive bidding. FAA and FCC conducted extensive inter-agency coordination prior to the release of these respective NPRMs, with the goal of aligning aviation and wireless objectives in a way that leads to continued safe coexistence. This proposed expansion of wireless services should occur as early as possible while providing a high level of confidence that the proposed implementation dates are achievable to minimize the impact on the safety, efficiency, and reliability of aviation operations.

B. Radio Altimeter Operation and Application

The U.S. has the safest aviation system in the world, and an RA is an essential component that contributes to this enviable safety record. An RA measures aircraft height above terrain and obstacles in all phases of flight for tens of thousands of commercial aircraft, helicopters, business jets, GA aircraft, and future operations by powered-lift. An RA operates in the frequency band 4.2-4.4 GHz (RA band). The receiver on an RA is typically highly accurate, measuring height to within a few feet. An RA operates like radar and must detect faint signals reflected off the ground to measure altitude. The receiver must be able to isolate a reflected signal as low as approximately -120 dBm.

Automatic and manual flight guidance systems on airplanes rely on accurate RA data to facilitate autoland and operation in low-visibility conditions. An RA is critical equipment for conducting operations when the cloud base is less than 200 feet above the runway, and it is embedded within all types of CAT II, CAT III, and EFVS landing systems. An RA determines when and where the pilot or automation systems initiate the aircraft flare for landing, when power reductions are made for landing, and when other control inputs are made. This is critically important when the pilot cannot see the runway in low-visibility conditions. Anomalous RA inputs to these systems may cause the aircraft to maneuver in an unexpected or hazardous manner during the final stages of approach and landing, and may not be detectable by the pilot within sufficient time to maintain continued safe flight and landing. This could result in catastrophic outcomes, including aircraft accidents that may be fatal. Inaccurate RA data can also reduce pilot confidence in their instruments, eroding the foundation of all instrument flight training.

An RA is also integrated into several safety systems, starting with the TAWS. TAWS is an onboard aircraft system designed to prevent unintentional impact with the ground, commonly referred to as controlled flight into terrain (CFIT) accidents. An operable RA is a required element of TAWS. The accurate altitude provided by the RA is

used to trigger an alarm in the flight deck when the aircraft is too low or there is an excessive closure rate to the ground. This system is required to generate alerts between 30 feet and 2,500 feet above ground level (AGL).[26] By definition, TAWS must be able to function everywhere, as there is no way to predict where a CFIT accident could occur. TAWS or predecessor safety equipment, such as ground proximity warning system (GPWS), has been required for over 50 years for many aircraft operations. In 1974,[27] FAA required all part 121 certificate holders and part 135 certificate holders operating large turbojet airplanes to install approved GPWS equipment. FAA extended the GPWS requirement to part 135 certificate holders operating turbojet-powered airplanes with 10 or more passenger seats in 1978,[28] and amended this requirement in 1992[29] to require GPWS equipment on all turbine-powered airplanes (including turbo-propellor powered) with 10 or more passenger seats. Advances in terrain mapping technology permitted the development of enhanced GPWS (EGPWS), which provides greater situational awareness for flight crews, and FAA adopted the broader term TAWS to include a variety of systems that would meet improved standards beginning in March 2000.[30] The look-ahead feature of TAWS provides the flight crew with an earlier aural and visual warning of impending terrain based on Global Positioning System (GPS), forward-looking capability, and continued operation in the landing configuration, all of which provide more time for the flight crew to make smoother and gradual corrective action. When GPS is not available, such as during scheduled testing or other interference events, the GPWS alerts are still provided to the pilots.

An RA is also used within TCAS. In 1987, Congress mandated in Public Law No. 100-223[31] that FAA require aircraft with more than 30 seats to have TCAS. FAA issued new regulations in 1989[32] requiring TCAS by December 1991 for all airplanes with 30 or more seats operating under 14 CFR parts 121, 125, and 129, and by December 1995 for all part 129 and part 135 aircraft with 10 or more seats. The TCAS mandate was

expanded to include cargo airplanes in 2004,[33] specifically requiring TCAS equipment on all airplanes over 33,000 pounds, with both requirements applicable to operations under parts 121, 125, and 129. In 2003,[34] new regulations for fractional aircraft ownership programs and on-demand operations included TCAS requirements for all aircraft operating under part 91, subpart K. TCAS depends on data provided by a properly functioning RA when below 2,350 feet AGL. If the aircraft's RA is not functioning normally, the TCAS system may fail to issue a collision warning to the pilot and fail to prevent a mid-air collision and a catastrophic loss of life.

Wind shear alerting systems also require accurate RA data. Wind shear alerting has been required for part 121 turbine-powered commercial operations since 1991.[35] Initial systems were only reactive, detecting when an aircraft is in a wind shear condition by the unexpected change in altitude, typically using the RA. Wind shear systems have advanced with additional sensors improving performance, and predictive wind shear systems use weather radar to improve wind shear detection. Even in the most sophisticated systems, the pilot uses RA callouts to diagnose the severity of the wind shear and take an appropriate course of action. Erroneous RA altitude during a wind shear condition could result in a failure to provide appropriate thrust to exit the wind shear, increasing the risk of an aircraft accident and catastrophic loss of life.

The aviation community has used RAs to improve pilot situational awareness in a variety of visual operations, and FAA has required it for certain helicopter operations due to the safety benefit it provides. Public Law No. 112-95[36] requires RAs and Helicopter Terrain Awareness and Warning Systems (HTAWS) for Helicopter Air Ambulance (HAA) operations, which FAA implemented in 2014[37] in 14 CFR 135.160 and 135.605, respectively, and extended to certain powered-lift via § 194.306.[38] While many HTAWS primarily rely on terrain maps, barometric altitude, and position information (horizontal and vertical) from GPS, some HTAWS do utilize RA data similar to TAWS in airplanes.

RA data is also used for vertical situational awareness in low visibility conditions (*e.g.,* snow and dust blown up by rotor downwash) and as an input into several procedures and automated systems. On helicopters, automatic and/or manual flight guidance systems rely on accurate RA height data to facilitate low-visibility operations such as Category A and Category B takeoff operations. Search and Rescue and Hover autopilot modes also rely on accurate RA data to function properly. The RA provides a precise measurement of the helicopter's height above the ground, which is critical for safety and performance during low altitude and hover operations. Anomalous RA inputs to these systems may cause the aircraft to be maneuvered in an unexpected or hazardous manner when operating at a low altitude and may not be detectable by the pilot in time to maintain continued safe flight and landing.

Night Vision Goggles (NVG), the common term to describe the use of Night Vision Imaging Systems and Night Vision Enhancement Devices, are used in the operation of airplanes, rotorcraft, and powered-lift. When used properly, NVGs can increase safety, enhance situational awareness, and reduce the pilot workload and stress typically associated with night operations. In 2009,[39] FAA updated § 91.205 by adding paragraph (h), which established the instruments and equipment required to be installed, functioning in a normal manner, and approved for use by FAA to conduct NVG operations. Before 2009, RA was included as required equipment under each design approval (type certificate or supplemental type certificate) of an aircraft for NVG operations.

In addition to these common use cases, some aircraft designers have integrated RA systems into other safety systems. This includes tail-strike prevention systems, which push the nose down if the RA indicates a tail-strike is imminent. Some aircraft use RA data to verify the aircraft is on the ground to permit automatic throttle power reduction as well as the safe deployment of thrust reversers and ground spoilers after landing or during

an aborted takeoff. RA data that erroneously show the aircraft is above the ground will increase the required stopping distance and increase the risk of overrunning the runway. Similarly, RA data that erroneously show the aircraft is lower than the actual position can trigger auto throttle and landing flare systems, which reduces aircraft speed and increases the risk of landing short of the runway if the pilots do not quickly identify and correct these automatic control systems.

All of these applications must be preserved in the presence of Upper C-band wireless services or restored for those that have been degraded by wireless services in the Lower C-band. Long-term safe coexistence between efficient aviation operations and next-generation wireless services requires RA systems resilient to spectrum interference from signals in neighboring spectrum bands.

C. Current RA Limitations

Historically, out-of-band emissions were not a problem for RA because there were no high-powered signals in neighboring spectrum bands. Current industry standards for RA such as RTCA/DO-155, Minimum Performance Standards Airborne Low-Range Radar Altimeters,[40] EUROCAE ED-30, MPS (Minimum Performance Standards) for Airborne Low Range Radio (Radar) Altimeter Equipment,[41] and TSO-C87[42] which is aligned with those industry standards, did not address this possibility when they were published in 1974 and 1980, respectively. Before 2020, satellite operators and other low-powered sources used the neighboring frequency bands, and those signals did not interfere with RA systems due to their low power. This changed when the Lower C-band was reallocated to permit higher-powered commercial wireless services.

The voluntary commitments by the wireless service providers have minimized the national economic impact of the AD restrictions and ensured airport access by designating 188 major airports as C-band Mitigation Airports (CMAs) at which Lower C-band licensees are limiting base station power, when necessary, at the request of FAA.

These 188 CMAs are the airports that would be most impacted by AD prohibitions on specific operations due to a number of factors, such as passenger traffic, cargo volume, very low-visibility approach procedures, historic weather information, or a combination of these factors. Due to extensive efforts from 2022 to 2024, the aviation industry successfully developed, produced, and installed supplemental (in-line) filters or replaced RA transceivers on thousands of air carrier airplanes with other available units that were more tolerant to interference from transmissions in the Lower C-band, and aligned with the interim voluntary agreements from all 21 FCC license holders. However, this work by the aviation industry to address the unsafe conditions and quickly upgrade within the limits of existing RA system capabilities did not provide sufficient time to develop more robust solutions that would enable the full range of RA applications or address the potential for additional spectrum expansion.

FAA permitted operators of approximately 26,500 aircraft to choose to accept operational restrictions instead of upgrading their systems. FAA analysis showed that there was not an immediate need to mandate RA replacement for non-part 121 operators when the highest risk operations remained prohibited by the ADs and the cumulative risk of other hazards was found acceptable in the short-term. However, the safety enhancements for these aircraft have been compromised, such as the potential for erroneous alerts or no alerts from TCAS and TAWS, due to the risk of interference causing incorrect RA altitude data. These cumulative risks must be resolved to support long-term safe coexistence.

The FAA requested the RA equipment manufacturers share available data concerning the performance of their equipment to interfering signals in the Upper C-band. All five existing manufacturers provided proprietary data for their Lower C-band tolerant equipment (e.g., those approved for compliance with AD 2023-10-02).[43] The data indicate that no existing civil equipment can tolerate wireless services aligned with

FCC's Lower C-band technical rules in the 100 MHz (or more) of the spectrum to be auctioned above 3.98 GHz. Allocating even 20 MHz of additional spectrum to rural or non-rural wireless services would be incompatible with the current Lower C-band tolerant RAs and would require more than 45% of Lower C-band tolerant RAs to be modified or replaced. Table 2 summarizes the achievable performance of the existing Lower C-band tolerant RAs, broken down by specific frequency ranges within the Upper C-band. The power flux-density indicates the minimum interference tolerance at 500 feet AGL and below, measured as a root mean square (RMS) in decibel-watts per square meter per MHz (dBW/m^2/MHz).

Table 2: Frequency Ranges within the Upper C-Band

Frequency Range (MHz)	**Power Flux-Density, RMS (dBW/m^2/MHz), 0-500 feet HAGL**
$3980 < f < 4100$	-40
$4100 \leq f < 4200$	-67
4200 to 4400	-105

There are also thousands of RA systems that have not been modified to be tolerant to Lower C-band wireless services under the current voluntary agreement and are more susceptible to interference than shown in Table 2.

D. Next Generation RA Capability

FAA is proposing an ITM that reflects the best achievable interference rejection using current technology and without compromising RA system performance. This proposal has been informed by briefings from existing RA suppliers and by various industry forums that have discussed performance collectively. The wireless and aviation

industries have also been engaged in ongoing discussions about how to promote safe coexistence between expanded wireless services in the Upper C-band and RA systems.[44]

The most substantive industry discussions concerning RA system performance have taken place in the RTCA and EUROCAE joint committee, which has been developing an industry consensus standard for next-generation RA systems since 2019. These next-generation RA systems will be responsible spectrum users, with an up-to-date design to provide the best currently achievable performance to tolerate and reject potential interference. RTCA SC-239 was established in 2019 and tasked with revising RTCA/DO-155. RTCA SC-239 is working on these MOPS jointly with EUROCAE WG-119, which will also be releasing an update to ED-30. The joint committee has completed a draft standard that is undergoing validation, which involves testing and analysis with prototype new designs to ensure that the requirements are both achievable and sufficient to meet the industry's needs. RTCA plans to publish a final new standard in March 2027. FAA has participated in the RTCA/EUROCAE industry standard development.

FAA has considered all available information from individual manufacturers and the various working groups to develop the ITM proposed in this NPRM. FAA plans to issue a TSO that references the final industry standard and will ensure the TSO aligns with this proposed rule, identifying differences from the final industry standard if necessary. The TSO will enable companies to use equipment qualified to the ITM and industry standard as a means of compliance with this regulation. FAA is not proposing changes to the intended function or performance requirements of RA systems, which may also include requirements derived by the aircraft design approval holder for each RA application. The proposed rule effectively defines an interference environment within which the intended RA system functions and performance are achieved.

The interference tolerance requirement would apply to the entire RA system, comprised of the RA antenna(s), cables, and transceiver. When defining interference

tolerance close to the edge of the RA band, the frequency selectivity of the antenna does not have an appreciable effect due to other design constraints, such as the group delay and the lack of available space for a separate radio frequency (RF) filter. The achievable ITM in the near-band is driven by the transceiver performance requirements. While it would be possible to require additional interference rejection due to the RA antenna's ability to reject signals far from the desired RA band, doing so would have a significant cost and schedule effect because it would require the requalification, and potentially replacement, of all RA antennas. The proposed ITM does not require this additional interference rejection, as it would not have a benefit in the potential use of the adjacent band for next-generation wireless services. As a result, operators can use RA transceivers that meet the ITM without requalification of an existing RA antenna. The ITM is specified as a PFD regardless of the angle of arrival to the RA antenna, so the maximum RA antenna gain must be used when showing compliance. The ITM is specified for a single polarization because the RA antennas are linearly polarized and the orientation of the polarization of an interference source and that of the RA antenna cannot be controlled.

FAA has developed additional guidance to address this and other aircraft-level qualification issues in the proposed AC 20-199 *Advisory Circular (AC) for Installation of an Airborne Low-Range Radio Altimeter System*.[45] FAA will solicit comments on the AC and update it based on those comments and any changes to the final rule.

E. Proposed Regulation and Retrofit Requirements

FAA is proposing new regulations that would require all RAs to meet specific minimum performance requirements for all aircraft operating under 14 CFR part 91 that are equipped with RAs. FAA is proposing two different compliance dates based on the safety risks associated with the different types of aircraft operations. Aircraft operating under 14 CFR part 121, and aircraft operating under 14 CFR part 129 with 30 or more

seats or a payload capacity of more than 7,500 pounds, would be required to meet the minimum RA performance requirements by an initial RA performance date that would be specified in the final rule. FAA proposes to provide an additional two years for compliance for all other operations of aircraft operating under part 91 in the airspace of the 48 contiguous United States and the District of Columbia and equipped with RAs.

The initial RA performance deadline is proposed to coincide with FCC's date authorizing the initiation of new wireless services in the Upper C-band. FAA expects this initial RA performance deadline to be sometime between 2029 and 2032. As addressed in section E.2, FAA is soliciting public comments on the proposed compliance dates. In the final rule, FAA would prescribe specific RA performance deadlines, as informed by public comments.

To implement the new minimum performance requirements, FAA is proposing to add § 91.220 to define the minimum RA interference tolerance necessary to address next-generation wireless in the Upper C-band aligned with Lower C-band technical rules, subject to resolving the spurious emissions from wireless base stations described in section IV.E.5. FAA also proposes new sections in parts 121 and 129 to implement the initial RA performance deadline. Specifically, § 121.326 would require all aircraft operating under 14 CFR part 121, if equipped with an RA system, to meet the RA system minimum performance requirements stated in § 91.220(b) by the initial RA performance deadline. Section 129.16(a) would require all aircraft with 30 or more seats or a payload capacity of more than 7,500 pounds operating under 14 CFR part 129, if equipped with an RA system, to meet the RA system performance requirements in § 91.220(b) by the initial RA performance deadline. Proposed § 91.220(a) would impose the same RA system performance requirement by the final RA performance deadline (two years after the initial compliance deadline) for all other aircraft equipped with RA operating under 14 CFR part 91, including GA, rotorcraft, other commercial aircraft, and public aircraft.

Proposed § 129.16(b) would also impose the final RA performance deadline for all other aircraft equipped with RA operating under part 129.

FAA is proposing in § 91.220(b) to specify the minimum RA interference tolerance necessary to address wireless services in both the Lower and Upper C-band as well as a broader range of frequencies surrounding the RA band. Table 3 shows the proposed minimum RA system interference tolerance requirement applicable to different frequency ranges. The RA system would be required to operate at an altitude of 0-500 feet above ground level in this proposed interference environment. The interference environment is broken down by specific frequency ranges above, in, and below the RA band as shown in Table 3. The interference environment is specified as a PFD at the surface of the aircraft antenna, measured as RMS in dBW/m^2/MHz, so the RA system compliance includes the maximum directional gain of a linearly-polarized RA antenna. Figure 1 illustrates the interference environment defined in Table 3.

Table 3: Proposed Minimum Requirement for RA System Interference Tolerance

Frequency Range (MHz)	**Power Flux Density, Single Polarization, RMS (dBW/m^2/MHz)**
$3000 \leq f < 4000$	9.5
$4000 \leq f < 4100$	9.5
$4100 \leq f < 4150$	9.5
$4150 \leq f < 4160$	6.5
$4160 \leq f < 4180$	-1
$4180 \leq f < 4190$	-17
$4190 \leq f < 4200$	-34
$4200 \leq f \leq 4400$	-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

Figure 1: Proposed Minimum RA System Interference Tolerance

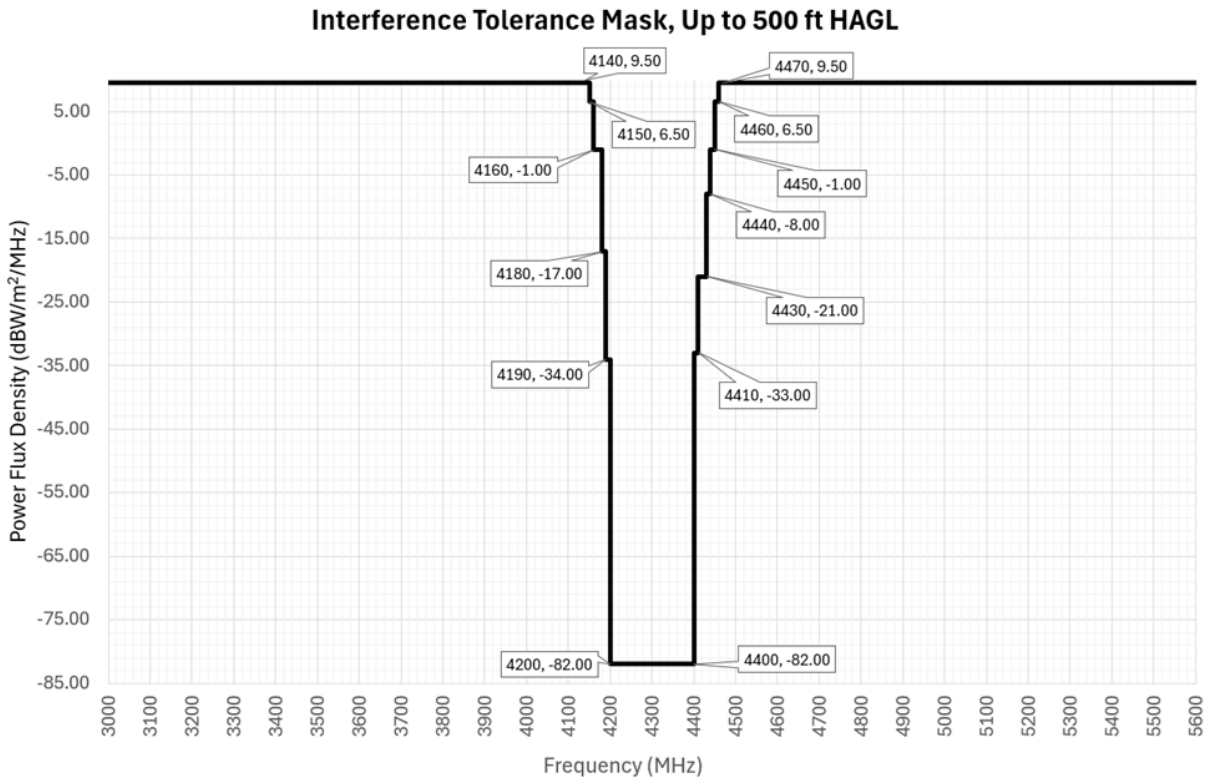

Table 4 shows the proposed CFR section additions to attain this compliance schedule.

Table 4: Regulatory Text Changes

CFR Addition	Section Text
§ 91.220 Radio Altimeter Systems	(a) After [two years after the initial RA performance deadline], no person may operate an aircraft in the airspace of the 48 contiguous United States and the District of Columbia with a radio altimeter unless the radio altimeter system meets the performance requirements of paragraph (b). (b) The radio altimeter system must operate at an altitude of 0-500 feet above ground level in the interference environment defined in Table 1 ...
§ 121.326 Radio Altimeter Systems	After [the initial RA performance deadline], no person may operate an aircraft under this part in the airspace of the 48 contiguous United States and the District of Columbia with a radio altimeter unless the

	radio altimeter system meets the performance requirements of § 91.220(b) of this chapter.
§ 129.16 Radio Altimeter Systems	(a) After [the initial RA performance deadline], no person may operate an aircraft with 30 or more passenger seats or a payload capacity of more than 7,500 pounds under this part in the airspace of the 48 contiguous United States and the District of Columbia with a radio altimeter unless the radio altimeter system meets the performance requirements of § 91.220(b) of this chapter. (b) After [two years after the initial RA performance deadline], no person may operate an aircraft under this part in the airspace of the 48 contiguous United States and the District of Columbia with a radio altimeter unless the radio altimeter system meets the performance requirements of § 91.220(b) of this chapter.

FAA considered potential changes to the current ADs that address interference with RA systems and found that no further regulatory action regarding those ADs needs to be taken at this time. The ADs address unsafe conditions with wireless services in the Lower C-band, and those conditions will continue until aircraft comply with the new performance requirements. FAA has also granted several exemptions providing relief from addressing the 14 CFR 91.205(h)(7) requirement for RA to support NVG operations, which will continue to be necessary until all aircraft comply with the new performance requirements. The regulations proposed in this rule would address these issues and resolve all known interference threats to RAs after the proposed final deadline.

1. Scope – Aircraft Affected

RA systems are used in a variety of aircraft as described previously. To maintain the safety advantages provided by reliable, accurate RA data, FAA proposes to require that all aircraft equipped with RA must be equipped with an RA system that can operate in the future interference environment. Many aircraft rely on accurate RA data to support

safety systems that are required by other regulations, and RA systems must function properly to provide the safety benefits that justify these equipment requirements.

There are also civil aircraft that have voluntarily been equipped with an RA for safety and operational reasons. The intended function of that equipment is to provide accurate altitude data, and FAA proposes to preserve that capability in the future operating environment. For these aircraft, there is a cost increase from the existing RA equipment to interference-tolerant RA equipment. Some avionics companies have proposed a class of equipment that would stop functioning by design when exposed to adjacent band interference. Their proposal would ensure the integrity of the RA output while exposed to the full RFI levels specified in this proposed rule by ensuring that the RA stops functioning rather than reporting an erroneous altitude. However, this would prevent the RA from enhancing safety in those environments and complicate the aircraft integration. The proposed regulation would require all GA aircraft with an RA to upgrade their equipment to be capable of operating in the interference environment specified in this proposed rule. FAA recognizes that the future voluntary adoption of RA may be negatively impacted by the increased costs of a compliant RA.

FAA proposes that these regulations apply to public aircraft operations, including military aircraft that are equipped with RA when operating in the airspace of the 48 contiguous United States and the District of Columbia. The RA is important equipment for public aircraft operations for the same reasons as civil aircraft (as discussed in sections E.3 and E.4), and its functionality must be assured. Military aircraft have unique use-cases for their RA systems, but the minimum safe distance described below is expected to be sufficient for their operations. Many military aircraft use RA technology that is different than the civil fleet and is more robust in the presence of interference.

The proposed rule would not address operations that are not conducted under 14 CFR part 91 and therefore would not apply to unmanned aircraft systems (UAS)

operating under part 107, the proposed part 108,[46] or limited recreational operations under 49 U.S.C. 44809.[47] RA systems are not currently integrated into these aircraft, and integrating them is challenging due to size restrictions. Any future use of RAs by UAS should consider the RF environment of their operation, and the performance requirements for such equipment should be handled through the appropriate aircraft or operational qualification process.

FCC is proposing to preserve the status quo regarding its current licenses outside of the contiguous United States, which would be permitted to continue in the entire 3.7-4.2 GHz band.[48] FCC notes that reallocating spectrum only within the contiguous U.S. would ensure the ongoing provision of C-band services necessary to protect life and property outside the contiguous U.S.—including telehealth, E911, and education services—for which C-band service may be the only option available, such as in remote areas of Alaska. Therefore, FAA is proposing that the RA performance requirement would not apply to operations in the airspace over the State of Alaska, the State of Hawaii, Puerto Rico, and other U.S. territories and possessions, including territorial waters. Aircraft that are only operated in the airspace where this rule does not apply would not need to equip with RA systems that meet the proposed performance requirements. FAA specifically requests comments on the suitability of applying the proposed rule only in the airspace of the 48 contiguous United States and the District of Columbia.

The proposed requirements would not extend into the airspace overlying the waters between 3 and 12 nautical miles (nm) from the coast of the U.S, and therefore does not propose a revision to § 91.1(b). The proposed requirements would be applicable to aircraft operating in that offshore airspace if they arrive, depart, or otherwise operate in the airspace within 3 nm of the coast of the 48 contiguous United States as described in

this proposed rule. FAA seeks comments about the need to require specific RA performance, as proposed, in additional offshore waters.

2. Schedule – Availability of Next Generation RA

FAA is proposing this rule to provide a permanent resolution for next-generation wireless services in the Lower and Upper C-band, as well as a broader range of frequencies surrounding the RA band. The objective is to maintain aviation safety in the NAS and provide high confidence that all aircraft equipped with RA operating under 14 CFR part 91 will be compatible with expanded next-generation wireless services in the Upper C-band. While FAA anticipates the initial RA performance deadline will be between 2029 and 2032, FAA does not have sufficient data to determine a specific date at this time. FAA will be considering a variety of factors to help balance the urgency as a result of expanding wireless services in the Upper C-band with the development of the next generation RA systems with acceptable schedule risk. FAA also asks for public comments in consideration of the factors discussed in this section. RA performance deadlines will be prescribed in the final rule as informed by public comments. We also seek comment on how the timing of the aviation industry's future implementation efforts should be aligned with FCC's statutory responsibility to complete an auction by July, 2027.

The schedule to accomplish the retrofit is driven by several activities and different stakeholders, so that no single stakeholder can provide a high-confidence schedule for the retrofit. Factors to consider in the compliance schedule include:

Requirement determination and product initiation: This proposed rule would require new transceivers and companies would have to make the decision to invest in detailed engineering and qualification for a new product. New products are designed to meet specific requirements, and without an agreement on the performance requirements for the next-generation product, any investment is at risk that the product will not be

found acceptable. By issuing this NPRM, FAA is proposing RA performance requirements that will be necessary for safe coexistence between aviation operations and next-generation wireless services. Aircraft-specific integration requirements are defined by each aircraft's original equipment manufacturer (OEM). Completion of the RTCA/EUROCAE industry standard may also be a factor in establishing international industry consensus.

Product development and certification: Companies intending to provide next-generation RA systems would have to develop new products to meet the ITM and market requirements. The typical product development schedule for flight-critical avionics is two to four years. To facilitate the demonstration of compliance with the proposed rule and to streamline equipment certification, FAA plans to recognize the industry standard with a new TSO for next-generation RA transceivers and a separate TSO for RA antennas. FAA would ensure that the TSOs conform to the ITM requirements in the final rule, identifying differences from the final industry standard if necessary. A TSO provides a means for obtaining FAA design and production approval based on the applicant's statement of compliance with the TSO. FAA plans to issue the TSOs immediately after the final RTCA MOPS.

Aircraft integration and compliance: As described previously, the RA is integrated into a variety of other aircraft systems. An applicant for an amended type certificate or supplemental type certificate would be required to demonstrate that any modification to the aircraft met FAA's airworthiness regulations, either as an amendment to the type certificate or as a supplemental type certificate. The extent of the engineering and associated qualification of the integrated system can vary significantly depending on the aircraft integration, which has a commensurate impact on the schedule to complete this work. A significant factor for the integration of RA systems is the potential re-use of existing RA antennas. When qualifying the RA system, the design approval holder would

be required to consider the antenna and cable performance. Since all existing aircraft and associated RA antennas were qualified without any specific requirements to withstand interference from adjacent bands, there is no certification data on antenna performance at those adjacent frequencies. Some companies have tested the performance of in-service antennas to provide an indication of their performance, but that data is not sufficient to address product variability or lifecycle effects. Given this and the considerations addressed in the next generation RA description in section IV.D., FAA proposes an interference mask that, if met only by the transceiver adjacent band rejection, would not require the in-service antennas to be re-evaluated or re-qualified. FAA assumes that aircraft integration can largely be accomplished in parallel with the equipment compliance demonstration. Some additional time is required to allow for testing of the integrated system, including the certified transceiver (and antenna if applicable).

Equipment availability: RA equipment is manufactured under an FAA-approved quality control system to ensure that every article conforms with the approved design. The production rate for the equipment varies by manufacturer and equipment. Changes in the production rate require investment by the company, and planning for a surge in production that is followed by a significant drop in production (when a retrofit is complete) may increase costs. Replacement RAs must be manufactured for the entire fleet of aircraft that are replacing their equipment, so the size of the retrofit is also a factor in the time needed to complete the fleet retrofit. FAA assumes that the production rate can increase to equal the installation rate within months of the equipment being approved and requests public comment on this assumption.

Aircraft alteration: The final step in accomplishing the retrofit is to install the new equipment in aircraft. Replacing an RA transceiver can typically be accomplished as part of overnight maintenance, provided mounting brackets, connectors, and other physical characteristics are compatible. Replacing an antenna and cables can take several

days to accomplish and would be scheduled to align with other heavy maintenance activities when the aircraft would otherwise be out of service (commonly referred to as a C-check). This type of maintenance typically occurs every two years for transport category aircraft. By providing a path to avoid the need for a replacement antenna if the transceiver demonstrates the required performance, FAA assumes that it will not be necessary to align the installation with heavy maintenance. The general aviation fleet may require additional time to complete the retrofit across the entire fleet due to the lack of centralized coordination of the modification of aircraft. FAA proposes an additional two years to demonstrate compliance with the proposed rule to allow for the challenges in coordinating the general aviation retrofit.

Financing and Incentive Considerations: FAA notes that FCC is seeking comments on ways in which RA retrofits can be incentivized and accelerated as part of the overall Upper C-band repurposing and transition process.[49] That includes specific proposals and mechanisms to facilitate RA retrofits from a financial perspective. In order to inform the deadlines for this proposed rule, FAA is seeking comments on the schedule impacts to the proposed RA system performance requirements resulting from such incentives.

In their terms of reference, RTCA SC-239 notes that the new MOPS "is envisioned to be referenced by the Federal Aviation Administration (FAA) and other civil aviation authorities (CAAs) as appropriate in certification guidance material, including TSOs or other national documents." FAA recognizes that adoption by other CAAs, as intended, is likely to increase worldwide demand for new RA systems that meet these performance requirements. This increased demand could result in competition for resources to support the retrofit for civil and military aircraft. FAA specifically requests comments about the potential impact on schedule and cost due to early adoption by operators who do not regularly fly to the U.S.

The aviation community has addressed a number of large-scale equipment mandates that provide additional experience-based insight into the schedule. For comparison, Table 5 shows the timeline for other broad equipage mandates.

Table 5: Equipment Mandate Timelines

Equipment Mandate	**Acronym**	**Compliance Time**	**Related Information**
Ground Proximity Warning System (14 CFR 121) (12/18/1974)	GPWS	1 year (12/1/1975)	*This equipment was subsequently upgraded to TAWS (add functionality).*
Terrain Awareness and Warning System (14 CFR 121) (3/29/2000)	TAWS	5 years (3/29/2005)	*Airplanes manufactured two or more years after the final rule's publication required TAWS be installed at time of delivery.*
Helicopter TAWS for Helicopter Air Ambulance (2/21/2014)	HTAWS (HAA)	3 years (4/24/2017)	
Traffic Alert and Collision Avoidance System (1/10/1989)	TCAS I *>30 seats*	3 years (12/30/1991)	
	TCAS I *1-30 seats*	7 years (2/9/95; 12/31/95)	*Extended due to equipment delays. Initially 6 years.*
Automatic Dependent Surveillance-Broadcast (5/28/2010)	ADS-B Out	10 years (1/1/2020)	*Some aircraft are accommodated without equipage*

These schedule drivers indicate that the initial RA performance deadline is achievable within 3 to 6 years of the final rule, or between 2029 and 2032, depending on a variety of factors as discussed previously. FAA intends to select compliance dates that reflect the urgency of expanding next-generation wireless services, recognizing any real constraints on the rapidity with which the retrofits can occur. FAA is requesting comments from the aviation stakeholders to inform the deadlines for inclusion in the final rule. When providing comments, please consider the following questions:

Transceiver manufacturers: What is the status of your product development? When do you project a next-generation RA transceiver to be certified, and how long after certification will it take to ramp up production? What factors could accelerate your schedule? What factors could delay your schedule, and what affects those factors?

OEMs: What is the status of incorporating next-generation RA systems into your aircraft designs? How long after transceiver certification do you require to complete an amended type certificate, and why? Are there aircraft-specific integration requirements that may require a replacement antenna? What factors could accelerate your schedule? What factors could delay your schedule, and what affects those factors?

Air carriers and other operators: After a design approval is completed for the aircraft, how long do you require to modify your fleet? What factors could accelerate your schedule? What factors could delay your schedule, and what affects those factors?

FAA analysis of current information indicates that these schedule risks will be resolved as additional information is finalized before the final rule is issued. FAA requests comments about the proposed timeline to meet RA performance requirements, from the perspective of RA transceiver and antenna suppliers, aircraft manufacturers, and operators. The most valuable comments to help inform final regulations are data-driven comments that detail capabilities, costs, benefits, timeline impacts, and other specific information directly relevant to the proposed regulations.

3. Part 121 Air Carriers and Large Part 129 Aircraft

FAA proposes that aircraft equipped with RA operating under part 121 and aircraft operating for foreign air carriers with 30 or more seats or a payload capacity of more than 7,500 pounds under part 129 must retrofit their RAs by the initial RA performance deadline. This compliance deadline is proposed to align with FCC's date authorizing wireless services in the Upper C-band. The initial RA performance deadline would be specified in the final rule and is anticipated to be between 2029 and 2032. These operations are the most critical to the national economy and have the highest expected level of safety, making them a priority. By completing these retrofits, the U.S. would preserve safe aviation operations while expanding the use of next-generation wireless services in the adjacent band as addressed in section E.5. Other actions must be

taken to ensure unsafe conditions do not arise between the sunset of the existing Lower C-band FAA-wireless voluntary agreement and the initial RA performance deadline; this is addressed in section G.

ICAO is planning updates to Annex 10 Volume V intended to help protect RAs from potentially harmful in-band and adjacent band interference caused by non-aeronautical systems operating in adjacent frequency bands. FAA seeks comment on the proposed compliance deadline for part 129 operators, in light of these potential updates to Annex 10.

FAA estimates that there are 8,014 aircraft operating under part 121, though some of those aircraft are temporarily or permanently inactive. With specific fleets requiring 1 to 3 RA per aircraft, FAA anticipates part 121 air carriers would need approximately 17,033 new RAs to comply with this proposed rule. While part 129 foreign air carriers operate a very large number of aircraft, not all of those aircraft fly in U.S. airspace on a regular basis. There are approximately 4,519 large aircraft with 30 or more seats or a payload capacity of more than 7,500 pounds operating under 14 CFR part 129 that fly to the U.S.,[50] which would result in approximately 10,341 new RA systems needed for part 129 foreign air carriers.

FAA recognizes that it may be more costly and complex to upgrade RAs in older aircraft models due to reduced support from manufacturers for out-of-production units and potential compatibility issues with older integrated systems, impacting the design, development, certification, and cost of replacement RA systems. Operators of those airplanes will need to decide whether to upgrade to RA systems that meet the proposed performance requirements or retire those airplanes from contiguous U.S. operations. FAA specifically requests comments about implementation challenges for older RAs and older aircraft and the associated costs of retrofit or aircraft retirement for older aircraft.

4. All Other Aircraft

FAA proposes an additional two years after the initial RA performance deadline for all other aircraft operating under 14 CFR part 91 including GA, rotorcraft, other commercial aircraft, and public aircraft. Some of these operators currently have AD-mandated restrictions on their operations dependent on accurate RA data due to the Lower C-band wireless services, and many of these operators are accepting the risks associated with localized interference that could disrupt TAWS, TCAS, and other RA applications. Those restrictions must continue until a retrofit is accomplished, which would address both the Lower and Upper C-band compatibility. Section H discusses the relationship between the proposed rule, current ADs, and other FAA policy.

FAA recognizes that there are potential challenges with the proposed deadlines due to the need to complete standards, develop prototypes, certify new RAs for multiple aircraft fleets, and install new RAs without significantly disrupting revenue service. With the final RA performance deadline two years after the initial RA performance deadline, FAA seeks to reduce stress on supply chains, manufacturing, and installation. This additional time accounts for unique market factors in general aviation, including the seasonality of aircraft maintenance in Alaska for those Alaska-based operators who also fly into the contiguous United States. FAA estimates that approximately 31,821 new or upgraded RA systems will be required to address helicopters, business aviation, GA, and other aircraft equipped with RAs that are not subject to the initial RA performance deadline.

FAA also recognizes that it may be more costly and complex to upgrade RAs in older aircraft models. Older RA models may be more difficult to replace due to reduced support from manufacturers for out-of-production units and potential compatibility issues with older integrated systems, impacting the design, development, certification, and cost of replacement RA systems. Operators of those airplanes will need to decide whether to

upgrade to RA systems that meet the proposed performance requirements, remove the RA system altogether, or retire those airplanes from contiguous U.S. operations. FAA specifically requests comments about implementation challenges for older RA and older aircraft and the associated costs of retrofit or aircraft retirement for older aircraft.

5. Safety Analysis of the Proposed Minimum Performance Requirements

The purpose of this proposed regulation is to achieve the full functionality of RAs in the presence of next-generation wireless services in the adjacent C-Band. This section summarizes FAA's methodology to ensure the safe operation of RAs and the equipment that relies on accurate RA data. Based on this analysis, RA systems compliant with the proposed rule can safely operate with more than 100 MHz for next-generation wireless services in the adjacent band (up to 4160 MHz) aligned with Lower C-band technical rules, provided emissions limits into the RA band are addressed as discussed below. This safety analysis assumes that there are no siting constraints on the wireless base stations.

To operate reliably, the RA system must be demonstrated for the expected operating environment, including interference levels that may be encountered in flight. The interference environment that will be encountered after the initial RA performance deadline has not yet been determined, so FAA is not able to evaluate a specific interference proposal. In lieu of that, FAA has applied FCC's baseline proposition that the existing 3.7 GHz Service rules would apply to new services in the Upper C-band. FAA has found that the proposed ITM is fully compatible with the power levels of rural next-generation wireless services (e.g., 65 dBm/MHz Effective Isotropic Radiated Power (EIRP)) up to 4160 MHz. FAA considered minimum separation distance (MSD) and safety margins, as discussed in this section, to determine the allowable interference as depicted in the following formula:

PFD (in dBW/m^2/MHz) = **EIRP** (per polarization, in dBm/MHz) – 30 – 10*log10(4*pi) – 20*log10(**MSD** (in meters)) + **SAFETY MARGIN**

As long as the calculated PFD at a given frequency is less than or equal to the ITM, the RA system will perform safely. Therefore, the ITM levels ≥ +6.5 dBW/m^2/MHz up to 4160 MHz can tolerate up to 65 dBm/MHz total EIRP for dual-polarization base stations as shown in Table 6. The 65 dBm/MHz applies to the aggregate power of all antenna elements in any given sector of a base station, consistent with existing FCC rules in the Lower C-band.

The rationale for the parameters used in Table 6 are discussed below. FAA considered MSD and 6 decibel (dB) safety margins to set these parameters. The RA antenna gain is not shown, as the maximum RA antenna gain is used when showing compliance to the ITM.

Table 6: Adjacent Band Compatibility Analysis

Parameter	**Value**
ITM (4150-4160 MHz)	+6.5 dBW/m^2/MHz
Minimum Separation Distance (MSD) (loss)	35 ft. (-31.6 dB)
Safety margin	6 dB
Safe level of wireless emission (EIRP)	62 dBm/MHz
Safe level of wireless emission (dual-pol EIRP)	65 dBm/MHz

Due to the wide range of applications for the RA system and the variety of aircraft equipped with RAs, FAA proposes that the RA must function reliably at 35 feet MSD from any wireless base station when the aircraft is 500 feet AGL or lower. MSD is defined as a sphere with a 35-foot radius, originating at the wireless base station antenna phase center, for an aircraft at 500 feet AGL and lower. The smallest transport category airplanes certificated under part 25 have wingspans greater than 35 feet (and half-wingspans of approximately 35 feet), and most helicopters required to be equipped with RA have an overall length of 35 feet or more. The proposed MSD supports the continued safe function of the RA and integrated safety systems in all normal, off-nominal, and

emergency operations unless the aircraft is so close to a wireless base station or the structure where it is mounted that the catastrophic risk of collision is greater than the risk of interference.

Thirty-five feet of vertical clearance is less than the closest expected distance during normal and off-nominal operation for aircraft equipped with RA systems. Aircraft have significantly greater separation from obstacles during normal operations due to the minimum safe altitude requirements in § 91.119, obstacle clearance criteria for instrument procedures and routes, and requirements for obstacle-free areas surrounding runways, including in the approach and departure area to protect low altitude operations and ensure approach light systems are not obscured. FAA heliport criteria[51] also define obstacle-free areas based on the largest helicopter supported and greater than 35 feet for the final approach and takeoff area, with an additional obstacle buffer in the safety area and under the recommended approach and departure paths. When there is sufficient visibility, pilots see and avoid obstacles to ensure safe minimum separation. Below 500 feet AGL, helicopters must be operated without hazard to persons or property on the surface, and helicopter operations away from airports or heliports must be performed with sufficient flight visibility to ensure safe separation from antenna structures, aligned with the MSD assumptions. In normal instrument approach operations and at a 200-foot AGL decision height, the airplane must descend almost twice as much as a full-scale low indication on the glide slope to get within 35 feet vertically of the obstacle clearance surface.

The MSD also considered off-nominal operations and emergency operations. One engine inoperative obstacle clearance requirements in § § 121.189, 135.379, and 135.398 require 35 feet of vertical clearance. The most demanding alerting function is the ground proximity warning of TAWS, which must properly analyze and alert pilots of hazards as low as 30 feet AGL. The 35-foot MSD provides assurance that GPWS will operate in all

but the most severe terrain scenarios. Predictive windshear alerting systems must also be able to function properly at a very low altitude due to the potentially catastrophic risks of microbursts, downdrafts, and similar wind shifts that cause the aircraft to lose altitude and approach the bottom of the normal approach obstacle clearance surface (OCS). The RA must function properly, even when very close to a wireless base station, to ensure that the RA does not report an erroneous low altitude, which could cause TCAS to fail to provide resolution advisory guidance if a nearby aircraft is on a collision course.

RA performance requirements for operations above 500 feet AGL are not specifically addressed in the proposed regulations. When an aircraft is above 500 feet AGL, interference that prevents the RA system from operating normally is less likely, and the consequence is also reduced as there is more time to recover after interference. Stricter obstacle clearance rules apply for all operations above 500 feet AGL. Minimum safe altitude requirements in § 91.119 define clearance from terrain and obstacles, such as the requirement to be at an altitude of 1,000 feet above the highest obstacle within a horizontal radius of 2,000 feet of the aircraft when operating over congested areas; the requirement to be at an altitude of 500 feet above the surface when operating over other than congested areas; and the requirement to be no closer than 500 feet to any person, vessel, vehicle, or structure when operating over water or sparsely populated areas. Under instrument flight rules, separation from obstacles increases at higher altitudes due to increases in required obstacle clearance for routes at higher altitudes and greater separation distances provided by sloping OCS when the aircraft is further from the runway and at a higher altitude. Given the larger MSD in operation, the RA system is expected to operate normally above 500 feet AGL as the amount of interference received by the RA antenna decreases with the increasing path loss.

For safety applications, the aviation community applies a minimum 6 dB safety margin above the expected interference environment to account for unknown issues that

could impact the safe operation of the RA. The equipment is required to operate normally when the actual interference level is 6 dB above the expected interference level. For spectrum compatibility, this accounts for uncertainties in the design and implementation of adjacent-band RF base stations, which do not have to meet aviation safety standards. The safety margin also addresses the risk from unforeseen factors. This is consistent with ICAO recommendations in ICAO Doc 9718, the Handbook on Radio Frequency Spectrum Requirements for Civil Aviation, which indicates that a safety margin of 6-10 dB is to be applied for aeronautical safety systems.

FAA also evaluated the safe compatibility with respect to interference into the RA band. Emissions into the RA band are a result of base station out-of-band spurious emissions. The RA system must operate with the interference from all emissions sources into the RA band, including, but not limited to, the interference from Lower and Upper C-band wireless service. The total aggregate in-band interference depends on the number and the relative position of all other interference sources to the RA system antenna. To simplify that analysis, FAA considered the out-of-band emissions from a dominant source. A dominant source would have the same MSD as the adjacent band case (35 feet), for the reasons described previously above. Wireless base stations may be housed on the same antenna structure operating at different frequencies. 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. Table 7 summarizes the parameters that are used to determine in-band compatibility.

PFD (in dBW/m^2/MHz) = **EIRP** (per polarization, in dBm/MHz) – 30 – 10*log10(4*pi) – 20*log10(**MSD** (in meters)) + **SAFETY MARGIN + AGGREGATION**

Table 7: In-Band Compatibility Analysis

Parameter	Value

ITM (In-Band tolerance)	-82 dBW/m^2/MHz
Minimum Separation Distance (MSD) (loss)	35 ft. (-31.6 dB)
Safety margin	6 dB
Emitter Aggregation	6 dB
Safe level of wireless emission into RA band (EIRP per polarization)	-33dBm/MHz
Safe level of wireless emission into RA band (EIRP for dual polarization)	-30 dBm/MHz

The RA system can operate safely if the aggregate in-band interference from external sources is less than the in-band interference limit of -82 dBW/m^2/MHz. Therefore, the RA system can operate safely with an EIRP from each base station of -33 dBm/MHz per polarization (or -30 dBm/MHz for equal dual-polarized signals). When FAA completed the safety analysis for the Lower C-band, FAA accepted maximum antenna coupling between the RA antenna and the wireless base station of 10 to 12 dBi. The coupling is the sum of the RA antenna gain and the base station gain. Under this proposal, the RA antenna gain is accounted for within the ITM requirement. With the base station tuned to a closer frequency to the edge of the 4.2-4.4 GHz band, FAA is seeking comment on base station antenna gain characteristics between 4.2 and 4.4 GHz so FAA can finalize the safety analysis. As a point of comparison, the voluntary commitment for the Lower C-Band specifies a maximum of -48 dBm/MHz conducted emissions in the 4.2-4.4 GHz band, which would be safe with up to 18 dBi of base station gain.

FAA is also seeking comments on the overall safety analysis presented in this section. The factors in the safety link analysis have many variables. Due to the potentially catastrophic severity of interference, FAA has adopted values that reflect a very low likelihood of occurrence. The typical interference will be considerably less. For example, the base station spot-beam is frequently pointed away from the aircraft when the aircraft is overhead, and the RA antenna would typically have low gain towards the base station

when the aircraft is adjacent to a wireless base station. Multipath can increase or decrease the received signal strength, though not typically within the maximum antenna spot beam. While the duty cycle of the base station is limited based on the next-generation wireless technology, FAA seeks to adopt an RA system requirement regardless of the wireless service technology to be used. The motion of the aircraft, as compared to a fixed wireless base station, can also affect the tolerable interference in the integrated aircraft systems. When considering the in-band interference, the spurious emissions would typically be decorrelated across multiple wireless base stations and not add constructively. Finally, the aggregate interference would typically be the sum of one or two collocated base stations, a large number of mobile units, and a few other base stations at different distances. FAA's analysis intentionally provides a very high assurance that interference will not occur, thus averting a catastrophic outcome. Comments on these factors should address the likelihood of the various conditions, so FAA can ensure that the likelihood of interference that could lead to a catastrophic outcome is sufficiently low.

F. Safety Analysis for Wireless Access Prior to the Initial RA Performance Deadline

Existing RA systems cannot accommodate wireless signals above 3.98 GHz aligned with Lower C-band technical rules without constraints on wireless base station location and power levels. While FAA and wireless service providers have agreed to similar constraints in the short term for the Lower C-band, FAA does not plan to expand that analysis to the Upper C-band. Instead, FAA proposes to require the RA retrofit to be completed in the most critical aircraft by the time FCC authorizes new wireless services in the Upper C-band. The safety analysis presented previously provides a template for MSD from next-generation wireless services in the 3.98-4.2 GHz band, accounting for the more sensitive RA performance described in section C, Current RA Limitations.

G. Lower C-band Mitigations

The suitability of a new RA cannot be assured without also addressing the potential for interference from wireless base stations in the Lower C-band (3.7-3.98 GHz). The twenty-one wireless licensees have filed a voluntary commitment with FCC to ensure their signals do not cause an unsafe condition, as determined by FAA, and that the most critical aircraft operations for commerce can continue without disruption.[52] The voluntary commitment runs through January 2028, unless extended or reduced by mutual agreement. FAA intends to seek an extension of the terms of the voluntary commitment until the initial RA performance deadline.

In the end state, after the RA retrofit proposed by this rule is complete, the updated RA systems will operate safely, assuming the final Lower and Upper C-band wireless transmissions into the RA band are harmonized.

H. Relationship to Airworthiness Directives and Other FAA Policy

There are a number of ADs that address the unsafe conditions posed by interference from the Lower C-band wireless services, as discussed previously in section III. The RA system performance requirements proposed by this rule would provide sufficient tolerance to Lower C-band wireless services to prevent the unsafe conditions identified and addressed in the current ADs, subject to resolving the spurious emissions issue described in section IV.E.5.

Under the wireless voluntary agreement, the wireless signals near 188 airports are limited to lower levels to allow certain aircraft to conduct unrestricted operations. Those aircraft were modified in 2022-2024 with RA systems that are tolerant to the Lower C-band wireless signals. The next generation RA systems proposed in § 91.220 would ensure continued unrestricted operations after the initial RA compliance deadline without any airport-specific wireless power limitations. After that date, if necessary, FAA would

supersede the current ADs to impose operating limitations on the use of RAs that do not meet the proposed performance requirements until such time as the RA system is replaced. The superseding ADs would address operators who have upgraded to a Lower C-band interference-tolerant RA, but do not upgrade to an RA system compliant with the proposed rule prior to the initial compliance date.

FAA plans to recognize an aircraft's compliance with the proposed 14 CFR 91.220(b) as an AMOC with all existing ADs and any superseded ADs that may be necessary, to permit operation without limitations for those aircraft once they are equipped. FAA also plans to authorize a foreign operator to operate without additional limitations in the U.S. if the aircraft complies with this retrofit requirement.

Most airplanes operating under part 121 and large airplanes operating under part 129 are equipped with RA systems that comply with FAA policy statement PS-AIR-600-39-01,[53] which provides guidance for operators and manufacturers to demonstrate that an aircraft is equipped with an interference-tolerant RA that meets the performance requirements in the current ADs. FAA has assessed the risk for these aircraft until a hypothetical initial RA performance deadline as late as 2032 and determined that the conditions of policy statement PS-AIR-600-39-01 will provide an acceptable risk mitigation, provided the terms and conditions of the voluntary commitments for the Lower C-band are extended to the initial RA performance deadline. An earlier compliance date would reduce the risk. As addressed in the Schedule section E.2, FAA is soliciting comments on the achievable initial and final RA performance deadline.

There are also a small number of transport category airplanes operating under the restrictions prescribed in the current ADs.[54] FAA has assessed the risk for operators of those airplanes and determined that the existing operating limitations are sufficient until the final RA performance deadline to address the additional sources of interference that

may arise from Upper C-band wireless services aligned with Lower C-band technical rules.

FAA also issued ADs applicable to helicopters,[55] where the interference from Lower C-band wireless services posed an unsafe condition. FAA has evaluated the additional risk to helicopter operators from Upper C-band wireless services aligned with Lower C-band technical rules and determined that the scope and conditions of the current helicopter AD are adequate until the final RA performance deadline. NVG operations under § 91.205 will continue to require an FAA exemption for aircraft not equipped with RA systems that meet the new performance requirements.

Finally, FAA had identified a number of aircraft systems that could be affected by erroneous RA data and issued SAFO 21007[56] to advise operators of the potential for erroneous or degraded RA output as it relates to those operations. The SAFO would remain in effect until aircraft comply with the proposed RA system requirements.

As FAA would end the accommodation of Lower C-band interference-tolerant RA systems at the initial RA performance deadline, several policies would end at that time. A current Flight Standards policy memo[57] would be canceled at the initial RA performance deadline. This policy memo requires an additional C-band assessment for specific new or amended CAT II/III and SA CAT I/II instrument approach procedures, primarily impacting the development of new procedures at airports that are not on the list of 188 CMAs. These additional requirements would no longer be necessary to support safe operations after the initial RA performance deadline.

FAA would withdraw PS-AIR-600-39-01 after the initial RA performance deadline. If there were aircraft that upgraded to Lower C-band tolerant equipment but did not subsequently upgrade to comply with the proposed 91.220(b), the relevant AD would need to be updated to restore the original operating limitations to reflect the sunset of the Lower C-band commitments and the onset of Upper C-band emissions.

After the final RA performance deadline, FAA may elect to remove the ADs as they would be made obsolete by the proposed RA requirements.

FAA will also be evaluating if any frequencies in the Lower and Upper C-band should be added to the Colo Void Policy[58] after the final RA performance deadline. The Colo Void Policy identifies frequencies that do not need to provide notice to FAA for a construction or alteration under 14 CFR part 77 because FAA has studied any potential impacts and found that the frequency is not a hazard to aviation safety. C-band frequencies cannot be added to the list of exempted frequencies until after the final RA performance deadline because wireless base station locations would still be required to support aircraft-specific AMOCs after the initial RA performance deadline.

I. Alternatives Considered

An alternative to this retrofit requirement would be for FAA to evaluate whether an unsafe condition is created by changes in the RF environment and issue additional ADs as appropriate. That alternative would not regain the full safety benefits of RA systems, would have a significant impact on aircraft operational capability by imposing new limitations for aircraft with RA systems that are currently compliant (limiting some aircraft from operating at all airports where C-band wireless base stations transmit and limiting low-visibility access for all aircraft), and would create market instability both for the aviation and wireless industries. Because ADs would be issued after FCC finalized service rules, ADs would impose severe operational limitations until the aviation industry has sufficient time to dedicate the necessary capital and resources to the appropriate RA upgrades and replacements. In addition, ADs would require an extension to the current voluntary wireless agreements or amendments to the current FCC R&O necessary to ensure long-term safe coexistence with Lower C-band wireless service, potentially exposing more severe operating conditions if the wireless service providers do not agree to indefinitely extend the voluntary agreements. Because ADs are not applicable to non-

U.S. registered aircraft, other methods would also be required to ensure safety for part 129 foreign air carriers, such as issuing notices to airmen (NOTAM) and amending the U.S. Aeronautical Information Publication (AIP) to address changes in the spectrum environment. In addition, FCC would have to determine the new Upper C-band wireless environment without a compatible RA standard. This may result in wireless interference that cannot be safely accommodated even with new RA systems, which would indefinitely prohibit certain aircraft from operating in the U.S. and prohibit all low-visibility approach and landing operations. The absence of a compatible standard could also result in FCC authorizing less spectrum than could otherwise be safely accommodated, such as if only 100 MHz were authorized. In the best case, FCC would define the Upper C-band wireless environment that is aligned with the feasible RA performance. However, this would not ensure that aircraft upgrade to suitable RA systems in time to avoid severe operational disruption.

Similarly, an alternative where FAA delays the proposed performance requirement until completion of the new RTCA/EUROCAE standards would introduce the same costs, limitations, and risks.

Another alternative, where FAA does not evaluate and address any unsafe conditions that would be created by changes in the RF environment, would create unacceptable catastrophic risks and would not address FAA's statutory mandate to ensure safe operations in the NAS. FAA risk assessments in support of the ADs issued to date[59] found the most significant risks are to operations in very low visibility and aircraft-specific risks with dependent safety systems. FAA has previously determined that training, service bulletins, and guidance would not be sufficient to overcome the high likelihood of hazardously misleading or missing RA information impacting multiple aircraft safety systems, some of which are required by legislation and regulations in large part due to fatal accidents in the past.

FAA also considered a two-phase implementation, with the goal of enabling earlier access to less than 100 MHz as soon as possible and transitioning to the next generation RA as a second phase. However, due to the existing RA performance (see Section IV.C), any early wireless access that requires an interim retrofit for safe operations would impose a significant additional cost on the aviation industry, requiring operators to procure and install interim RA solutions available now that are not likely to meet these proposed RA performance requirements. Increased demand and manufacturing requirements for an interim retrofit would also significantly extend the timeline for all operators to equip with RA systems that meet these proposed requirements, duplicating the requirements and efforts needed and diverting aviation manufacturers' resources and personnel who are working towards the development and certification of new RA systems that will meet the proposed RA performance requirements. Also, it would not result in the full 100 MHz being available to next-generation wireless services, requiring extensive and ongoing coordination, reduced power level, and constraints on wireless base station antenna height/elevation masks.

V. Regulatory Notices and Analyses

A. Regulatory Impact Analysis (RIA)

E.O. 12866 ("Regulatory Planning and Review") and E.O. 13563 ("Improving Regulation and Regulatory Review") require agencies to regulate in the "most cost-effective manner," to make a "reasoned determination that the benefits of the intended regulation justify its costs," and to develop regulations that "impose the least burden on society." The Office of Management and Budget has determined this proposed rulemaking is a significant regulatory action under section 3(f) of E.O. 12866.

1. Statement of the Need for the Proposed Action

i. Description of Problem

Radio or Radar Altimeters (RAs) are devices that measure an aircraft's current height above terrain by sending out low-powered radar waves in the 4.2 to 4.4 GHz spectrum and measuring their return against the ground or other obstacles. The accurate height data RAs provide is crucial to a variety of automatic safety systems and is used by pilots in low-visibility situations. Since RAs utilize relatively low-powered transmissions, there is a risk that wireless signals, such as those emitted by next-generation wireless base stations utilizing adjacent spectrum bands, can interfere with or overpower the RA signal and result in missing or erroneous data. As was discussed in more detail in the preamble to the NPRM, the coming expiration of current voluntary commitments by wireless license holders to limit base station power level and out-of-band emissions in the Lower C-band spectrum (3.7-3.98 GHz) in 2028 and the upcoming FCC auction reallocating some or all of the Upper C-band spectrum (3.98-4.2 GHz) directly adjacent to the RA band are expected to exceed the ability of current avionics technology to mitigate the risk of spectrum interference and will create unacceptable risk to the NAS.

ii. Need for Regulation

Public Law 119-21 requires FCC to complete an auction of at least 100 MHz in the Upper C-band, and FAA has found that the associated authorization would cause existing RAs to experience interference and cause unsafe conditions. The upcoming auction would create an externality, defined as a market failure in OMB Circular A-4 occurring when one party's actions impose uncompensated benefits or costs on another party.[60] The proposed utilization of Upper C-band spectrum directly imposes uncompensated safety costs (increased risk of accidents) and fiscal costs (replacing RA systems to redress safety costs) to aircraft operators and the flying public.

iii. Summary of the Proposed Regulation

To address this risk, FAA proposes requiring the replacement of all existing RA systems with ones that meet the new interference tolerance performance standards for aircraft operating under part 91 in the airspace of the 48 contiguous United States and the District of Columbia. FAA is proposing RA performance requirements that reflect the best achievable interference rejection and without compromising the RA system performance. These requirements would apply first to all aircraft with an RA operating under 14 CFR part 121 and all aircraft with an RA operating under 14 CFR part 129 with 30 or more passenger seats or a payload capacity of more than 7,500 pounds, which have the highest expected level of safety and are the most critical to the national economy. All other aircraft operating under part 91 in the airspace of the 48 contiguous United States and the District of Columbia and equipped with RAs would have two additional years from the initial RA performance deadline to replace any RAs with units that meet the proposed performance requirement.

2. Baselines for the Analysis

To properly evaluate regulations, agencies must weigh the costs and benefits against a baseline. OMB Circular A-4 defines the "no action" baseline as "the best assessment of the way the world would look absent the proposed action." It also specifies that the baseline "should incorporate the agency's best forecast of how the world will change in the future," absent the regulation. FAA considers the primary baseline for this analysis to be a no action baseline, in which FAA assumes FCC completes the auction required by Public Law 119-21 and the voluntary commitments of the wireless service providers lapse. Under this scenario, FAA would have to react to the interference to prohibit all operations of certain aircraft makes and models and prohibit low-visibility operations in all aircraft, causing significant operational impacts. Aircraft owners would need to replace their RA systems to achieve compatibility with the new spectrum

environment, if it is possible to do so. The inherent costs of delays, cancellations, and groundings resulting from re-imposing AD operational prohibitions under this no action baseline can be negated by the cost of retrofitting the RA system in compliance with proposed performance standards. FAA could also seek voluntary constraints from the wireless carriers in order to mitigate these aviation impacts. There is no assurance that an agreement could be reached, and that scenario could impact FCC as the constraints would not be known at the time of the auction.

These costs are based on the prior expansion of next-generation wireless services in the Lower C-band, where FAA issued 14 ADs for aircraft equipped with RAs. These ADs maintained the safety environment of the NAS by prohibiting operations when spectrum interference affects the accuracy of RA data critical for safe operation of the aircraft. To accomplish this goal, the ADs prohibited transport and commuter category airplanes without an upgraded RA from flying in very low visibility conditions (CAT II/III and other operations), prohibited rotorcraft without an upgraded RA from flying in specific automation modes dependent on RA data, and imposed additional operating restrictions on specific model airplanes with vital safety systems heavily tied to RA data. The airplane model-specific ADs cover Boeing, McDonnell Douglas, MHI RJ, and Airbus 220/Bombardier 500 models. All combined, these aircraft make up around 52 percent of the U.S. commercial fleet based on MITRE fleet data.[61] These ADs are still in effect, but do not significantly restrict operations currently due to operator compliance with lower C-band interference mitigation, including RA retrofits or other measures as specified in the ADs. If the spectrum environment changes due to the expiration of the voluntary commitments in 2028 or the utilization of the Upper C-band after FCC auction, the current AD compliance requirements would not be sufficient to mitigate the unsafe condition caused by interference with the RA. To maintain safety in the NAS, FAA would supersede the ADs along the same restrictions, with the potential for issuing

additional ADs covering other operations or aircraft models as required, resulting in significant operational impact and baseline costs.

Along with the aircraft specific ADs, FAA would have additional ADs restricting operations in low visibility CAT II or III conditions, which would impact air travel in the NAS. In 2019, these conditions ranged from 0 to 1.14 percent of hours at the core 30 airports,[62] overall averaging 0.24 percent.[63] With over 56.5 million operations at towered airports in 2024,[64] AD limitations on flying in CAT II/III conditions would disrupt an average of 135,600 takeoffs and landings per year, inducing recurring delay, diversion, and cancellation costs to aircraft operators and the flying public until emission interference mitigation of the Upper C-band is achieved. These baseline costs from any effective reduction in NAS capacity due to the aircraft model and low-visibility weather ADs can be significant. For example, regarding similar limitations due to air traffic controller staffing constraints when FAA issued Emergency Order Establishing Operating Limitations on the Use of Navigable Airspace (90 FR 50884, Nov. 12, 2025),[65] Airlines for America (A4A) stated, "When the FAA flight-reduction order reaches 10 % on Nov. 14, A4A estimates a daily average U.S. economic impact of $285 [million] - $580 [million], depending on the degree to which airlines can reaccommodate cancellation-disrupted passengers on the remaining flights."[66]

Air carriers may choose to voluntarily upgrade their RA units to address potential interference concerns associated with the use of the Upper C-band spectrum, either to directly address the related safety risks to their aircraft or as a method of compliance with the new ADs to avoid the cost of capacity disruption. This action would limit both the operational impacts of the ADs and any impacts on the wireless industry's use of the spectrum. However, without the proposed rule, FAA is unable to assume the availability of Upper C-band compliant units or the extent and timeline of voluntary compliance.

FAA also considers an alternative pre-C-band utilization baseline, in which FAA avoids the prohibition of certain operations by achieving full fleet retrofit of RA systems to the proposed performance standards before any change in the spectrum environment. With no need for new ADs in this alternative baseline, only the costs of RA retrofit are considered in the current environment prior to the auction mandated by Public Law 119-21. With the pre-C-band utilization baseline representing a world where FAA considers mandating equipage of RAs that are tolerant to the Upper C-band spectrum and aircraft operators continue being able to fly without restrictions, baseline costs are $0.

As discussed in the preamble, RAs are not directly required by regulation for most aircraft, except for NVG operations under § 91.205(h)(7) and for rotorcraft operations under § 135.160, but are still carried on nearly all commercial and many noncommercial aircraft due to the vital role they play in the safety of aircraft operations by providing critical information directly to pilots and for mandated safety systems such as TCAS, TAWS, and other functions like autoland. Some aircraft may only need one RA unit, but given how vital the information is to safe operation, many commercial aircraft use two or more RA units to ensure accurate data. Using April 2025 data from MITRE, FAA estimates that there are roughly 58,579 RA units across 40,871 aircraft in the current operating civilian fleet (including many State-owned aircraft) that would be affected by the proposed rule.[67] This estimate is likely an overcount as FAA currently lacks data to specify which U.S. aircraft operate solely in Alaska or Hawaii, which would not be subject to this proposed rule. Conversely, though the proposed performance requirements would apply to all aircraft equipped with an RA operating in the airspace of the 48 contiguous United States and the District of Columbia, military and Federal law enforcement-owned aircraft are not included in the estimates as FAA lacks data on RA-equipped aircraft totals and the costs to purchase and replace military RA units. The breakout of RAs by 14 CFR part operation and aircraft type can be found in Table 8:

Table 8: Number of Aircraft and RA Units by CFR Operation

CFR Operational Part	Aircraft Type	Count of Aircraft	Count of RA Units
Part 91	Airplane	16,657	18,452
	Rotorcraft	2,818	2,819
Part 121	Airplane	8,014	17,033
	Rotorcraft	-	-
Part 129[1]	Airplane	5,050	11,127
	Rotorcraft	18	27
Part 135	Airplane	6,385	7,151
	Rotorcraft	1,929	1,970
Total	Airplane	36,106	53,763
	Rotorcraft	4,765	4,816
	Total	40,871	58,579

1. Part 129 totals only include aircraft that had at least one U.S. operation in the 17-month period from 04/01/2024 to 09/01/2025

From the same MITRE data, Table 9 below shows the estimated number of operators of affected RA-equipped aircraft operating under the rules of each CFR part.

Table 9: Operators of RA Equipped Aircraft

CFR Operational Part	Number of Operators
91	12,365
121	60
129	330
135	1,131
Total	13,886

FAA requests comment, with supporting documentation, on the no action and pre-C-band utilization baseline estimates and assumptions.

3. Benefits

The benefits of this proposed rule stem from maintaining the safety benefits of RAs and preventing operational restrictions due to the high risk to aviation safety when utilizing current generation RA systems that are unable to filter out wireless signals (e.g., Upper C-band wireless services aligned with Lower C-band technical rules, if allocated as proposed by FCC). Installing RA systems that meet the requirements of this proposed rule would limit the risk of inaccurate or missing height above terrain data, allowing air transportation operations to continue at their current tempo and safety environment. At the immediate safety level, having accurate data provided by the RA is essential information for pilots, especially in low-visibility airport operations that can affect, on average, 135,600 takeoffs and landings each year.

Beyond data provided directly to pilots, RA information is used by several mandated systems whose safety benefits this proposed rule aims to preserve. Systems such as TCAS and TAWS, which rely on accurate RA altitude data, provide pilots vital safety enhancements for collision avoidance. Since implementation, these systems have played a large role in significantly reducing mid-air collisions or CFIT accidents on equipped aircraft in the United States.[68] Additional aircraft systems that rely on RA information, such as autoflight functions, wind shear protection, and other aircraft-specific features, provide further unquantified safety benefits by aiding pilots in operating the aircraft and avoiding unsafe conditions.

Should interference-tolerant RAs not be available or mandated, FAA would supersede the current ADs to maintain the safety environment, with the potential to issue additional ADs covering other operations or aircraft models as needed. These ADs would maintain the appropriate level of safety in the NAS by preventing the operation of certain

aircraft or in conditions where accurate RA data is vital to the safe operation, but do not retain the additional safety benefits generated by RAs and their dependent safety systems. There also would be further loss of economic benefits from the resulting groundings, cancellations, and delays of operational restrictions affecting the efficiency of air travel in the NAS. FAA currently lacks data to assess the estimated potential effects and requests comment with supporting documentation on the expected economic impact or on any other benefit assumption or estimate in this analysis.

4. Costs

Under the proposed rule, airlines and other operators would incur costs to retrofit their RA equipped aircraft with systems meeting the proposed RA interference tolerance standards. When issuing ADs in 2023 for transport and commuter category airplanes and for rotorcraft to mitigate interference from Lower C-band wireless services, FAA estimated that replacement of the RA transceiver unit for a civil aircraft would cost up to $80,000 for an airplane[69] and $40,000 for a rotorcraft,[70] inclusive of parts and labor. FAA acknowledges that the unit cost of the new and more complex RA units required by this rule may be greater and would result in an underestimation, but does not have any alternative estimates at this time since the new products are not yet available, and thus for purposes of this analysis uses estimates based on the current unit cost. These values assume replacement of just the RA transceiver unit, which for most aircraft is expected to be a "plug-and-play" operation requiring minimal labor hours, aircraft downtime, or time out of service, such as during regular maintenance. Retrofitting just the transceiver unit is expected to solve the spectrum interference issue and would not require changing out the RA antenna or wiring, which would greatly increase completion time and costs. Once installed, there are not any expected notable operational differences between the current RAs and the new units, so there are no estimated recurring costs associated with the new units after replacement. In addition, as this analysis uses current prices for RA units, there

is no estimated price delta and therefore costs for future built aircraft using an Upper C-band compliant system. FAA requests comments, with supporting documentation, on the expected RA unit price difference, estimated future annual production of units, and any other cost assumptions or estimates presented in this analysis.

FAA proposes the compliance timeline to complete the retrofitting as two tranches. For the first, all aircraft with RAs operating under 14 CFR part 121, and those aircraft operating under 14 CFR part 129 with 30 or more passenger seats or a payload capacity of more than 7,500 pounds, would have to retrofit with RA systems meeting the new performance requirements by the initial RA performance deadline. These operations are the most critical to the national economy and have the highest expected level of safety, making them a priority. FAA proposes that this initial RA performance deadline be between 2029 and 2032. Based on the fleet data from MITRE, FAA estimates there are roughly 27,374 RA units on aircraft subject to the first deadline: 17,033 used by domestic part 121 operators and 10,341 used by foreign part 129 operators.[71] Applying the $80,000 cost to the RA totals yields a total retrofit expense of $1.36 billion for part 121 operators and $827 million for part 129 operators, yielding a total undiscounted cost of $2.19 billion for the first group. FAA requests comment on the expected schedule of replacement or retrofit of RA units to Upper C-band tolerant systems to develop discounted cost estimates.

The second tranche includes any other aircraft operating under part 91 in the airspace of the 48 contiguous United States and the District of Columbia and equipped with an RA; they would have an additional two years after the initial RA performance deadline to complete the retrofit. FAA currently estimates that there are 31,205 RA units across this category, covering both airplanes and rotorcraft.[72] Applying the respective cost for airplanes and rotorcraft to the populations, FAA estimates an undiscounted cost of $2.30 billion to retrofit the remaining RA units in the second group. FAA requests

comment on the expected Upper C-band tolerant RA adoption curve for this group of aircraft to develop a discounted cost total.

Combining the estimates from both groups, the expected undiscounted total cost of retrofitting RAs across the civil fleet is $4.49 billion. Table 10 shows the total and annualized costs, broken out by type of CFR operation and annualized discount rate.

FCC's NPRM section 3.D also discusses exploring options for potential incentivization or reimbursement of RA retrofits. This action would be considered a transfer of costs under OMB Circular A-4 accounting, reducing or eliminating the burden of RA system retrofit for aircraft operators. The availability of incentive or reimbursement payments could affect the rate at which RAs are replaced in response to the requirements of this proposed rule.

FAA requests comment with supporting documentation on the estimated costs.

Table 10: Costs of RA Replacement (millions of 2025$)

CFR Operational Part	Undiscounted Total Cost	Annualized Costs[1]	
		3% Discount Rate	7% Discount Rate
Part 91	$1,589	$107	$150
Part 121	$1,363	$92	$129
Part 129	$891	$60	$84
Part 135	$651	$44	$61
Total	$4,494	$302	$424

Notes: Columns may not sum due to rounding
1. Costs are annualized over a 20-year period, estimated to be the average remaining service life for current fleet aircraft.

5. Alternatives to Proposed Rule

Scenario 1: AD operational restrictions with no retrofit requirement (Baseline)

FAA considers this scenario as an alternative to the Pre-C-band Utilization Baseline. Without the availability of new interference-tolerant RAs, either due to failure to certify the new product in time, uncertainty regarding supply within the compliance timeframe, or not issuing the proposed regulations on RA performance, FAA would follow the actions presented in the baseline section and supersede the ADs covering Lower C-band interference based on changes in the spectrum environment to maintain current safety levels. Expiration of the wireless agreements in 2028 and expansion into frequencies closer to the RA band from the upcoming FCC auction would likely require prohibiting specific operations and grounding aircraft that cannot operate safely without interference-resistant RAs. These ADs would not be applicable to non-U.S. registered aircraft, so other methods would be required to ensure safety, such as issuing NOTAMs and amending the U.S. AIP to address changes in the spectrum environment.

The method by which the ADs would maintain the safety of the NAS is by prohibiting flights in low visibility conditions for aircraft that are heavily dependent on RA data for their safety systems. In doing so, safety is maintained by preventing scenarios where there is an unacceptable risk of incorrect RA data causing a catastrophic accident; however, this also comes with the loss of the additional safety benefits RAs and their dependent systems provide. The cost of these ADs would be flight delays and cancellations by operators, with spillover effects for the flying public.

FAA compares these grounding costs that may be incurred by aircraft operators to the costs within the pre-C-band utilization baseline to further consider this scenario. The International Bureau of Aviation (IBA) estimated in 2019 that the direct costs for an operator to ground a passenger jet like the Boeing 737 Max could be up to $150,000 per day.[73] Based on that value, grounding the 8,014 aircraft in part 121 under the weather and model restrictions of the ADs for just 4 days would cost operators $4.8 billion, exceeding the undiscounted cost of $4.49 billion to retrofit RAs for the entire civil fleet. Beyond the

costs to operators of the aircraft, as a representation of how expensive airline delays and cancellations are to the economy, a 2010 FAA-commissioned study found the total delay impact of flight delays in 2007 cost the U.S. $32.9 billion between airline operators, passengers, and general economic welfare losses.[74] Adjusted forward using the Bureau of Labor Statistics (BLS) Consumer Price Index for All Urban Consumers (CPI-U), this equates to $51.2 billion in 2025 dollars.[75] If FAA has to issue new ADs and NOTAMs to maintain safety due to changes in the Upper C-band spectrum environment, approximately 4 percent of the part 121 fleet and 22 percent of the part 129 airplane fleet would not be able to operate in the contiguous U.S.,[76] and the majority of the part 121 and part 129 fleets would experience delays due to prohibiting operations in low visibility conditions. The resulting economic consequences of shutting down portions of major domestic and international air carrier operations due to AD restrictions under this baseline would likely exceed the cost of the proposed rule well within the compliance period and incur additional recurring costs until the interference issue is addressed.

In this environment, industry would likely turn to the upcoming new RTCA/EUROCAE standards to guide development of Upper C-band tolerant RAs. However, due to the timeline mandated by PL 119-21, FCC would have to determine the new Upper C-band wireless environment prior to standards publication. This may result in FCC establishing an environment where wireless interference cannot be safely accommodated, even with new RA systems, which would have significant economic costs as FAA would indefinitely prohibit certain aircraft from operating in the U.S. and prohibit all low-visibility approach and landing operations. In the best case, FCC would define the Upper C-band wireless environment that is aligned to the feasible RA performance. Even then, awaiting the international standards to be published would delay the design and production of RAs that can accommodate the new spectrum environment,

requiring FAA to use the more costly ADs to cover the safety gap until the fleet is fully equipped.

This scenario would also require an extension of the current voluntary wireless agreements to continue safe coexistence with Lower C-band wireless service and continue to mitigate operational limitations in the current ADs. FAA lacks the authority to compel wireless licensees to extend the voluntary agreements, and notes that, even if extended, new voluntary emission limits for safe RA use are not commercially viable for the Upper C-band wireless services (see section IV.C for discussion). The additional uncertainty and timeline pressure of interference tolerant RA availability would continue to inhibit wireless companies' usage of the C-band and would severely limit realizing the full value of the FCC spectrum auction and the general economic benefits of expanding spectrum usage compared to the proposed rule.

Scenario 2: No AD operational restrictions or retrofit requirement

If new interference-tolerant RA units are not developed or available, and the current ADs are withdrawn, FAA would be maintaining the current tempo of air operations, but would be accepting the risk of Upper C-band interference on the RA and all dependent aircraft safety systems. The most recent FAA risk assessments rated these risks from minor to catastrophic, with the most significant risks to operations in very low visibility (e.g. CAT II/III, use of EFVS to touchdown, Autoland). In addition, aircraft with dependent safety systems may react incorrectly and catastrophically at low altitude due to erroneous or missing RA data. Training, service bulletins, and guidance will not be sufficient to overcome the high likelihood of hazardously misleading or missing RA information impacting multiple aircraft safety systems, some of which are required by legislation and regulations based on previous fatal accidents. In comparison to the no-action baseline, this scenario would retain economic benefits from maintaining the pace

of air operations but is considered unacceptable, as FAA has a statutory responsibility to protect the safety of the NAS from the high level of risk this option creates.

6. Summary

This proposed rule aims to address a critical safety issue in the NAS, with the upcoming auction and proposed reallocation of the Upper C-band spectrum for next-generation wireless services posing a serious risk to the accuracy and usability of RAs. RAs provide height above terrain information, and the accuracy of its data is critical for low visibility operations and use in numerous mandated automatic safety systems. Without the ability to filter out neighboring C-band signals and prevent inaccurate or missing RA data, and absent the extension or modification of voluntary agreements from Upper C-band spectrum holders, FAA would have to issue ADs prohibiting the operation of certain aircraft and prohibiting specific operations in low visibility conditions to maintain the safety of the NAS.

To prevent this disruption to air operations and maintain high levels of aviation safety, FAA is proposing new regulations to require all RA systems meet specific minimum performance requirements on aircraft operating in the airspace of the 48 contiguous United States and the District of Columbia by an initial performance deadline between 2029 and 2032 for all aircraft operating under 14 CFR part 121 and aircraft operating under part 129 with 30 or more passenger seats or a payload capacity of more than 7,500 pounds. All other aircraft operating under part 91 in the airspace of the 48 contiguous United States and the District of Columbia and equipped with an RA will have an additional two years after the initial performance deadline to use a unit that meets the proposed performance standard. These new RA systems must be resilient to interference from signals in neighboring spectrum bands and continue to provide accurate altitude readings to pilots and integrated aircraft safety systems.

FAA estimates the undiscounted total cost to retrofit all RAs in the civil fleet is $4.49 billion, or $424 million annualized at a 7 percent discount rate over a 20-year average remaining aircraft service life compared to the pre-C-band utilization baseline. Compared to the no-action baseline, FAA assumes relative cost savings for operators of RA equipped aircraft to retrofit to units that meet the new interference tolerance standards and therefore not be subject to the operating restrictions of the current ADs, which would also be required in future ADs. FAA requests comments, with supporting documentation, on the assumptions and estimates made in this RIA. As the estimated cost exceeds the threshold for an economically significant rule under section 3(f)(1) of E.O. 12866, FAA prepared the required OMB Circular A-4 accounting statements below.

Table 11: OMB Circular A-4 Accounting Statement, No-Action Baseline, U.S. and Non-U.S. Parties (millions of 2025$)

Category	3-Percent Discount Rate	7-Percent Discount Rate	Source Citation (RIA. Preamble, etc.)
BENEFITS			
Annualized Monetized $millions/year	N/A	N/A	N/A
Annualized Quantified	N/A	N/A	N/A
Qualitative	• ADs maintain baseline safety in the NAS by prohibiting operations where RA interference presents unacceptable risk. • Use of interference-tolerant RA units allows operators to keep safety benefits of RAs and their dependent systems. • Permits airlines with a retrofitted RA to maintain current schedule efficiency and reliability. • Allows FAA to remove ADs associated with RA interference once the fleet has fully equipped to upgraded RA systems.		Preamble, RIA Section A.2
COSTS			
Annualized Monetized $millions/year	N/A	N/A	Preamble RIA Section A.2

Annualized Quantified	N/A	N/A	N/A
Qualitative	• The baseline cost to aircraft operators includes recurring delays, cancellations, and groundings due to model and visibility operating restrictions covered by the ADs. These baseline costs can be negated by the cost of retrofitting RAs to be in compliance with the ADs. • Retrofit costs include purchasing new RA transceiver units, installation is expected to be simple and done during regular maintenance cycles. • Split between two groups, first compliance requirement is all part 121 and 30+ seat or 7,500+ pounds payload capacity part 129 aircraft, all others will have two additional years to retrofit. • No expected operational or recurring cost differences between current and potential future RAs.		Preamble, RIA Sections A.2 and A.4
TRANSFERS			
Annualized Monetized $millions/year	N/A	N/A	N/A
Annualized Quantified	N/A	N/A	N/A
Qualitative	• FCC is requesting proposals to facilitate these retrofits from a financial perspective • Would allow full utilization of auctioned wireless spectrum.		N/A
State, Local, and/or Tribal Government	• Any state, local, or tribal governments that utilize aircraft with an RA onboard, such as police or search and rescue rotorcraft, will have restrictions on operating in conditions specified in the ADs. • The cost of not being able to utilize some aircraft under such conditions may be greater than the cost of retrofitting with an RA unit meeting the new performance standards.		Preamble, RIA Section A.4
Small Business	• Small businesses utilizing RA-equipped aircraft will be subject to restrictions of the ADs. • Lost revenue and other expenses from groundings, delays, and cancellations stemming from the ADs are likely greater than the cost to retrofit RAs per the proposed standards of the rule. • Total cost to an entity is dependent on the size of their fleet.		Initial Regulatory Flexibility Analysis
Wages	N/A		N/A
Growth	N/A		N/A

Table 12: OMB Circular A-4 Accounting Statement, Pre-C-band Utilization Baseline,

Retrofit Cost to U.S. and Non-U.S. Parties (millions of 2025$)

Category	3-Percent Discount Rate	7-Percent Discount Rate	Source Citation (RIA. Preamble, etc.)
BENEFITS			
Annualized Monetized $millions/year	N/A	N/A	N/A
Annualized Quantified	N/A	N/A	N/A
Qualitative	• Use of interference-tolerant units allows operators to keep safety benefits of RAs and their dependent systems. • Permits airlines to maintain the current schedule efficiency and reliability. • Allows FAA to remove ADs associated with RA interference once the fleet has fully equipped to upgraded RA systems.		Preamble, RIA Section A.3
COSTS			
Annualized Monetized $millions/year	$302	$424	Preamble RIA Section A.4
Annualized Quantified	N/A	N/A	N/A
Qualitative	• Burden on operators of RA carrying aircraft to replace or retrofit to units that meet the new interference tolerance standards. • Split between two groups, first compliance requirement is all 14 CFR part 121 and 30+ seat or 7,500+ pounds payload capacity part 129 aircraft, all others will have two additional years to retrofit. • Primary cost is purchasing new RA transceiver units, installation is expected to be simple and done during regular maintenance cycles. • No expected operational or recurring cost differences between current and potential future RAs.		Preamble, RIA Section A.4
TRANSFERS			
Annualized Monetized $millions/year	N/A	N/A	N/A
Annualized Quantified	N/A	N/A	N/A
Qualitative	• FCC is requesting proposals to facilitate these retrofits from a financial perspective • Would allow full utilization of auctioned wireless spectrum.		N/A

State, Local, and/or Tribal Government	Any state, local, or tribal governments that utilize aircraft with an RA onboard, such as police or search and rescue rotorcraft, will incur costs to replace the unit with an interference-tolerant version.	Preamble, RIA Section A.4
Small Business	Small businesses will incur $40k to $80k in costs per aircraft to retrofit with an RA that meets the proposed performance requirement. Total cost to an entity is dependent on the size of their fleet.	Initial Regulatory Flexibility Analysis
Wages	N/A	N/A
Growth	N/A	N/A

B. Regulatory Flexibility Act

The Regulatory Flexibility Act (RFA) of 1980, Public Law 96–354, 94 Stat. 1164 (5 U.S.C. 601–612), as amended by the Small Business Regulatory Enforcement Fairness Act of 1996 (Pub. L. 104–121, 110 Stat. 857, Mar. 29, 1996) and the Small Business Jobs Act of 2010 (Pub. L. 111–240, 124 Stat. 2504 Sept. 27, 2010), requires Federal agencies to consider the effects of the regulatory action on small business and other small entities and to minimize any significant economic impact. The term "small entities" comprises small businesses and not-for-profit organizations that are independently owned and operated and are not dominant in their fields, and governmental jurisdictions with populations of less than 50,000.

FAA is publishing this Initial Regulatory Flexibility Analysis (IRFA) to aid the public in commenting on the potential impacts to small entities from this proposal. FAA invites interested parties to submit data and information regarding the potential economic impact that would result from the proposal. FAA will consider comments when making a determination or when completing a Final Regulatory Flexibility Analysis.

Under Section 603 (b) and (c) of the RFA, an IRFA must contain the following:

(1) A description of the reasons why the action by the agency is being considered;

(2) A succinct statement of the objective of, and legal basis for, the proposed rule;

(3) A description of and, where feasible, an estimate of the number of small entities to which the proposed rule will apply;

(4) A description of the projected reporting, recordkeeping, and other compliance requirements of the proposed rule, including an estimate of the classes of small entities which will be subject to the requirement and the type of professional skills necessary for preparation of the report or record;

(5) An identification, to the extent practicable, of all relevant Federal rules that may duplicate, overlap, or conflict with the proposed rule; and

(6) A description of any significant alternatives to the proposed rule which accomplish the stated objectives of applicable statutes and which minimize any significant economic impact of the proposed rule on small entities.

1. Reasons the Action is Being Considered

This rule is being proposed to address a critical safety issue with RAs. RAs are dependent on receiving faint waves in the 4.2 to 4.4 GHz spectrum reflected by terrain and obstacles to determine the aircraft's height above the terrain. Higher power signals in neighboring spectrum bands, such as those emitted by next-generation wireless services, can interfere with the RA waves and cause the unit to indicate missing or erroneous data. In turn, the lack of accurate height above terrain data presents a significant safety risk for pilots operating in low-visibility conditions and affects numerous safety systems that are dependent on RA information. These issues have been previously mitigated with wireless companies voluntarily agreeing to limit base station power level and out-of-band emissions in the Lower C-band (3.7 to 3.98 GHz) and operators making changes to their RA units to improve interference tolerance. However, with the voluntary agreements expiring in 2028, and the mandate for FCC to auction off the Upper C-band spectrum (3.98 to 4.2 GHz) adjacent to the RA band, these measures will no longer be adequate to prevent RA interference and associated catastrophic risk to air operations.

2. Objectives and Legal Basis of the Proposed Rule

To address the safety issue from wireless interference, this rule proposes that all RA units on aircraft operating under part 91 in the airspace of the 48 contiguous United States and the District of Columbia must be replaced by new RA systems that meet the proposed interference tolerance requirements. RA systems that meet the new requirements will continue to function properly when the Lower and Upper C-band wireless services become active following FCC auction and expiration of the voluntary Lower C-band wireless agreements. Installing these interference-tolerant RAs in the fleet would allow air operations to continue at their current tempo and preserve safety levels provided by the benefits of accurate RA data and its use in numerous dependent safety systems. In the absence of requiring interference-tolerant RAs, FAA would issue ADs to maintain the safety environment, which would cost operators more over time due to groundings, delays, and cancellations of aircraft operations.

The legal basis for this action lies in FAA's authority to issue rules on aviation safety found in Title 49 of the United States Code. Subtitle I, Section 106 describes the authority of the FAA Administrator. Subtitle VII, Aviation Programs, describes in more detail the scope of FAA's authority. This rulemaking is promulgated under the authority described in 49 U.S.C. 106(f), which establishes the authority of the Administrator to promulgate and revise regulations and rules related to aviation safety. This rulemaking is also issued under the authority described in Subtitle VII, Part A, Subpart III, Section 44701: General requirements. Under that section, FAA is charged with prescribing regulations promoting safe flight of civil aircraft in air commerce by prescribing regulations for practices, methods, and procedures the Administrator finds necessary for safety in air commerce.

3. Description and Estimate of the Number of Small Entities

FAA used the definition of small entities in the RFA for this analysis. The RFA defines small entities as small businesses, small governmental jurisdictions, or small organizations. In 5 U.S.C. section 601(3), the RFA defines "small business" to have the same meaning as “small business concern” under section 3 of the Small Business Act. The Small Business Act authorizes the Small Business Administration (SBA) to define "small business" by issuing regulations.

SBA (2023) has established size standards for various types of economic activities, or industries, under the North American Industry Classification System (NAICS).[77] These size standards generally define small businesses based on the number of employees or annual receipts. Table 13 shows the SBA size standards for airlines as an example. Note that the SBA definition of a small business applies to the parent company and all affiliates as a single entity.

Table 13. Small Business Size Standards: Air Transportation

NAICS Code	Description	Size Standard
481111	Scheduled Passenger Air Transportation	1,500 employees
481112	Scheduled Freight Air Transportation	1,500 employees
481211	Nonscheduled Chartered Passenger Air Transportation	1,500 employees
481212	Nonscheduled Chartered Freight Air Transportation	1,500 employees
481219	Other Nonscheduled Air Transportation	$25.0 million
Source: SBA (2023) NAICS = North American Industrial Classification System SBA = Small Business Administration		

To identify small entities, FAA first identified the primary NAICS of the airline or parent company and then used data from different sources (e.g., company annual reports, FAA operator data, Bureau of Transportation Statistics, D&B Hoovers) to determine whether the airline meets the applicable size standard. Table 14 provides a summary of the results.

Table 14. Estimated Number of Small Entities

CFR Operational Part	Number of Entities	Number Small Entities	Percent Small Entities
Part 91[1]	12,365	11,371	91.95%
Part 121	60	35	58.3%
Part 135	1,131	1,114	98.5%
Total	13,535	12,520	92.5%

1. The percent of part 91 small entities, and resulting total number of small entities, is based on a random sample of 373 operators. This estimate is likely an overcount as FAA is unable to remove private/GA aircraft owners from its dataset.

In general, entities classified as scheduled air transportation (NAICS 481111 and 481112) operate under part 121, and entities engaged in nonscheduled air transportation (NAICS 481211 and 481212) operate under part 135. Part 91 operations include entities under NAICS 481219, such as air clubs and sightseeing operations, as well as entities in any other non-air transportation NAICS code that own and operate aircraft for private use or internal company transportation.

4. Projected Reporting, Recordkeeping, and Other Compliance Requirements

In the absence of cost data on a future product, FAA assumes the cost to retrofit an interference-tolerant RA in accordance with this proposed rule is up to $80,000 for an airplane and $40,000 for a rotorcraft, based on the 2023 ADs concerning Lower C-band interference mitigation.[78] Therefore, the cost to each entity is based on how many aircraft are in their fleet, which induces higher costs to larger operators that have larger fleets. However, since operations and resulting revenue scale with fleet size as well, larger firms may be able to better absorb those increased costs compared to small entities with only one or two aircraft. By applying these equipment costs to the average number of aircraft for a small entity based on its size category, FAA estimates the average one-time RA replacement cost per small entity. These costs are then weighed against the average annual revenue per small entity data from the 2022 U.S. Census Statistics of U.S. Businesses (SUSB)[79], displayed in table 15 for part 121 operators and table 16 for part 135 operators.

Table 15. Part 121 Cost of Compliance (thousands of 2025$)

Number of Employees	Number of Small Entities	Average Number of Aircraft	Average One-Time RA Cost per Entity[1]	Average Annual Revenues per Entity [2]	Average Cost/ Annual Revenue
20-99 employees	9	4	$356	$69,356	0.5%
100-499 employees	18	13	$1,031	$246,082	0.4%
500+ employees	8	29	$2,310	$5,075,566	0.0%

Notes: Rows may not sum due to rounding
1. Based on a unit and labor cost of $80,000 for a new RA
2. FAA estimates receipts per entity using 2022 SUSB data on NAICS 48111 firm counts and receipts. Receipts are adjusted to 2025 dollars using the BLS Consumer Price Index for all Urban Consumers (Series ID: CUUR0000SA0).

Table 16. Part 135 Cost of Compliance (thousands of 2025$)

Number of Employees	Number of Small Entities	Average Number of Aircraft	Average one-time RA cost per entity[1]	Average annual revenues per entity[2]	Average Cost/ Annual Revenue
1-19 employees	640	2	$155	$2,906	6.8%
20-99 employees	376	7	$469	$21,400	2.8%
100-499 employees	76	20	$1,402	$84,939	2.1%
500+ employees	22	75	$5,301	$250,641	2.7%

Notes: Rows may not sum due to rounding
1. Based on RA unit and labor cost of $80,000 for aircraft and $40,000 rotorcraft, applied by the ratio of each type within part 135.
2. FAA estimates receipts per entity using 2022 SUSB data on NAICS 48112 firm counts and receipts. Receipts are adjusted to 2025 dollars using the BLS Consumer Price Index for all Urban Consumers (Series ID: CUUR0000SA0).

FAA does not estimate the per entity costs for part 91 operators, as companies operating under this section are generally not engaged in commercial air transportation services. While there are some operators for sightseeing services or aviation club activities under NAICS 481219, the vast majority of these aircraft are used by private operators or entities for personal transportation across many different industries (i.e. corporate jets). This is reflected in the fleet data FAA used, as roughly 90 percent of operators under part 91 only have one aircraft, and another eight percent operate just two. Depending on whether the RA unit is used in automated aircraft safety systems or not,

some part 91 operators may even have the choice to simply remove their RA after the proposed rule takes effect to avoid the replacement cost, though they would not retain the safety benefits RAs provide as discussed in section V.3. Entities that choose to replace the RA may also have access to noncommercial use units at lower cost than the estimated $40,000 - $80,000. However, without information on what models manufacturers will provide in the future, FAA is unable to determine a potential reduction in burden.

5. All Federal Rules That May Duplicate, Overlap, or Conflict

There are no relevant Federal rules that may duplicate, overlap, or conflict with the proposed rule.

6. Significant Alternatives Considered

As discussed in Section V.A.5 of the preamble, the alternative to not requiring the use of interference-tolerant RAs would be for FAA to supersede the current ADs to impose new requirements curtailing operations where inaccurate RA data poses a catastrophic risk to air safety. These ADs would cover commuter and transport category airplanes, rotorcraft, and some specific large passenger aircraft, with potential as needed for FAA to issue additional ADs based on changes in the C-band spectrum environment. The cost of these ADs is likely to outweigh the cost of retrofitting with an interference-tolerant RA in expenses incurred from resulting groundings, cancellations, and delays. The option of not controlling the risk of spectrum interference with ADs or requiring interference-tolerant RAs is not considered acceptable as FAA has a statutory responsibility to protect the safety of the NAS. FAA requests comments on alternatives to the proposed rule that accomplish the stated objectives of the applicable statutes, and that minimize impact of the proposed rule on small entities.

C. International Trade Impact Assessment

The Trade Agreements Act of 1979 (Pub. L. 96-39), as amended by the Uruguay Round Agreements Act (Pub. L. 103-465), prohibits Federal agencies from establishing

standards or engaging in related activities that create unnecessary obstacles to the foreign commerce of the United States. Pursuant to these Acts, the establishment of standards is not considered an unnecessary obstacle to the foreign commerce of the United States, so long as the standard has a legitimate domestic objective, such as the protection of safety, and does not operate in a manner that excludes imports that meet this objective. The statute also requires consideration of international standards and, where appropriate, they be the basis for U.S. standards.

FAA has assessed the potential effect of this proposed rule and determined that it ensures the safety of the American public. If this proposed rule is not implemented, there would be no cost savings and no significant differences in the potential impacts to foreign commerce. In the absence of new regulations, FAA will have to issue new or amended ADs to address U.S. registered aircraft, as well as other necessary policy changes directly relevant to foreign air carriers to prevent catastrophic risk to aviation safety due to future changes in the spectrum environment. The cost of compliance with the ADs would likely be higher than the cost of compliance with the proposed rule, as a lack of RA retrofit compliance would result in significant impacts to domestic and foreign air carrier capacity, efficiency, and schedule reliability. As a result, FAA does not consider this proposed rule as creating an unnecessary obstacle to foreign commerce and welcomes comment on this assessment.

D. Unfunded Mandates Assessment

Section 202 of the Unfunded Mandates Reform Act of 1995 (UMRA) requires Federal agencies to prepare a written assessment of the costs, benefits, and other effects of proposed or final rules that include a Federal mandate likely to result in the expenditure by State, local or tribal governments, in the aggregate, or by the private sector, of more than $100 million in any one year (adjusted for inflation with base year of 1995). The value equivalent of $100 million in 1995 adjusted for inflation using the most

current Implicit Price Deflator for the Gross Domestic Product is $187 million. Before promulgating a rule for which a written statement is needed, section 205 of the UMRA generally requires FAA to identify and consider a reasonable number of regulatory alternatives and adopt the least costly, most cost-effective, or least burdensome alternative that achieves the objectives of the rule. The provisions of section 205 do not apply when they are inconsistent with applicable law. Moreover, section 205 allows FAA to adopt an alternative other than the least costly, most cost-effective, or least burdensome alternative if the agency publishes with the final rule an explanation why that alternative was not adopted.

This proposed rule would not result in the expenditure by State, local, or tribal governments, in the aggregate, of more than $187 million annually, but would result in the expenditure of that magnitude by airlines and other private operators of RA-equipped aircraft. This document seeks comments on the alternatives presented in section V.A.5 for achieving the purposes of FAA's safety mandate in support of the spectrum auction mandate of Public Law 119-21 (One, Big, Beautiful Bill Act).

E. Paperwork Reduction Act

The Paperwork Reduction Act of 1995 (44 U.S.C. 3507(d)) requires FAA consider the impact of paperwork and other information collection burdens imposed on the public. According to the 1995 amendments to the Paperwork Reduction Act (5 CFR 1320.8(b)(2)(vi)), an agency may not collect or sponsor the collection of information, nor may it impose an information collection requirement unless it displays a currently valid OMB control number.

FAA has determined there would be no new information collection associated with the proposed requirement to operate aircraft with RA systems that comply with the specified performance. This proposed requirement will update the RA performance standard, but there will be no new requirements beyond existing policy.

F. International Compatibility

In keeping with U.S. obligations under the Convention on International Civil Aviation, it is FAA policy to conform to International Civil Aviation Organization (ICAO) Standards and Recommended Practices (SARPs) to the maximum extent practicable. FAA has determined that there are currently no ICAO SARPs that correspond to these proposed regulations. ICAO is planning updates to Annex 10 Volume V intended to help protect RAs from potentially harmful in-band and adjacent band interference caused by non-aeronautical systems operating in adjacent frequency bands. FAA will continue to work with the international community to promote the spectrum compatibility achieved by the proposed next generation RA system requirements.

Considering these SARPs have yet to be finalized, FAA seeks comment on the interoperability of the proposed RA requirements across international airspace and the feasibility of making such updates within the proposed compliance timeline.

G. Environmental Analysis

The Department has analyzed the environmental impacts of this proposed rule pursuant to the National Environmental Policy Act of 1969 (NEPA) (42 U.S.C. 4321 et seq.). FAA has determined that this rule is categorically excluded pursuant to Paragraph B-2.6(d) of Appendix B to FAA Order 1050.1G, FAA National Environmental Policy Act Implementing Procedures (90 FR 29615, July 3, 2025). Categorical exclusions are categories of actions that the agency has determined normally do not significantly affect the quality of the human environment and therefore do not require either an environmental assessment (EA) or an environmental impact statement (EIS). See DOT Order 5610.1D § 9. In analyzing the applicability of a categorical exclusion, the agency must also consider whether extraordinary circumstances are present that would warrant the preparation of an EA or EIS. Id. § 9(b). This rulemaking, which requires all RAs to

meet specific minimum performance requirements to support resilience to interference from wireless signals in neighboring spectrum bands, is categorically excluded pursuant to Paragraph B-2.6(d) of FAA Order 1050.1G: "Issuance of regulatory documents (e.g., Notices of Proposed Rulemaking and issuance of Final Rules) covering administrative or procedural requirements. (Does not include air traffic procedures; specific air traffic procedures that are categorically excluded are identified under Appendix B, Paragraph B-2.5 of this Order)." FAA does not anticipate any environmental impacts, and there are no extraordinary circumstances present in connection with this rulemaking.

H. Regulations Affecting Intrastate Aviation in Alaska

Section 1205 of the FAA Reauthorization Act of 1996 (110 Stat. 3213) requires the Administrator, when modifying 14 CFR regulations in a manner affecting intrastate aviation in Alaska, to consider the extent to which Alaska is not served by transportation modes other than aviation, and to establish appropriate regulatory distinctions. FAA expects reduced impact because this proposed rule would not apply to aircraft equipped with RA that only conduct intrastate operations in Alaska. However, this proposed rule could, if adopted, affect aviation operations in Alaska because it applies to aircraft equipped with RA based in Alaska that operate regularly to the 48 contiguous United States, or aircraft based in the 48 contiguous United States that operate regularly to and from Alaska. FCC is proposing to preserve the status quo regarding its current licenses outside of the contiguous United States, which would be permitted to continue in the entire 3.7-4.2 GHz band. FCC notes that its proposal to only reallocate spectrum within the contiguous U.S. would ensure the ongoing provision of current C-band services necessary to protect life and property outside the contiguous U.S.—including telehealth, E911, and education services—for which C-band service may be the only option available, such as in remote areas of Alaska. Therefore, FAA specifically requests

comments on the suitability of applying the proposed rule differently for intrastate operations in Alaska.

VI. E.O. Determinations

A. E.O. 13132, Federalism

FAA has analyzed this proposed rule under the principles and criteria of E.O. 13132, Federalism. FAA has determined this action would not have a substantial direct effect on the States, or the relationship between the Federal Government and the States, or on the distribution of power and responsibilities among the various levels of government, and, therefore, would not have federalism implications.

B. E.O. 13175, Consultation and Coordination With Indian Tribal Governments

Consistent with E.O. 13175, Consultation and Coordination with Indian Tribal Governments,[80] and FAA Order 1210.20, American Indian and Alaska Native Tribal Consultation Policy and Procedures,[81] FAA ensures Federally Recognized Tribes (Tribes) are given the opportunity to provide meaningful and timely input regarding proposed Federal actions that have the potential to affect uniquely or significantly their respective Tribes. At this point, FAA has not identified any unique or significant effects, environmental or otherwise, on Tribes resulting from this proposed rule.

C. E.O. 13211, Regulations That Significantly Affect Energy Supply, Distribution, or Use

FAA analyzed this proposed rule under E.O. 13211, Actions Concerning Regulations that Significantly Affect Energy Supply, Distribution, or Use (May 18, 2001). FAA has determined it would not be a "significant energy action" under

the E.O. and would not be likely to have a significant adverse effect on the supply, distribution, or use of energy.

D. E.O. 13609, Promoting International Regulatory Cooperation

E.O. 13609, Promoting International Regulatory Cooperation, promotes international regulatory cooperation to (1) meet shared challenges involving health, safety, labor, security, environmental, and other issues and reduce, eliminate, or (2) prevent unnecessary differences in regulatory requirements. FAA has analyzed this action under the policy and agency responsibilities of E.O. 13609. FAA has determined this action would help prevent future differences between U.S. aviation standards and those of other CAAs by being the first nation to adopt and require these new RA system performance standards, to set a standard for future harmonization with other CAAs, and inform future wireless standards for the spectrum authorities of other nations who are considering similar spectrum reallocation near the RA band.

E. Executive Order 14192, Unleashing Prosperity Through Deregulation

Executive Order 14192 (Unleashing Prosperity Through Deregulation) requires that, for each new regulatory rule, an agency must identify 10 prior regulations for elimination. This proposed rule responds to statutory requirements of section 40002 of the One Big Beautiful Bill Act, which re-institutes FCC's general auction authority and specifically directs the Commission to complete a system of competitive bidding for not less than 100 megahertz in the Upper C-band. To ensure safe, efficient, and reliable aviation operations in the presence of wireless signals in the Upper C-band, FAA is proposing new regulations that would require all RAs to meet specific minimum performance requirements. This proposed rule, if finalized as proposed, is expected to be an E.O. 14192 regulatory action.

VII. Additional Information

A. Comments Invited

FAA invites interested persons to participate in this rulemaking by submitting written comments, data, or views. FAA also invites comments relating to the economic, environmental, energy, or federalism impacts that might result from adopting the proposals in this document. The most helpful comments reference a specific portion of the proposal, explain the reason for any recommended change, and include supporting data. To ensure the docket does not contain duplicate comments, commenters should submit only one time if comments are filed electronically, or commenters should send only one copy of written comments if comments are filed in writing.

FAA will file in the docket all comments it receives, as well as a report summarizing each substantive public contact with FAA personnel concerning this proposed rule. Before acting on this proposal, FAA will consider all comments it receives on or before the closing date for comments. FAA will consider comments filed after the comment period has closed if it is possible to do so without incurring expense or delay. FAA may change this proposal in light of the comments it receives.

FCC has initiated a rulemaking on repurposing the 3.98-4.2 GHz band for advanced wireless services consistent with the One Big Beautiful Bill Act. As part of that rulemaking, FCC seeks comments on issues related to adjacent band coexistence.[82] Interested parties should also submit comments in FCC's proceeding.

B. Confidential Business Information

Confidential Business Information (CBI) is commercial or financial information that is both customarily and actually treated as private by its owner. Under the Freedom of Information Act (FOIA) (5 U.S.C. 552), CBI is exempt from public disclosure. If your comments responsive to this NPRM contain commercial or financial information that is customarily treated as private, that you actually treat as private, and is relevant or

responsive to this NPRM, it is important you clearly designate the submitted comments as CBI. Please mark each page of your submission containing CBI as "PROPIN." FAA will treat such marked submissions as confidential under the FOIA, and they will not be placed in the public docket of this NPRM. Submissions containing CBI should be sent to the person in the **FOR FURTHER INFORMATION CONTACT** section of this document. Any commentary FAA receives that is not specifically designated as CBI will be placed in the public docket for this rulemaking.

C. Electronic Access and Filing

A copy of this NPRM, all comments received, any final rule, and all background material may be viewed online at www.regulations.gov using the docket number listed above. Electronic retrieval help and guidelines are available on the website. It is available 24 hours each day, 365 days each year. An electronic copy of this document may also be downloaded from the Office of the Federal Register's website at www.federalregister.gov and the Government Publishing Office's website at www.govinfo.gov. A copy may also be found at FAA's Regulations and Policies website at www.faa.gov/regulations_policies.

Copies may also be obtained by sending a request to the Federal Aviation Administration, Office of Rulemaking, ARM-1, 800 Independence Avenue S.W., Washington, D.C. 20591, or by calling (202) 267-9677. Commenters must identify the docket or notice number of this rulemaking.

All documents FAA considered in developing this proposed rule, including economic analyses and technical reports, may be accessed in the electronic docket for this rulemaking.

D. Small Business Regulatory Enforcement Fairness Act

The Small Business Regulatory Enforcement Fairness Act of 1996 (Pub. L. 104 121, 110 Stat. 857, Mar. 29, 1996) requires FAA to comply with small entity requests for information or advice about compliance with statutes and regulations

within its jurisdiction. A small entity with questions regarding this document may contact its local FAA official, or the person listed under the **FOR FURTHER INFORMATION CONTACT** heading at the beginning of the preamble. To find out more about SBREFA on the Internet, visit www.faa.gov/regulations_policies/rulemaking/sbre_act/.

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[1] RA systems are generally comprised of a transceiver, cabling, and antennas. When necessary, different terms are used throughout the NPRM to discuss the RA system as a whole or specific parts of it.

[2] Available at https://www.fcc.gov/ecfs/search/search-filings/filing/1022884849315.

[3] Pub. L. No. 119-21 (July 4, 2025), *available at* https://www.congress.gov/bill/119th-congress/house-bill/1.

[4] *In the Matter of Upper C-band (3.98-4.2 GHz)*, 90 FR 56076 (proposed December 5, 2025) *available at* https://www.federalregister.gov/documents/2025/12/05/2025-22020/in-the-matter-of-upper-c-band-398-42-ghz.

[5] Letter from Henry G. Hultquist, Vice President-Federal Regulatory, AT&T Services, Inc., et al., to Marlene H. Dortch, Secretary, FCC, GN Docket No. 18-122 (filed Mar. 31, 2023) (discussing voluntary commitments), *available a*t https://www.fcc.gov/ecfs/search/search-filings/filing/1033142661477.

[6] https://www.rtca.org/sc-239/.

[7] https://www.eurocae.net/working-group/wg-119/.

[8] *See* Letter from Dorothy B. Reimold, Vice President Civil Aviation, Aerospace Industries Assoc., *et al.*, to Marlene H. Dortch, Secretary, FCC, GN Docket No. 25-59, at 1–2 (filed Aug. 21, 2025).

[9] National Telecommunications and Information Administration (NTIA) Comments re Upper C-band NOI, *available at:* https://www.fcc.gov/ecfs/search/search-filings/filing/1080426626787.

[10] Speech: "Downward Pressure on the Accident Rate". Nicholas A. Sabatini.
International Society of Air Safety Investigators. May 12, 2006. Retrieved September 2025 from China Aviation Daily, http://www.chinaaviationdaily.com/news/0/456.html.

[11] The aircraft used in this analysis average 14 to 21 years in age depending on CFR operation. While aircraft retirement age can vary significantly depending on multiple factors, FAA assumes impacted aircraft will average 20 more years of service with an updated RA system installed.

[12] In the Matter of Expanding Flexible Use in the 3.7-4.2 GHz Band, GN Docket No. 18-122, Federal Communications Commission (March 3, 2020), *available at* https://www.fcc.gov/document/fcc-expands-flexible-use-c-band-5g-0.

[13] RTCA Paper No. 274-20/PMC-2073, Assessment of C-Band Mobile Telecommunications Interference Impact on Low Range Radar Altimeter Options, dated October 7, 2020, page i. This document is available on www.regulations.gov in Docket No. FAA-2021-0953, and at https://www.rtca.org/wp-content/uploads/2020/10/SC-239-5G-Interference-Assessment-Report_274-20-PMC-2073_accepted_changes.pdf.

[14] Airworthiness Directive; Transport and Commuter Category Airplanes, 86 FR 69984 (12/09/21) *available at* https://www.federalregister.gov/documents/2021/12/09/2021-26777/airworthiness-directives-transport-and-commuter-category-airplanes.

[15] Airworthiness Directives; Various Helicopters 86 FR 6992 (12/09/21) *available at* https://www.federalregister.gov/documents/2021/12/09/2021-26779/airworthiness-directives-various-helicopters.

[16] AD 2022-03-05 for Boeing 747-8 and 777 models, AD 2022-02-16 for Boeing 787 models, AD 2022-03-20 for newer Boeing 737 models, AD 2022-04-05 for Boeing 757 and 767 models, AD 2022-05-04 for older Boeing 737 models, AD 2022-06-16 for older Boeing 747 models, and AD 2022-09-18 for legacy McDonnell Douglas models.

[17] https://www.fcc.gov/document/fcc-announces-winning-bidders-37-ghz-service-auction.

[18] For example, one voluntary agreement is available at https://www.fcc.gov/ecfs/search/search-filings/filing/1033142661477.

[19] Airworthiness Directives; Transport and Commuter Category Airplanes, 88 FR 34065 (May 26, 2023) *available at* https://www.federalregister.gov/documents/2023/05/26/2023-11371/airworthiness-directives-transport-and-commuter-category-airplanes.

[20] Airworthiness Directives; Various Helicopters, 88 FR 40685 (June 22, 2023) *available at* https://www.federalregister.gov/documents/2023/06/22/2023-13319/airworthiness-directives-various-helicopters.

[21] AD 2023-12-05 for Boeing 747-8 and 777 models, AD 2023-12-10 for Boeing 787 models, AD 2023-12-11 for newer Boeing 737 models, AD 2023-12-12 for Boeing 757 and 767 models, AD 2023-12-13 for older Boeing 737 models, AD 2023-12-14 for older Boeing 747 models, and AD 2023-12-15 for legacy McDonnell Douglas models.

[22] AD 2025-04-08 for MHI RJ regional jet models; AD 2023-06-13 for Bombardier Model BD-700-2A12 airplanes, which was subsequently replaced by AD 2023-14-01; AD 2023-03-06 for Bombardier Model BD-700-1A10 and -1A11 airplanes, which was subsequently replaced by AD 2023-13-15; AD 2023-06-13 for Bombardier Model BD-700-2A12 airplanes; and AD 2023-14-02 for Airbus Model BD-500-1A10 and -1A11 airplanes.

[23] https://www.rtca.org/sc-239/.

[24] https://www.eurocae.net/working-group/wg-119/.

[25] *See* Letter from Dorothy B. Reimold, Vice President Civil Aviation, Aerospace Industries Assoc., *et al.*, to Marlene H. Dortch, Secretary, FCC, GN Docket No. 25-59, at 1–2 (filed Aug. 21, 2025).

[26] Minimum Performance Standards – Airborne Ground Proximity Warning Equipment, RTCA/DO-161A, RTCA Incorporated.

[27] *Ground Proximity Warning Systems,* 39 FR 44439 (Dec. 18, 1974).

[28] *Special Federal Aviation Regulation No. 30; Ground Proximity Warning System,* 43 FR 28176 (June 29, 1978).

[29] *Ground Proximity Warning Systems,* 57 FR 9944 (March 20, 1992).

[30] *Terrain Awareness and Warning System*, 65 FR 16736 (March 29, 2001).

[31] Pub. L. No. 100-223, 101 Stat. 1486 (1987), *available at* https://www.govinfo.gov/app/details/STATUTE-101/STATUTE-101-Pg1486.

[32] *Traffic Alert and Collision Avoidance System,* 54 FR 940 (Jan. 10, 1989).

[33] *Collision Avoidance Systems*, 68 FR 15884 (Apr. 1, 2003).

[34] *Regulation of Fractional Aircraft Ownership Programs and On-Demand Operations*, 68 FR 54520 (Sept. 17, 2003).

[35] *See Airborne Low-Altitude Windshear Equipment Requirements*, 55 FR 13236 (Apr. 9, 1990).

[36] Pub. L. No. 112-95, 126 Stat. 11 (Feb. 14, 2012) *available at* https://www.congress.gov/bill/112th-congress/house-bill/658/text.

[37]*Helicopter Air Ambulance, Commercial Helicopter, and Part 91 Helicopter Operations*, 79 FR 9932 (Feb. 21, 2014), available at https://www.federalregister.gov/documents/2014/02/21/2014-03689/helicopter-air-ambulance-commercial-helicopter-and-part-91-helicopter-operations.

[38] *Integration of Powered-Lift: Pilot Certification and Operations; Miscellaneous Amendments Related to Rotorcraft and Airplanes*, 89 FR 92296 (Nov. 21, 2024), available at https://www.federalregister.gov/documents/2024/11/21/2024-24886/integration-of-powered-lift-pilot-certification-and-operations-miscellaneous-amendments-related-to.

[39] *Pilot, Flight Instructor, and Pilot School Certification*, 74 FR 42500 (Aug. 21, 2009).

[40] https://my.rtca.org/productdetails?id=a1B36000001IcnqEAC.

[41] https://www.eurocae.net/product/ed-30-mps-for-airborne-low-range-radio-radar-altimeter-equipment/.

[42] https://drs.faa.gov/browse/excelExternalWindow/3E13DA064E29A5F586257A1B005889A8.0001.

[43] Airworthiness Directives; Transport and Commuter Category Airplanes, 88 FR 34065 (May 26, 2023) a*vailable at* https://www.federalregister.gov/documents/2023/05/26/2023-11371/airworthiness-directives-transport-and-commuter-category-airplanes.

[44] *See* Letter from Dorothy B. Reimold, Vice President Civil Aviation, Aerospace Industries Assoc., *et al.*, to Marlene H. Dortch, Secretary, FCC, GN Docket No. 25-59, at 1–2 (filed Aug. 21, 2025).

[45] FAA Advisory Circular (AC) 20-199, Installation of an Airborne Low-Range Radio Altimeter System, will be available for review and comment at https://www.faa.gov/aircraft/draft_docs, under "Aircraft Certification Service (AIR) Draft Documents"

[46] NPRM published in 90 FR 38212.

[47] https://www.govinfo.gov/content/pkg/USCODE-2023-title49/pdf/USCODE-2023-title49-subtitleVII-partA-subpartiii-chap448-sec44809.pdf.

[48] *In the Matter of Upper C-band (3.98-4.2 GHz)*, 90 FR 56076 (proposed December 5, 2025), paragraph 20, *available at* https://www.federalregister.gov/documents/2025/12/05/2025-22020/in-the-matter-of-upper-c-band-398-42-ghz.

[49] *In the Matter of Upper C-band (3.98-4.2 GHz)*, 90 FR 56076 (proposed December 5, 2025), paragraphs 119-122, *available at* https://www.federalregister.gov/documents/2025/12/05/2025-22020/in-the-matter-of-upper-c-band-398-42-ghz.

[50] Defined as conducting at least one U.S. operation between 04/01/2024 and 09/01/2025.

[51] AC 150/5390-2D, Heliport Design, available at https://www.faa.gov/airports/resources/advisory_circulars/index.cfm/go/document.current/documentnumber/150_5390-2.

[52] Letter from Henry G. Hultquist, Vice President-Federal Regulatory, AT&T Services, Inc., et al., to Marlene H. Dortch, Secretary, FCC, GN Docket No. 18-122 (filed Mar. 31, 2023) (discussing voluntary commitments), *available a*t https://www.fcc.gov/ecfs/search/search-filings/filing/1033142661477.https://www.fcc.gov/ecfs/search/search-filings/filing/1033142661477.

[53] *Demonstration of Radio Altimeter Tolerant Aircraft*, 88 FR 46055 (July 19, 2023), *available at* https://www.federalregister.gov/documents/2023/07/19/2023-14927/demonstration-of-radio-altimeter-tolerant-aircraft.

[54] Airworthiness Directives; Transport and Commuter Category Airplanes, 88 FR 34065 (05/26/2023) *available at* https://www.federalregister.gov/documents/2023/05/26/2023-11371/airworthiness-directives-transport-and-commuter-category-airplanes.

[55] Airworthiness Directives; Various Helicopters, 88 FR 40685 (06/22/2023) *available at* https://www.federalregister.gov/documents/2023/06/22/2023-13319/airworthiness-directives-various-helicopters.

[56] *Risk of Potential Adverse Effects on Radio Altimeters (RA) when Operating in the Presence of 5G C-Band Wireless Broadband Signals,* SAFO 21007 (Dec. 23, 2021), *available at* https://www.faa.gov/other_visit/aviation_industry/airline_operators/airline_safety/safo/all_safos/SAFO21007R1.pdf.

[57] Clarification to FAA Order 8400.13, Procedures for the Evaluation and Approval of Facilities for Special Authorization Category I Operations and All Category II and III Operations, available at https://www.faa.gov/about/office_org/headquarters_offices/avs/offices/afx/afs/afs400/afs420/order_ac_memo/Clarification_Order_8400.13_5G-C-Band.pdf.

[58] *Colo Void Clause Coalition; Antenna Systems Co-Location; Voluntary Best Practices*, 87 FR 39746 (July 5, 2022), *available at* https://www.federalregister.gov/documents/2022/07/05/2022-14306/colo-void-clause-coalition-antenna-systems-co-location-voluntary-best-practices.

[59] Airworthiness Directives; Transport and Commuter Category Airplanes, 88 FR 34065 (May 26, 2023) *available at* https://www.federalregister.gov/documents/2023/05/26/2023-11371/airworthiness-directives-transport-and-commuter-category-airplanes; Airworthiness Directives; Various Helicopters, 88 FR 40685 (June 22, 2023) *available at* https://www.federalregister.gov/documents/2023/06/22/2023-

13319/airworthiness-directives-various-helicopters; and AD 2023-12-05 for Boeing 747-8 and 777 models, AD 2023-12-10 for Boeing 787 models, AD 2023-12-11 for newer Boeing 737 models, AD 2023-12-12 for Boeing 757 and 767 models, AD 2023-12-13 for older Boeing 737 models, AD 2023-12-14 for older Boeing 747 models, and AD 2023-12-15 for legacy McDonnell Douglas models.

[60] OMB Circular A-4 can be found at https://www.whitehouse.gov/wp-content/uploads/2025/08/CircularA-4.pdf.

[61] The MITRE Corporation (MITRE) is a private, not-for-profit company that provides research and development services, primarily to the federal government. The data provided by MITRE consists of FAA fleet data combined with RA equipage specifications and number of aircraft operations.

[62] The core 30 airports are the busiest 30 U.S. commercial airports by passenger emplacements, the list of which can be found at https://www.aspm.faa.gov/aspmhelp/index/Core_30.html.

[63] The Aerology analysis of 2019 METAR data from the core 30 airports can be found at https://aerology.substack.com/p/what-does-low-visibility-mean.

[64] Data on operations is sourced from the FAA Operations Network (OPSNET), with the 2024 data provided in the most recent FAA Air Traffic by the Numbers found at https://www.faa.gov/air_traffic/by_the_numbers.

[65] The airspace limitation order can be found at https://www.federalregister.gov/documents/2025/11/12/2025-19850/emergency-order-establishing-operating-limitations-on-the-use-of-navigable-airspace.

[66] The A4A cost estimate can be found in their November 10, 2025 press release at https://www.airlines.org/news-update/new-data-shows-huge-impact-of-the-government-shutdown-on-airlines-and-our-customers/.

[67] The part 129 foreign carrier totals for this fleet only include operators and aircraft that have had at least one U.S. operation in the 17-month period from April 1, 2024, to September 1, 2025.

[68] Speech: "Downward Pressure on the Accident Rate". Nicholas A. Sabatini. International Society of Air Safety Investigators. May 12, 2006. Retrieved September 2025 from China Aviation Daily. http://www.chinaaviationdaily.com/news/0/456.html.

[69] Transport and commuter category airplane costs are found in the associated final rule for Airworthiness Directive; Transport and Commuter Category Airplanes (05/26/2023), *available at* https://www.federalregister.gov/documents/2023/05/26/2023-11371/airworthiness-directives-transport-and-commuter-category-airplanes.

[70] Rotorcraft costs are found in the associated final rule for Airworthiness Directives; Various Helicopters (12/09/21) *available at* https://www.federalregister.gov/documents/2021/12/09/2021-26779/airworthiness-directives-various-helicopters

[71] The 10,341 RA units for aircraft operating under part 129 do not include units that are covered under the second compliance deadline (786 airplane and 27 rotorcraft RAs).

[72] This group consists of the 16,657 aircraft under part 91, 8,314 aircraft under part 135, and the 18 rotorcraft and 531 airplanes with less than 30 passenger seats or 7,500 lbs. cargo capacity under part 129.

[73] The IBA estimate is found at https://www.iba.aero/resources/articles/the-direct-cost-of-grounding-the-boeing-737-max-8-fleet/.

[74] The 2010 Total Delay Impact Study can be found at https://rosap.ntl.bts.gov/view/dot/6234.

[75] The BLS CPI-U values can be found at https://data.bls.gov/timeseries/CUUR0000SA0.

[76] New ADs to address Upper C-band RA interference would likely align with current ADs addressing Lower C-band interference and would prohibit operating Boeing 777s and 747-8s, making up 295 of the 8,014 airplanes operating under part 121 and 1,100 out of 5,050 operating under part 129, with the potential for issuance of further ADs covering additional models.

[77] Information on NAICS can be found at https://www.census.gov/naics/.

[78] Transport and commuter category airplane costs are found in the associated final rule for Airworthiness Directive; Transport and Commuter Category Airplanes (05/26/2023), *available at* https://www.federalregister.gov/documents/2023/05/26/2023-11371/airworthiness-directives-transport-and-

commuter-category-airplane and rotorcraft costs are found in the associated final rule for Airworthiness Directives; Various Helicopters (12/09/21) *available at* https://www.federalregister.gov/documents/2021/12/09/2021-26779/airworthiness-directives-various-helicopters.

[79] The 2022 U.S. SUSB files can be found at https://www.census.gov/data/tables/2022/econ/susb/2022-susb-annual.html.

[80] 65 FR 67249 (Nov. 6, 2000).

[81] FAA Order No. 1210.20 (Jan.28, 2004), available at www.faa.gov/documentLibrary/media/1210.pdf.

[82] *In the Matter of Upper C-band (3.98-4.2 GHz)*, 90 FR 56076 (proposed December 5, 2025) *available at* https://www.federalregister.gov/documents/2025/12/05/2025-22020/in-the-matter-of-upper-c-band-398-42-ghz.

List of Subjects

14 CFR Part 91

Air carriers, Air taxis, Aircraft, Aviation safety.

14 CFR Part 121

Air carriers, Aircraft, Aviation safety, Safety.

14 CFR Part 129

Air carriers, Aircraft, Aviation safety.

The Proposed Amendment

For the reasons discussed in the preamble, the Federal Aviation Administration proposes to amend chapter I of title 14, Code of Federal Regulations as follows:

PART 91—GENERAL OPERATING AND FLIGHT RULES

1. The authority citation for part 91 continues to read as follows:

Authority: 49 U.S.C. 106(f), 40101, 40103, 40105, 40113, 40120, 44101, 44111, 44701, 44704, 44709, 44711, 44712, 44715, 44716, 44717, 44722, 46306, 46315, 46316, 46504, 46506-46507, 47122, 47508, 47528-47531, 47534; Pub. L. 114-190, 130 Stat. 615 (49 U.S.C. 44703 note); Sec. 828 of Pub. L. 118-63, 138 Stat. 1330 (49 U.S.C. 44703 note); articles 12 and 29 of the Convention on International Civil Aviation (61 Stat. 1180), (126 Stat. 11).

2. Add § 91.220 to read as follows:

§ 91.220 Radio Altimeter Systems

(a) After [two years after the initial RA performance deadline], no person may operate an aircraft in the airspace of the 48 contiguous United States and the District of Columbia with a radio altimeter unless the radio altimeter system meets the performance requirements of paragraph (b).

(b) The radio altimeter system must operate at an altitude of 0-500 feet above ground level in the interference environment defined in table 1:

Table 1

Frequency Range (MHz)	**Power Flux-Density, Single Polarization, RMS ($dBW/m^2/MHz$)**
$3000 \leq f < 4000$	9.5
$4000 \leq f < 4100$	9.5
$4100 \leq f < 4150$	9.5
$4150 \leq f < 4160$	6.5
$4160 \leq f < 4180$	-1
$4180 \leq f < 4190$	-17
$4190 \leq f < 4200$	-34
$4200 \leq f \leq 4400$	-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

PART 121—GENERAL OPERATING AND FLIGHT RULES

3. The authority citation for part 121 continues to read as follows:

Authority: 49 U.S.C. 106(f), 40103, 40113, 40119, 41706, 42301 preceding note added by Pub. L. 112-95, sec. 412, 126 Stat. 89, 44101, 44701-44702, 44705, 44709-44711, 44713, 44716-44717, 44722, 44729, 44732; 46105; Pub. L. 111-216, 124 Stat. 2348 (49 U.S.C. 44701 note); Pub. L. 112-95, 126 Stat. 62 (49 U.S.C. 44732 note); Pub. L. 115-254, 132 Stat. 3186 (49 U.S.C. 44701 note).

4. Add § 121.326 to read as follows:

§ 121.326 Radio Altimeter Systems

After [the initial RA performance deadline], no person may operate an aircraft under this part in the airspace of the 48 contiguous United States and the District of Columbia with a radio altimeter unless the radio altimeter system meets the performance requirements of § 91.220(b) of this chapter.

PART 129—GENERAL OPERATING AND FLIGHT RULES

5. The authority citation for part 129 continues to read as follows:

Authority: 49 U.S.C. 1372, 40113, 40119, 44101, 44701-44702, 44705, 44709-44711, 44713, 44716-44717, 44722, 44901-44904, 44906, 44912, 46105, Pub. L. 107-71 sec. 104.

6. Add § 129.16 to read as follows:

§ 129.16 Radio Altimeter Systems

(a) After [the initial RA performance deadline], no person may operate an aircraft with 30 or more passenger seats or a payload capacity of more than 7,500 pounds under this part in the airspace of the 48 contiguous United States and the District of Columbia with a radio altimeter unless the radio altimeter system meets the performance requirements of § 91.220(b) of this chapter.

(b) After [two years after the initial RA performance deadline], no person may operate an aircraft under this part in the airspace of the 48 contiguous United States and the District of Columbia with a radio altimeter unless the radio altimeter system meets the performance requirements of § 91.220(b) of this chapter.

Issued under authority provided by 49 U.S.C. 106(f) and 44701(a), in Washington, D.C.

Hugh J. Thomas,

Acting Executive Director, Flight Standards Service.

[FR Doc. 2026-00051 Filed: 1/5/2026 4:15 pm; Publication Date: 1/7/2026]