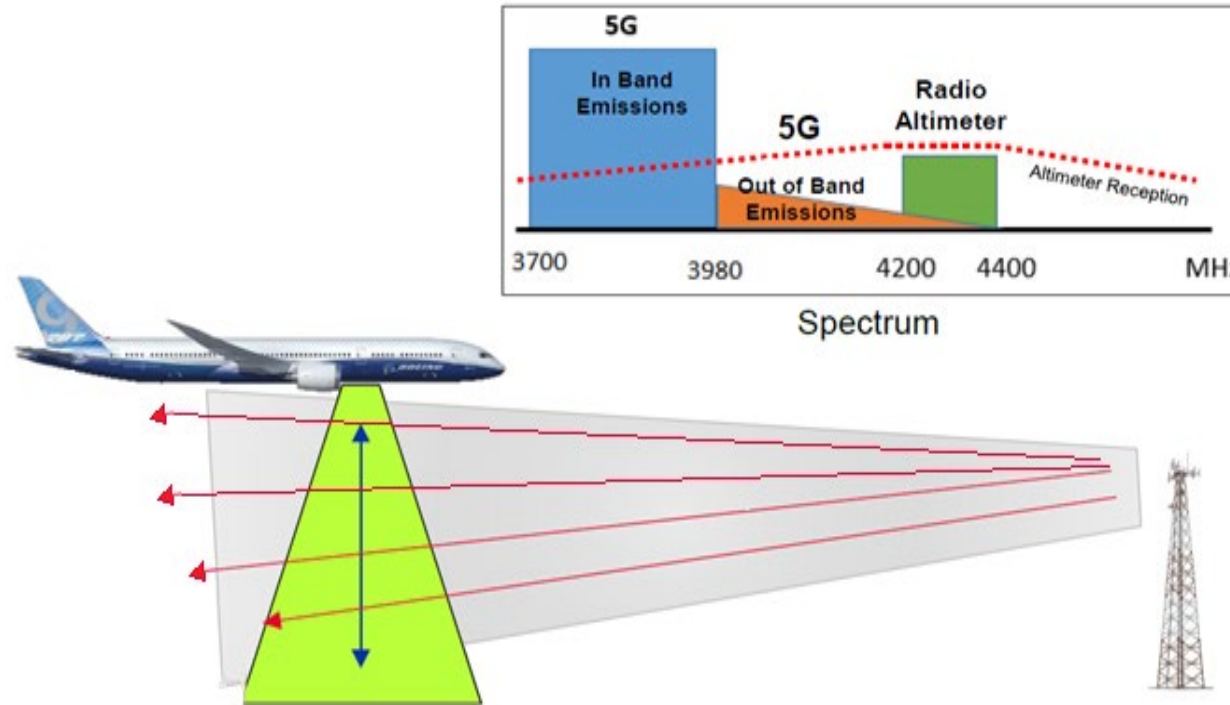




Radio Altimeters and 5G C-Band Deployment

October, 2022

What Makes Radio Altimeters Susceptible to Interference?



- Radio Altimeters (RA) are designed to “listen” for quiet signals which bounce back within or close to the RA band
- 5G signals broadcast close to the RA band, and may bleed over into the RA band

Scope of the Hazard

- **Radio Technical Commission for Aeronautics (RTCA) and Manufacturer Testing**
 - Loss of RA data or misleading RA data may occur
 - Different RA models have different levels of susceptibility
- **FAA Flight Evaluations**
 - Confirmed that aircraft in the United States will encounter 5G C-Band signals at power levels shown to create interference
- **Affected US Fleet Sizes**
 - ~7,500 Transport Airplanes (2-3 RAs per airplane)
 - ~6,000 Rotorcraft (1 RA per aircraft)
 - ~17,000 Small Airplanes (1 RA per aircraft)
- **Foreign-registered aircraft which fly into the United States**



Mitigations

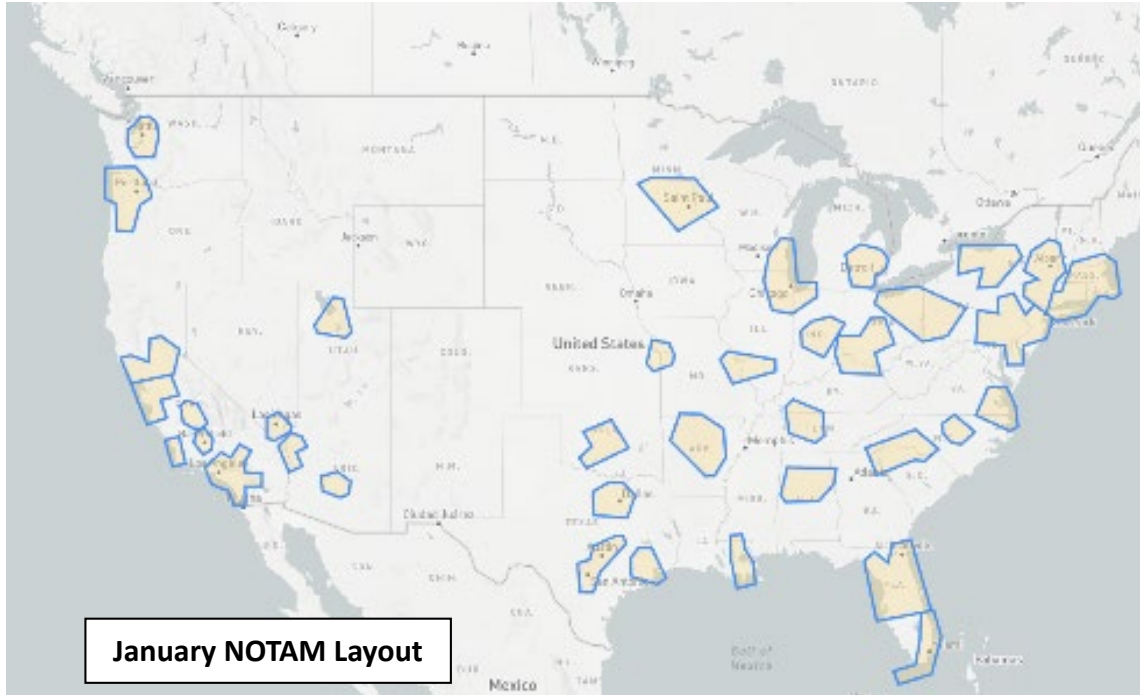
- Airworthiness Directives (AD)
 - Transport
 - Rotorcraft
 - 6 aircraft specific
- NOTAMs
- Alternative Methods of Compliance (AMOC)
- Voluntary Actions by ATT and Verizon
 - Reduced power levels
 - Lower frequency
 - Partial protection of 114 airports
- Additional guidance (SAIB, SAFO)

FAA Actions since January 2022

- Monthly assessment of new antenna locations (approximately 5,000-8,000 per month)
- Monthly Notice to Air Missions (NOTAMs), Alternative Methods of Compliance (AMOCs)
- Monthly meetings with stakeholders to increase outreach efforts
- Continued refinement of airspace protection models
- Work with manufacturers to expedite filter design approvals
- 5G roundtable discussions between aviation and telecommunications stakeholders to develop and implement retrofit plan

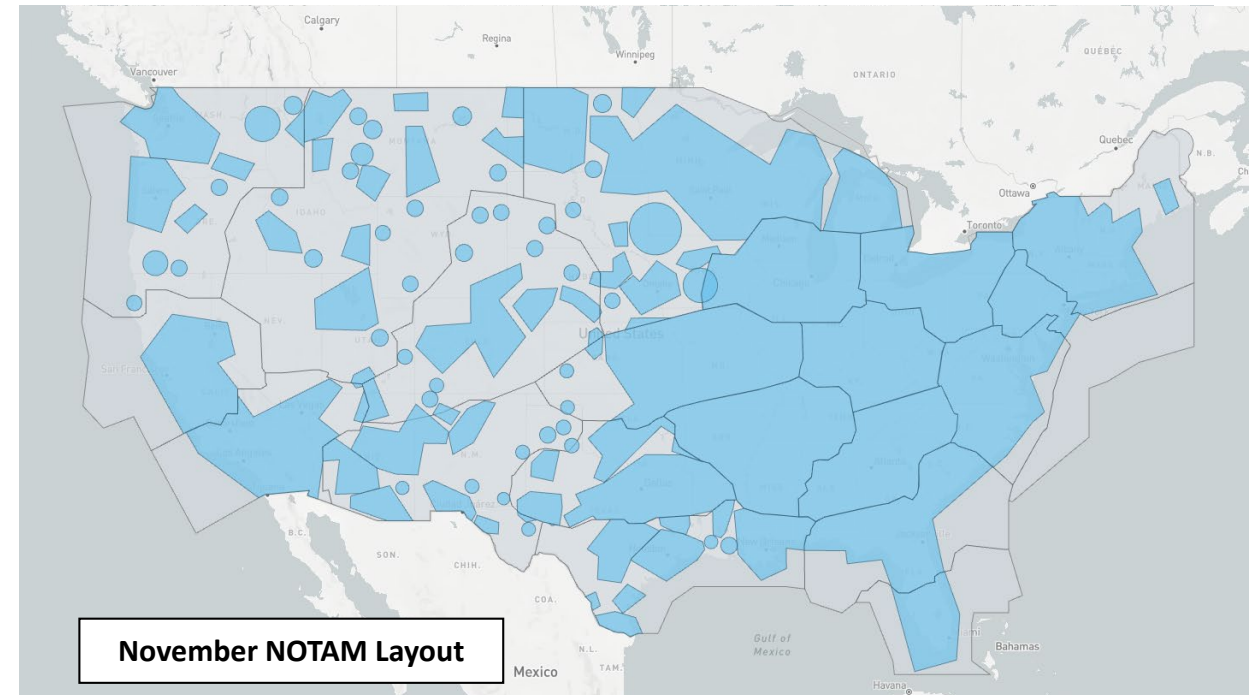


Airspace NOTAMs January vice November



As of Jan 19, NOTAM totals

- Airspace: 54
- Aerodrome: 1289
- Instrument Approach Procedures (IAP):
 - 114 Public
 - 12 Special
 - 131 DoD



As of Nov 1, NOTAM totals *(subject to change)*

- Airspace: 120
- Aerodrome: 2747
- Instrument Approach Procedures (IAP):
 - 146 Public
 - 103 Special
 - 261 DoD

November Airspace NOTAMs Domestic Notice

5G C-BAND AIRSPACE NOTAMS CONTINENTAL UNITED STATES (CONUS) NOVEMBER 1, 2022 UNTIL FURTHER NOTICE

Since January 2022, multiple areas of the CONUS have been impacted by the presence of 5G C-Band wireless broadband interference. This Domestic Notice outlines the airspace restrictions impacting helicopter operations as stated in Airworthiness Directive 2021-23-13, unless approved through an alternative method of compliance (AMOC):

- Performing approaches that require radio altimeter minimums for rotorcraft offshore operations. Barometric minimums must be used for these operations instead.
- Engaging hover autopilot modes that require radio altimeter data.
- Engaging Search and Rescue (SAR) autopilot modes that require radio altimeter data.
- Performing takeoffs and landings in accordance with any procedure (Category A, Category B, or by Performance Class in the Rotorcraft Flight Manual or Operations Specification) that requires the use of radio altimeter data.

INFORMATION ON AIR ROUTE TRAFFIC CONTROL CENTERS (ARTCCs)

1. 5G C-Band wireless broadband interference exists in every ARTCC in the CONUS and its effect on radio altimeters can potentially extend up to 17 NM from the U.S. coastline.
2. 5G C-Band wireless broadband interference exists from surface to 5000 feet AGL.
3. U.S. 5G C-Band restrictions do not cross the U.S. border into Canada or Mexico (refer to Canadian or Mexican publications for any applicable 5G C-Band restrictions).
4. 5G C-Band wireless broadband is not currently deployed in Alaska, Hawaii, Puerto Rico, or any other U.S. territories, therefore does not impact these locations.
5. ARTCC boundary latitudes and longitudes are located at the following website for download as a CSV file: https://www.faa.gov/air_traffic/flight_info/aeronav/aero_data/Center_Surface_Boundaries/.
6. National Geodetic Survey (NGS) shoreline mapping and data can be downloaded at: <https://shoreline.noaa.gov/data/datasheets/index.html> or <https://nsde.ngs.noaa.gov/>.

- ZTL AIRSPACE RDO ALTIMETER UNREL **WI AN AREA DEFINED AS 313113N0874951W (MVC275024.8) TO 313103N0881718W (GCV017027.2) TO 314422N0881921W (GCV007039.4) TO 324348N0875115W (OKW225043.1) TO 330319N0875702W (OKW253036.9) TO 331905N0873812W (OKW284020.0) TO 340111N0873208W (VUZ302038.0) TO 340543N0871241W (VUZ327029.9) TO 340420N0864529W (VUZ014025.2) TO 342139N0861018W (GAD347023.5) TO 343111N0860824W (RQZ122029.5) TO 344823N0855501W (RQZ087035.3) TO 345027N0852839W (GQO245017.5) TO 352347N0851410W (HCH211026.3) TO 361138N0852244W (LVT206025.6) TO 365921N0820350W (GZG006009.9) TO 361219N0811002W (BZM016020.5) TO 364019N0802211W (PSK152029.9) TO 371609N0805438W (BLF102013.7) TO 372004N0803808W (PSK020015.3) TO 363708N0801250W (GSO345036.3) TO 360817N0795641W (GSO019005.8) TO 360453N0794444W (GSO082011.4) TO 352332N0794815W (SDZ318015.0) TO 345121N0800858W (CTF030013.8) TO 341731N0813502W (GRD086028.4) TO 335415N0815051W (IRQ057019.6) TO 325402N0815157W (IRQ167050.7) TO 323540N0815511W (SAV313045.4) TO 321730N0821044W (DBN121036.8) TO 322756N0823838W (DBN127011.1) TO 320723N0833116W (VNA192005.6) TO 315916N0842354W (PZD347020.7) TO 313046N0865424W (MVC078023.1) TO 311810N0872442W (MVC194009.9) TO POINT OF ORIGIN SFC-5000FT AGL. HEL OPS REQUIRING RDO ALTIMETER DATA TO INCLUDE OFFSHORE INSTRUMENT OPS, HOVER AUTOPILOT MODES, SAR AUTOPILOT MODES, AND CAT A/B/PERFORMANCE CLASS TKOF AND LDG NOT AUTHORIZED EXC FOR ACFT USING APPROVED ALTERNATIVE METHODS OF COMPLIANCE DUE TO 5G C-BAND INTERFERENCE PLUS SEE AIRWORTHINESS DIRECTIVE 2021-23-13**
- ZTL AIRSPACE RDO ALTIMETER UNREL **WI ATLANTA ARTCC AIRSPACE** SFC-5000FT AGL. HEL OPS REQUIRING RDO ALTIMETER DATA TO INCLUDE OFFSHORE INSTRUMENT OPS, HOVER AUTOPILOT MODES, SAR AUTOPILOT MODES, AND CAT A/B/PERFORMANCE CLASS TKOF AND LDG NOT AUTHORIZED EXC FOR ACFT USING APPROVED ALTERNATIVE METHODS OF COMPLIANCE DUE TO 5G C-BAND INTERFERENCE PLUS SEE AIRWORTHINESS DIRECTIVE 2021-23-13 **AND DOMESTIC NOTICE**

Post July 1, 2023 Considerations

- Voluntary Telco Mitigations end July 2023
 - With the exception of power limits at 5G CMAs
- 5G C-Band emitters are anticipated in all 406 PEAs
- NOTAM/AMOC process is untenable
- Current transport AD prohibits certain low vis landing operations (plus Boeing ADs)
 - No avenue to get relief of the restrictions
- 19 new telecom entrants (in addition to VZ and ATT)
- Updated transport AD
 - Aircraft proven to be hardened against catastrophic/hazardous effects of 5G, will be permitted to perform certain operations (e.g., low visibility landing operations) at 5G CMAs
 - Aircraft not proven to be hardened against catastrophic/hazardous effects of 5G, will not be permitted to perform certain operations (e.g., low visibility landing operations) anywhere
 - All cumulative major/minor effects of radio altimeter interference would continue to be realized without any mitigation

Conditions Necessary for 5G C-Band in the U.S.

- **Reduction in Spurious Emission Limits***
 - **Current:** High spurious emissions allowed
 - **Change Needed:** Limit spurious to a low emissions level
- **Implementation of a downward tilt requirement***
 - **Current:** Radiation in all directions allowed at full power above the horizon
 - **Change Needed:** Require reduced power limits above the horizon for all towers nationwide
- **Maintain 220 MHz Guard Band (Separation)***
- **Power Limits Near Airports**
 - **Current:** Towers can be installed anywhere up to maximum power
 - **Change Needed:** Reduced allowed power level in areas around certain airports

**These are part of the current AT&T/Verizon deployment*



Post July 2023 for NOTAMs

- **Domestic Aircraft**
 - Follow restrictions in AD
 - Reference Domestic Notice *Maintaining Safe Operations in the 5G C-Band NAS Environment*
- **Foreign Operators (Part 129)**
 - Aeronautical Information Publication (AIP)
 - Reference Domestic Notice *Maintaining Safe Operations in the 5G C-Band NAS Environment*
- **As an additional safety measure, we will also put a ‘Reference Domestic Notice’ NOTAM in each of the 20 CONUS Air Traffic Control Centers, which all pilots would reference.**

Draft AIP language for Apr 2023

1.3. In the United States, some telecommunications companies launched 5G services on January 19, 2022, using frequencies in a portion of the radio spectrum called the C-band. These frequencies can be close to those used by radio altimeters, an important piece of safety equipment in aircraft. The 5G deployment involves a new combination of power levels, frequencies, proximity to flight operations, and other factors. The FAA requires that radio altimeters are accurate and reliable, and therefore imposes restrictions on flight operations using certain types of radio altimeter equipment. These safety restrictions are posted in the Domestic Notice titled *Maintaining Safe Operations in the 5G C-Band NAS Environment*, and could affect flight schedules and operations. All operators (domestic and international) must comply with the guidance and restrictions provided in this Domestic Notice titled *Maintaining Safe Operations in the 5G C-Band NAS Environment*.

Maintaining Safe Operations in the 5G C-Band NAS Environment

Domestic Notice

Potential Information:

- **Background**
- **Impacted ATC Centers**
- **Explanation of RA Tolerance Requirements Power Curve**
 - **Restricted Operations**
- **5G C-band mitigated airports (5G CMAs)**
 - A 5G C-band mitigated airport (5G CMA) is an airport at which the telecommunications companies have agreed to voluntarily limit their 5G deployment in order to minimize disruptions to aviation at the request of the FAA. 5G CMAs are defined as the primary commercial service and significant cargo airports with low visibility approaches used by mainline and regional carriers. 5G CMAs may also include those with essential RNP vertically guided approaches, or regular or diversion use by aircraft types with unique provisions in their airworthiness directives related to 5G. (List 5G CMAs below)



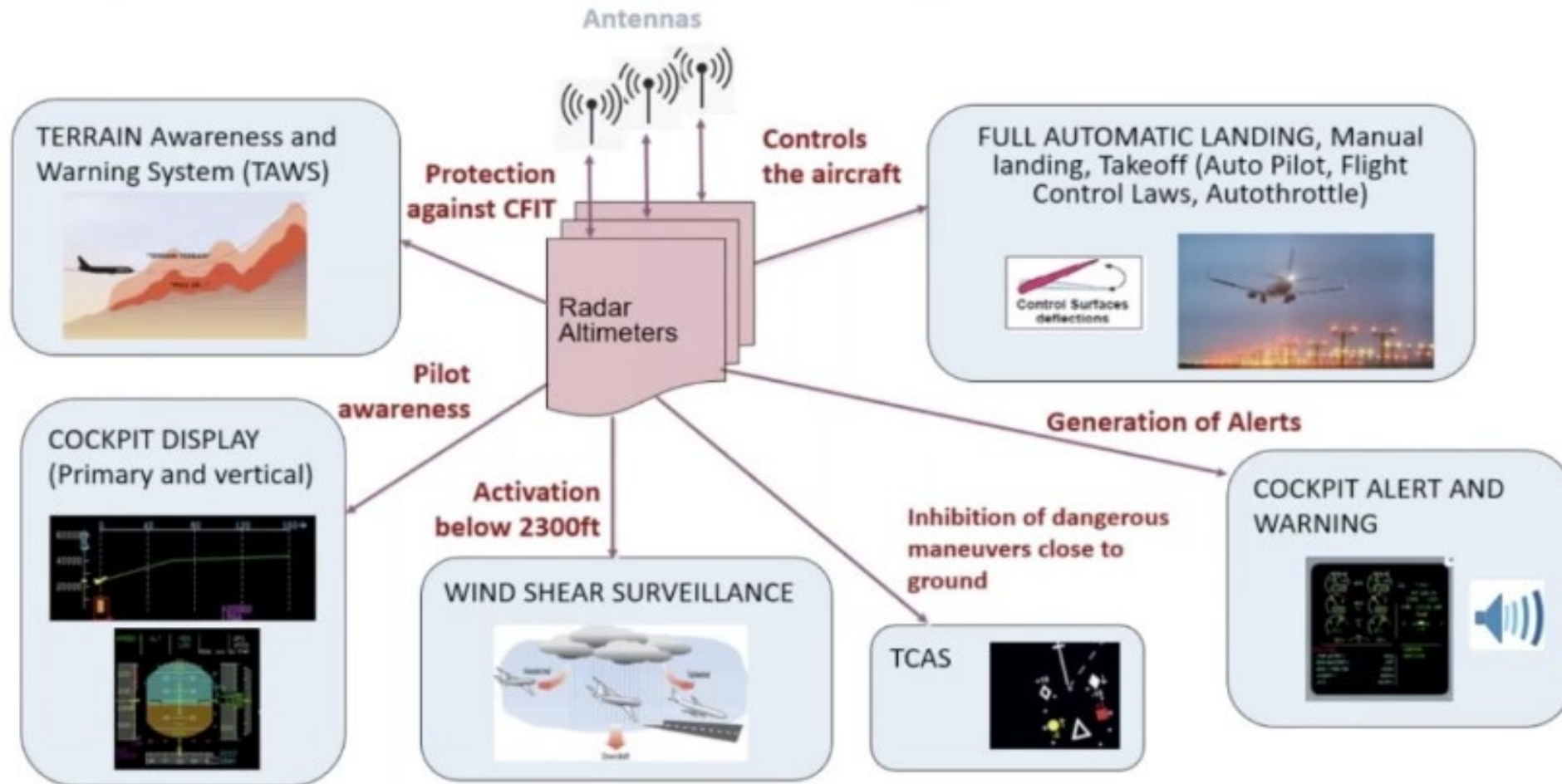


5G C-Band

October | ACM

Questions

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



Radio Altimeter Airworthiness Directives

- The AD for transport category aircraft addresses operations prohibited in the presence of 5G C-Band wireless broadband interference as identified by NOTAM
 - **Instrument Landing System (ILS) Instrument Approach Procedures (IAP) SA CAT I, SA CAT II, CAT II, and CAT III**
 - **Required Navigation Performance (RNP) Procedures with Authorization Required (AR), RNP AR IAP**
 - **Automatic Landing operations**
 - **Manual Flight Control Guidance System operations to landing/head-up display (HUD) to touchdown operation**
 - **Use of Enhanced Flight Vision System (EFVS) to touchdown under 14 CFR 91.176(a)**
- The AD requires limitations be added into the Airplane Flight Manual



Radio Altimeter Airworthiness Directives

- The AD for helicopters addresses operations prohibited in the presence of 5G C-Band wireless broadband interference as identified by NOTAM
 - **Performing approaches that require radio altimeter minimums for rotorcraft offshore operations. Barometric minimums must be used for these operations instead.**
 - **Engaging hover autopilot modes that require radio altimeter data**
 - **Engaging Search and Rescue (SAR) autopilot modes that require radio altimeter data.**
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- The AD requires limitations be added into the Rotorcraft Flight Manual



U.S. Fleet Retrofit

- The mitigations from wireless companies around airports end in July 2023
- Filter solutions for some aircraft/radio altimeter combinations are available now
- Additional solutions available by end of 2022
- All transport airplanes must have a radio altimeter that is compatible with 5G C-Band interference without the wireless mitigations post July 2023
- FAA, Airframe Manufacturers (OEMs), Radio Altimeter (RA) Manufacturers, and Associations are tracking parts of the fleet retrofit



Radio Altimeter (RA) Interference Reporting

as of Oct 1, 2022

- The FAA receives reports from multiple sources including the FAA's online radio altimeter (RA) anomaly reporting form, CMOs, OEMs and operators.
- A multi-functional team meets regularly to review the previous reports, categorize, and identify trends. The team focuses on reports of interference to RA related systems in areas of known 5G deployment.
- Team has reviewed 558 reports and closed 88% since January.
 - ~99 events of “possible 5G interference” (reviewed maintenance data, aircraft and airport trends, and event description).
 - Within this set of 99, most of the assumed interference directly affected the radio altimeter display and/or caused nuisance alerts (e.g., TAWS, aural callouts, warning and caution systems).

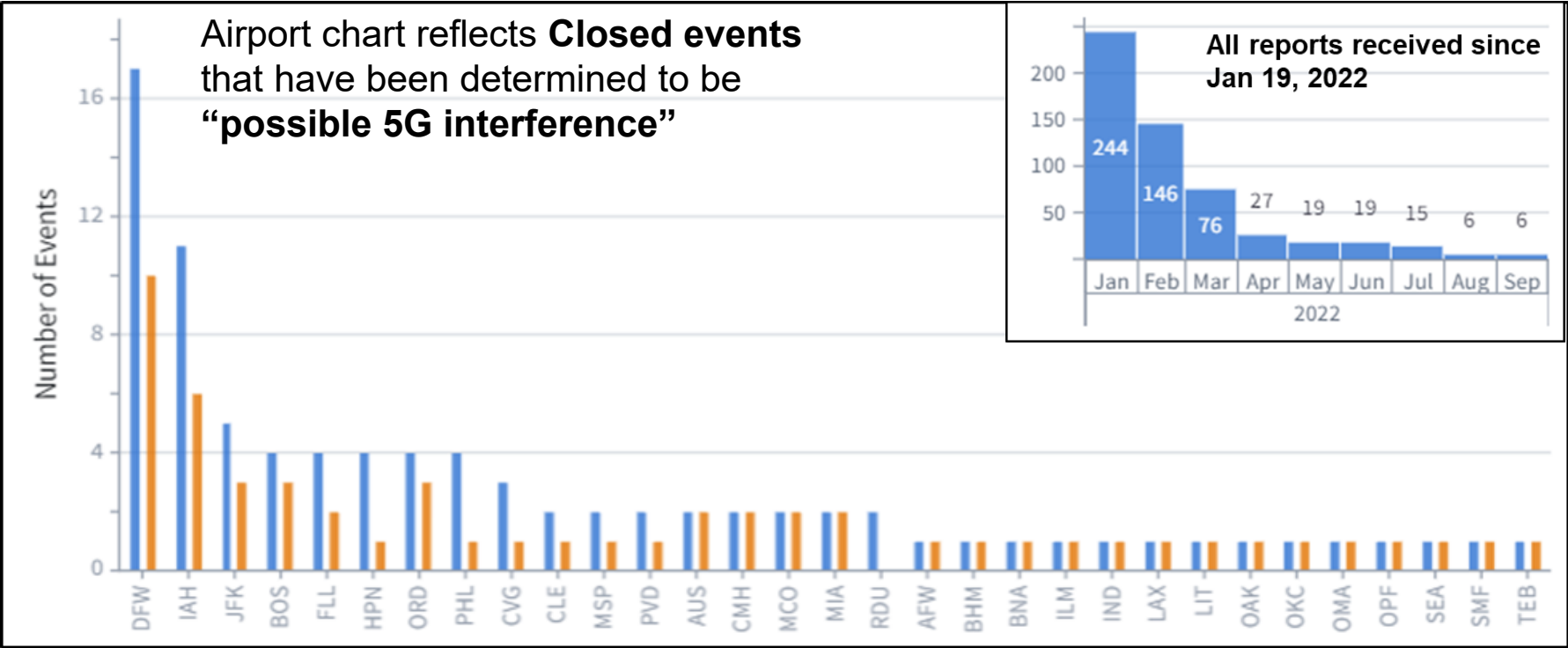
FAA and Wireless Providers voluntary mitigations (reduced power levels, ADs, NOTAMs, AMOCs, protection of certain airports) are working

5G C-BAND

October, 2022 | ACM

Radio Altimeter (RA) Interference Reporting

Oct 1, 2022



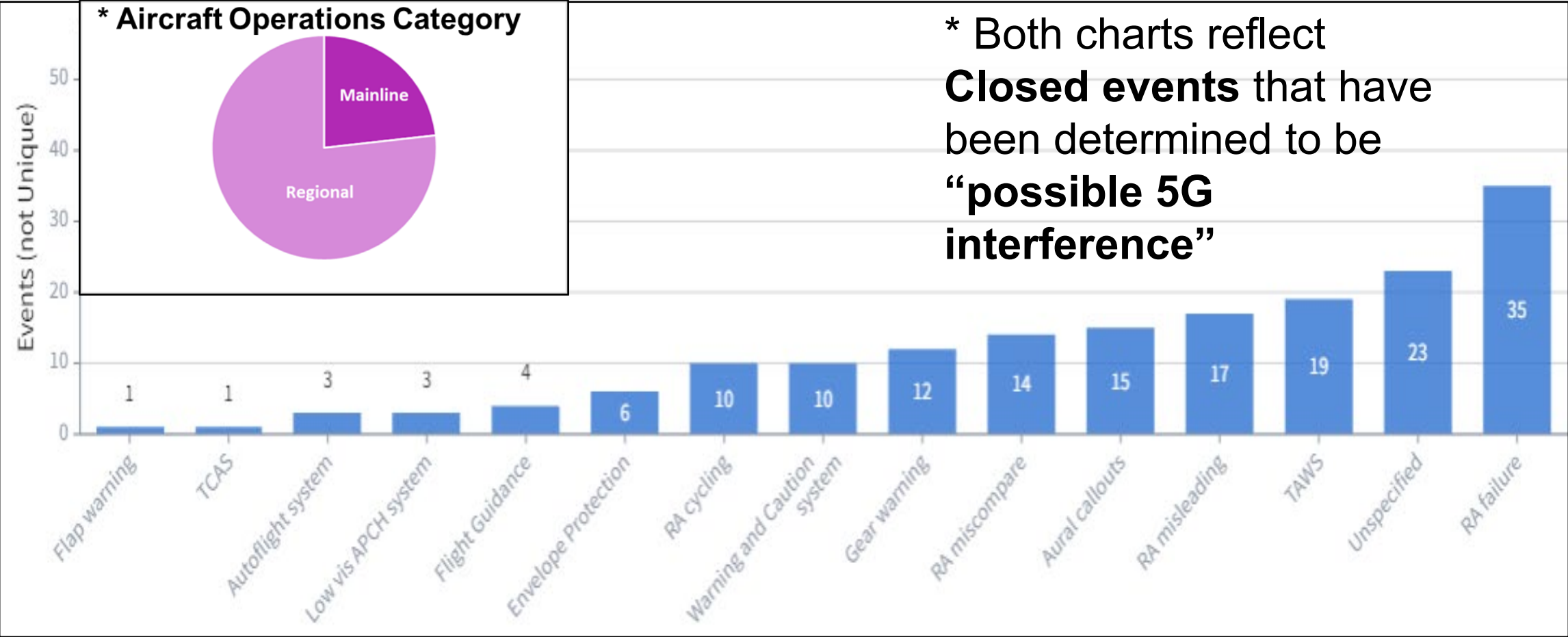
Airports*

* Includes airports with the most reports

■ Closed Events ■ Closed events inside 2nm and/or below 1000'

Radio Altimeter (RA) Interference Reporting

as of Oct 1, 2022



*** Systems Impacted**

Explanation of Groups

Aircraft Grouping	Description	Impact	Estimated Part 121 Aircraft	Target Retrofit Completion
Group 1	Equipped with RadAlts most susceptible to interference. Mostly Embraer regional jets.	Requires special considerations by telcos to protect access to priority airports	~915	75% by 11/1/2022
Group 2	Mostly Thales equipped narrow body Airbus.	Current telco mitigations protect access to priority airports	~730	75% by 12/1/2022
Group 3	Mostly Collins equipped Airbus, Boeing, and CRJs.	Incremental “powerups” to protect access to priority airports	~4135	TBD – expect telco mitigations to end 7/1/2023
Group 4	Boeing and Airbus equipped with Honeywell ALA-52B	Currently have all airports AMOC and anticipate that continuing after end to mitigations	~1640	N/A

