Radio Altimeters and 5G C-Band Deployment in the United States

Speakers

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Setting the Stage

- The FAA and two major U.S. based telecommunications companies have demonstrated that 5G C-band and aviation can safely co-exist
- FAA has worked closely with aviation industry stakeholders, ANAC, EASA, TCCA, and other international partners to harmonize approaches to global deployment of 5G.
- Technology will continue to evolve…how do we leverage and apply what’s been learned for the future?
- Today is a conversation among partners to share experiences and listen to other viewpoints
- We welcome thoughts and questions that will help us lay out a better path for the future
Radar Altimeters Measure Height Above Ground Level (AGL) and Feed into a Number of Safety Critical Systems such as:

- TERRAIN Awareness and Warning System (TAWS)
- FULL AUTOMATIC LANDING, Manual landing, Takeoff (Auto Pilot, Flight Control Laws, Autothrottle)
- COCKPIT DISPLAY (Primary and vertical)
- Generation of Alerts
- Inhibition of dangerous maneuvers close to ground
- WIND SHEAR SURVEILLANCE
- TCAS
- COCKPIT ALERT AND WARNING
- Protection against CFIT
- Pilot awareness
- Activation below 2300ft
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 US 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 US**
Timeline of 5G Deployment in the US

2015
- Mobile C-band Allocations are Proposed at World Radio Communications Conference
- ICAO Job Cards Created

2017
- US Initiates Procedures to Allocate C-band for 5G
- Aviation Submits Comments Expressing Concerns

2019-20
- Testing by Aviation Demonstrates Potential Interference
- RTCA Report Published in 10/2020
- FCC Auctions 5G C-band Spectrum

2020
- US Completes Allocation of C-band Spectrum for 5G

2021
- FAA brokers Cross-Industry Information Sharing to Manage Operational Impacts
- US Government Interagency Discussions
- FAA Issues Safety Mitigation Actions

2022
- Verizon and AT&T Begin Deploying 5G C-band Services in the US
FAA Actions: November-December 2021

- **Special Airworthiness Information Bulletin (SAIB): AIR-21-18 November 2, 2021;**
  - Provides recommendations for radio altimeter manufacturers, aircraft manufacturers, and operators and pilots.

- **Airworthiness Directives (AD): 2021-23-12 and 2021-23-13 December 9, 2021.**
  - Prohibits certain rotorcraft and transport category airplane operations in the presence of 5G C-band (3.7-3.98 GHz) emissions.
  - The Unsafe condition is unreliable RAs in the presence of 5G C-Band.

- **Safety Alert for Operators (SAFO): 21007 December 23, 2021**
  - Provides information and guidance to operators regarding the risk of potential adverse effects on radio altimeters when operating in the presence of 5G C-band wireless broadband signals.

- **Beginning of data exchange with AT&T and Verizon—site locations, antenna characteristics**
FAA Actions since January 2022

• Monthly assessment of new antenna locations (approximately 5-8K/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
• 5G Roundtable Discussions between Aviation and Telecommunications Stakeholders
Signal in Space Animation
5G C-band Mitigation Airports

Criteria used to identify 5G C-band Mitigation Airports:

- Primary commercial service (>10,000 annual enplanements), or
- Significant cargo airports (>100 million landed tons), and
- Low visibility approaches published or scheduled
- Also include airports:
  - With essential Required Navigation Performance – Authorization Required (RNP AR) vertically guided approaches
  - Diversion or regular use by aircraft types with unique provisions in their airworthiness directives related to 5G
  - Operationally significant
Radio Altimeter Interference Reporting

- The FAA receives reports from multiple sources
  - Focus is operations with the US, but includes partnership with other CAAs for global event monitoring
- Team has reviewed 568 reports and closed 91% since January.
  - 103 events of “possible 5G interference” (reviewed maintenance data, aircraft and airport trends, and event description).
  - Within this set, the majority were found to be direct radio altimeter impacts and nuisance alerts (e.g., Terrain Avoidance Warning System (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**

As of November 1, 2022
Radio Altimeter Interference Reporting

* Aircraft Operations Category

As of November 1, 2022

As of November 1, 2022
Managing Cumulative Fleet Risk

- FAA ADs mitigate risks of hazardous/catastrophic outcomes
- Numerous major/minor hazards are not addressed by current ADs
- Expanded 5G deployments will increase the rate of major/minor events
- Residual risk is accumulating globally; FAA, EASA, TCCA, ANAC are discussing how to harmonize our approach to global risk management

### Safety Risk vs. Severity Matrix

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<th>Probability</th>
<th>Catastrophic A</th>
<th>Hazardous B</th>
<th>Major C</th>
<th>Minor D</th>
<th>Negligible E</th>
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<td>5B</td>
<td>Neut 5C</td>
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<td>3B</td>
<td>Neut 3C</td>
<td>3D</td>
<td>3E</td>
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<tr>
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<td>2A</td>
<td>2B</td>
<td>Neut 2C</td>
<td>2D</td>
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<tr>
<td>Extremely improbable</td>
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<td>1B</td>
<td>Neut 1C</td>
<td>1D</td>
<td>1E</td>
</tr>
</tbody>
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*Source: ICAO Safety Management Manual (SMM) (Doc 9859)*
US 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
Objectives:

- Wireless deployment unencumbered by signal-strength constraints
- Aviation maintains safe operations at all 5G C-Band Mitigation Airports (5G CMA) with a single retrofit*

Aircraft Requirement:

- Radio Altimeter installations performance in airplanes must meet or exceed the Group 4 power curve after July 2023

* Confirmed one RA requires a second retrofit (~150 airplanes)
Conditions Necessary for 5G C-Band in the US

• 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
Lessons Learned Summary

• **US Approach is an example of safe integration**

• **Radio Altimeters (after modification) will perform reliably in a 3.7-3.98 GHz C-band environment, provided the following conditions are met:**
  – Maintain a Guard Band
  – Reduced emissions around airports
  – Limit spurious emissions
  – Downward Tilt requirement for antenna energy

• **If any of these conditions are not met, then further investigation is needed to assure safety**

• **New generation of performance standards to ensure technology evolutions won’t impact**