Radio Altimeters and 5G C-Band Deployment in the US National Airspace System (NAS)

Speakers: US Federal Aviation Administration
5G C-Band Coordination Team

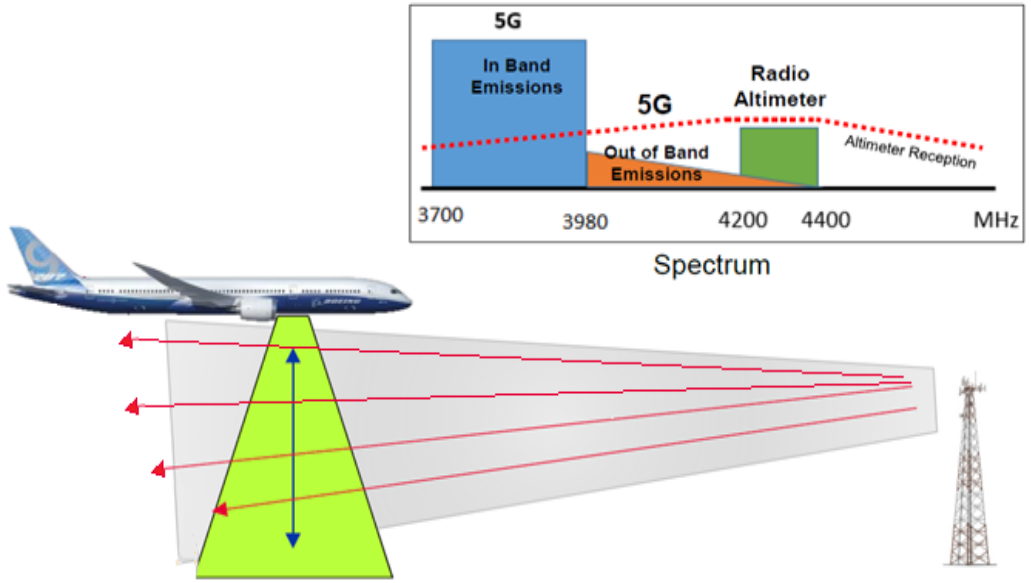
Setting the Stage

- FAA, ANAC, EASA and TCCA have worked closely together and with aviation industry stakeholders, and telecom industry, to demonstrate that 5G in C-Band and aviation can safely co-exist, moreover in a harmonized way around the globe.

- Technology will continue to evolve…how do we leverage and apply what's been learned for the future?

- We welcome thoughts and questions that will help us lay out a better path for the future.

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 Real World 5G Flight Measurement**
  - 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**

Timeline of 5G Deployment in the U.S.

FAA Actions: November-December 2021

- **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
- **Special Airworthiness Information Bulletin (SAIB): AIR-21-18R1 December 23, 2021**
  - Provides recommendations for radio altimeter manufacturers, aircraft manufacturers, and operators and pilots
    - Rev 1 requests operators report radio altimeter anomalies
- **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

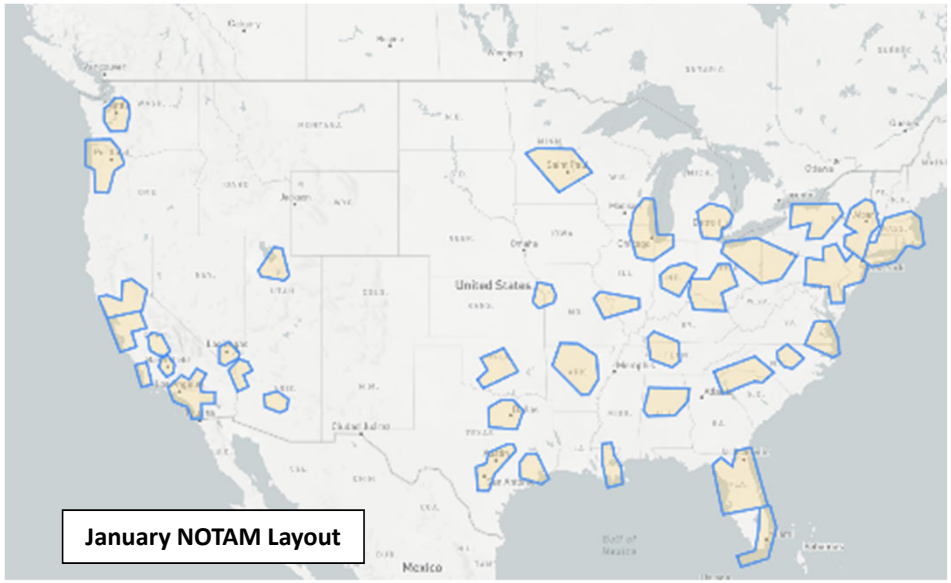
FAA Actions since January 2022

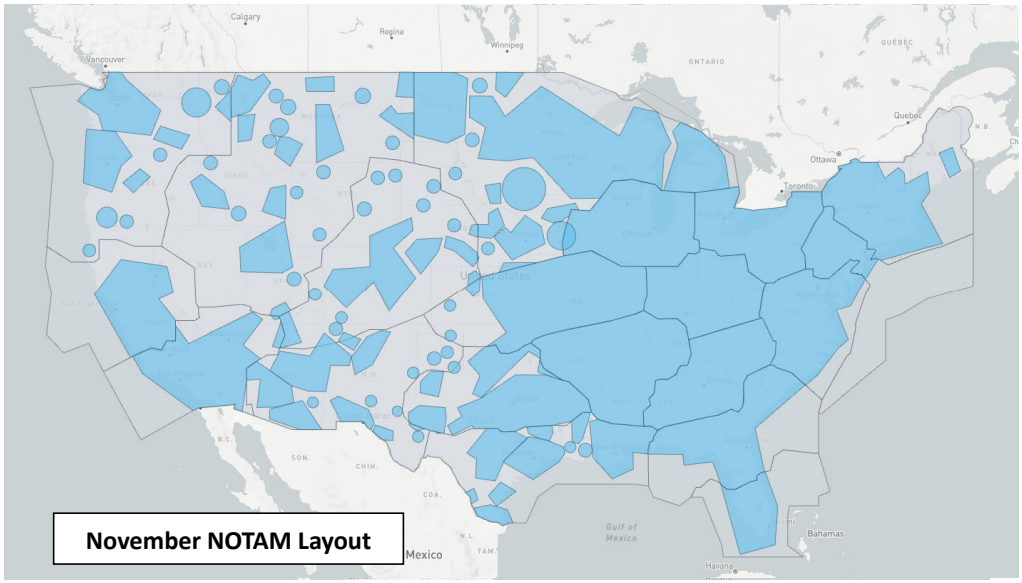
- Monthly assessment of new antenna locations (approximately 5,000-8,000 per month)
- Monthly Notice to Air Missions (NOTAMs), Alternative Methods of Compliance (AMOCs)
- Monthly meetings with stakeholders to increase outreach efforts
- Continued refinement of airspace protection models
- Work with manufacturers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

5G / RA Coexistence Timeline

- **19 additional 5G license holders can begin to operate from 3.8 to 3.98 GHz at any time in this window (plus AT&T and Verizon)**
- **Even with retrofits, altimeter performance is not compatible with *unmitigated* 5G**
- **Tremendous risk to aviation as wireless operations begin with no requirement to mitigate their networks to protect aviation**
- **The FCC rules must change for FAA to properly ensure and coordinate aviation safety**

Airspace NOTAMs January vice November





As of Jan 19, NOTAM totals

- **Airspace: 55**
- **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**

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 (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 FAA considers likely caused by 5G interference (all other sources eliminated as a cause).
  - 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

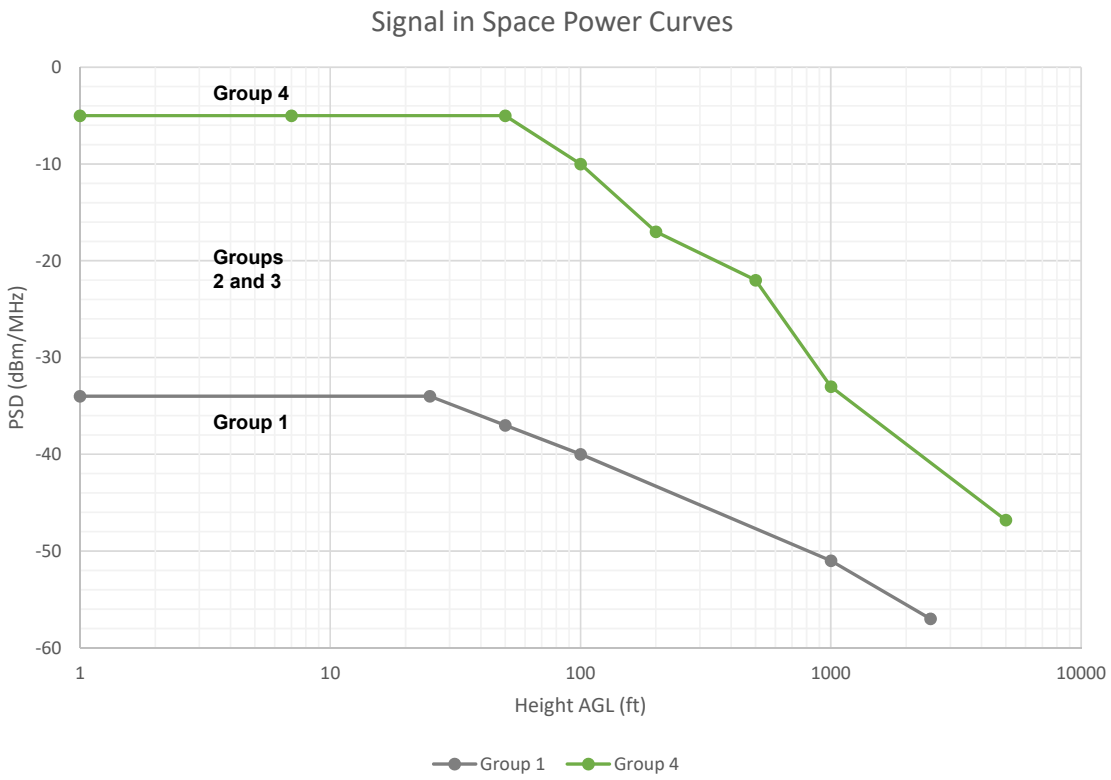
U.S. Fleet Retrofit

- Most voluntary mitigations from wireless companies 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

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

(Group 4) RA Tolerance Requirements Power Curve



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 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

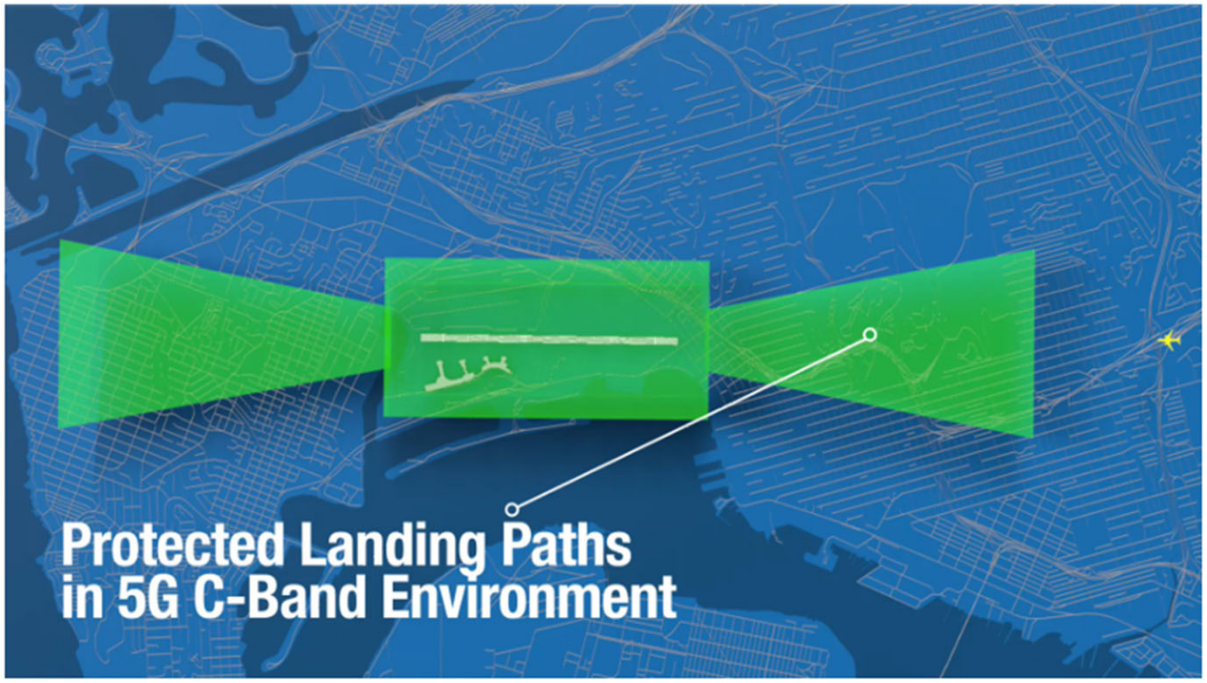
**These are part of the current AT&T/Verizon deployment*

Lessons Learned Summary

- **U.S. approach is an example of safe integration—other countries have also had success**
- **Once modified, most Radio Altimeters 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**
- **The highest performing RAs won't require modifications**
- **New generation of performance standards are needed to ensure future technology evolutions won't disrupt coexistence**
- **Government and industries need to work together**
- **Industry and Safety Management System (SMS)**

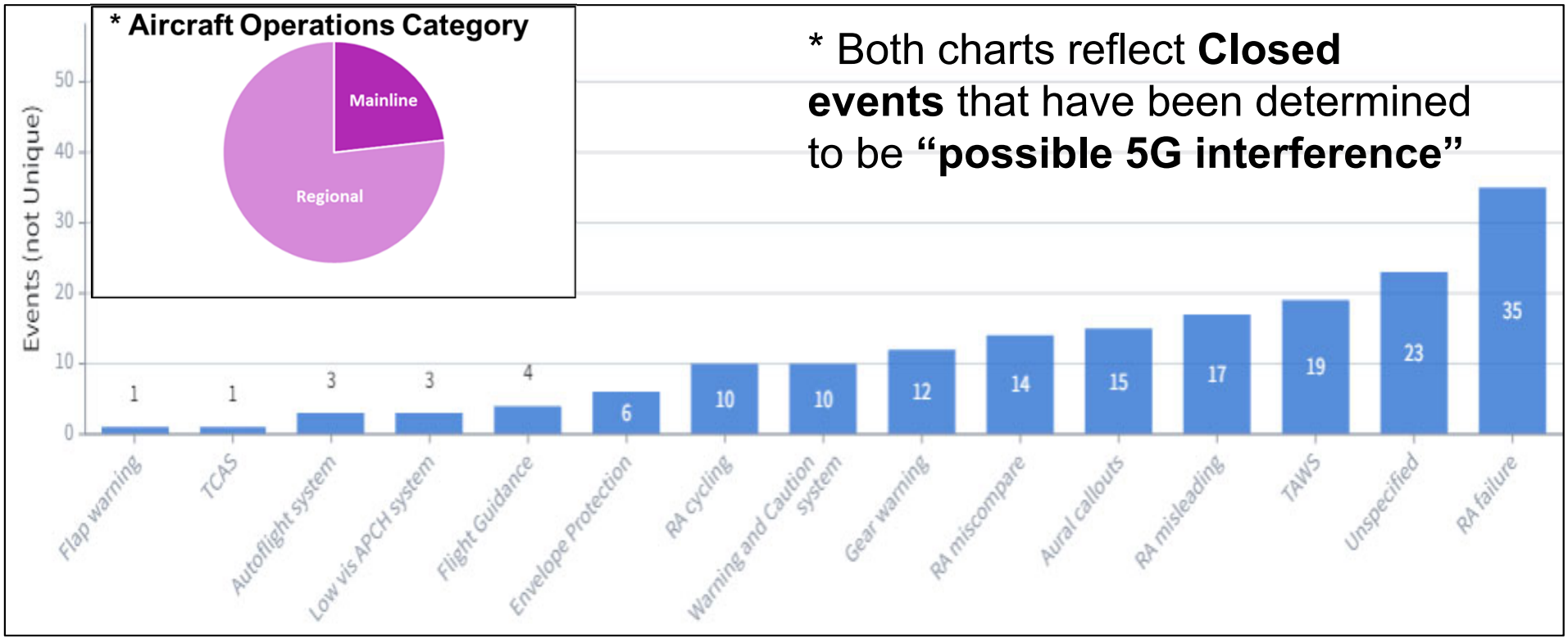
Additional Materials

Signal in Space Animation



- The FAA has refined protection zones around key airports as shown in this figure and the associated animation (if available).
  - The signal-in-space approach defines a maximum level of 5G C-band emissions that can be experienced within the volume of airspace where aircraft would be expected to operate.
  - C-band transmitters can be deployed at any location as long as they do not create emissions inside the protected airspace which exceed those maximum levels.

Radio Altimeter (RA) Interference Reporting as of Oct 1, 2022



*** Systems Impacted**

Managing Cumulative Fleet Risk

Source: ICAO Safety Management Manual (SMM) (Doc 9859)

Safety Risk		*Severity*				
Probability		*Catastrophic A*	*Hazardous B*	*Major C*	*Minor D*	*Negligible E*
Frequent	5	5A	5B			5E
Occasional	4	4A	4B	4C	4D	4E
Remote	3			3C	3D	3E
Improbable	2	2A	2B			2E
Extremely improbable	1	1A	1B	1C	1D	1E

Major / Minor

Hazardous / Catastrophic

Major / Minor

- 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

Required Changes to R&O

- **Request 1:** 5G Operations in 3800 to 3980 MHz
  - **Current R&O provision:** Can begin as soon an incumbent license holder vacate
  - **Required Change:** Delay all operations in this frequency range until January 2024
  - **Impact:** Provides critical time needed to retrofit the mainline and regional aircraft fleet
- **Request 2:** Rural 5G Maximum EIRP Limits
  - **Current R&O provision:** 5G can radiate at 65 dBm/MHz in rural PEAs
  - **Required Change:** Limit maximum power to 62 dBm/MHz until January 2024
  - **Impact:** Provides critical time needed to retrofit the mainline and regional aircraft fleet
- **Request 3:** Enactment of an EIRP Elevation Mask
  - **Current R&O provision:** Omni-directional vertical radiation at full power
  - **Required Change:** Current Priority Airport Elevation Mask for all towers nationwide
  - **Impact:** Limited upwards 5G power radiation *dramatically* shortens the minimum vertical separation distance required by aircraft for safe operation of the radio altimeter (especially impactful near airports)

Changes to FCC C-Band R&O (2 of 2)

- **Request 4:** Reduction in Spurious Emission Limits
  - **Current R&O provision:** Spurious emissions as high as -13 dBm/MHz
  - **Required Change:** Limit spurious to what retrofitted equipment can tolerate
  - **Impact:** Allows the FAA's signal-in-space safety process to focus only on fundamental 5G emissions
- **Request 5:** Fundamental EIRP Limits Near Airports
  - **Current R&O provision:** Towers can be installed anywhere up to max power
  - **Required Change:** In areas around airports, EIRP would be capped to a level which FAA has determined to be safe
  - **Impact:**
    - The FAA would create a coordination process where wireless companies can request a safety evaluation of the tower to determine if a higher EIRP can be tolerated
    - All airport environments would be protected—even those not in mitigated areas today
    - Wireless companies would still have opportunities to operate in airport environments (ie in and near terminals)