

Radar Altimeter and Compatibility with 5G

Presented to: **Aviation Community**

By: **Federal Aviation Administration**

Date: **July 1, 2021**



**Federal Aviation
Administration**

Purpose of Forum

- Communicate the FAA's current engagements regarding the 5G radar altimeter issue**
- Gain a better understanding of concerns and issues facing aviation stakeholders**
- Create an awareness of timelines**
- Promote a path forward for collaboration between aviation and telecom industries**

At this forum the FAA is not seeking consensus or collaborative recommendations from industry stakeholders, but rather individual perspectives on the issues discussed.



Discussion Outline

- Aviation 5G Support
- Spectrum Management
- FAA Early Engagement
- FAA Recent Activities
- JI-FRAI Effort
- Operational Implications
- System Safety and Certification Perspective
- Moving Forward



Aviation Supports 5G Development

- ❑ Radio altimeter has existed in the C-Band middle frequency range radio frequency spectrum for more than 40 years
- ❑ The spectrum is also well-suited for moving data. This and its propagation properties make it very attractive for 5G telecommunications
- ❑ US and other countries support the expansion of 5G capabilities and aviation safety

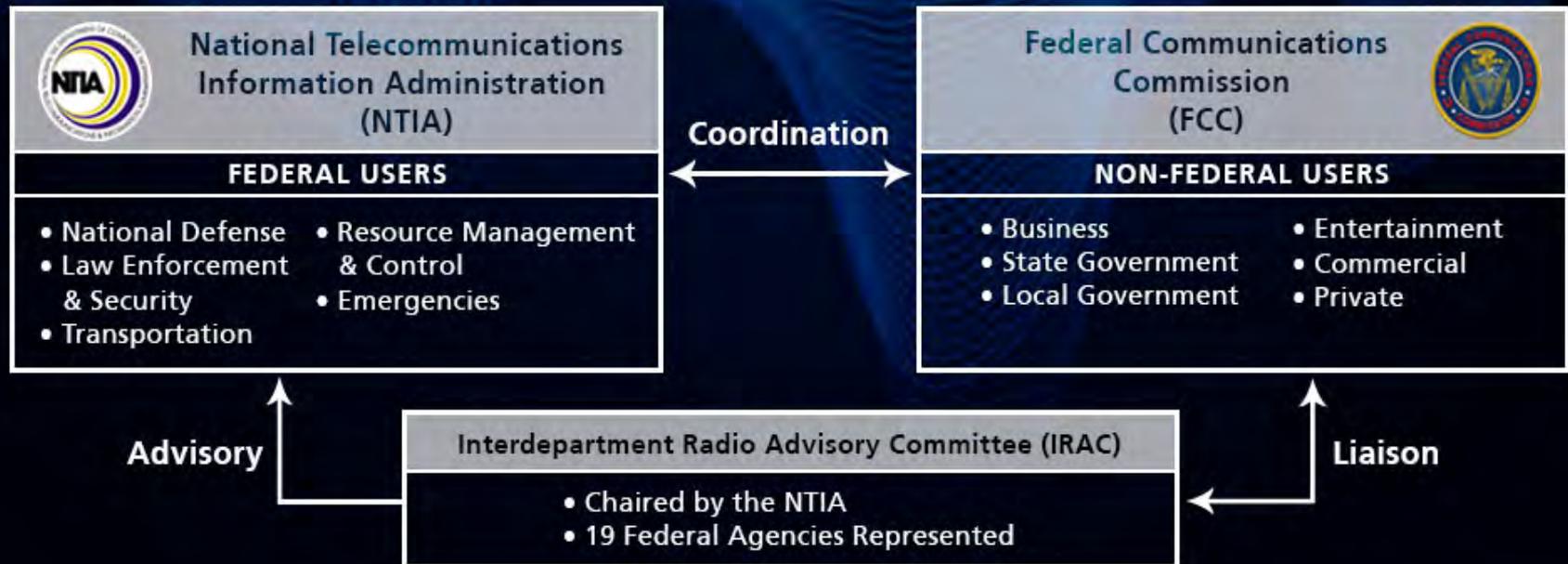
Successful coexistence requires collaboration



NATIONAL SPECTRUM MANAGEMENT



COMMUNICATIONS ACT OF 1934



US Spectrum Management

- ❑ **FCC – an independent US government agency overseen by Congress**
 - Regulates non-Federal use of spectrum
 - Rules and regulations in Title 47 of Code of Federal Regulations (CFR)
 - Uses public “notice and comment” rulemaking
- ❑ **NTIA – an Executive Branch agency located within the Department of Commerce**
 - Regulates Federal use of spectrum
 - Identifies additional spectrum for commercial use
 - Advises the President on telecommunications and information policy issues
- ❑ **FCC and NTIA coordinate spectrum policy for shared Federal/non-Federal spectrum use**

FAA does not regulate spectrum – concern is aviation safety



Spectrum Background

- Ensuring compatibility between 5G waveforms in the 3.7-3.98 GHz band and radar altimeters in the 4.2-4.4 GHz band operating in the United States

Federal (NTIA)	Non-Federal (FCC)	
3700-4200	3700-4000 FIXED MOBILE except aeronautical mobile NG182 NG457A	← 5G
	4000-4200 FIXED FIXED-SATELLITE (space-to-Earth) NG457A NG182	
4200-4400 AERONAUTICAL RADIONAVIGATION		← Radar Altimeters
5.440 US261		

US Table of Frequency Allocations

FAA Early Engagement

- ❑ **World Radio Conference (WRC)-15**
- ❑ **ICAO Frequency Spectrum Management Panel (FSMP) job card**
- ❑ **July 2019 – ICAO Position on WRC 19**
- ❑ **October 2019 – FAA partners with AVSI for testing**
- ❑ **December 2019 – RTCA PMC establishes SC-239 at request of AIRBUS; FAA supports**
 - **April 2020 – SC-239 begins meeting; FAA participates**



FAA Recent Activity (1/2)

❑ International Civil Aviation Organization (ICAO) FSMP; FAA participates

❑ ICAO State letter—March 25, 2021

Encouraged administrations to consider “as a priority, public and aviation safety when deciding how to enable cellular broadband/5G services in radio frequency bands near the bands used by radio altimeters.” They noted “several States have already implemented temporary technical, regulatory and operational mitigations on new 5G systems in order to protect radio altimeters while more permanent solutions are being devised.”



FAA Recent Activity (2/2)

❑ Inter-government Activity

- Coordination leads to NTIA participation in RTCA SC-239
- FAA/NTIA/FCC coordination on RTCA report leads to May 2021 meeting with Aviation and Aerospace Experts
- Joint Interagency FiveG Radar Altimeter Interference (JI-FRAI) Collaboration

❑ Military equipment not the subject of the RTCA report

- FAA is engaged with DoD to understand any impact

❑ FAA/Industry Communication

- Compatibility assessments with currently fielded radio altimeters are not “one size fits all”

❑ RTCA SC-239 Standards Work



Joint Interagency – FiveG Radar Altimeter Interference (JI-FRAI) Quick Reaction Test (QRT)

Challenge

Need to Accelerate Development & Validation of
5G Interference Operational Test Methodologies

1970s

Radar Altimeters were widely adopted following several deadly Controlled Flight into Terrain (CFIT) accidents

Radar Altimeters are the only device on aircraft that provides height over terrain/water/obstacles

2020

RTCA w/ Industry conducted laboratory bench testing of 5G interference in the 3.7-3.98 GHz spectrum range with civil aircraft radar altimeters

Testing revealed out-of-band emissions may affect flight safety with catastrophic results. No military radar altimeters were tested. U.S. and DoD lack 5G interference operational test procedures and test range

2021

First operational 5G C-Band use in U.S. estimated as early as December 2021

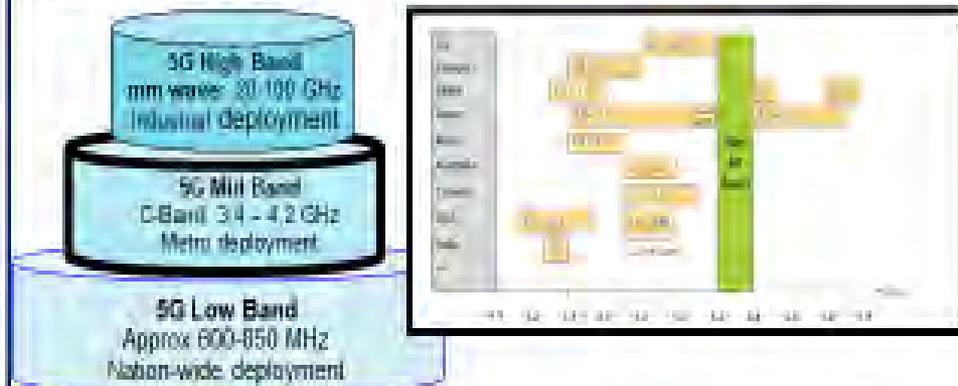
International Partners already utilize 2.4 - 3.8GHz frequency for 5G

Approach

- Leverage OSD Joint Test & Evaluation (JTE) program
- Establish joint service/interagency/industry planning & execution team
- Serve as catalyst and focal point for action
- Garner added funding and combine expertise and resources

Operational Test Focus

Develop and test 5G Operational Combined Test Procedures & capabilities using military radar altimeter use case & C-Band focus to support current and future 5G operational avionics testing, mitigations & standards development



Way Ahead*

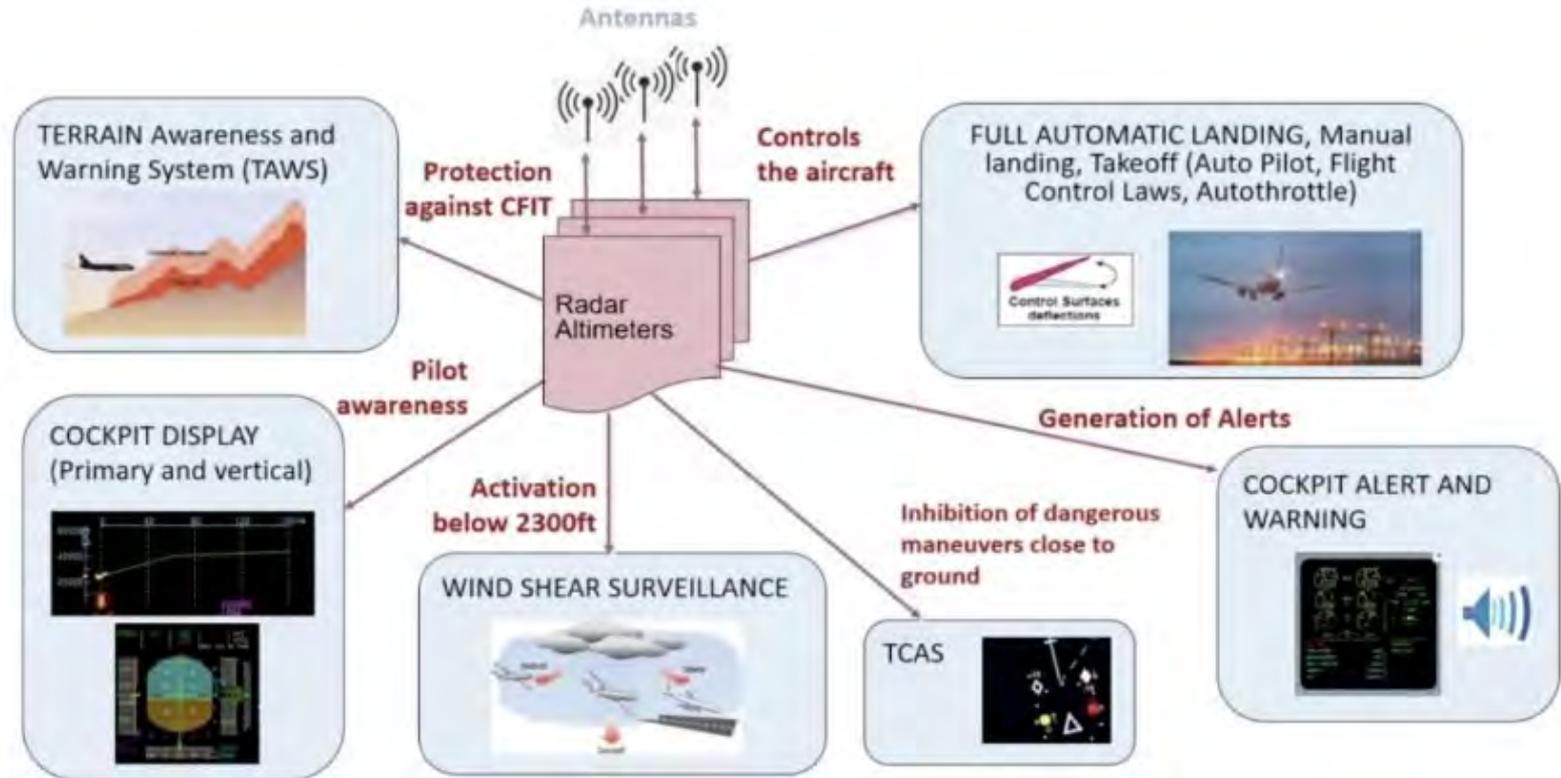
- 4 Mar 2021 Complete and submit JTE QRT nomination package
- 1 Apr 2021 OSD JTE QRT funding decision
- Apr 2021 Establish interagency, industry, academia SME Team
- Jul-Sep 2021 Plan/conduct Improved Bench Test (MITRE 5G O-RAN)
- Oct-Nov 2021 RF Over-the-air 5G Ops Test (Atlantic Test Range*)
- Feb-May 2022 Final 5G Ops Flight Test Events (Hill AFB*)
- Jun 2022 Final Outbrief/Product Transition
- *Based on preliminary coordination; Quick Look Reporting after each test phase



Operational Implications



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



Source: RTCA

MEL Examples (1/2)

□ Associated systems possibly affected:

- Ground Proximity Warning Systems (GPWS) including EGPWS
- Terrain Awareness Warning Systems (TAWS)
- Traffic Collision Avoidance Systems (TCAS or ACAS)
- Associated Flight Director
- Auto throttle systems
- Stick pusher below 500 feet
- Auto flight limits bank angle to 8 degrees
- Manual landings only
- Heads Up Display unusable for t/o, app and landing
- Tail strike protection unusable



MEL Examples (2/2)

□ Associated systems possibly affected:

- Erroneous indications cause LNAV FMA to flash (ground/low altitudes)
- Untimely flare/throttle commands could cause late/unstable approach—hard/long landing and potential overrun or hull loss
- Engine and wing anti ice automatic systems inop
- Synthetic Vision Systems affected-considered inop
- Lateral/Vertical guidance used for night visual app
- Takeoff and landing wind limitations 10kts
- Stick pusher is deactivated
- Center of gravity not greater than 20% MAC
- Flights not conducted in known or forecast icing



Loss of RADALT on Transport Aircraft

- Significant impact on transport category aircraft safety systems and defined flight paths in terminal (approach/departure) area**
- Access limitation during low vis ops**
 - SA CAT I, CAT II, SA CAT II and CAT III ops not authorized w/o RADALT
- Access limitation on RNP-AR**
 - Requirement for Class A TAWS which requires a RA
- Negative impact to schedule integrity and reliability**
- Additional fuel required/additional flights needed**
- Economic impact of displaced people and cargo**



Loss of RADALT on Helicopter

- ❑ **Majority of flights are conducted 500' AGL and below and flight paths are more susceptible to interference over entire route**
 - Takeoff and landing operations also occur outside of traditional airports
- ❑ **On the modern helicopter, radar altimeters are integrated into many systems that provide aural and visual warnings, flight control functions, and protection modes**
 - Commercial operations require RADALT equipage
 - Helicopters conducting air ambulance operations must be equipped with Helicopter Terrain Awareness and Warning System (HTAWS)
 - A large number of general aviation and public use helicopters operate in the airspace system and are equipped with RADALT
- ❑ **Loss of RADALT should not limit access to heliports and landing zones, but degrades safety due to reduction of situational awareness relative to height above the ground**
- ❑ **As relayed from an OEM: “The impact of potential interference to radar altimeters in use could potentially lead to ‘misleading’/inaccurate indications”**



Potential Costs to Aviation

- ❑ **Many of the safety critical systems using RADALT were mandated by rule**
 - TCAS final rule estimated the cost of saving lives by preventing mid-air accidents at \$1.7B in today's dollars
 - TAWS rule estimated monetary value of aircraft preserved by reduced "CFIT risks" at \$1.97B in today's dollars
 - These estimates do not take into account the economic cost of loss of confidence in aviation as a result of fatal accidents
- ❑ **There could be a lost of access cost if certain operations (e.g., CAT II/III, RNP-AR) are not permitted due to loss of RADALT**
 - Schedules are built around multiple factors that can cost the airline and also impact the operations (cascading effect)
 - First flight and last flight of day - Focus flights as schedule depends on "In position" crew/aircraft - impacts ripple through schedule



System Safety and Certification Considerations



FAA Pursuing Dual Approach

Standards Development (Future Designs)

- ❑ Revise civil radio altimeter standards to increase rejection of in band & out of band interference
- ❑ Requirements will address 5G and other current and expected potential interference threats near radar altimeter band worldwide
- ❑ Including performance requirements, detailed test procedures, & means of compliance determination

Constraints and Mitigations (Fielded equipment)

- ❑ Assess aviation and 5G Compatibility
- ❑ Develop Operational Mitigations (as necessary to maintain safety)
- ❑ Potential 5G Constraints
 - 5G base station placement/ deployment planning
 - Potential 5G base station antenna design/operating improvements
 - 5G antenna scan angle range limits
 - Reduced 5G spurious emission limits

The only viable approach is a combination of mitigations and constraints from both the aviation and telecommunication communities.

FAA has ZERO authority on 5G constraints. That authority lies with the FCC.



Safety Considerations for Aircraft OEMs

- ❑ **Aircraft architecture & radio altimeter(s) integration**
 - Single “point of failure,” whether single or dual thread equipment
 - Cascading effects
- ❑ **Review aircraft and system safety and safety risk documentation, MMEL, flight manuals, FCOM or equivalent, etc.**
 - Consider assumptions made or inherent in the integration of the radio altimeter (for example, “performs better” at a lower altitude than a higher altitude)
 - Aircraft level loss of function effects
 - Aircraft level effects of misleading information
 - Increased probability of both loss of function and misleading info
 - Crew presentations and decision making
- ❑ **Anomaly reporting with focus on isolating radio frequency interference and maintenance processes**
 - Existing processes likely not well suited to isolate interference effects
- ❑ **Steps taken and/or plans to inform aircraft operators**



“Box” level performance to aircraft level risk

- ❑ **Interference to LRRRA can result in loss of altitude or erroneous altitude**
 - Hazards for multiple downstream systems could vary from “minor” to “catastrophic” depending upon aircraft and integration
 - Hazards can vary based upon phase of flight at event onset and event duration
- ❑ **Characteristics of error (for example size, time) when loss of function occurs may not conform to previous assumptions**
 - Relevant for downstream systems that make assumptions of the “most likely” value of error when no-computed-data (NCD)
 - Downstream equipment could expect the aircraft is at high altitude, low altitude, or last valid value for example; if in error, this could cause an unanticipated new risk
- ❑ **Characteristics of error before loss of function may not conform to previous assumptions**
 - Relevant for downstream systems that “coast,” “extrapolate,” combine information from (like or non-like kind) multiple systems, “vote” or compare outputs
- ❑ **Could induce loss of a downstream critical function at a frequency/probability higher than anticipated by the original design of the downstream function**
- ❑ **Could induce correlated loss of function of redundant equipment at a frequency/probability higher than anticipated by the original design**



Education and Proliferation Tools

Certification Tools

- TSO Withdrawals
- Special Airworthiness Information Bulletin (SAIB)
- TSO Revisions
- Airworthiness Directives (AD)
- Rulemaking

Operational Tools

- Notice to Airmen (NOTAMS)
- Safety Alert for Operators (SAFO)
- Information for Operators (InFO)
- Operational Specification
- Rulemaking



Scope of New MOPS

□ Scope of new MOPS/TSO

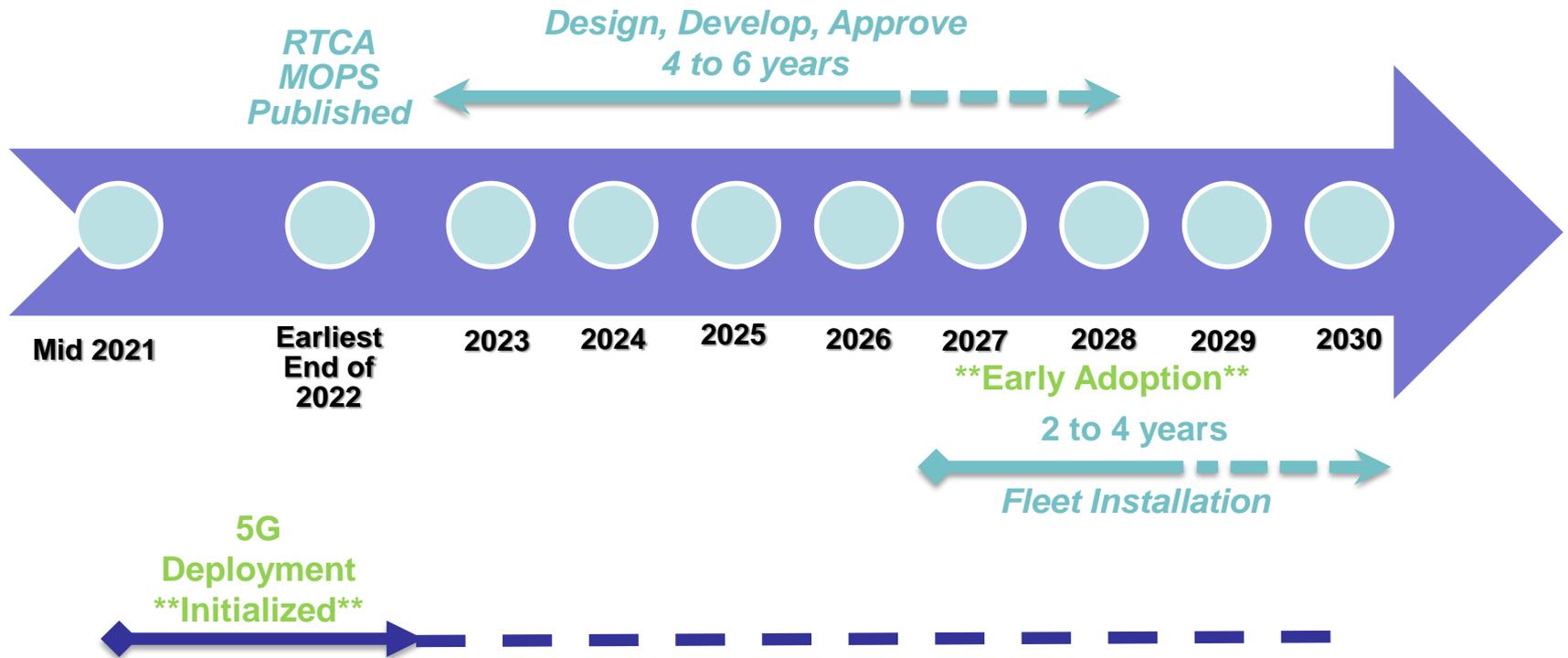
- Modernization of a 40+ year old document
- Compliance with spectrum regulations
- Future proofing against current and future RF interference environments
- Scope of new TSO will include allocated requirements for the receiver/transmitters LRU and antennas
 - Standard Antenna
 - System level requirements
- Benefit of antenna standardization
 - Avoid the need to characterize performance of multiple antenna models
 - Assist with future compatibility studies for interference issues
 - Ensure sufficient protections between the LRU and the antennas to guard against susceptibility to the interference environment

□ Questions to be answered

- Will existing antennas be compatible and adequate for future environment
- Need to understand the long-term interference environment
- How do we establish sufficient confidence in the (new) receiver performance standards and existing antenna installations to ground decisions on 5G deployment and mitigations



Timeline to Compatibility



Final Thoughts

- ❑ FAA is in fact finding mode and still gathering information
- ❑ No peer reviewed assessment has concluded “across the board” compatibility
- ❑ FAA has facilitated technical meetings between FCC/NTIA engineers and major contributors of the RTCA report to discuss the testing that was done and the RTCA analysis
- ❑ No group is tasked with coordinating *technical* communication between the aviation and telecommunication communities to develop conditions for coexistence
 - RTCA has offered to assist with this

Successful coexistence requires collaboration



Discussion Session Potential Topics

- **Actions the FAA should be taking to assist OEMs in their immediate radio altimeter continued operational safety (COS) process to address the changing RF environment**
- **Primary “asks” aviation has for our telecommunications colleagues to address COS**
- **Steps the community can take to avoid restricting airspace/airport/heliport access or aircraft operations, if further information on 5G installations and performance is not available**
- **Steps to proactively, instead of reactively, assess the risk to aircraft operations**
- **OEM and operator activities to determine the scope of the compatibility issue**
- **Additional studies or tests to build upon the RTCA report and/or establish standards**
- **Actions the FAA should be taking to help establish long-term compatibility between radio altimeters and near-band 5G use**
- **Primary “asks” aviation has for our telecommunications colleagues to address “future proofing,” to the extent possible, new radio altimeter designs**
- **Other concerns or topics**

