Radar Altimeters and 5G Interference
A Radar Altimeter (Rad-Alt) is an aviation instrument designed to measure height above terrain or obstacle. It is composed of a transmitter and receiver unit/section (with antennas) and it emits a low-power Radio Frequency (RF) pulse from the aircraft down toward the terrain and receives the reflected signal back. The time recorded between the transmitted and received signal is translated into altitude that is reported to the cockpit and shared with other avionic and flight control equipment.

Rad Alts are used on all types of civil and military aircraft, including transport and cargo airplanes, private airplanes, helicopters, combat aircraft, missiles, UAVs, etc. **Radar altimeters are the only sensor onboard an aircraft that can make a direct measurement of altitude above ground.** All other altitude sources, e.g., barometric, Global Navigation Satellite System (GNSS), etc., are referenced to an absolute datum (sea level or ellipsoid) and not relative to the terrain.
Radar Altimeter — Operational Details

Operating Details

Radar Altimeters, by nature of operation, suffer from performance issues depending on the surface that the signal reflects off. This is more apparent for helicopters than fixed wing aircraft due to dwell times.

The reason for these performance issues is the type of surface (material, water, ice, tarmac, wet grass, etc.), which affects the return signal. This causes different degradations to the return signal such as fading, phasing, dispersion, absorption, etc.

All aircraft manufactures incorporate some type of “integrity validation” scheme for radar altimeter indications to the operators. These include averaging over several returns, consecutive valid returns, hysteresis of values for damping, etc.

Generally, Rad Alts are designed to track the valid target at the lowest range, corresponding to the minimum clearance height of the aircraft.
Radar Altimeter — Certification Guidance

Civil aircraft utilize radar altimeters that have been approved by the FAA (or EASA) through the Technical Standard Order (TSO) using an STC or TC-related process.

The current governing FAA/EASA requirements for radar altimeters are TSO-C87a (dated: 2012) with performance requirements being RTCA/DO-155 and EUROCAE ED-30 MPS.

Of critical note is the fact that there are no requirements or limitations associated with reception bandwidth (aka reception mask) or spurious emission rejection or susceptibility.

The SC-239, Low Range Radar Altimeter, working group committee was established on December 19, 2019. Their charter was to update the current Minimum Operational Performance Standard, DO-155, for Low Range Radar Altimeters. The group also focused on protecting future Radar Altimeters from existing and planned IN BAND and OUT OF BAND interferences and to better align DO-155 with ED-30.
Radar Altimeter — Applications

- Primary Flight/Low-altitude Operations.
- Autopilot/Flight Controls
- Precision Approaches
- Search And Rescue (SAR)
- Night Vision Infrared System (NVIS)/Night Vision Goggles (NVG)
- Situational awareness
- DMAP/Terrain Avoidance and Warning System (TAWS) /Ground Proximity Warning Systems
- Vertical guidance on landings, including aural callouts (on both instrument and visual landings)
- Traffic Collision Avoidance System (TCAS)
- Flight of Terrain/Terrain Tracking
- Specialized Flight Control Modes
Background Cellular History

• 5G is the 5th generation technology standard for broadband cellular networks

• The first specification for 5G was released in 2017

• In early 2019, the first 5G mobile networks rolled out
• Verizon was the first carrier to roll out a 5G mobile network in Chicago and Minneapolis in 2019

• 5G Cellular is transmitted in 3 bands:
  • **High band**: 28 GHz band; the 24 GHz band; and the upper 37 GHz, 39 GHz, and 47 GHz bands
  • **Mid band**: 2.5 GHz, 3.5 GHz, and 3.7-4.2 GHz bands
  • **Low band**: 600 MHz, 800 MHz, and 900 MHz bands

• The key to 5G is increased bandwidth. Increased bandwidth equals results in more data transmitted over the same time period.
Background Cellular History — FCC and 5G

In March 2020, the FCC issued a Report and Order regarding opening up the 3.7 to 4.2 GHz spectrum for 5G use.

In response, the RTCA established a 5G Task Force within the existing Radar Altimeter MOPS Special Committee SC-239 to investigate potential coexistence issues between 5G and radar altimeters. This was due to the proximity of the radar altimeter operating spectrum of 4.2 to 4.4 Ghz. This task force consisted of representatives from industry, the Air Line Pilots Association, airlines and the FAA. On October 7, 2020, RTCA released their report (PDF) and submitted it to the FCC.

The report documented, using a small sample set of commercial RAs, that potential interference from either fundamental 5G emissions and/or 5G spurious emissions during laboratory tests.

Fundamental emissions have to do with potential RA receiver overload due to lack of adequate out-of-band rejection of the 5G signals and/or because the RA’s reception mask extends beyond the allocated 4.2 to 4.4 Ghz. (NOTE: Older DO-155 and ED-30 Requirements). The spurious emissions are potential frequency multiples emitted by 5G transmitters that have the potential of land in the 4.2-4.4 GHz range and/or because the RA’s reception mask extends beyond the allocated 4.2 to 4.4 Ghz.
Summary of the 5G Midband (C-Band) Issue

- Radar altimeters are inherently wideband systems, and currently have no FAA or EASA requirements for front-end spurious signal rejection

- Two means of potential interference to radar altimeters:
  - 5G fundamental emissions overcoming the filtering in the altimeter receivers (blocking)
  - 5G spurious emissions landing within the 4.2–4.4 GHz band directly

- Different manufactures and models have different receiver sensitivity and susceptibility to interference

- 90% of current radar altimeters cannot meet the current FAA AD (July 2023) PSD spurious and conducted emission levels
Regulatory History — FCC and 5G

On December 2020, the FCC auctioned off the 3.7 to 4.2 Ghz spectrum for several billion dollars to AT&T and Verizon. This was done against the recommendations of the FAA, RTCA and Aviation community including HAI.

On November 2, 2021, the FAA released Special Airworthiness Information Bulletin (SAIB), AIR-21-18, recommending “voluntary” self assessments of Radar Altimeter by Suppliers and Aircraft Manufacturers.

On November 4, 2021, on the request of the Department of Transportation, Version and AT&T agreed to delay the launch of their C-Band 5G until January 5, 2022, in order not to impact the holiday air travel.

On December 23, 2021, the FAA issued AD 2021-23-12 - Airworthiness Directive on altimeter interference and airplanes and AD 2021-23-13 - Airworthiness Directive on altimeter interference and helicopters. These ADs established the first, restrictions on Operators regarding Radar Altimeter operations, requiring a complex process of certification. It was based on radar altimeter manufacturers submitting 5G protection radius estimator assessments and statement of performance to the FAA with reference to a test report and/or drawing that defines test environment. Based on this assessment the FAA would qualify the model radar altimeter for use on aircraft via an AMOC process. The AMOC process was used within FAA-established 5G NOTAMs.
Regulatory History — FCC and 5G

During the 2022 timeframe, Cellular operators AT&T and Verizon had agreed to operate at reduced power levels as they began to activate C-Band Towers across the Continental United States (CONUS). Instead of the FCC-approved 65dBm/Mhz, operators had agreed to a reduced max power of 62dBm/Mhz and to a 32dBm/Mhz with airport vicinity (2 Nm). These reduced power levels would remain until July 1, 2024.

In parallel, the FAA AMOC approach to certification of aircraft and radar altimeters models via NOTAMs became unmanageable. At this point, the FAA switch to a universal Signal and Space enforcement model.

Previously approved aircraft/RA models under the AMOC process were being assessed for operation on a month-by-month basis.

The NOTAMs were also becoming continuous across the U.S., which also made the process unusable.
Current Regulations – FCC and 5G

As of July 1, 2023, C-Band 5G power levels in the U.S. increased from 62dBm/Mhz to 65dBm/Mhz (double the power). As a result of this, as well as the fact that the Dept. of Transportation refused to extend the reduced power levels, forced the FAA to issue two new ADs incorporating the new PSD levels. Airworthiness Directive, Transport and Commuter Category Airplanes (AD 2023-10-02).

The new PSD levels require Operators to have 5G Tolerant Radar Altimeters to these new levels as a function of altitude.

The Transport/Commuter AD prohibits the following operations in the contiguous U.S.:

- 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)
Current 5G Power Spectral Density (PSD) Curves

Fundamental Effective Isotropic PSD at Outside Interface of Airplane Antenna

<table>
<thead>
<tr>
<th>Height above ground (ft)</th>
<th>Effective Isotropic PSD (dBm/MHz)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Airplanes on the ground</td>
<td>-5</td>
</tr>
<tr>
<td>50</td>
<td>-5</td>
</tr>
<tr>
<td>100</td>
<td>-10</td>
</tr>
<tr>
<td>200</td>
<td>-17</td>
</tr>
<tr>
<td>500</td>
<td>-22</td>
</tr>
<tr>
<td>1000</td>
<td>-33</td>
</tr>
<tr>
<td>5000</td>
<td>-47</td>
</tr>
</tbody>
</table>
Current 5G Power Spectral Density (PSD) Curves

Spurious Effective Isotropic PSD at Outside Interface of Airplane Antenna

<table>
<thead>
<tr>
<th>Airplane Altitude (ft AGL)</th>
<th>Effective Isotropic PSD (dBm/MHz)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>-116.50</td>
</tr>
<tr>
<td>400</td>
<td>-116.50</td>
</tr>
<tr>
<td>500</td>
<td>-126.00</td>
</tr>
<tr>
<td>1000</td>
<td>-139.00</td>
</tr>
<tr>
<td>2000</td>
<td>-147.00</td>
</tr>
<tr>
<td>3000</td>
<td>-151.00</td>
</tr>
<tr>
<td>5000</td>
<td>-156.00</td>
</tr>
</tbody>
</table>
The Specific Failure Condition of Concern

Under SAE ARP-4754 and ARP-4761, Functional Hazard Assessments and System Safety Assessments of aircraft platforms (per FAA CFR FAR 25.1309) all Civil and Modern Military aircraft are assessed for both:

A. Erroneous Undetected Failure of the Radar Altimeter
B. Erroneous Detected Failure of the Radar Altimeter

Both of the cases are taken into account in the design and mitigated through backup systems and advisories. Based on the specific operations performed by the aircraft or aircrew, criticality of these failures range from minor to catastrophic.

5G however creates a new failure condition that is not accounted previously.

C. Valid Erroneous Undetected Signal.

This is the case where the value of the Radar Altimeter is still valid but inaccurate in terms of true AGL.
Potential Affects on Aircraft Systems and Operation

Incorrect radio altimeter readouts can have a multitude of effects on various aircraft systems, with some of these systems directly affecting the safety of the aircraft.

Some examples of these include the Traffic Collision Avoidance System (TCAS), the Ground Proximity Warning System (GPWS), the Predictive Windshear System (PWS), the Auto flight system and the Fly by wire and other control systems.
Actual Impacted Systems and Subsystems – Examples

TCAS is used by aircraft to prevent collisions with other aircraft. The system uses the closure rate between aircraft to generate avoidance guidance for the pilot to follow if two aircraft are on a collision course. This guidance called Resolution Advisories (RA) gives descent or ascent orders for pilots to follow.

These maneuvers can sometimes be quite “aggressive” and can pose a crash risk if they are done close to the ground. As a result TCAS alerts are inhibited when the aircraft is at low altitudes. The altitude for this is determined by the radio altimeter. In most aircraft, when below 1000 ft all RA messages are inhibited when the aircraft is in a climb and all RA messages below 900 ft are inhibited when in a descent. A false radio altimeter height can make the TCAS give out false resolution advisories when the aircraft is near the ground, which can lead to Controlled Flight Into Terrain (CFIT).
Actual Impacted Systems and Subsystems – Examples

The GPWS uses the radio altimeter to calculate how close the aircraft is to the terrain or ground.

The GPWS generates as a function of Radar Altimeter AGL, aural and visual alerts such as “TERRAIN, TERRAIN,” “PULL UP,” “DON’T SINK, DON’T SINK,” etc., to notify the pilot so that he/she can immediately apply the avoidance maneuvers.

Given the GPWS dependency on the radio altimeter inputs to generate such alerts, an inaccurate or invalid radio altimeter can provide the wrong data into the GPWS system, which can prevent it from alerting the pilots leading to a terrain impact or force the operators to take Terrain following would be a similar condition to this.
Actual Impacted Systems and Subsystems – Examples

The aircraft automatic flight control system uses the radio altimeter when close to the ground for various operations and especially when conducting auto-coupled approaches in low visibility conditions or precision approaches where the aircraft systems automatically land the aircraft. During such operations, the radar altimeter signal is critical to the aircraft flight control system functions.

For example, the timing of the flare during landing is decided by the radar altimeter AGL height. If, for example, an aircraft flare is set at 30 ft and the radar altimeter height becomes erroneous and gives the auto-flight a higher altitude, the aircraft may not flare. This can lead to a hard landing, which can severely damage the aircraft, and injure passengers and crew. The opposite is also true where the radar altimeter provides a lower altitude and the aircraft flares prematurely. This could lead to a stall condition that could be catastrophic.

The engine thrust during an automatic landing is also controlled by the radar altimeter AGL height, whereby it is reduced at a particular height. An example of this is if the auto-throttle/auto-thrust system that is designed to reduce the engine power to idle for landing at 25 ft AGL and the radar altimeter erroneously reports an AGL of 25 ft when the aircraft altitude is much higher, the thrust may go to idle. When close to the ground, this can lead to a stall disaster as jet engines take about 7-8 seconds to spool up from idle to maximum thrust.
C-130J Specifics

The C-130J utilizes the Honeywell Radar Altimeter HG-9550.

The HG-9550 is an LPI radar altimeter with capabilities that include frequency agility, power management and code/pulse repetition frequency jitter. It has the ability to vary the system track rate and Electronic Counter Counter Measures (ECCM) response as functions of real-time inputs. It is also pre-programmable (track rate, ECCM 43 response, sensitivity, altitude range and output formats).

Currently the HG-9550 cannot meet the FAA Fundamental and Spurious Emission PSD curves.

Honeywell is beginning to look into possible options (bandpass, filters internal/external) to improve 5G resilience performance.

No USG aircraft have been modified to date against the new FAA PSD levels.
Joint Interagency 5G Radar Altimeter Interference (JI-FRAI) Team

The Department of Defense in 2022 conducted live test flights at Hill Air Force Base as part of the department’s Joint Interagency Five G Radar Altimeter Interference, (JI-FRAI)

While JI-FRAI/U.S. DoD military testing has correlated some of the RTCA lab results, but real-world flights test not correlating susceptibility levels/performance.

The operational tests flew rotary and fixed wing aircraft in critical phases of flight profiles with a focus on answering what the impact C-Band 5G will have on DOD’s fleet equipment.

The tests were critical to connect bench test results to a realistic representation of commercial and military deployments.

Tests at Hill captured aircraft RADALT Height Above Ground Level outputs to determine if radar altimeter interference was detected. Trials were run with 5G on and off to assist in ruling out other environmental factors. Aircraft flown included Boeing 777 and 737, UH-60 Blackhawk and FA-18 Hornet.
Real-World Data Point

To date, out of hundred of thousand of flight hours, we do not have a single confirmed case of 5G interference. This is a concern for the Aviation industry and the FAA.

While pilots have been instructed to be more “focused” on radar altimeter anomalous readings, and report them, all reports that have been investigated to date do not have a quantitative correlation to 5G interference.

The same applies to global 5G networks flight operations.

Many people (depending on interests), see this as proof that the FAA, RTCA and Aviation Subject Matter Experts (SMEs) have over exaggerated the criticality and severity of “real-world” operations.

Many variables exist that can reason to such comments:
- Cellular towers are still increasing in the U.S., approximately 45,000 at present, to grow to 100,000 by end of first quarter 2023.
- Only two cellular providers currently in C-Band. Spurious emissions not at worst case PSD.
- Power levels currently not at FCC max levels, 62dBm/Mhz (approx.1.6 KW) vs. 65dBm/Mhz (approximately 3.2 KW) after July 2023.
- Additional cellular providers entering market/spectrum after July 2023.
- Power level restrictions in and around airports.
Current State of the Industry

• Commercial airlines and rotary wing operators working to retrofit their fleets in order to meet the FAA ADs.

• Supply chain issues are making the retrofit process slow in some cases. Particularly for the small RG operators and rotorcraft.

• Not all radar altimeter Original Equipment Manufacturers (OEMs) or radar altimeter models can be improved via filters. In many cases, a complete replacement must occur.

• Process is costly and is not covered by aircraft OEMs. The responsibility lies on the operators as this is an airspace limitation.

• USG has not conducted new testing via the JI-FRAI and MITRE organization. Last such tests were done in 2022 to the older PSD limits. New testing is required.

• EASA has not adopted the FAA AD or PSD limits for their airspace. This is due to the differences in C-Band implementation in Europe.

• Other countries around the globe also have not adapted this AD.
Cellular/Aviation Safety Event Timeline

**PAST**

2021
- 1st FAA AD Release
- SC-239 Begins

2022
- FAA FIX WING AD Update
- ICAO Interim Guidance

2023
- FAA Heli AD NPRM
- ICAP Final Guidance
- RTCA DO-399 NEW RAD ALT MOPS
- ICAO Final Guidance

2024
- FAA 2nd AD Update (?)

2025
- FIRST NEW RAD ALT CERTIFIED

**FAA Activity**

**Aviation Industry Standards & Regulations**

**RADAR ALTIMETER INSTALLATIONS/MITIGATIONS**

- Group 1 RAD ALTs
- Group 2 RAD ALTs
- Group 3 RAD ALTs
- Group 4 RAD ALTs

**5G CELLULAR DEPLOYMENTS AND MITIGATIONS**

- 5G Cellular Deploys 3.7 – 3.8 Ghz
- Group 2 – 4 RAs Priority Airport

**Transition Period for the Aviation Industry. Multiyear replacement period**

- New RA Installation

**NOTES:**
- Some RAs may meet new MOPS.
- During transition period safety mitigations from 5G RF Hazards will be required. Temporary RF Restrictions. OPs Restrictions.
What is Happening Around the World?

The United States did not follow the same type of 5G C-Band deployment as in Europe. So the ICAO and EASA analysis in not comparing the same standards. The FAA published a comprehensive analysis of the situation posted on its website.

The primary differences between the deployment in the USA and other regions of the world are the use of Higher Power Transmitters, Higher Density, Closer Proximity to Aerodromes/Airports, and the use of antenna arrays with no horizontal tilt on the arrays relative to ground.
5G C-Band in Europe

- CEPT in Europe has harmonized 3.4-3.8 GHz for 5G spectrum auctions and deployments. The upper 100 megahertz, 3.7-3.8 GHz, is identical to the lowest 100 megahertz auctioned in the United States.
- **Finland’s** carrier Elisa launched 5G service in the 3.4-3.8 GHz band in 2018, with no interference complaints attributed to 5G.
- **Finland’s** carrier Elisa launched 5G service in the 3.4-3.8 GHz band in 2018, with no interference complaints attributed to 5G.
- **Finland’s** carrier Elisa launched 5G service in the 3.4-3.8 GHz band in 2018, with no interference complaints attributed to 5G.
- **Finland’s** carrier Elisa launched 5G service in the 3.4-3.8 GHz band in 2018, with no interference complaints attributed to 5G.
- **Finland’s** carrier Elisa launched 5G service in the 3.4-3.8 GHz band in 2018, with no interference complaints attributed to 5G.
- **Finland’s** carrier Elisa launched 5G service in the 3.4-3.8 GHz band in 2018, with no interference complaints attributed to 5G.
- **Finland’s** carrier Elisa launched 5G service in the 3.4-3.8 GHz band in 2018, with no interference complaints attributed to 5G.
- **Finland’s** carrier Elisa launched 5G service in the 3.4-3.8 GHz band in 2018, with no interference complaints attributed to 5G.
- **Finland’s** carrier Elisa launched 5G service in the 3.4-3.8 GHz band in 2018, with no interference complaints attributed to 5G.
- **Finland’s** carrier Elisa launched 5G service in the 3.4-3.8 GHz band in 2018, with no interference complaints attributed to 5G.
- **Finland’s** carrier Elisa launched 5G service in the 3.4-3.8 GHz band in 2018, with no interference complaints attributed to 5G.
- **Finland’s** carrier Elisa launched 5G service in the 3.4-3.8 GHz band in 2018, with no interference complaints attributed to 5G.
- **Finland’s** carrier Elisa launched 5G service in the 3.4-3.8 GHz band in 2018, with no interference complaints attributed to 5G.
- **Finland’s** carrier Elisa launched 5G service in the 3.4-3.8 GHz band in 2018, with no interference complaints attributed to 5G.
- **Finland’s** carrier Elisa launched 5G service in the 3.4-3.8 GHz band in 2018, with no interference complaints attributed to 5G.
- **Finland’s** carrier Elisa launched 5G service in the 3.4-3.8 GHz band in 2018, with no interference complaints attributed to 5G.
- **Finland’s** carrier Elisa launched 5G service in the 3.4-3.8 GHz band in 2018, with no interference complaints attributed to 5G.
- **Finland’s** carrier Elisa launched 5G service in the 3.4-3.8 GHz band in 2018, with no interference complaints attributed to 5G.
- **Finland’s** carrier Elisa launched 5G service in the 3.4-3.8 GHz band in 2018, with no interference complaints attributed to 5G.
- **Finland’s** carrier Elisa launched 5G service in the 3.4-3.8 GHz band in 2018, with no interference complaints attributed to 5G.
- **Finland’s** carrier Elisa launched 5G service in the 3.4-3.8 GHz band in 2018, with no interference complaints attributed to 5G.
- **Finland’s** carrier Elisa launched 5G service in the 3.4-3.8 GHz band in 2018, with no interference complaints attributed to 5G.
- **Finland’s** carrier Elisa launched 5G service in the 3.4-3.8 GHz band in 2018, with no interference complaints attributed to 5G.
- **Finland’s** carrier Elisa launched 5G service in the 3.4-3.8 GHz band in 2018, with no interference complaints attributed to 5G.
- **Finland’s** carrier Elisa launched 5G service in the 3.4-3.8 GHz band in 2018, with no interference complaints attributed to 5G.
- **Finland’s** carrier Elisa launched 5G service in the 3.4-3.8 GHz band in 2018, with no interference complaints attributed to 5G.
- **Finland’s** carrier Elisa launched 5G service in the 3.4-3.8 GHz band in 2018, with no interference complaints attributed to 5G.
- **Finland’s** carrier Elisa launched 5G service in the 3.4-3.8 GHz band in 2018, with no interference complaints attributed to 5G.
- **Finland’s** carrier Elisa launched 5G service in the 3.4-3.8 GHz band in 2018, with no interference complaints attributed to 5G.
- **Finland’s** carrier Elisa launched 5G service in the 3.4-3.8 GHz band in 2018, with no interference complaints attributed to 5G.
- **Finland’s** carrier Elisa launched 5G service in the 3.4-3.8 GHz band in 2018, with no interference complaints attributed to 5G.
- **Finland’s** carrier Elisa launched 5G service in the 3.4-3.8 GHz band in 2018, with no interference complaints attributed to 5G.
- **Finland’s** carrier Elisa launched 5G service in the 3.4-3.8 GHz band in 2018, with no interference complaints attributed to 5G.
- **Finland’s** carrier Elisa launched 5G service in the 3.4-3.8 GHz band in 2018, with no interference complaints attributed to 5G.
- **Finland’s** carrier Elisa launched 5G service in the 3.4-3.8 GHz band in 2018, with no interference complaints attributed to 5G.
- **Finland’s** carrier Elisa launched 5G service in the 3.4-3.8 GHz band in 2018, with no interference complaints attributed to 5G.
- **Finland’s** carrier Elisa launched 5G service in the 3.4-3.8 GHz band in 2018, with no interference complaints attributed to 5G.
- **Finland’s** carrier Elisa launched 5G service in the 3.4-3.8 GHz band in 2018, with no interference complaints attributed to 5G.
- **Finland’s** carrier Elisa launched 5G service in the 3.4-3.8 GHz band in 2018, with no interference complaints attributed to 5G.
- **Finland’s** carrier Elisa launched 5G service in the 3.4-3.8 GHz band in 2018, with no interference complaints attributed to 5G.
- **Finland’s** carrier Elisa launched 5G service in the 3.4-3.8 GHz band in 2018, with no interference complaints attributed to 5G.
- **Finland’s** carrier Elisa launched 5G service in the 3.4-3.8 GHz band in 2018, with no interference complaints attributed to 5G.
- **Finland’s** carrier Elisa launched 5G service in the 3.4-3.8 GHz band in 2018, with no interference complaints attributed to 5G.
- **Finland’s** carrier Elisa launched 5G service in the 3.4-3.8 GHz band in 2018, with no interference complaints attributed to 5G.
- **Finland’s** carrier Elisa launched 5G service in the 3.4-3.8 GHz band in 2018, with no interference complaints attributed to 5G.
- **Finland’s** carrier Elisa launched 5G service in the 3.4-3.8 GHz band in 2018, with no interference complaints attributed to 5G.
- **Finland’s** carrier Elisa launched 5G service in the 3.4-3.8 GHz band in 2018, with no interference complaints attributed to 5G.
5G C-Band in Asia

JAPAN Cellular

- Japan has 90,000 5G sites in service.
- Frequency separation is 100 megahertz, less than half of the 220 megahertz separation in the United States.
- No exclusions or power restrictions apply to 4 GHz and below.
- A base station exclusion zone applies within the closest 100 MHz channels, e.g., 4.0-4.1 GHz, for 1 km x 200 m around airport landing approaches.
- No known reports of interference

SOUTH KOREA

- South Korea has deployed 195,000 5G sites in 3400-3700 MHz.
- No mitigations or exclusions are in place.
- No known reports of interference.
Path Forward

• FAA needs to work with the RTCA SC-239 committee so that the Minimum Operational Performance Standards for radar altimeters are revised and new TSO guidance for certification of such radar altimeters becomes guidance.

• Radar altimeter manufactures need to notify the aerospace industry what model radar altimeters are more susceptible to C-Band 5G interference than others. The means testing all of the radar altimeters currently available and installed on aircraft. Collins, Honeywell and Thales have already started this process. No completion date announced as of yet.

• Lockheed Martin and industry need to assure that the FAA and FCC work together to limit the possibility of airline and operator disruptions, as well as mitigate and potential RF exposure risks. (i.e., create avoidance cylinders around cell towers, limit tower placement near airports, hospitals, heliports, etc.)

• DoD Military Certification Office and well as Foreign Military Operators and Certification Offices will have similar actions and requirements.
Path Forward (Continued)

- FAA is still fine-tuning Power Spectral Density (PSD) susceptibility curves to accommodate additional aggregation factors, such as helipad antennas, 5G repeaters, buildings, etc. Another revision of the AD’s for both Fixed wing and Rotary wing is expected before the end of the year (2023).

- Aviation industry as a whole is struggling to meet FAA AD. Radar Altimeter OEMs are still working to develop filters and certify their modifications. Aircraft or operators that cannot meet the AD susceptibility requirements will not be able to operate or fly modes or functions that are dependent on radar altimeter input.

- Department of Transportation announced that there will be no “grace period” beyond the July 1 date.

- EASA formally announced through bulletin that they accept the FAA AD as a “safety awareness” but will not adopt it within the EU countries or on any EU registered aircraft or helicopters. This decision creates a dichotomy in policy, particular as pertaining to flight operations entering the U.S. airspace.

- Transport Canada has fully adopted the FAA AD and has issued their version on the TC website.

- Cellular Providers, AT&T, Verizon and others, have sent a formal letter to the FAA and FCC declaring the use of reduced power levels surrounding major airports and heliports. This is a voluntary action and not only cellular providers have signed on. The reductions would be from 65dBm/Mhz to 32 dBm/Mhz.
Certification Guidance

• The aerospace industry is fully engaged in supporting and participating in all 5G RAD ALT FAA committees. Membership is broad including but not limited to Collins, Honeywell, Boeing, Thales, Airbus, Airlines Association, HAI, ICAO, Garmin, etc. Weekly meetings both technical and policy take place weekly with FAA participation.

• Lockheed Martin Government Affairs (R. Terry) and Lockheed RMS (N. Kefalas) serving on multiple industry and FAA regulatory committees since 2020.

• All Lockheed Martin SAC aircraft, civil and military conduct safety hazard evaluations of avionic architectures for loss of radar altimeter operation as part of the qualification/certification process.

• No “real-world” testing has been conducted to date by Lockheed Martin SAC, as we need radar altimeter manufacturer data first, in order architect test cases. Without knowledge of radar altimeter reception sensitivity and wide band reception mask, it will be impossible to quantitively assess aircraft-level performance or susceptibility.

• To date, Lockheed Martin has certified one radar altimeter with filter (Honeywell RT-300 + RFF-100) against the new FAA PSD limits: The S-92A.
Looking Forward

- The aviation industry has been actively examining the mitigations or solution they and the FAA can take to maintain operations and protect the safety of those operations.

- Retrofitting radio altimeters with out-of-band filters in a timely fashion is a practical impossibility and does not offer a comprehensive solution to mitigate the risks. It also may require new mitigations post-July 2023. RA Manufacturers expect this to be the case. Global supply chain management issues make this impossible to achieve by FAA’s original request of end of 2023. (February 2024 is the current date for retrofit.)

- Operator-initiated limitations would also severely disrupt the National Airspace System. Training would have limited effectiveness and cannot overcome loss of safety offered by reliably-functioning radio altimeters.

- RTCA SC-239 continues to work jointly with EUROCAE Working Group 119 to develop new radar altimeter MOPS, which will include interference tolerance requirements and other parameters as part of current lessons learned from 5G deployments. No release date has been set (estimated Q4 2023).

- Retrofitting radio altimeters: Requires new standards to be developed and TSOs to be implemented. Not soon enough to be effective (post-2025 at earliest. Most likely 2026).

- U.S. military must decide to formally adopt the FAA AD. This will require test and potentially retrofit of thousand of radar altimeters.
Questions?