5G Radio Altimeter Interference

Online Workshop for the NAM/CAR/SAM Regions on Aviation Risk Mitigation Measures Due to the Implementation of 5G Frequencies

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Agenda

- Problem and Impacts
- 5G Spectrum
- Representative 5G Implementations
- Aerospace Industry Efforts
- Roadmap to Safety
- Variables Affecting Interference Potential
- Q & A
The Problem and Impacts

▪ Governments around the world are implementing 5G cellular systems in frequency ranges adjacent to or near the radio frequency band used by radio altimeters.

▪ The aviation industry and aviation regulators are concerned these 5G deployments will cause interference to radio altimeters operating in the radio frequency band 4.2 - 4.4 GHz.

▪ Concerns are based on a study done by industry and the U.S. Federal Aviation Administration (FAA) via the RTCA organization.
  ▪ The study concluded 5G transmissions can interfere with radio altimeters
  ▪ Study was limited to regulations issued by the U.S. Federal Communications Commission (FCC) permitting 5G to operate in the radio frequency band 3.7 – 3.98 GHz and was limited to review of only 9 radio altimeters

▪ As a result of the study, alerts for 5G interference were issued by the Civil Aviation Authorities (CAAs) of France, Canada, Australia, New Zealand, Czech Republic, Saudi Arabia, Oman and United Arab Emirates.
The Problem and Impacts

- Boeing supports having more 5G available for consumers. However, 5G should not risk public and aviation safety.
- Potential impacts to airplane systems:
5G Spectrum

- **New mid-band spectrum 3 -16 GHz**
  - Good propagation and data rates
  - (Desired by 5G)

- **Existing Allocations ~700 MHz – 2 GHz**
  - Long Range/Penetrating Low Bandwidth

- **Radio Altimeter Allocation (4.2-4.4 GHz)**

- **New Millimeter Wave Allocations**
  - ~ 26, ~ 40 and ~ 66 GHz
  - Short Range High Bandwidth

*Not to scale

5G systems only impact public safety near the radio frequency band used by the radio altimeter
Representative 5G Implementations
Countries set their own regulatory constraints on 5G

<table>
<thead>
<tr>
<th>Country</th>
<th>Frequency Range</th>
<th>Power Limit (dBm/MHz)</th>
</tr>
</thead>
<tbody>
<tr>
<td>United States</td>
<td>3700-3980 MHz</td>
<td>65.15 Rural/62.15 Non-Rural Areas</td>
</tr>
<tr>
<td>UK</td>
<td>3400-3800 MHz</td>
<td>58</td>
</tr>
<tr>
<td>Japan</td>
<td>3400-4100 MHz, 4600-4700 MHz</td>
<td>56 (avg per sector)</td>
</tr>
<tr>
<td>Brazil</td>
<td>3300-3700 MHz</td>
<td>55</td>
</tr>
<tr>
<td>Ireland</td>
<td>3410-3800 MHz</td>
<td>61</td>
</tr>
<tr>
<td>Denmark, Finland, Sweden</td>
<td>3400-3800 MHz</td>
<td>61</td>
</tr>
<tr>
<td>Czech Republic</td>
<td>3400-3800 MHz</td>
<td>61</td>
</tr>
<tr>
<td>Canada</td>
<td>3450-3650 MHz</td>
<td>61</td>
</tr>
<tr>
<td>Romania</td>
<td>3490-3800 MHz</td>
<td>55</td>
</tr>
<tr>
<td>Saudi Arabia</td>
<td>3400-3800 MHz</td>
<td>58</td>
</tr>
<tr>
<td>Europe</td>
<td>3400-3800 MHz</td>
<td>61 - Recommended</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Country</th>
<th>Frequency Range</th>
<th>Licensed Power Limit (dBm/MHz)</th>
</tr>
</thead>
<tbody>
<tr>
<td>France</td>
<td>3400-3800 MHz</td>
<td>Between 55.44 and 60.34</td>
</tr>
<tr>
<td>New Zealand</td>
<td>3410-3580 MHz</td>
<td>Between 52.2 and 65.2</td>
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Aerospace Industry and Aviation Regulator Efforts

- Developing modifications to existing altimeters to be more robust against interference.
  - RTCA/EUROCAE updating Minimum Operational Performance Standards (MOPS) via SC-239/WG-119 to ensure sufficient immunity to foreseeable interference.
    - New MOPS must be validated
    - FAA will issue a Technical Standard Order (TSO) with equipment requirements
    - Radio altimeter manufacturers build to that TSO, then test and secure approval from FAA
    - Aircraft manufacturers or radio altimeter manufacturer must obtain a modified Type Certificate (aircraft maker) or Supplemental Type Certificates (radio altimeter maker) from the FAA to install new radio altimeters on each aircraft model
    - Availability of new radio altimeters for installation will likely be constrained by production

- US FAA continues to issue Airworthiness Directives while working to upgrade all altimeters
- European Aviation Safety Agency (EASA) issued a Continuation Airworthiness Review Item to investigate the vulnerability of Radio Altimeters to 5G signals, and is engaging with European spectrum regulators.
- European Conference of Postal and Telecommunications Administrations (CEPT) is studying compatibility between 5G and Radio Altimeters

Boeing is participating actively in all these initiatives
Roadmap to Safety

▪ Efforts are vigorous.
  ▪ Working to finalize radio altimeter standards
  ▪ Test and certify altimeters and aircraft (every make and model must be certified)
  ▪ Install via retrofit and new installations in every aircraft and helicopter requiring an altimeter

▪ Until changes can be made:
  ▪ Mitigations to 5G deployment, power levels and antenna tilt limitations need to be recognized and adopted
  ▪ Important to build a working relationship between Aviation and Telecom regulators
**Variables Affecting Interference Potential**

<table>
<thead>
<tr>
<th>Elements:</th>
<th>Mfg / Model # Aircraft + Supplier Platform/Altimeter + Spectrum band for 5G Deployment Spectrum + 5G Base Station Power Spectrum + 5G Base Station Emission Level + 5G Base Station Tilt Angle + 5G Base Station Distance from Aircraft Path Location - Airplane Path (Horizontal) + Unknowns / Unintended Safety Issue Safety Factor</th>
</tr>
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**5G Spectrum**

- **New mid-band spectrum 3-15 GHz**: Good propagation and data rates (Desired by 5G)
- **Radio Altimeter Allocation (4.2-4.4 GHz)**
- **New Millimeter Wave Allocations (~28, ~40 and ~66 GHz)**: Short range, high bandwidth

**Travel Path**

- **Approach Angle @ 3:1 Slope**

**Variables Affecting Interference Potential**

- **Power emissions**
- **Above Ground Level (AGL)**
- **Red-Alt Reception**

**Example:**

- **Blue**: reduced power base stations
- **Red**: no 5G stations permitted

**Unknowns / Unintended Safety Issue**

**Safety Factor**
5G Interference into Radio Altimeters is a Global Problem

- Interference to Radio Altimeters is a public safety issue!

- Interference can cause numerous aircraft safety hazards

- Restricting deployment and providing mitigations along flight paths and airports will help significantly

- National Aviation and Telecom regulators need to work together

- Your support is critical to maintaining public safety

Q & A

Boeing can Support and Collaborate on Efforts