### FAA Issues New Radar Altimeter 5G C-Band Risk Assessment...

...interference issues facing aircraft radar altimeter systems two weeks ahead of the planned launch of new 5G C-Band wireless networks.

Source: [Aviation Today](https://www.aviationtoday.com)

### Boeing and Airbus urge a delay in 5G wireless service over...

...The companies have expressed concern that 5G, which operates on a frequency close to that used by aircraft systems such as radio altimeters,...

Source: [NPR](https://www.npr.org)
Use modeling and simulation to analyze the effects of interference between radar and wireless communications systems.

Increasing Congestion in the RF Spectrum

Scenario Modeling for Radar and Wireless Coexistence

Analyze and Simulate in the RF Domain
Increasing Congestion in the RF Spectrum
5G applications drive demanding data rate & efficiency requirements

New Applications
- 4K and 8K 360° Video
- Virtual Reality
- Connected Vehicles
- Internet of Things

5G Requirements / Use Cases
- Enhanced mobile broadband (>10 Gbps)
- Ultra low latency (<1 ms)
- Massive machine-type communication (>1e5 devices)

Technical Solutions
- Increased bandwidth
- Better spectral efficiency
- Flexible air interface
- Densification

Higher Frequency Bands
Higher frequency operations result in propagation challenges

Signal Attenuation

Wideband performance

Scatterer-rich propagation
Shared spectrum operations present interference challenges

LTE 5G Custom

Communications Radar Interference

https://www.5gtechnologyworld.com/
Signal-level and power-level analysis can help with planning
Scenario Modeling for Radar and Wireless Coexistence
Typical radar scenario modeling workflow

Model Platforms and Targets
Model Surfaces and Clutter
Model Trajectories
Model Sensors
Simulate Scenarios
Model the radar altimeter sensor

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Center Frequency</td>
<td>4.3 GHz</td>
</tr>
<tr>
<td>PRF</td>
<td>143 Hz</td>
</tr>
<tr>
<td>Chirp Bandwidth</td>
<td>150 MHz</td>
</tr>
</tbody>
</table>

Source of radar altimeter specifications: Recommendation ITU-R M.2059-0
Simulate the scenario and generate IQ signal

```matlab
while advance(scene)
    iqsig = receive(scene);
    xr = dechirp(iqsig{:}, refSig);
    xr = pulsint(xr, 'coherent');
    fb_rng = rootmusic(xr, 1, RadarAlt.fs);
    MeasuredAltitude = beat2range(fb_rng, ... RadarAlt.SweepSlope, c);
end
```
Model the base stations close to the flight path
Generate 5G signal with the wireless waveform generator App
Model base station antenna with NR rectangular panel array

5G Antenna Array (3GPP TR 38.901)

Maximize directivity for worst case scenario
Simulate radar and interference signal propagation
Simulate the interference from fundamental emissions of 5G
Analyze and Simulate in the RF Domain
Two Problems to Analyze and Simulate in the RF Domain

Problem #1: 3GPP fundamental emissions

Problem #2: 3GPP spurious emissions
Problem #1: 3GPP Fundamental Emissions

- **Amplifier**
  - Gain
  - Noise figure
  - Non-linearity (IP3)
  - Saturation (P1dB/Psat)

- **ADC**
  - Quantization noise
  - Saturation
  - Dynamic range

- **Input filter**
  - S-parameters selectivity

- **5G TX power**
- **5G center frequency**
- **Saturation and spectral regrowth**
- **Noise floor**
Can 3GPP Fundamental Emissions Cause Front-End Overload?

It depends …
- Location of the base station and flight path
- 5G beam direction and transmitted power
- Receiver filter selectivity and saturation power

Simulate the (worst-case) scenario and verify the altitude reading!
Simulation of Worst-Case Scenario: Erroneous Altitude Reading

- 5G Base station
  - TX power = 67.5dBm
  - Antenna steered towards airport
- Altimeter receiver
  - RF filter attenuation ~3dB
  - Input referred saturation power ~ -30dBm

- Possible mitigation strategies
  - Increase RF filter attenuation: ~ -40dB
  - Increase receiver saturation: -10dBm
  - Change signal processing algorithm
Problem #2: 3GPP Spur Emissions

- **Spur power**
- **Input filter**
  - S-parameters selectivity
- **In-band spurs**

**Amplifier**
- Gain
- **Noise figure**
- Non-linearity (IP3)
- Saturation

**ADC**
- Quantization noise
- Saturation
- Dynamic range

**Noise floor**
Can 3GPP Spur Emissions Cause Receiver Desensitization?

Desensitization = increase of the receiver noise floor by 1dB due to spur emissions

- Model the base station worst-case scenario and compare with regulations
  - TX power = -13.6dBm/MHz
  - Antenna steered towards airport
- Simulate spurious signals and measure noise floor / SNR!

NF = 8dB and BW = 150MHz
Noise floor = -174dBm/Hz + 10*log10(BW) + NF
= -84dBm or -166dBm/Hz
Regulation: Spur < Noise floor - 6dB = -172dBm/Hz
In summary, you can analyze the effects of interference between radar and wireless systems with modeling and simulation.
Thank you