WiMax Interference to Nexrad Radars

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Background

- UK OFCOM has been aware of potential interference into its Watchman air surveillance radar since 2009 from adjacent band WiMax operations.
- OFCOM has published papers in the UK and the ITU-R (WP5B) on WiMax to radar interference.
- OFCOM suspended their auction of the band 2500-2690 MHz till after 2012 Olympics and issues have been resolved.
- In fall of 2010 NTIA began initial investigation of possible WiMax interference into US radars operating in the band 2700-2900 MHz using web based tools.
- Nexrad data can still be corrupted when strobes are ***not visible*** on radar ppi displays (See NTIA Technical Report TR-06-444).
- Corrupted data can lead to errors in weather prediction and measurements, which can cause alerts to be late or weather events to be underestimated putting property and lives at risk.

Background, cont.

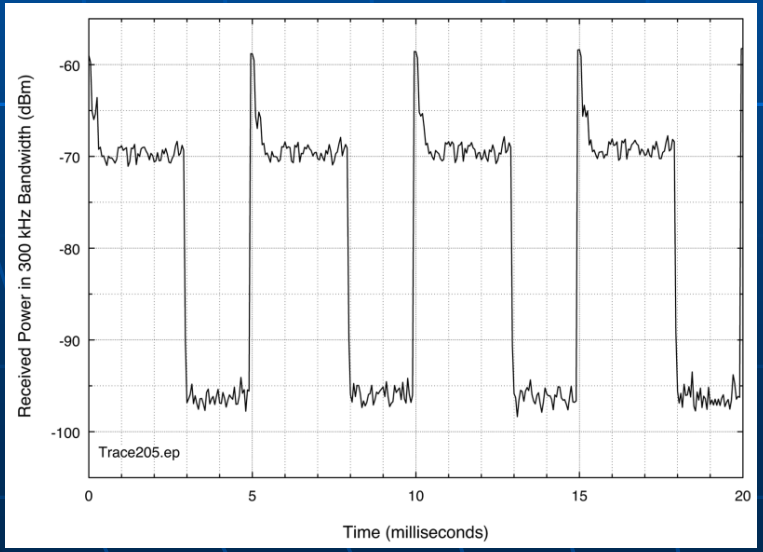
- Initial analyses seemed to show that interference strobes visible on the Nexrad ppi lined up with the locations of WiMax base station towers operated by Clear in 3-5 cities.
- Radar-to-radar interference does happen, as they are tending to go to longer duty cycles. For example FAA ASR-11 radars used to cause interference to Nexrad receivers; that problem has now been fixed. (See NTIA Report TM-06-439.)
- In October 2010, the NWS asked NTIA to investigate interference into its Nexrad at Grand Rapids, Michigan.
- ITS went to Grand Rapids to categorize the interference in the time and frequency domains to determine the source of it.

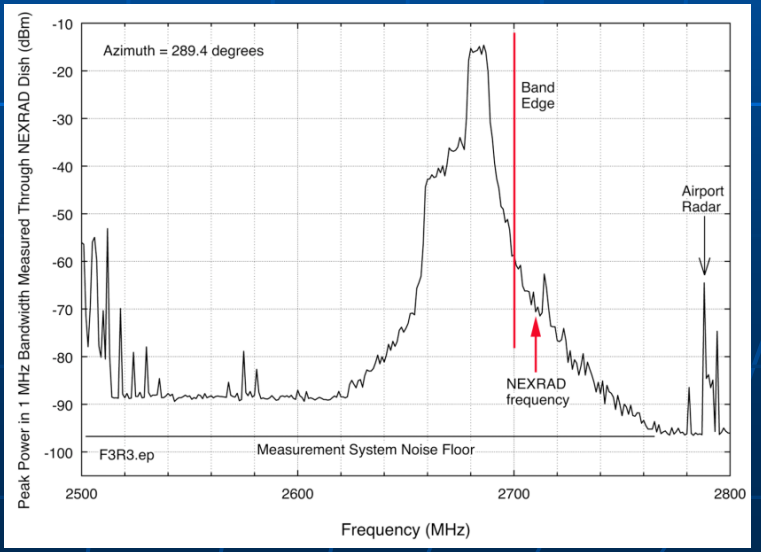
Characteristics of Grand Rapids Nexrad

- The Grand Rapids Nexrad is tuned to 2710 MHz and is operating according to RSEC Criteria D and all other NTIA regulations.
- The Nexrad receiver uses a bandpass filter in front of its LNA to protect it from saturation and gain compression due to high-power adjacent-band signals.
- The Nexrad receiver uses an IF filter commensurate with its emission bandwidth (i.e., matched filter) about 1 MHz wide.
- The Nexrad tower is standard 80 feet AGL with a pencil beam antenna (1 degree beamwidth) and a gain of 50 dBi.
- The protection criterion for Nexrad receivers is an I/N ratio of -10 dB, which equates to a signal level of -121 dBm in its receiver (IF bandwidth = 1 MHz and noise figure = 3 dB).

Results from Grand Rapids

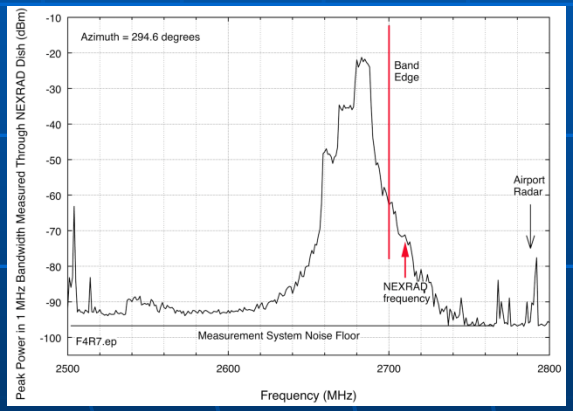
- Interference to the Grand Rapids Nexrad is from WiMax signals only, verified by using measurements of distinctive WiMax characteristics in the time domain and frequency domain inside the receiver IF and RF stages respectively.
- Measurement data show that the interference is due to the WiMax emissions *above* 2700 MHz, *not* due to overload from its fundamental at 2680-2690 (See figure).

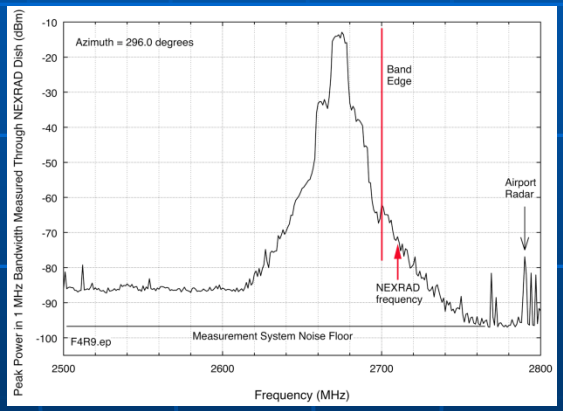


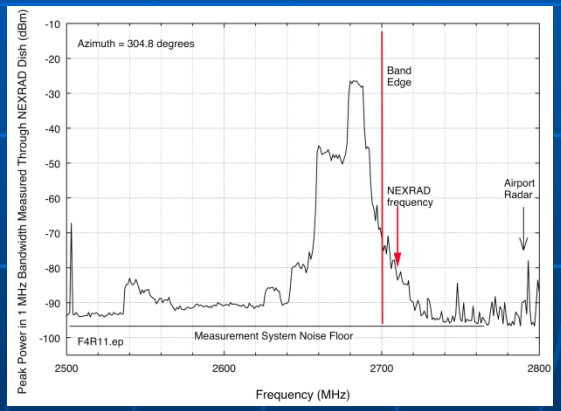


Results of Grand Rapids Measurements

- The interference was identified on four azimuths that showed visible strobes. Measurements in the Nexrad IF stage in the time domain and in the RF stage in the frequency domain showed the sources to be WiMax base station signals.







- Subsequent on/off tests performed by the FCC, Clear, and the NWS confirmed these sources. NTIA understands that Clear wanted more clarification as to whether front-end overload might have been occurring; detailed analysis shows that front-end overload is not occurring.

Results of Jacksonville Nexrad Measurements

- Jacksonville Nexrad operates at 2705 MHz, which represents the worst case for adjacent-band interference coupling.
- This frequency is the lowest that is assigned in the Government Master File (GMF) for radars in the band 2700-2900 MHz .
- The Jacksonville Nexrad shows 4 visible strobes. However…
- ...the Nexrad IF measurements showed 12 azimuths with interference from WiMax transmitters. (That is, 8 of the 12 degraded data but were too weak to appear as strobes.)
- On/off tests were performed at 84.5 and 200.3 degree azimuths, which had visible strobes, to confirm that the sources were Clear WiMax base stations.
- One of the interfering signals was tuned to 2561 MHz, 144 MHz from the Nexrad's frequency.

How Might We Resolve the Problem?

- The data show that for worst-case coupling (Wimax at 2690 MHz and Nexrad at 2705 MHz, 2-3 km apart) the WiMax emissions need an additional 52 dB or so of suppression.
- Off-tuning the WiMax transmitter helps mitigate the interference (dependent on the roll-off of the transmitter, as some are better than others and have a faster roll-off rate).
- Increased physical separation between the Nexrads and WiMax base stations helps to mitigate the interference.
- Down-tilting the Wimax antenna a few degrees helps to mitigate the interference.
- Using lower Wimax antenna height helps to mitigate interference.
- All of these less expensive and obtrusive options can be used together to mitigate interference.
- Placing filters on the output of the Wimax transmitters to reduce their OOB levels in the 2700-2900 MHz band mitigates the interference.
- Filters can cost more money to install, especially to retrofit them to existing Wimax base stations. New installations the cost is minimal.

Long-Term Solution is Needed That Can Work at *All* Locations

- NTIA understands that Clear is still building out its network.
- The NWS Nexrad and FAA ASR radars will continue to operate in the band 2700-2900 MHz.
- Any solution must protect both Nexrads and ASRs.
- Filtering on the WiMax base stations to reduce their out-of-band emissions above 2700 MHz is thought to be the most effective solution to protect both types of radar systems.
- Working with NTIA, Clear bought and installed filters at Grand Rapids and Jacksonville that had the required suppression levels and were built weatherproof. The filters mitigated the interference based on post-testing analyses of the Nexrad data by the NWS.
- The other techniques were also used in places where enough isolation could be attained without them, and the filters were not required.

Status and update

- Clear has been coordinating wit the NWS to obtain frequencies and locations of Nexrad radars. They use this information to site their network tower locations and to set their frequency plan to avoid interference problems as they add new base stations, using geographical and frequency separation from Nexrad stations.

- Using the filters and the other techniques (cited in the report given in the next paragraph), Clear has mitigated the interference at most places. There are still a few instances of interference to resolve but they are fixable.

- Adjacent channel interference can be resolved by coordination between stake holders and using sound engineering practices with testing and measurements.

- NTIA has published the final report of the investigations, findings, and EMC analyses to determine WiMax and Nexrad coordination distances in NTIA Technical Report TR-13-490 titled: *Analysis and Resolution of RF Interference to Radars Operating in the Band 2700-2900 MHz from Broadband Communication Transmitters*, which can be downloaded at: http://www.its.bldrdoc.gov/publications/2684.aspx