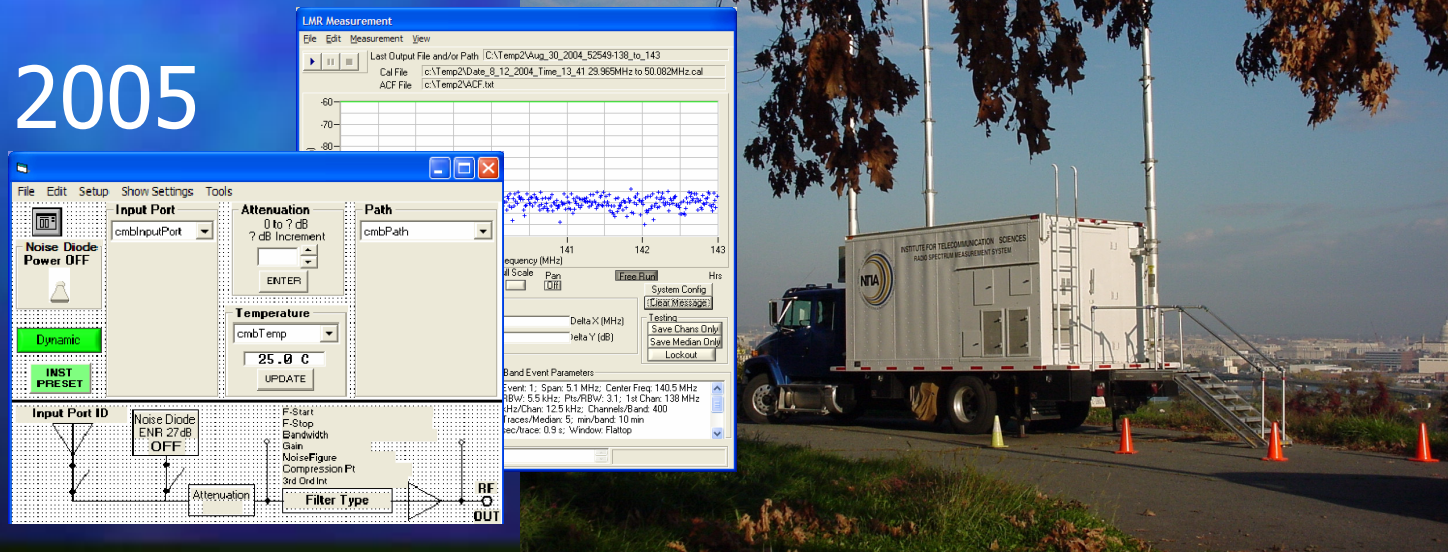
Institute for Telecommunication Sciences
Boulder, Colorado

Measurement and Processing to Determine Land-mobile Radio (LMR) Channel Occupancy

Randy Hoffman

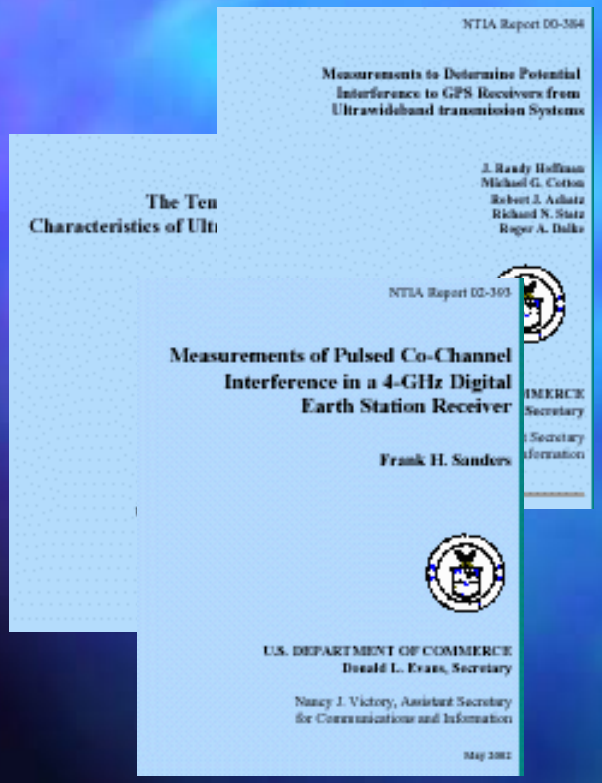
ISART 2005



Topics of Discussion

- Who are we?
- Purpose of measurements
- Challenges
- Techniques for measurement
- Post processing methods

Radio Spectrum Measurement Program - Mission



To provide the Executive Branch, critically needed:

- Radio spectrum data
- Data analysis
- Reports and summaries

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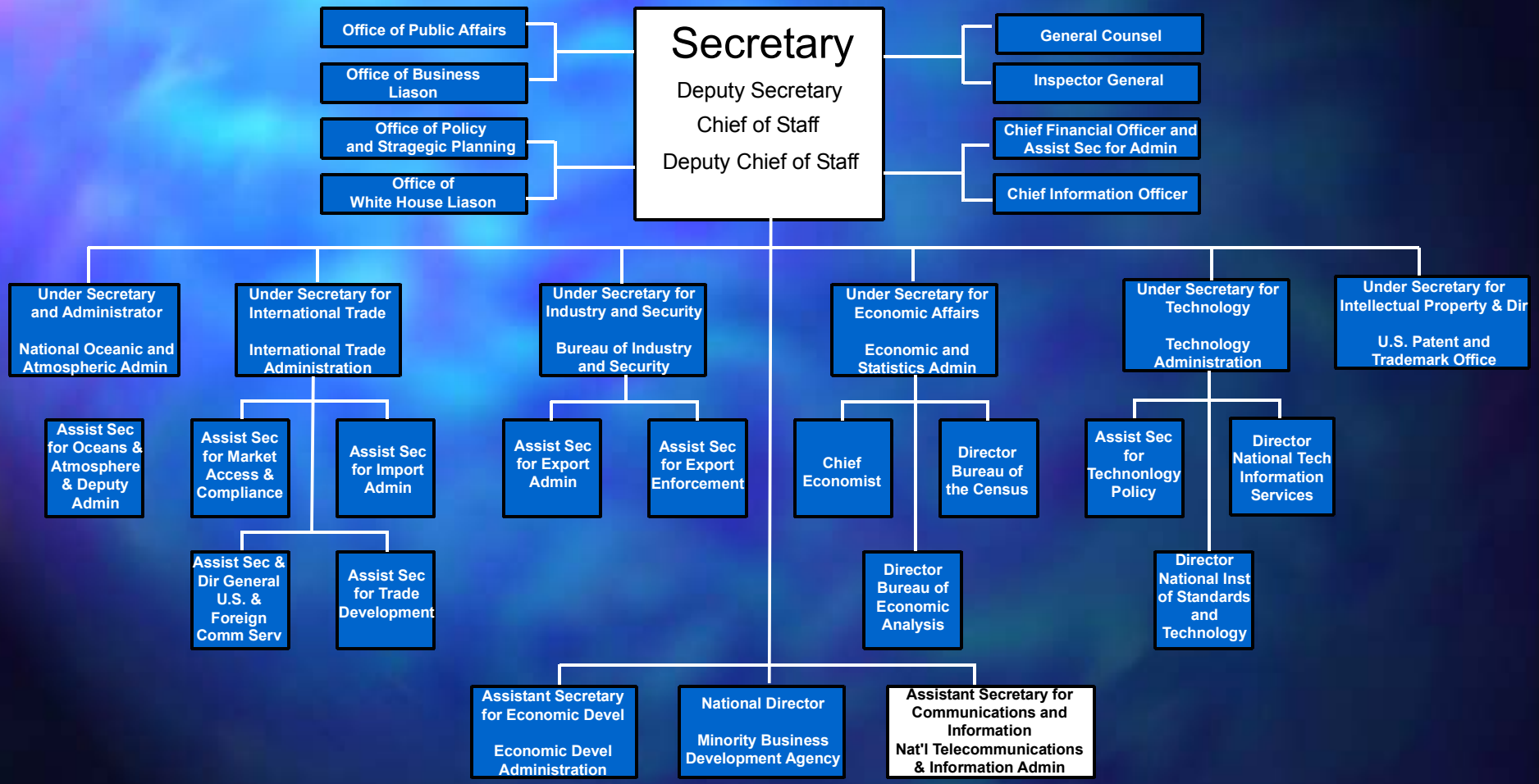
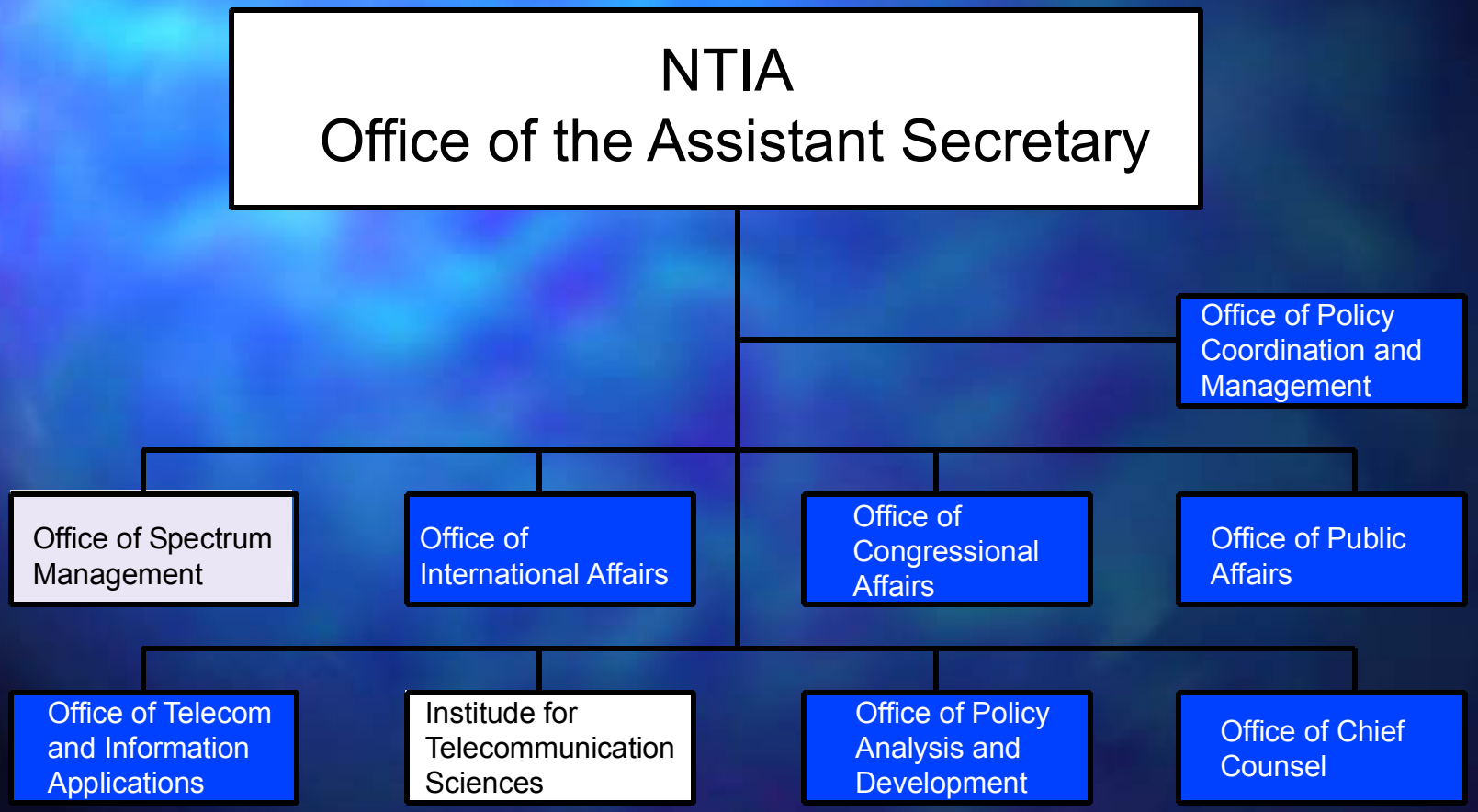
U.S. Department of Commerce



National Telecommunications and Information Administration



Responsibilities

- Under Departmental Organization Order 25-7, issued 5 October 1992, and amended 3 December 1993, the NTIA Office of Spectrum Management (OSM) is responsible for identifying and making arrangements for measurements necessary to provide NTIA and the various departments and agencies with information to ensure effective and efficient use of the spectrum.
- The Radio Spectrum Measurement System (RSMS) resides at ITS and is tasked to perform spectrum measurements as required to fulfill this mission.

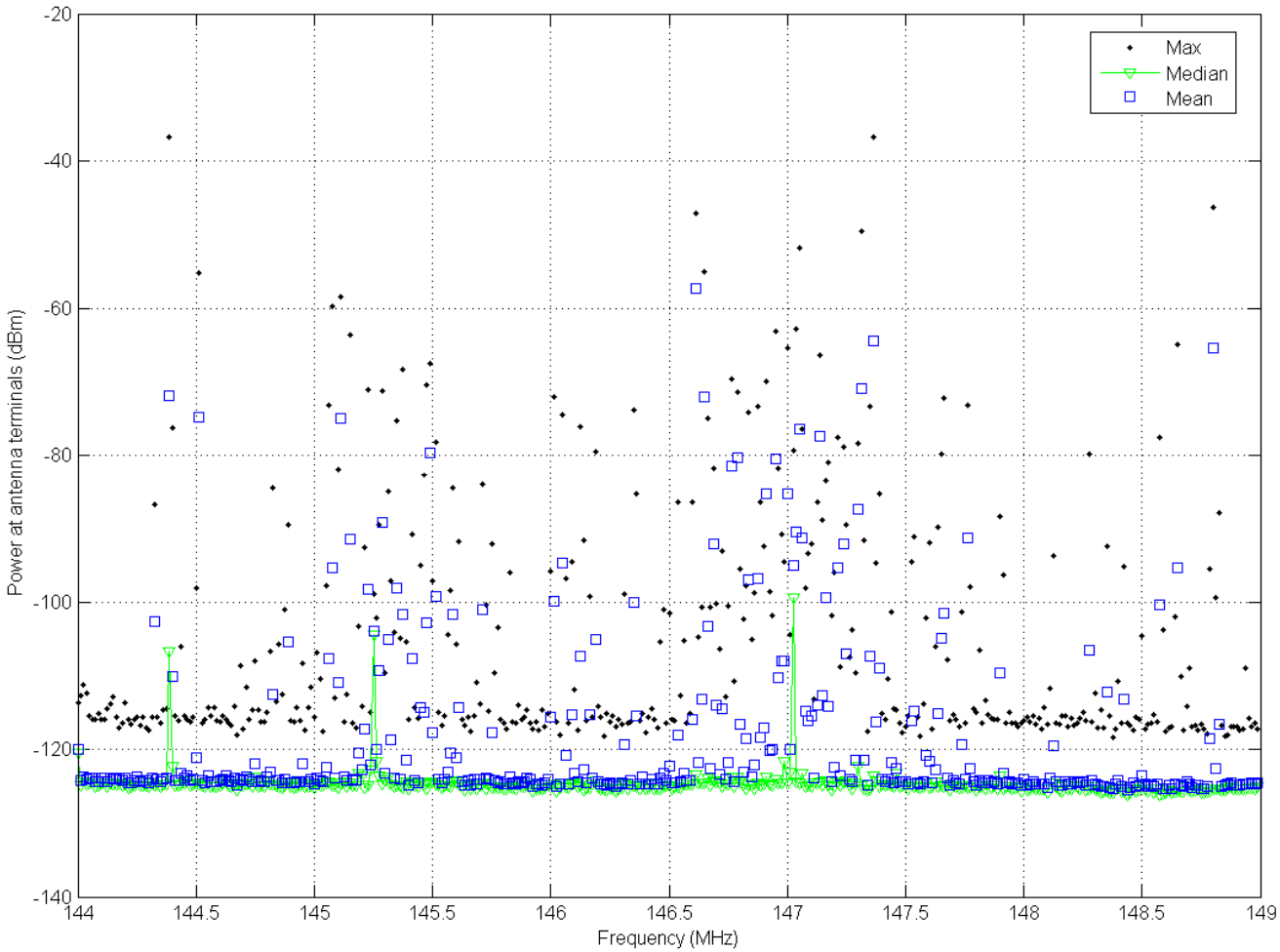
Why LMR Measurements?

- Update usage trend information comparing data collected in mid 70's – for future LMR spectrum management.
- To determine current usage:
  - to help with decisions regarding how to make federal LMR radio operations more efficient.
  - Provide information for realistic design of possible shared trunked system.

Challenges

- Wide dynamic range
  - Need for high sensitivity (low noise figure)
  - Strong local signals
  - 100 dB Dynamic Range

Challenges


Max
Median
Mean
-20
-40
-60
-80
-100
-120
-140
Power at antenna terminals (dBm)
144
144.5
145
145.5
146
146.5
147
147.5
148
148.5
149
Frequency (MHz)

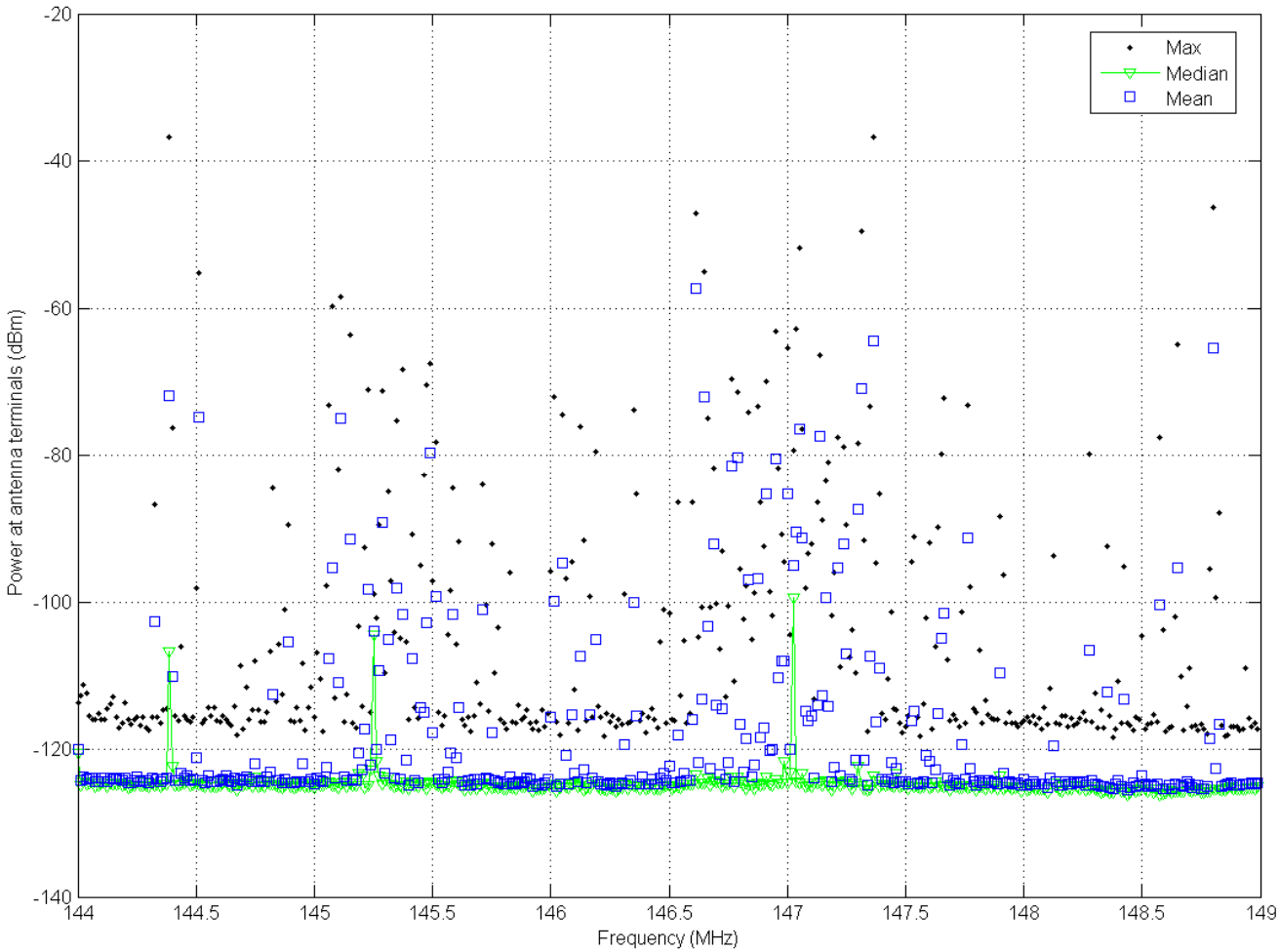
Challenges

- Wide dynamic range
- Narrow channel spacing
  - Need to resolve individual channels with a minimum of 12.5 kHz spacing
  - Requires:
    - narrow resolution bandwidth
    - sharp roll-off
    - large stopband attenuation.

Challenges

- Wide dynamic range
- Narrow channel spacing
- Differentiation from system noise
  - Need to know what is system noise and what is signal

Challenges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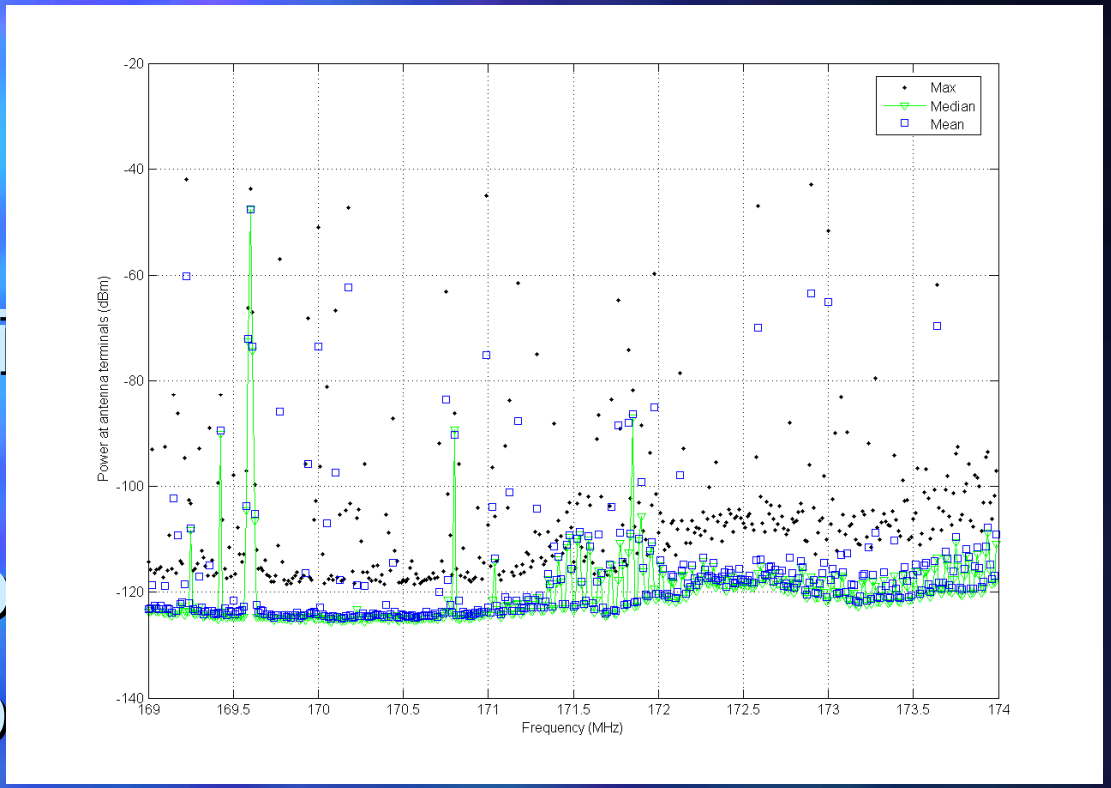
Frequency (MHz)

Challenges

- Wide dynamic range
- Narrow channel spacing
- Differentiation from system noise
- Impulsive noise
  - Need to reduce the probability that impulsive noise is mistaken for a signal

Challenges

- Wide dynami
- Narrow chan
- Differentiatio
- Impulsive no
- Strong out-of-band signals
  - System overload
  - Complicate in-band thresholds



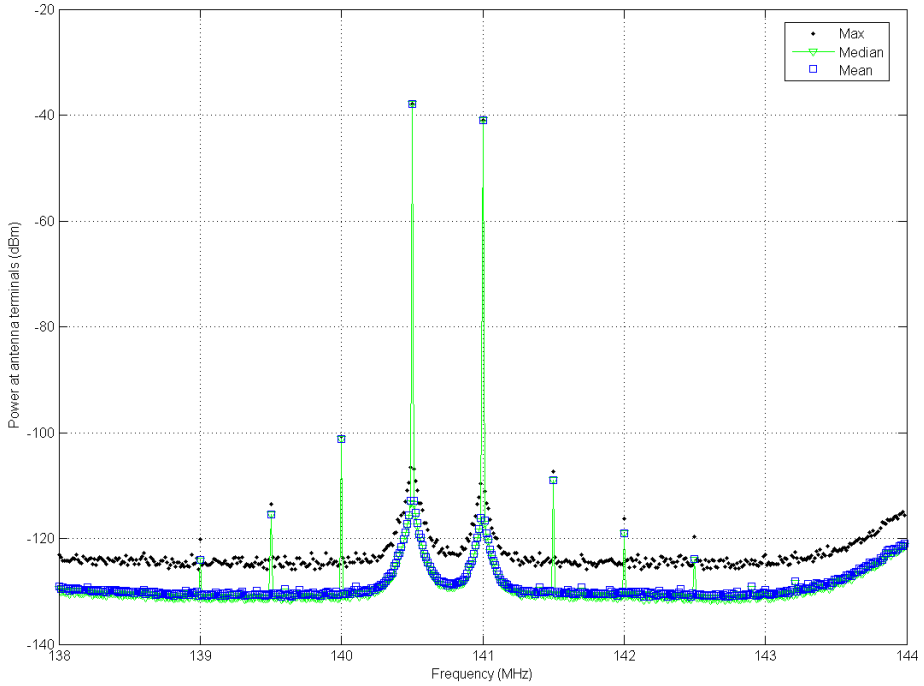
Challenges

- Wide dynamic range
- Narrow channel spacing
- Differentiation from system noise
- Impulsive noise
- Strong out-of-band signals
- Strong in-band signals
  - System overload

Challenges

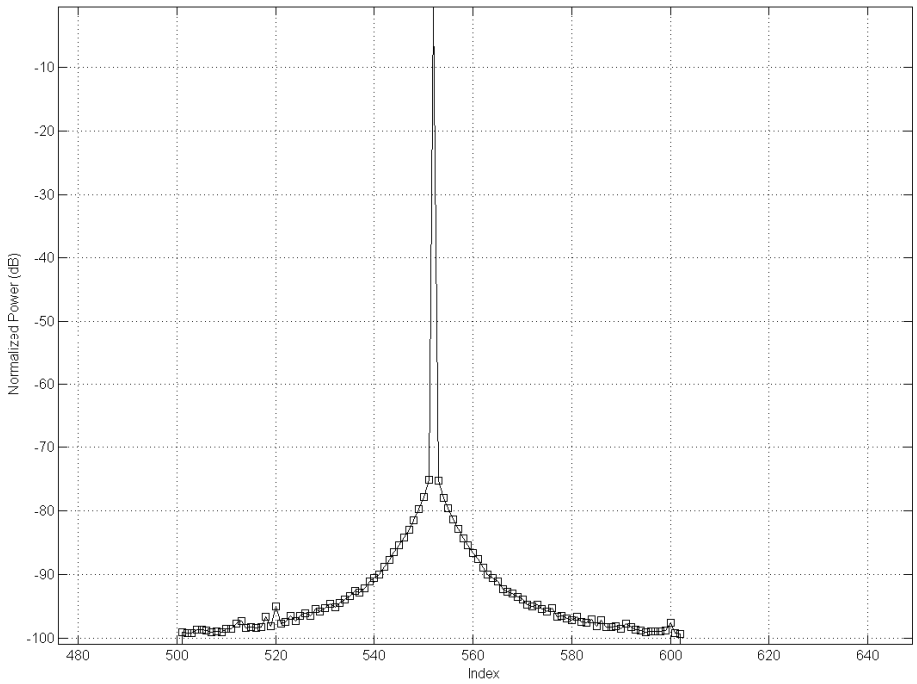
- Wide dynami
- Narrow chan
- Differentiatio
- Impulsive no
- Strong out-o
- Strong in-band signals
  - Intermodulation products

IM = +/- mF1 +/-nF2

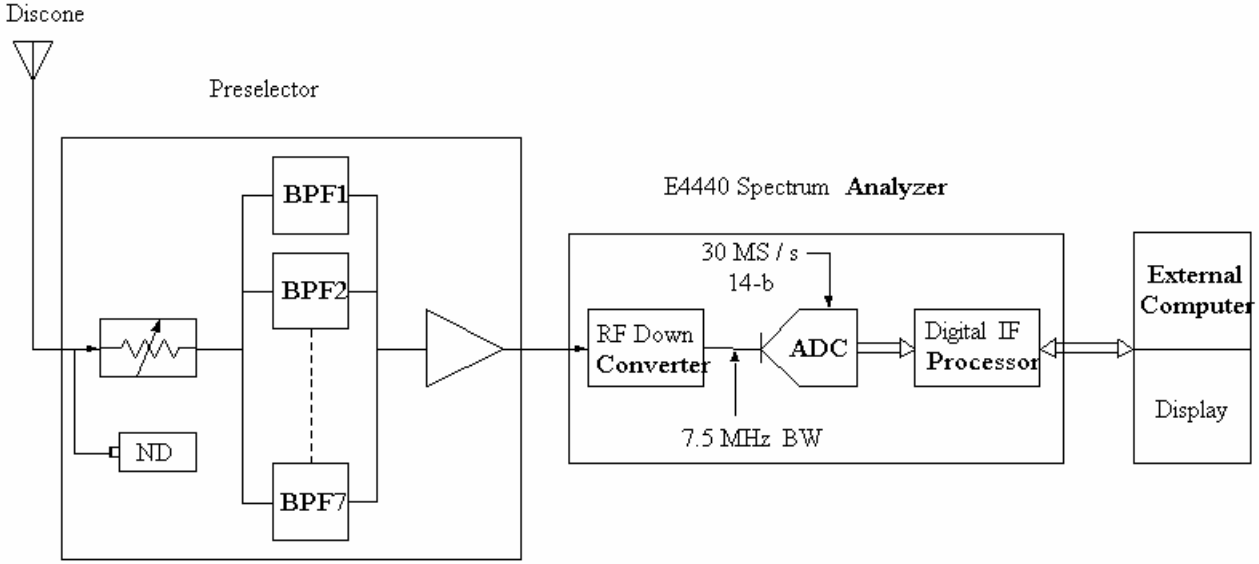


Challenges

- Wide dynami
- Narrow chan
- Differentiatio
- Impulsive no
- Strong out-of
- Strong in-band signals
  - Sideband noise



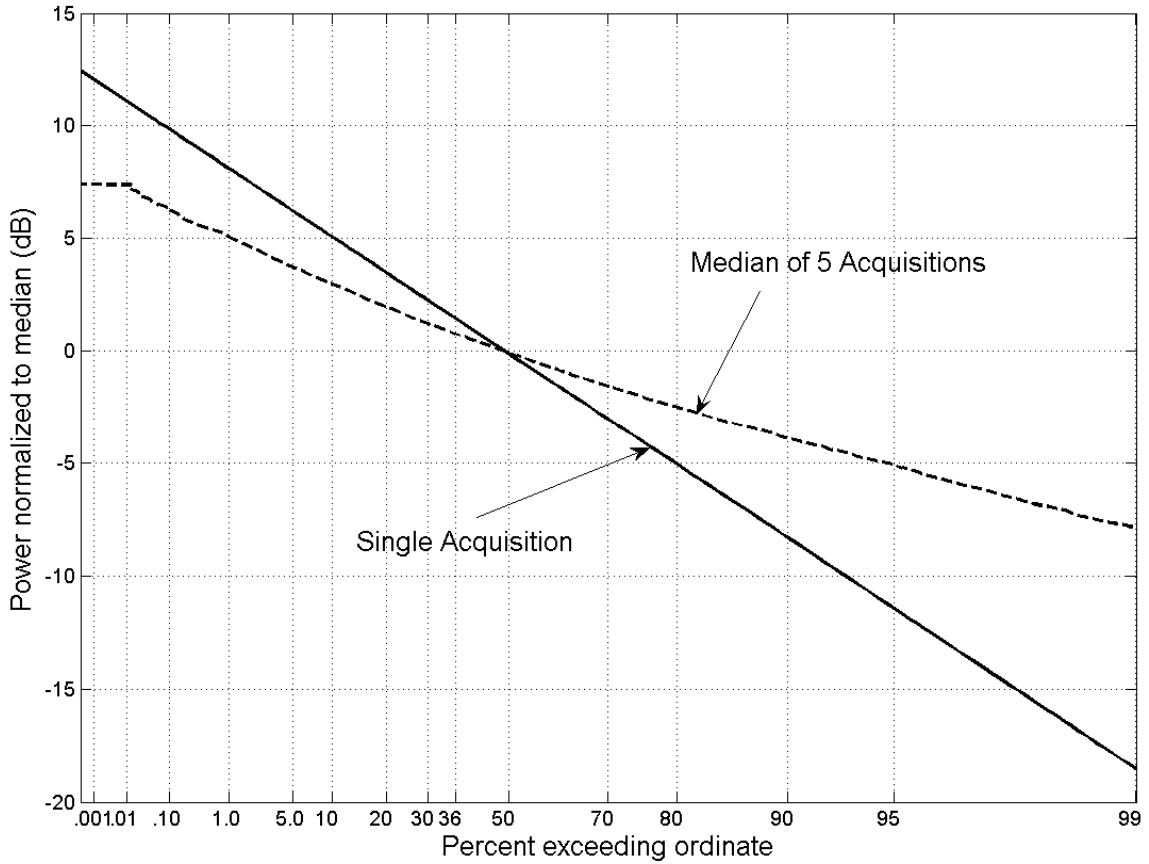
Measurement System



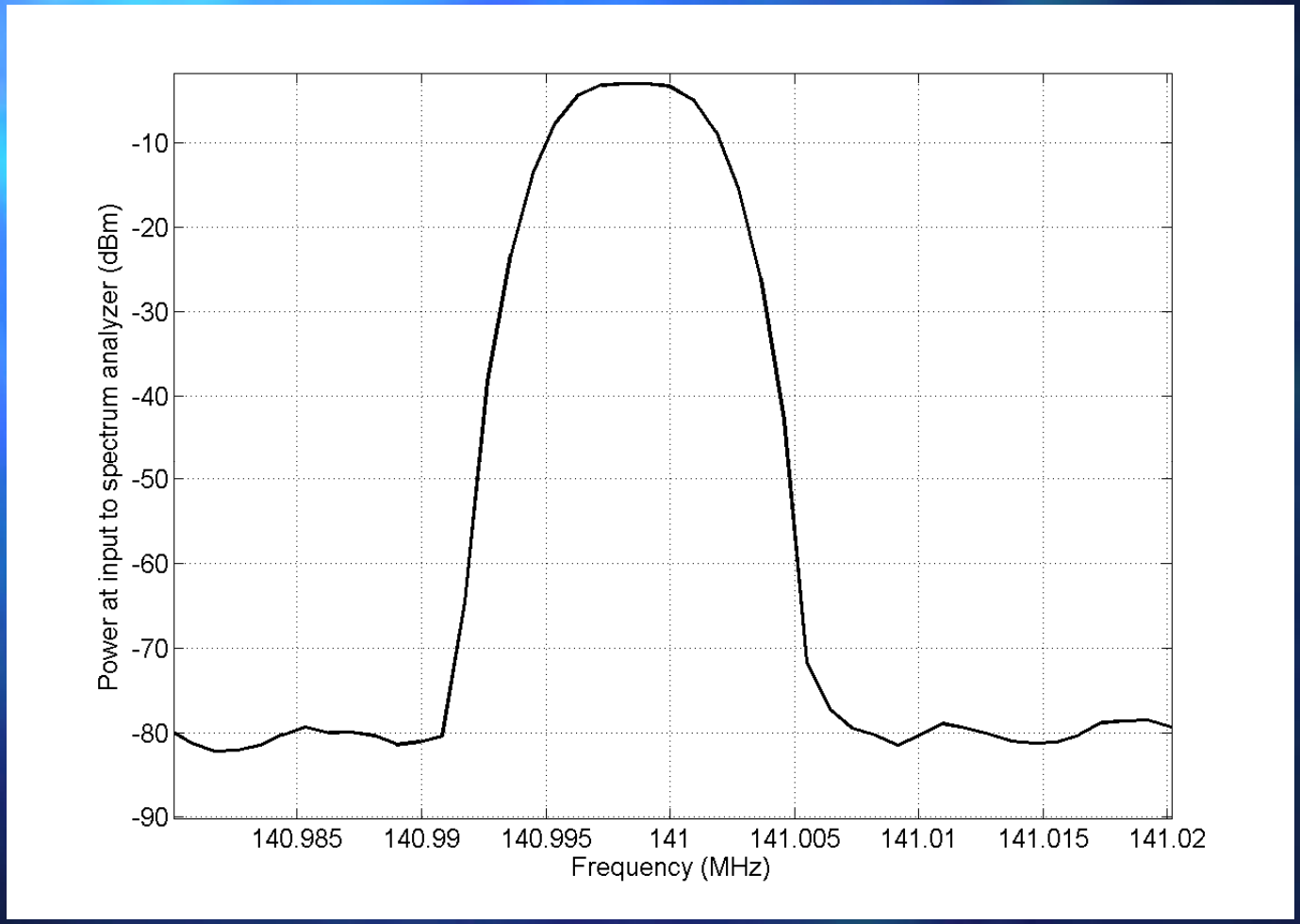
Measurement Procedure

- Careful site selection
- Signals detected by measuring RF energy at the channel frequency – inferring LMR transmission if signal greater than system noise.
- Digitized at 30 Msamples/s in 5.5 MHz bandwidth chunks
- Do fft with flattop window, decimated to 12.5 kHz or 15 kHz spacing with samples centered on the channels, and downloaded via internet connection.
- Acquisition every 200 ms (up to 480 channels)
- Capability for message length statistics.
- Measure for 4 minutes / 5.5 MHz span and switch to next span. Sufficient data to characterize the channel every hour. Measure 24 hours/day for a week.
- Throw away data during overload conditions

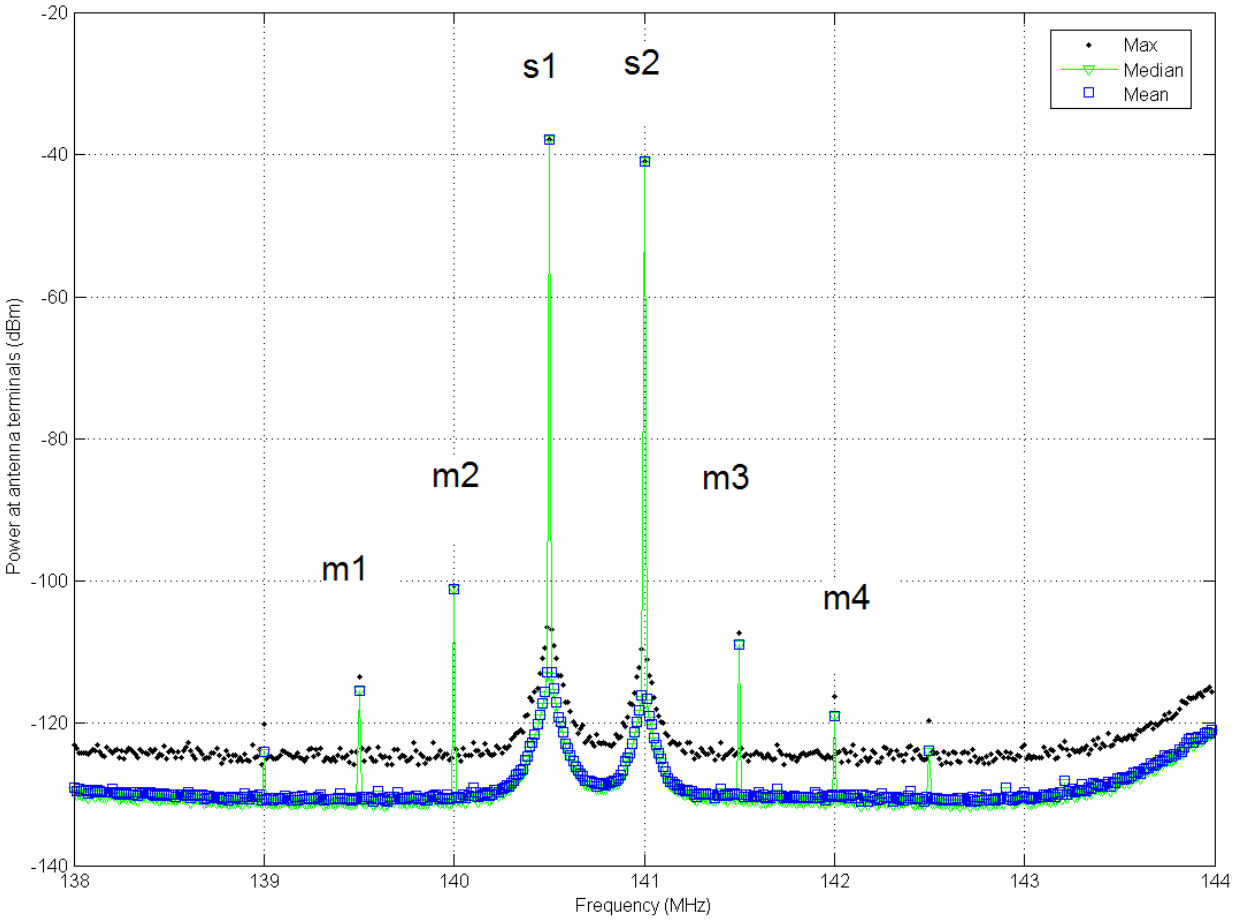
Median Processing



Resolution Bandwidth



Post Processing – Intermodulation



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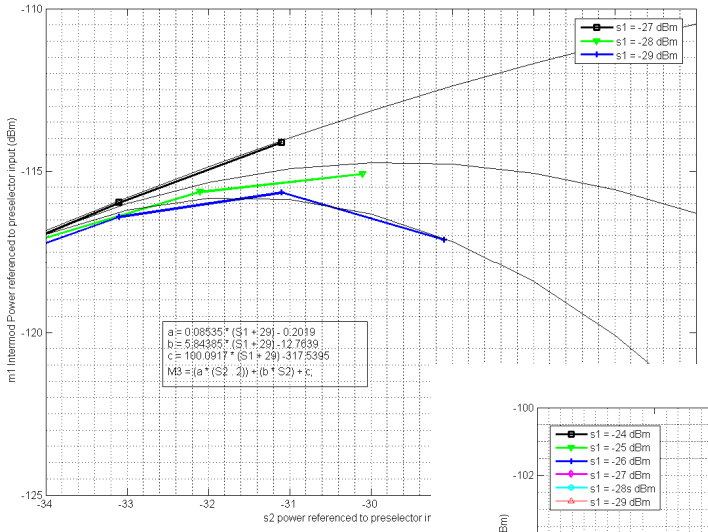

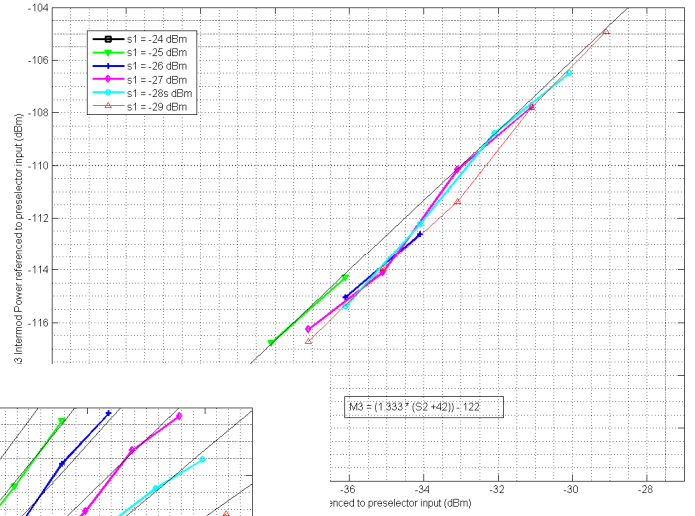

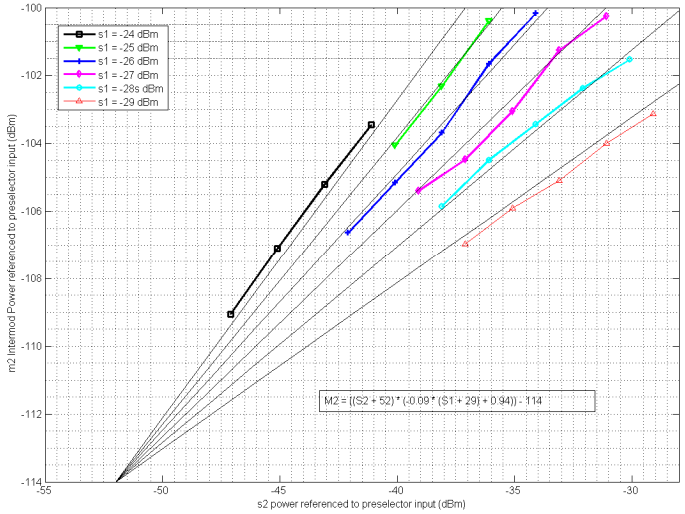

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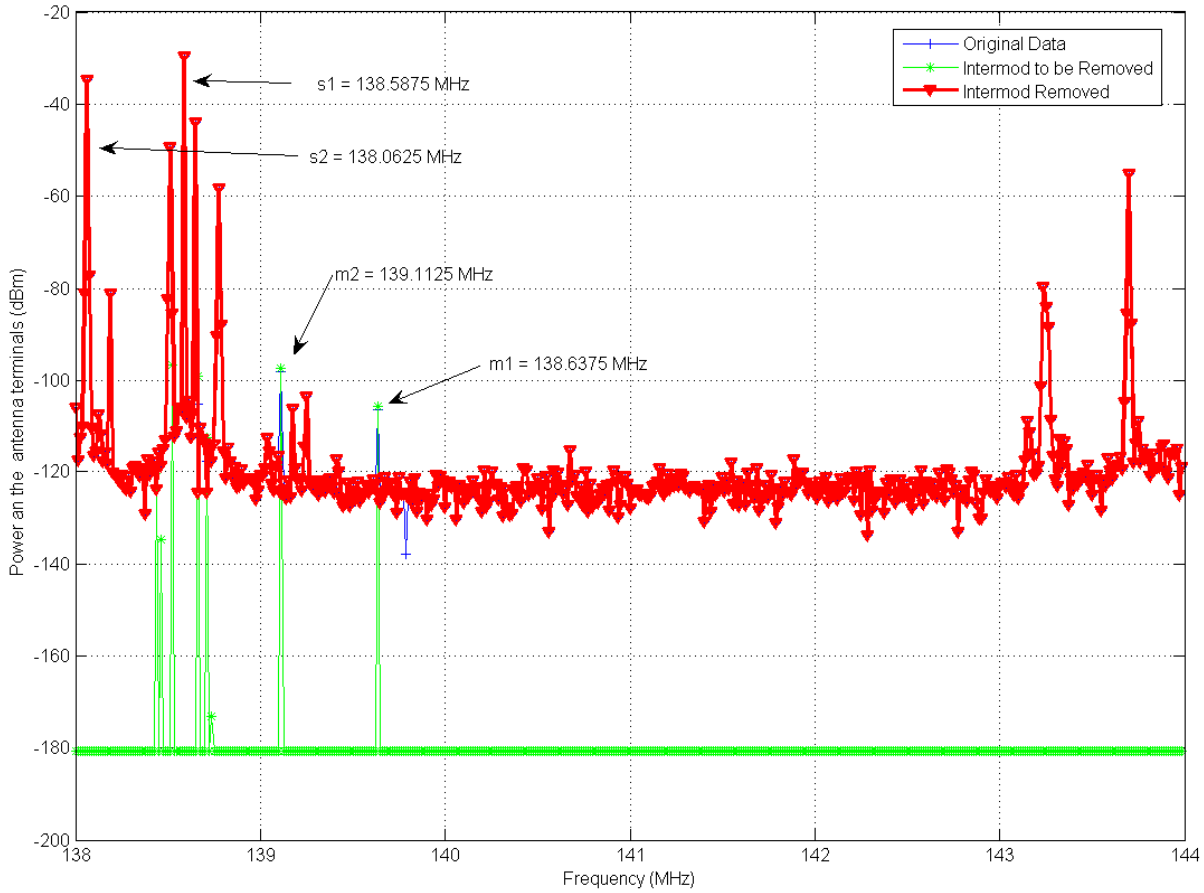

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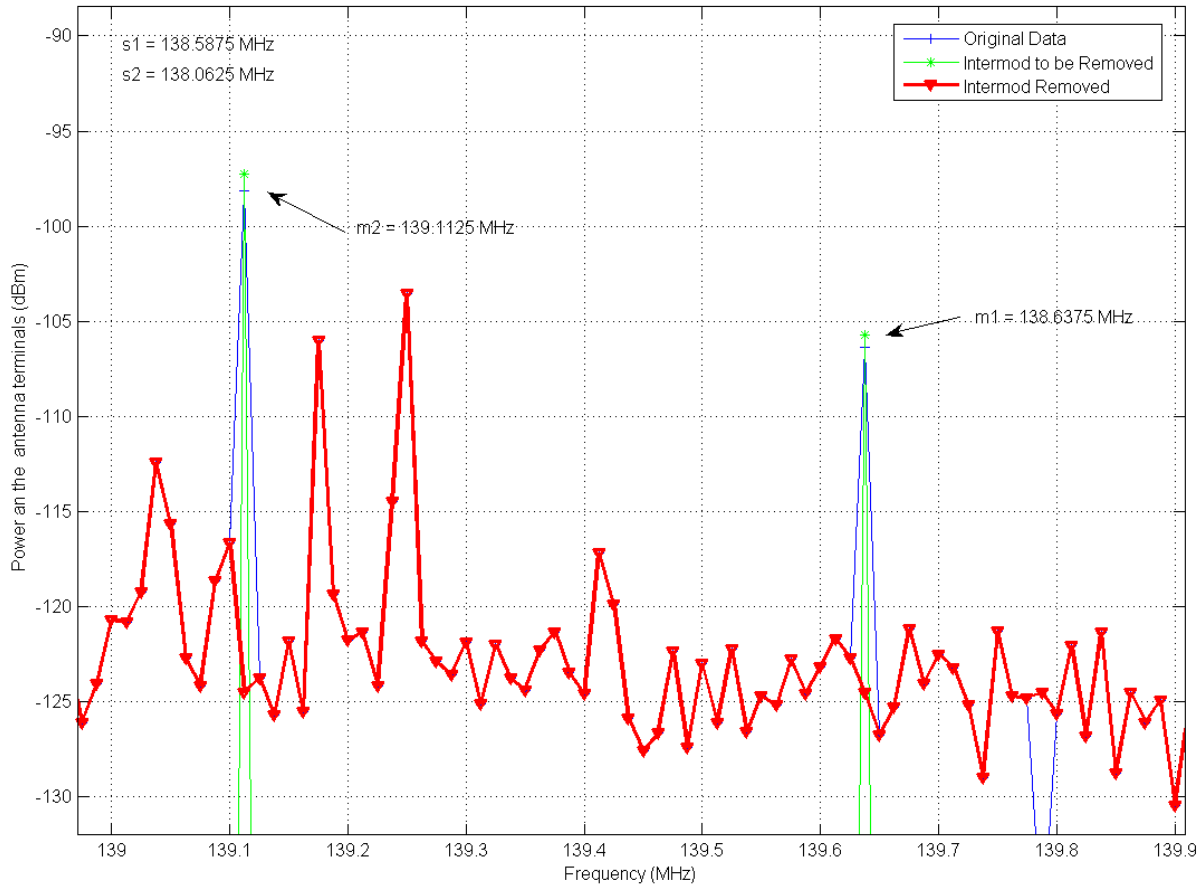
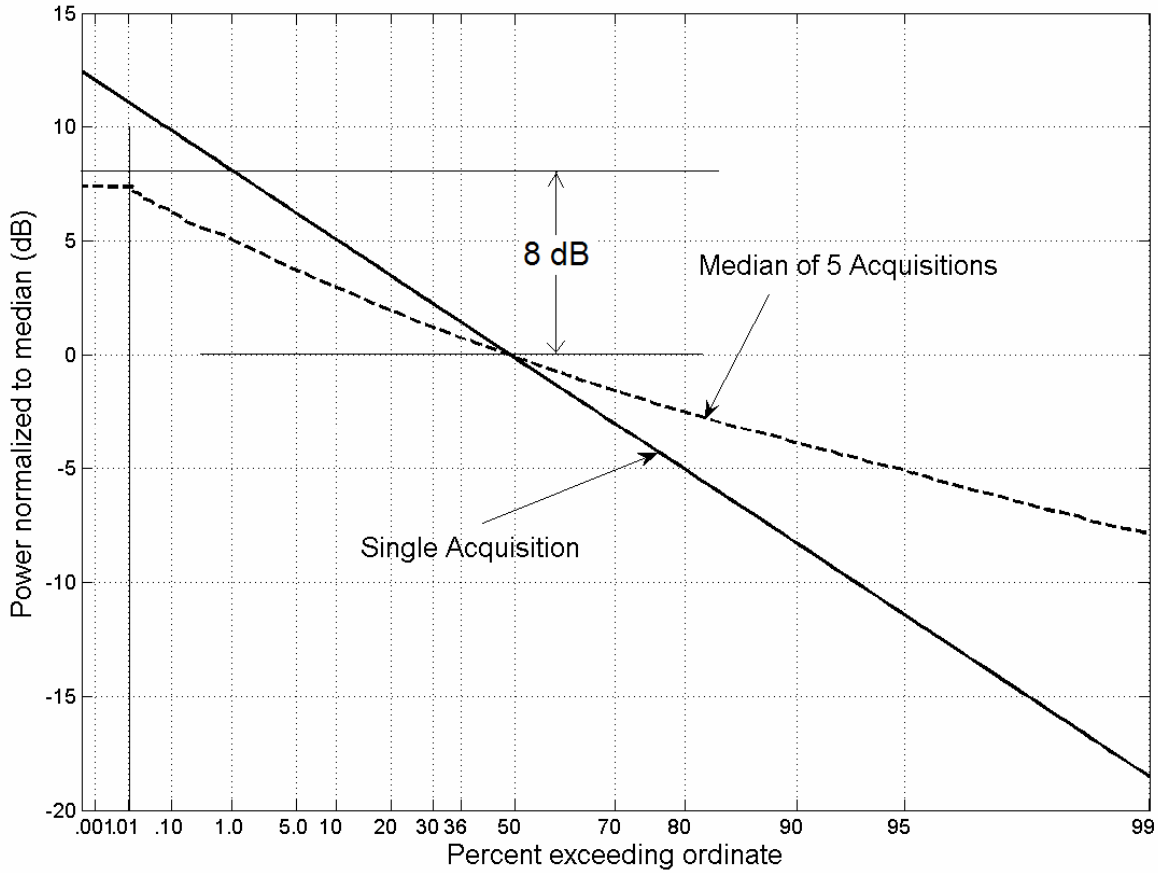


Post Processing – Sideband Noise

Post Processing – Min Threshold



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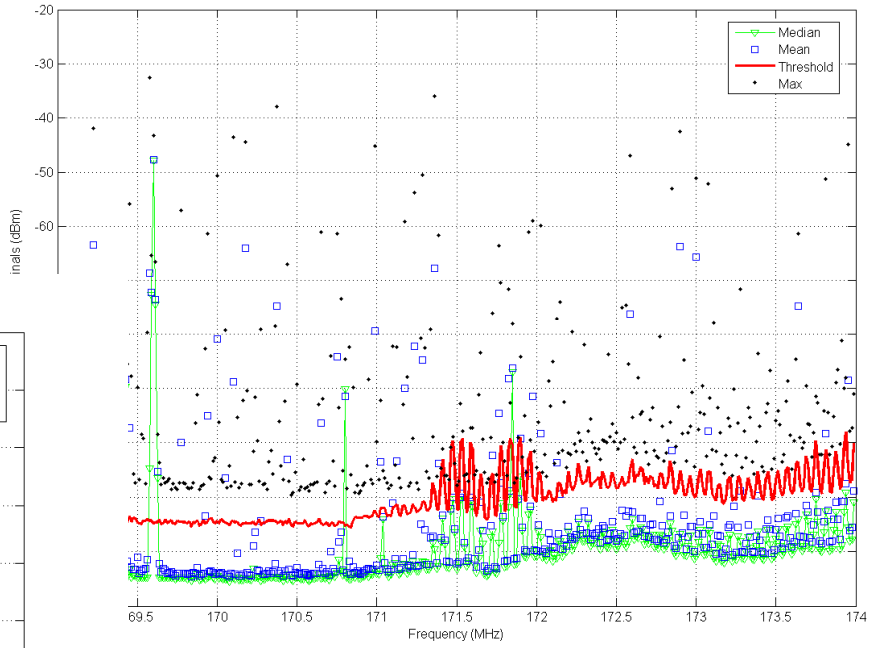
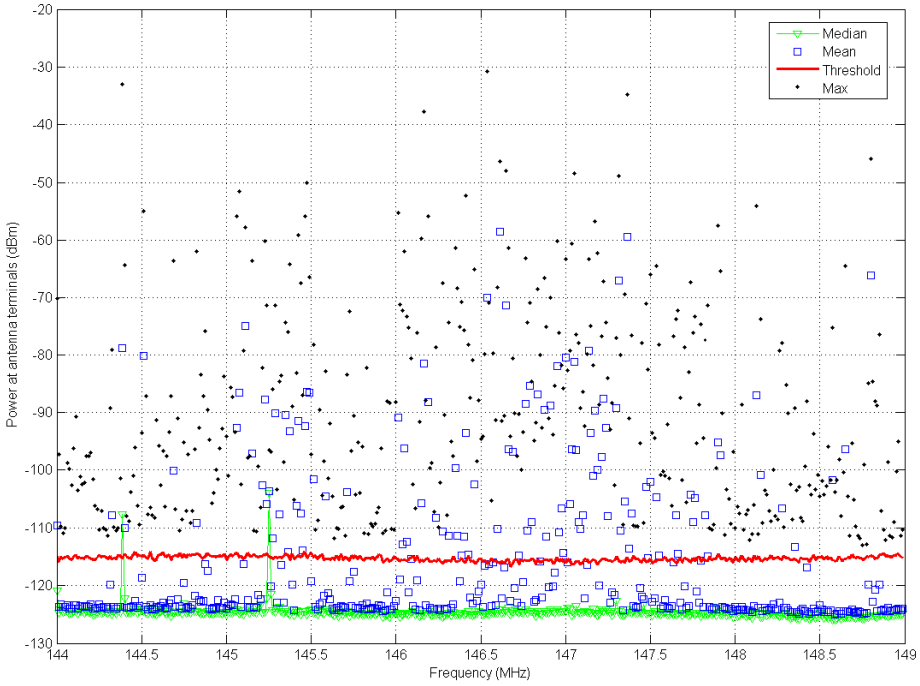
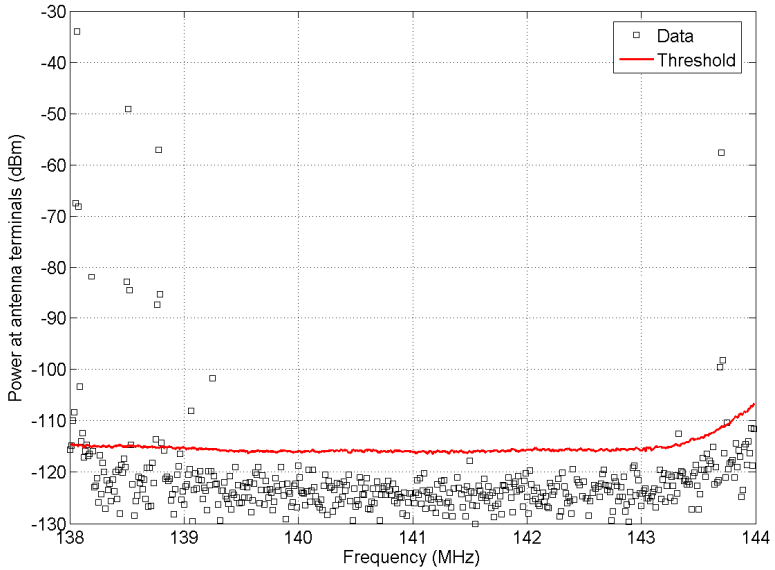
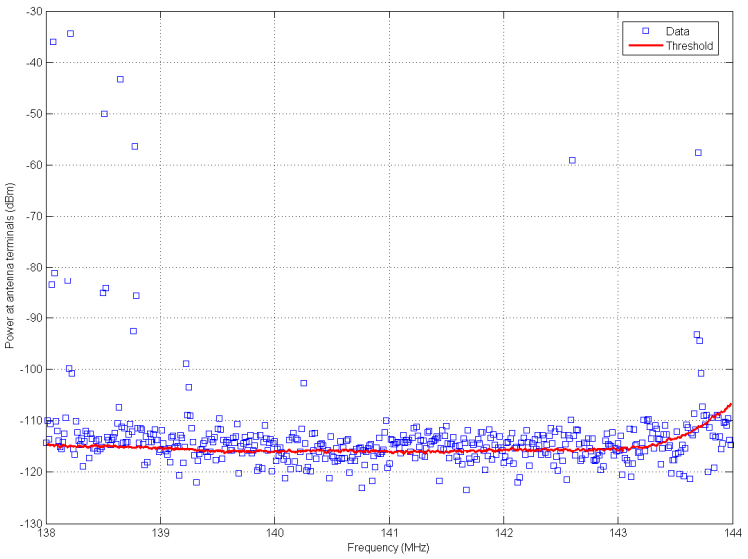




Post Processing – Impulsive Noise





Summary

- Challenges and Solutions
  - Wide Dynamic Range
  - Narrow Channel Spacing
  - Differentiation from System Noise
  - Impulsive Noise
  - Strong Out-of-band Signals
  - Strong In-band Signals
    - Overload
    - Intermodulation Products
    - Sideband Noise
- Report – to be published this year