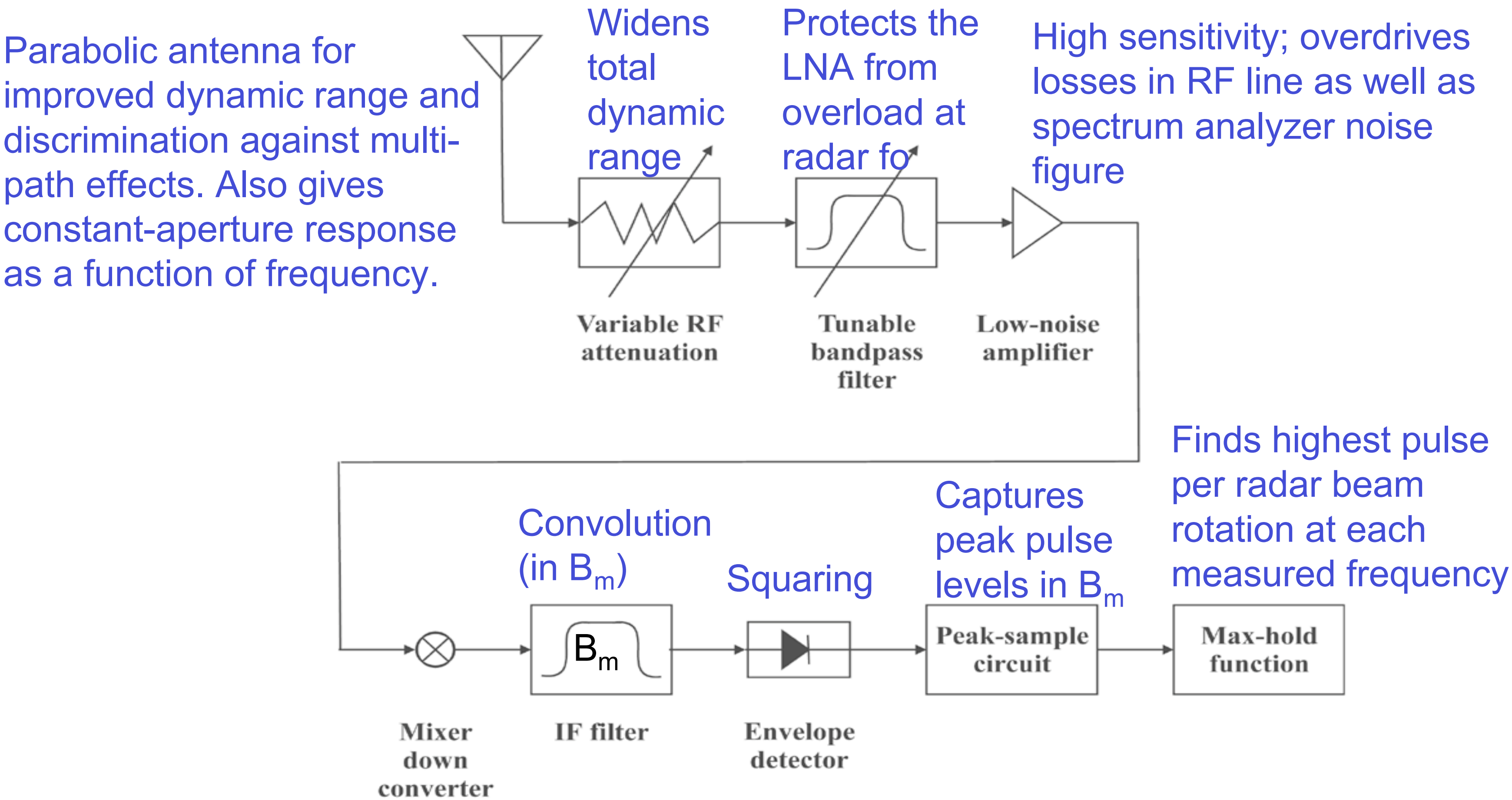
Measurement system functional block diagram



Stepped Mode Measurements

- Basic strategy is to *step* (in a series of zero-hertz time slices) across a frequency range. Each time slice is a little longer than the radar beam rotation interval (2.5 seconds for this radar).

- Sophisticated mode requiring computer control of spectrum analyzer

- Dynamic range of about 60 dB (spectrum analyzer) plus 70 dB (front-end attenuator) for a total of 130 dB maximum dynamic range

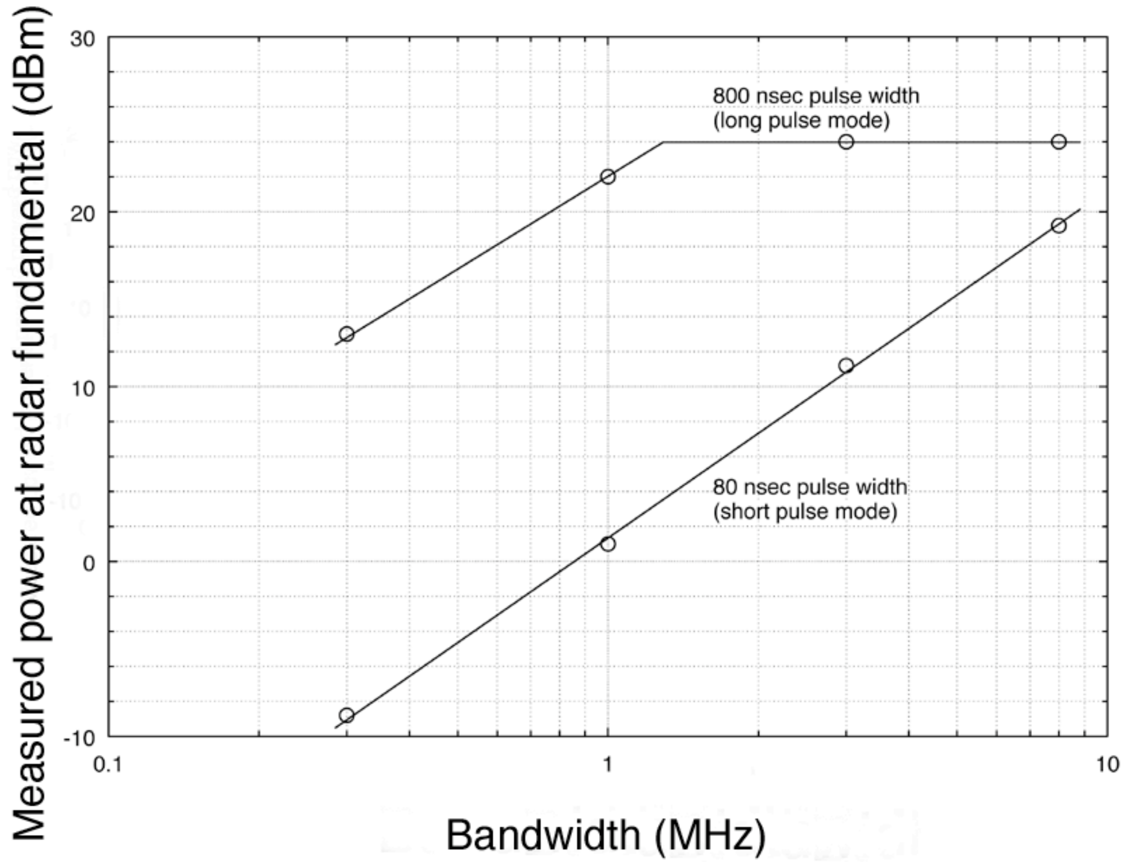
- Critical for measuring radar emissions, plus miscellaneous applications to other transmitters

Extended Dynamic Range

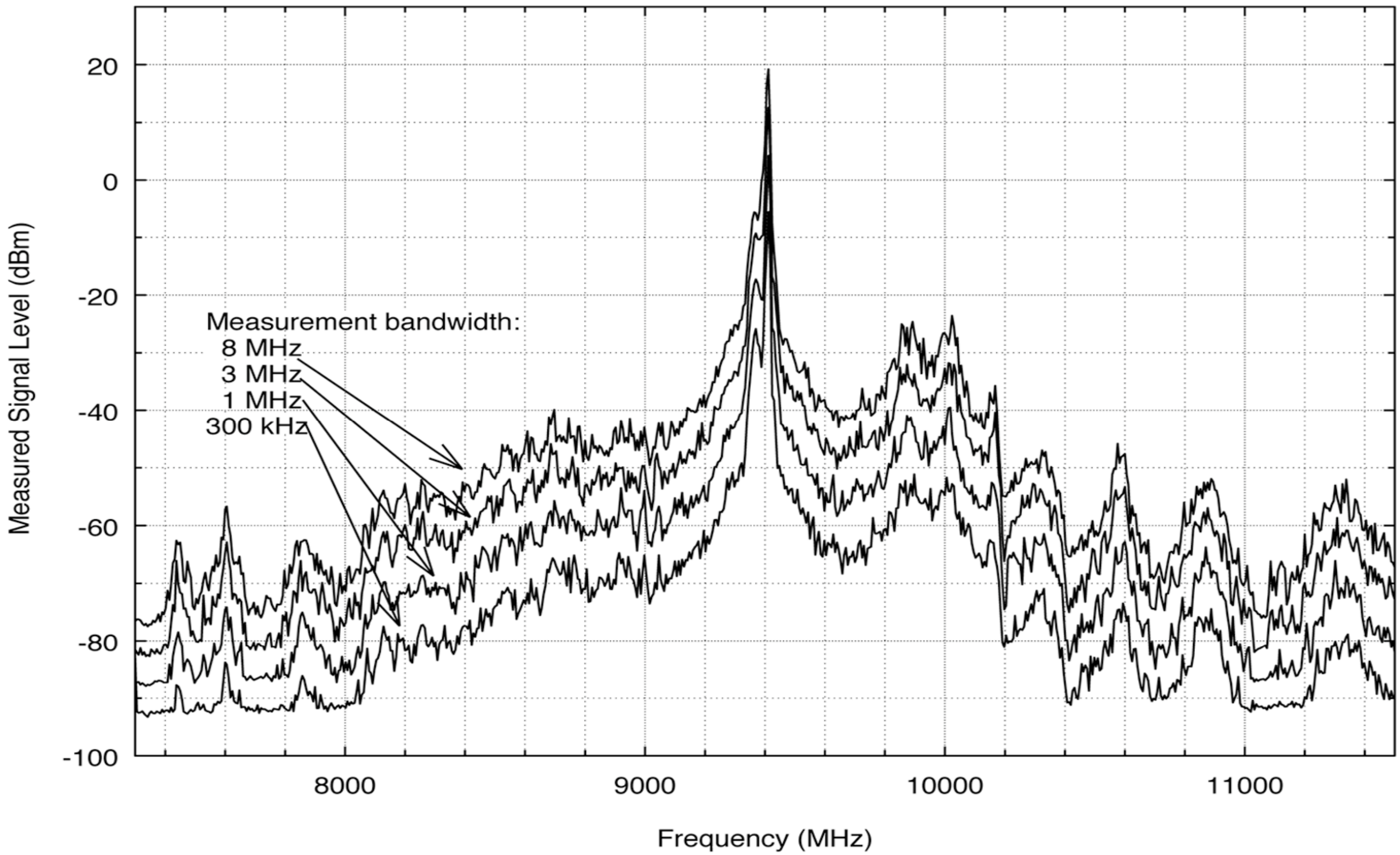
- The combination of hardware and software shown here are critical for measuring radar emission spectra for spectrum management (and other) purposes. This is because of requirements for dynamic range, sensitivity, and efficiency and completeness of the spectrum measurement.

- Incidentally, this is a unique NTIA capability that few (if any) other organizations possess. And it is my personal favorite, as measurements go.

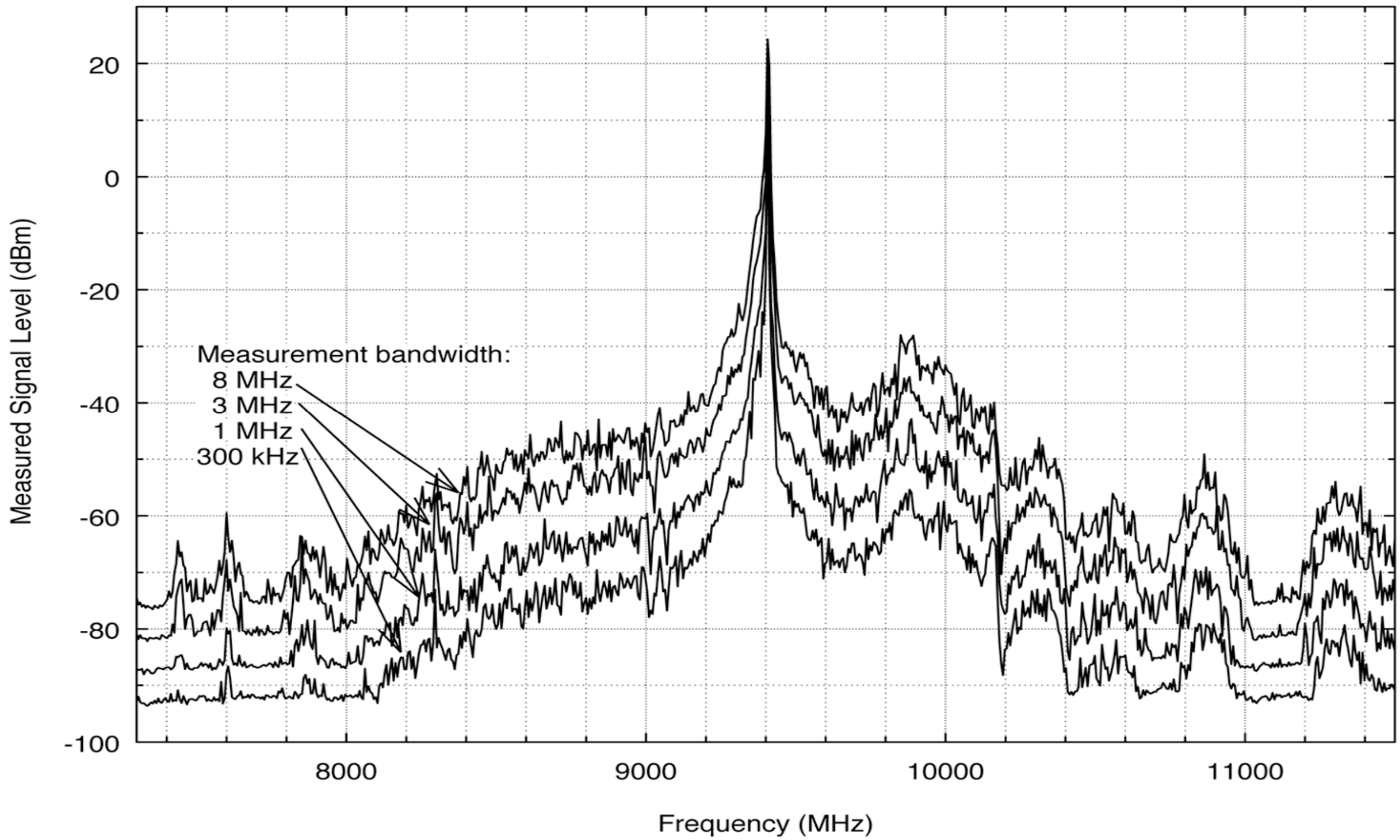
Variation in measured power at radar fundamental as function of measurement bandwidth & pulse mode:



Radar emission spectra measured in four bandwidths, short-pulse mode.



Radar emission spectra measured in four bandwidths, long-pulse mode.



Analysis: Quantify deviation from 20 log progression with B_m:

$$\Delta = \left[\frac{P_x - P_y}{\log\left(B_x / B_y\right)} \right] - 20 \qquad \text{(unitless)}$$

Where:

Delta = deviation from 20log(B_m) progression;
$P_{[x,y]}$ = log power measured in B_x and $B_{y;}$
$B_{[x.y]}$ = measurement bandwidth;
[x,y] are subscripts for successive measurement IF bandwidths (e.g., 3 MHz and 1 MHz)

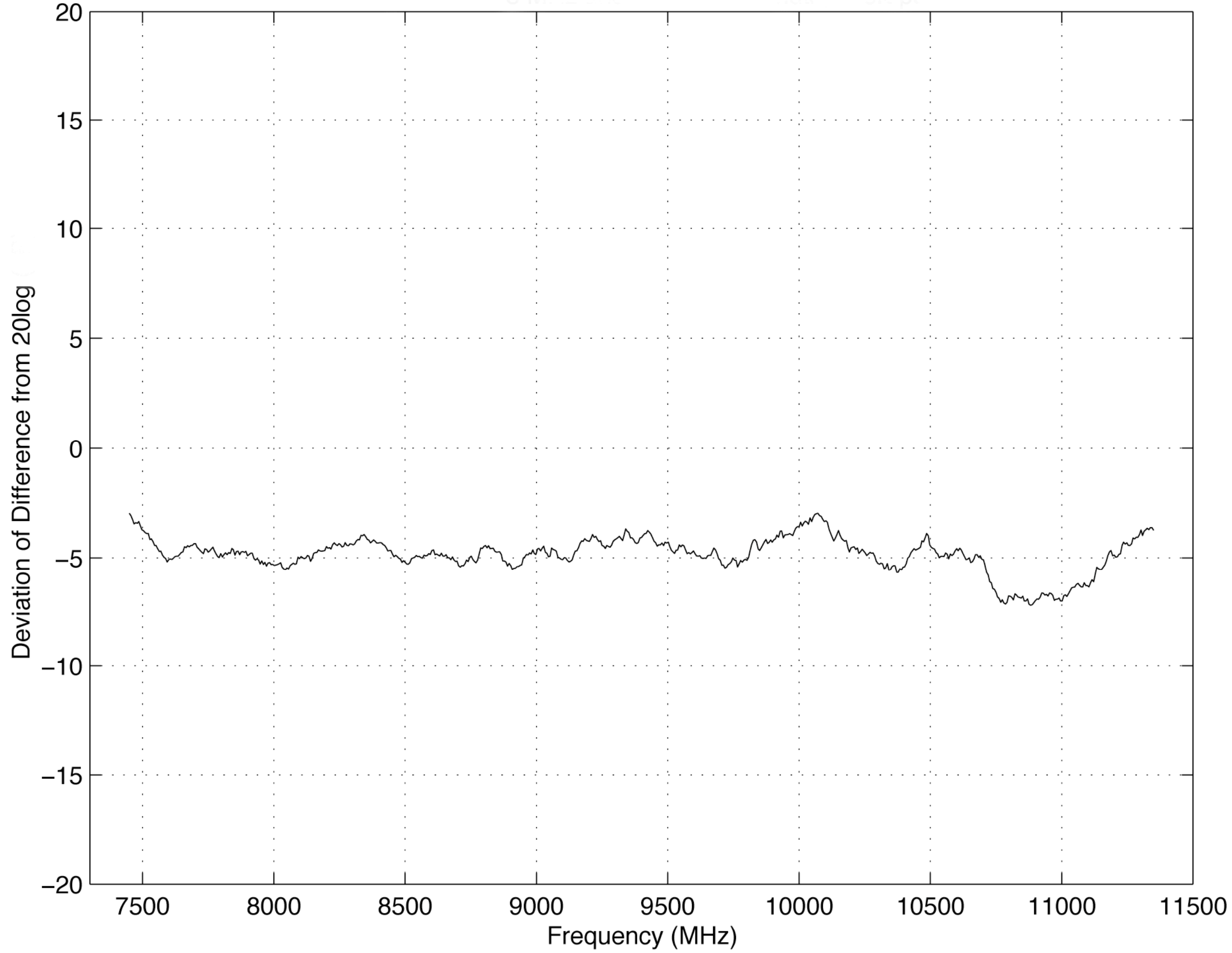
Legal Fine Print

1) All measurements were performed on exactly the same frequencies, so that we could legitimately subtract values on successive curves.

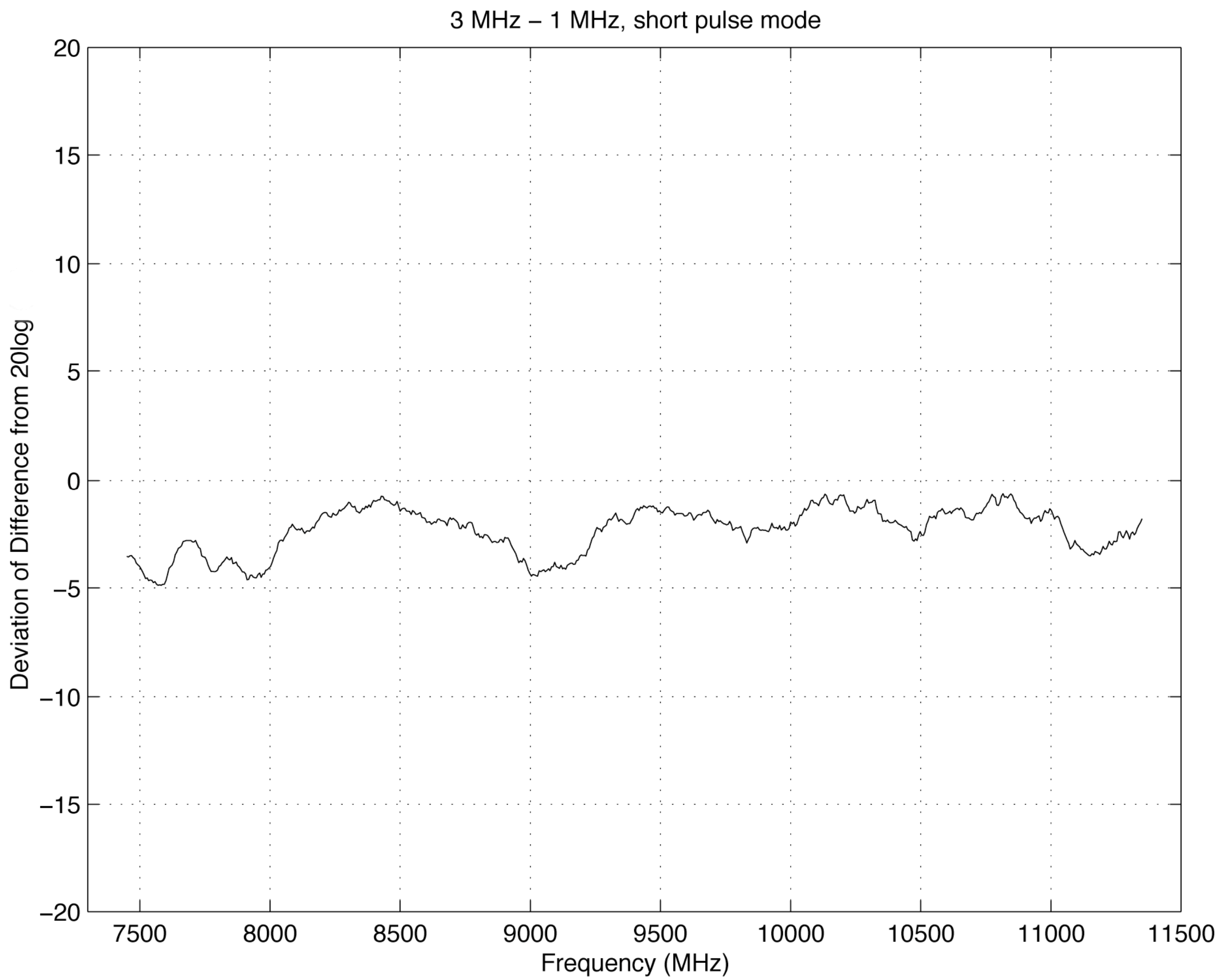
2) Measurement step size was 7 MHz. But special measurements were made on radar fundamental frequencies to make sure that we caught them exactly, too.

3) Differences between the curves were somewhat noisy. So we used a smoothing window to make the difference curves easier to read.

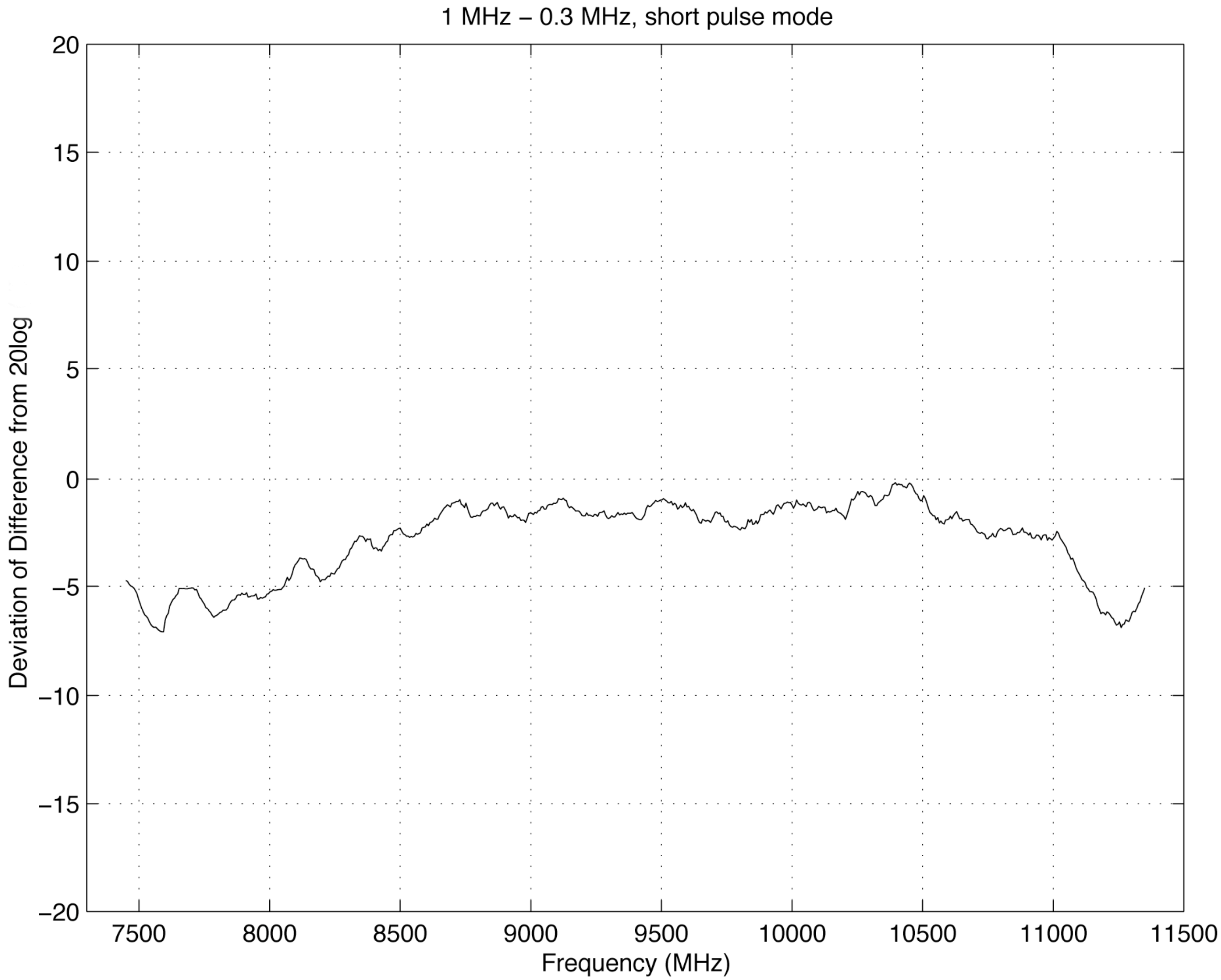
Difference: 8 MHz-3 MHz short pulse mode



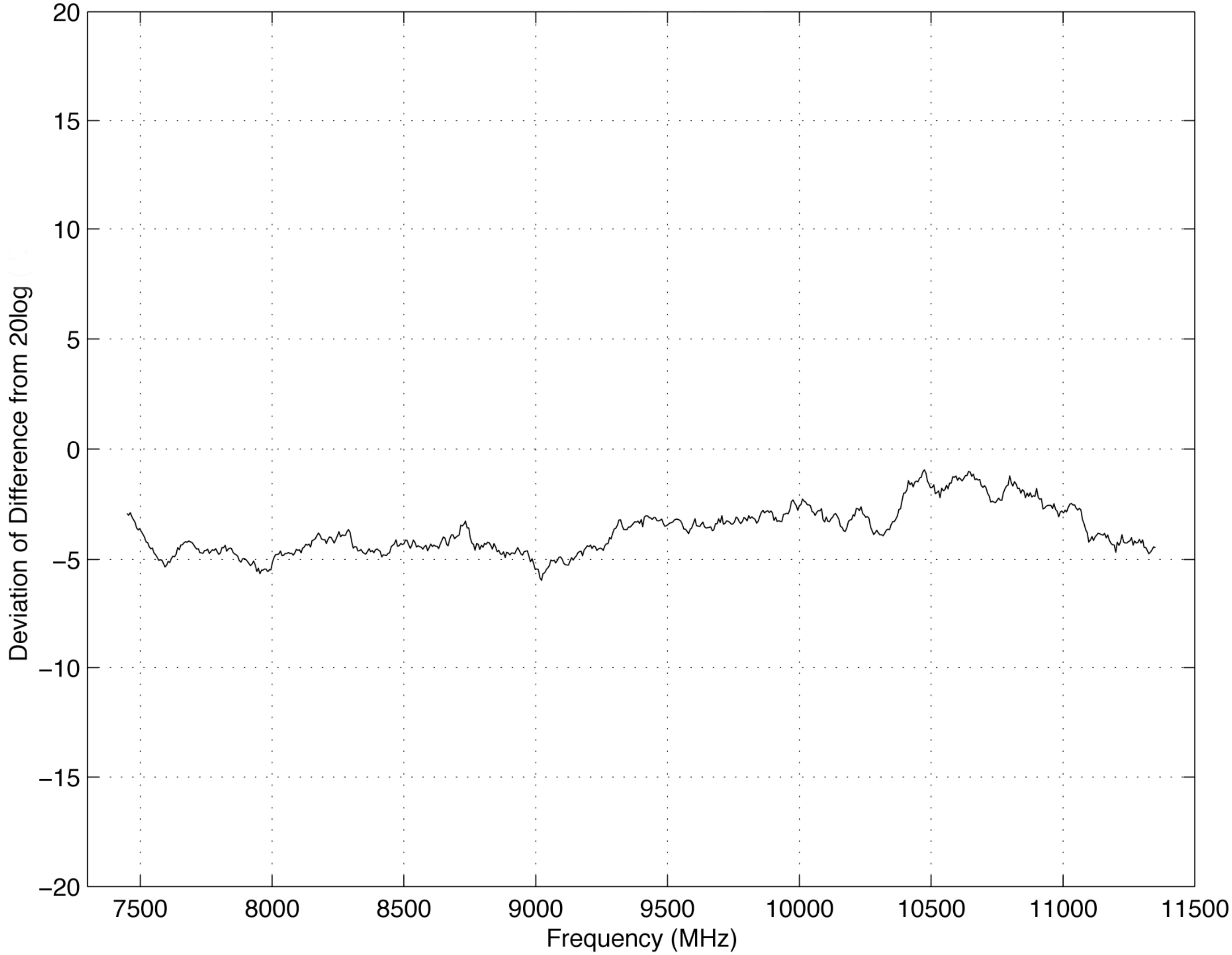
Difference: 3 MHz-1 MHz short pulse mode



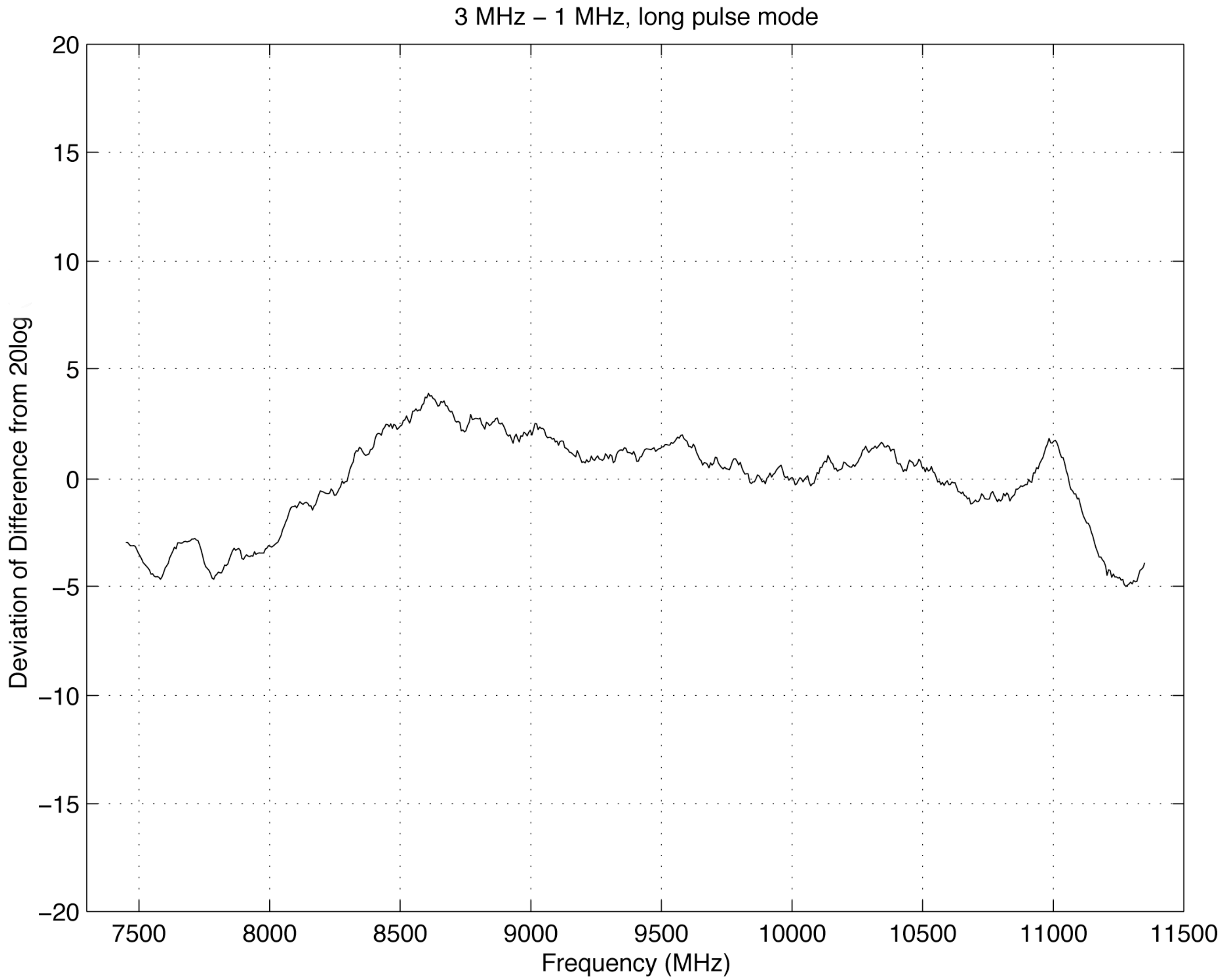
Difference: 1 MHz-300 kHz short pulse



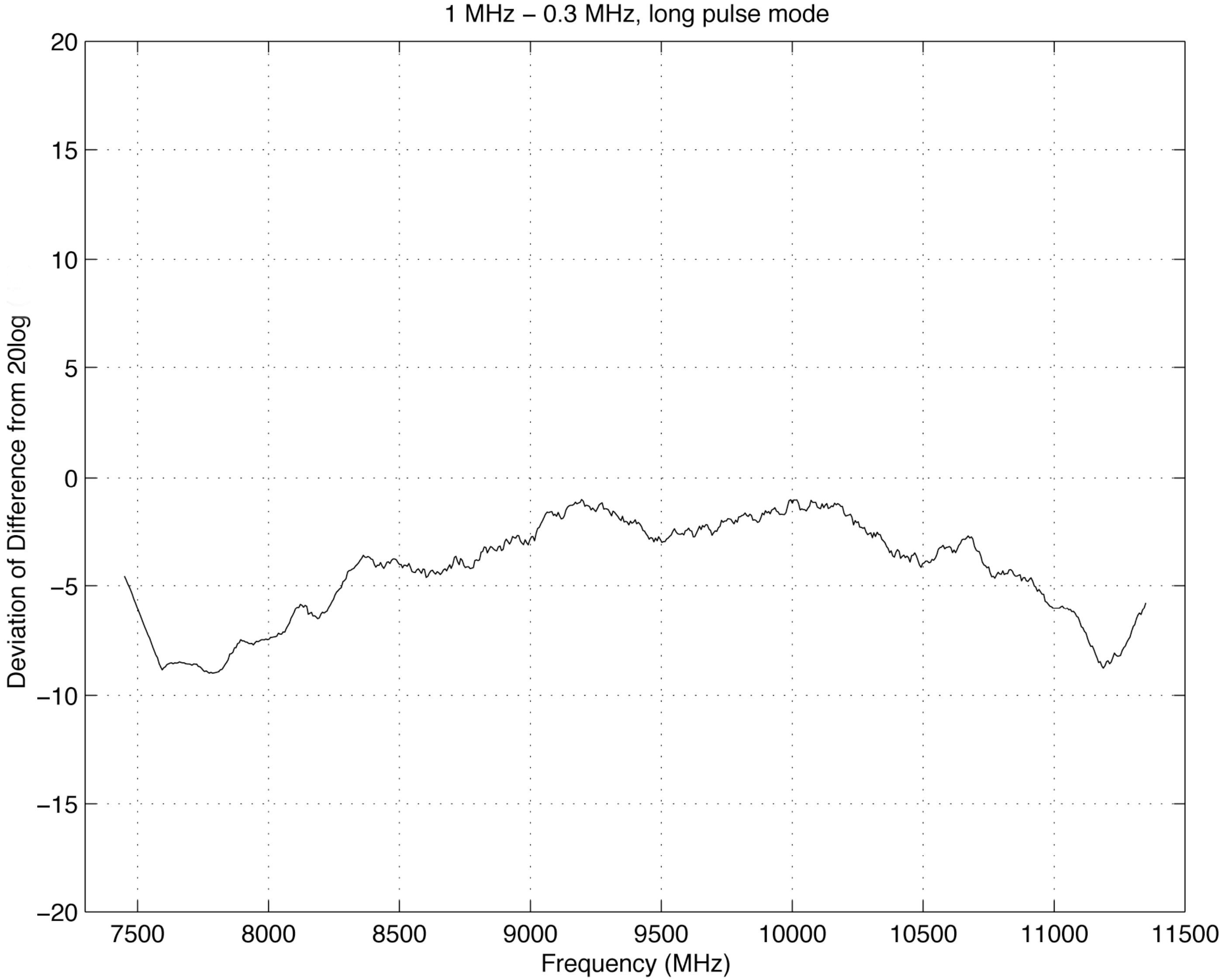
Difference: 8 MHz-3 MHz long pulse mode



Difference: 3 MHz-1 MHz long pulse mode



Difference: 1 MHz-300 kHz long pulse



Summary

Out-of-band and spurious emissions from this maritime radionavigation radar were found to vary at a value typically between **16 log(B_m) and 18 log (B_m).**

(Although extreme coefficient values were as low **12** and as high as **20**)

Conclusions

* Radar out-of-band and spurious emissions do NOT vary as would be predicted for thermal noise (10 log). In this sense at least, they are NOT noise-like.

* Although the observed variation for this radar is typically closer to 20 log than to 10 log, the spurious emission levels nevertheless typically deviated from 20 log by a few decibels.

* **Until this phenomenon is better understood, it would be a good idea for measurement personnel to routinely measure radar emission spectra in several bandwidths. (That's how we normally do these measurements for NTIA, anyway.)**

Future Work

 Perform this same sort of measurement on additional radar types. (Also make repeated measurements on the same radar to better understand variation of measured spectra.)

 Undertake study to understand how time-domain features in pulse rising and falling edges affect the OOB and spurious emissions. This would include understanding of their level of *coherency*.

 Document and apply our knowledge both *nationally* and *internationally*, in the ITU-R.

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- **Richard N. Statz** for software development that allowed us to use a new-model spectrum analyzer with our custom front-end.

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John D. Ewan who set up the radar and got it running.