Dependence of Radar Emission Spectra on Measurement Bandwidth and Implications for Compliance with Emission Mask Criteria

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Frank Sanders
Chief, ITS Theory Division

NTIA/ITS.T
fsanders@its.bldrdoc.gov
303.497.5727

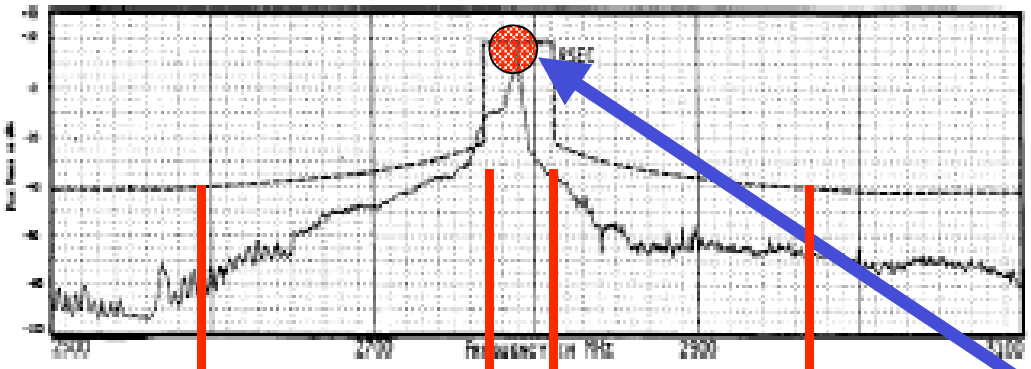
Introduction

Emissions: Radar transmitters produce measurable emissions far outside the classical sinc^2 spectrum. These are called *out-of-band* and *spurious*.

Emission masks: Out-of-band (OOB) and spurious emission levels of Government radars are regulated in the United States by the NTIA *Radar Spectrum Engineering Criteria* (RSEC). Other masks may be specified for non-Government radars and radars in foreign countries.

Specification: Emission masks typically specify suppression levels in decibels *relative* to the measured peak power transmitted from a radar.

Subtlety: Absolute power is measured at radar fundamental frequencies, but spectral power density is measured in the OOB and spurious regions. This leads to an interesting phenomenon…



a. ASR-5, conventional magnetron.

Spurious emissions

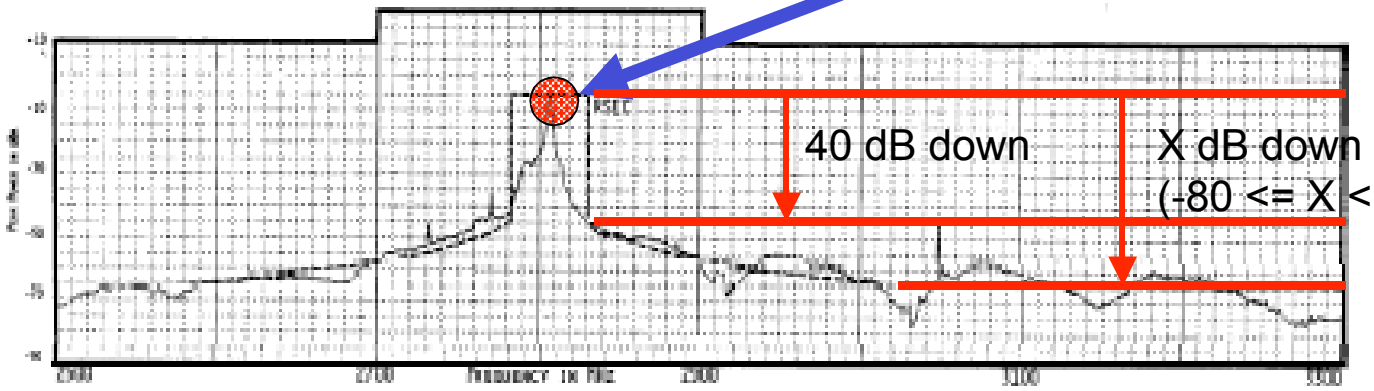
out of band (OOB)

-40 dB bandwidth

out of band (OOB)

Spurious emissions

Classical sinc^2 line spectrum envelope



b. CPN-4, conventional magnetron.

The Problem

Measurement Bandwidth: Emission spectra are convolved with measurement system response functions. These are typically the IF bandwidths of a spectrum analyzer, for example.

Measured power at the radar fundamental varies as 20 log of the measurement bandwidth, up to the point that measurement bandwidth (B_m) exceeds emission bandwidth (B_e), (approximately 1/pulse width).

Measured power (density) in the OOB and spurious regions continues to increase when $B_m > B_e$. Furthermore, the 20 log relationship does not necessarily hold. Some references claim that OOB and spurious emissions are “noise-like” and should therefore vary as 10 log (B_m).

Question: How do OOB and spurious emissions vary with B_m? 10 log, 20 log, or somewhere in between? Somewhat equivalent question is, how noise-like *are* OOB and spurious emissions?

Importance

Possibility that corrections might need to be applied to compliance criteria measurement results: If measured levels of spurious and OOB emissions do **NOT** vary as 20 log (B_m), then some sort of correction might be required for the purposes of fitting an emission mask.

For example, if OOB and spurious emissions vary as 10 log (B_m), then a correction factor of [(20 log)-(10 log)] might have to be applied between those regions and the measured fundamental power.

This issue has arisen in **ITU-R Working Party 8B** in connection with Draft New Recommendation M.1177, *Recommended Measurement Procedures for Radar Spurious Emissions*.

(It's also something that's just worth knowing.)

Approach

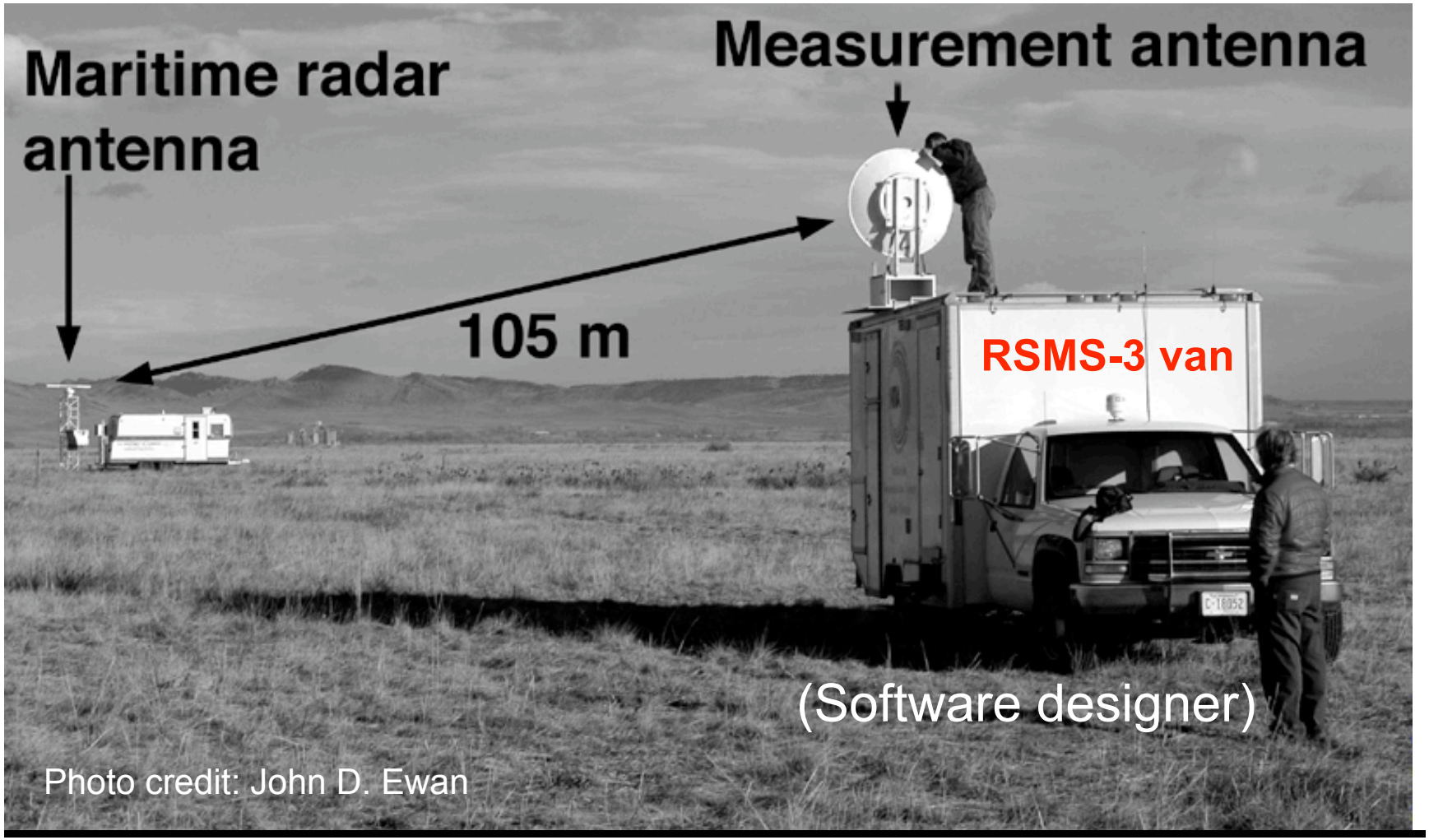
Modelling of radar spurious emissions might have much to offer, but level of effort was beyond our immediate resources (especially time).

Instead, we decided to employ an empirical approach for our introductory effort.

Decision was made to measure emission spectrum of a single radar in multiple bandwidths and then determine how measured OOB and spurious emissions were observed to vary with B_m.

More detailed studies may well follow, but this work represents a first look at this question in a systematic way.

Setup: Radiated

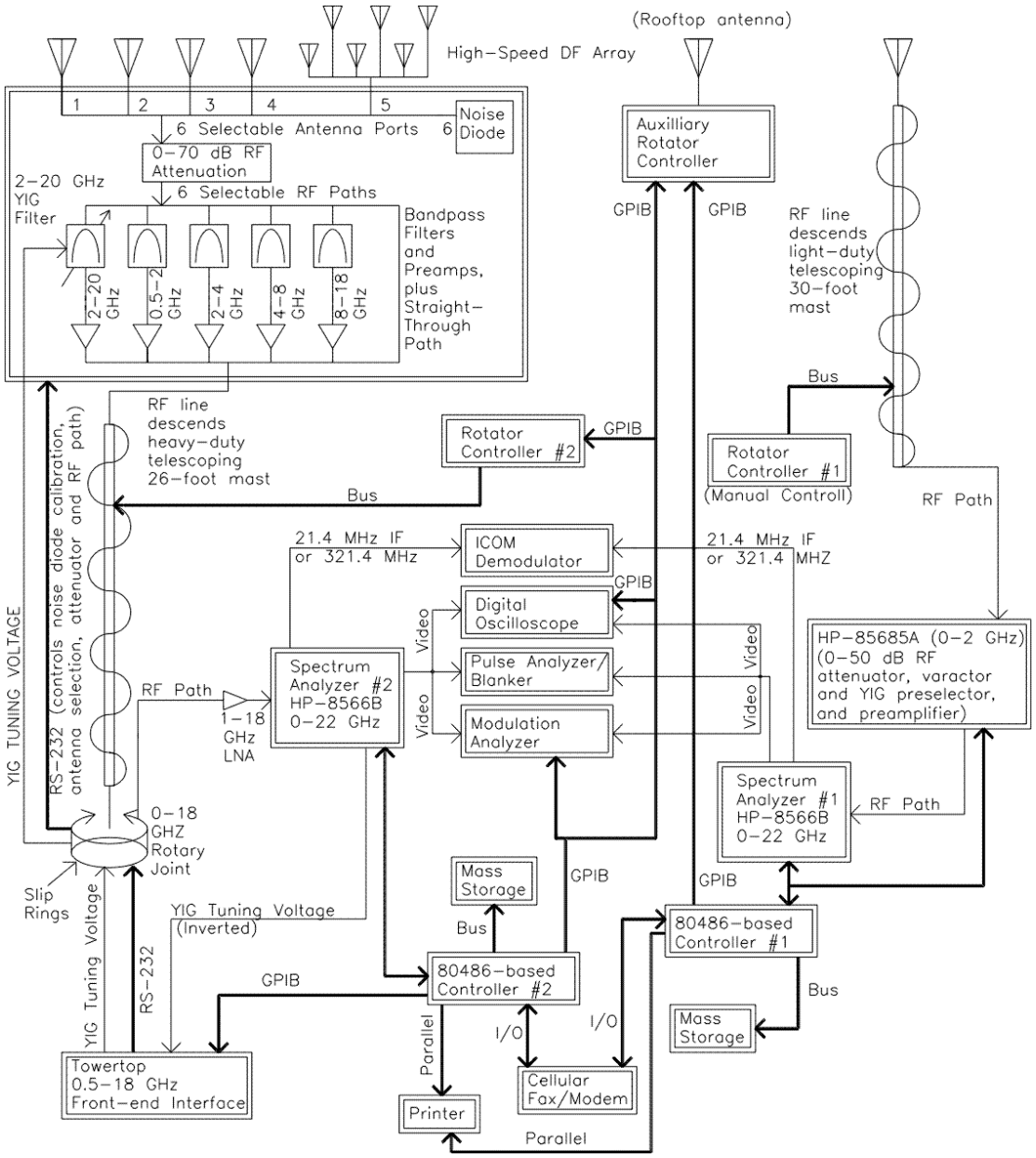


RSMS-3 Hardware

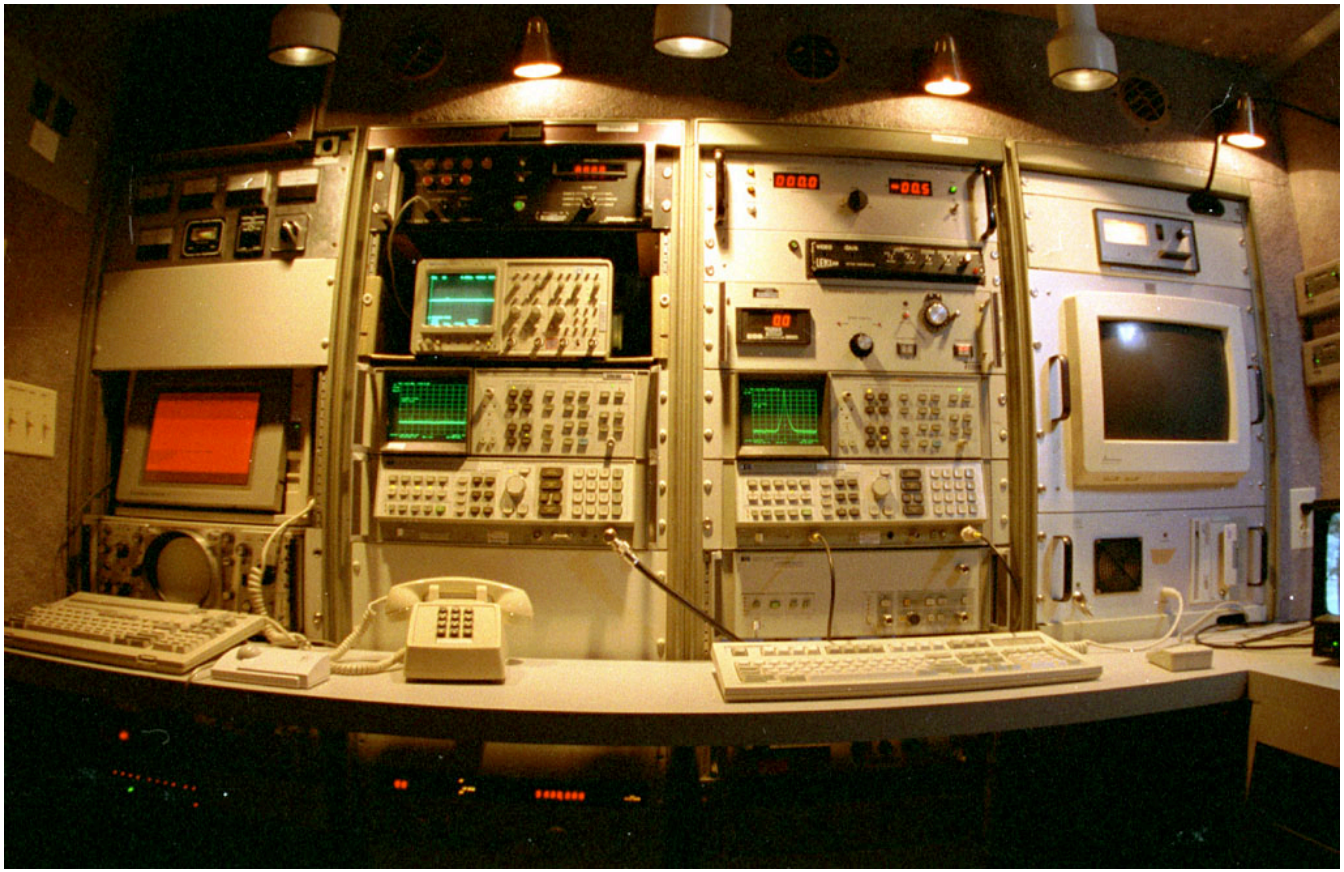
System 1 - 0-1 GHz
Small tower, YIG and varactor preselectors.

System 2 – 1-18 GHz
Large tower, tower-top YIG & bandpass filters/preamps.

Computer control, GPS, noise diode calibration at antennas, radar pulse analyzer, digital oscilloscope, etc.



RSMS-3 Hardware



Interior equipment bay of RSMS-3