NEXRAD Now
October, 1999
Issue 9

CW Substitution Reflectivity Error Check

What's inside?

In order to meet the demand for NEXRAD product mosaics, developers for the tri-agencies (NWS, FAA, and DOD) and NEXRAD Information and Dissemination Service (NIDS) vendors are increasingly at work analyzing and testing mosaic applications. As attention to mosaic products has increased, so too have the number of incidences when the CW Substitution Reflectivity Error Check *"bulls eye"* test pattern is reported as being seen in the WSR-88D mosaic products.

The CW Substitution Reflectivity Error check is one of the *84-Day Inspections* referenced in the WSR-88D Preventive Maintenance Inspection (PMI) Work Cards (EHB 6-503-2, AF TO 31P1-4-108-6WC-8, FAA TI 6460.1 V4). The check is performed in accordance with paragraph 6-6.28.24 and Figure 6-6.28 Sheet 4 of the NWS EHB 6-510. EHB 6-510, Section 6-6.28.2.4.2, begins with the following Note: **"Off-line procedures require cessation of normal activities, including narrowband communications. With the exception of the associated PUP used for this test, all other narrowband communications should be disconnected before performing this procedure."**

Figure 1 is an FAA Weather and Radar Processor (WARP) mosaic display of NEXRAD data. Distribution of the bull's eye pattern has a severe affect on this display which is used by Air Traffic Controllers. Maintenance technicians must disconnect narrowband users prior to running the CW substitution test to prevent distribution of this product. The OSF is assessing

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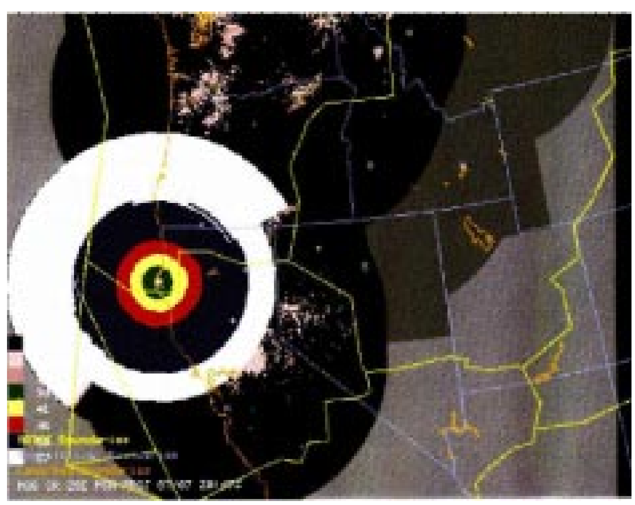

Figure 1 - WARP mosaic with test pattern.

OTB Produces PUP to AWIPS Instructional Component

The Operations Training Branch (OTB) has developed a web-based Instructional Component entitled: "From the PUP to AWIPS, A Transition in Using Radar Data" . This web site, available from the OTB home page at http://www.osf.noaa.gov/otb/tngmat/pds/pup2awips/nexrad.htm is intended to provide NWS personnel familiarization with basic AWIPS radar functionality by describing workstation characteristics of manipulating and displaying AWIPS radar products. The web site is composed of several AWIPS radar product functionality descriptions and cross-referenced to comparable PUP job sheets and AWIPS User's Manual sections.

The advanced integrated display capabilities of AWIPS will gradually allow for phasing out the WSR-88D Principal User Processor (PUP), which, since the early 1990s, has been used to display and manipulate radar data in NWS offices. However, as forecasters begin depending solely on the AWIPS D2D (Display 2-Dimensional) workspace component for displaying and manipulating radar data, they should become aware of some functionality and product display differences between AWIPS D2D and the PUP. Many of these differences have been minimized with the latest AWIPS Release (4.2), but some discrepancies and limitations still exist. This Instructional Component is intended to provide a helpful transition from the PUP to AWIPS in displaying and manipulating radar data. It should be used to complement existing documentation on basic radar functionality as described in the AWIPS User's Manual.

The Instructional Component consists of an Index and 4 parts:

1) PUP/ Graphics Tablet Functionality Comparisons
2) PUP/ Applications Terminal Functionality Comparisons
3) PUP/ AWIPS Product Comparisons
4) AWIPS Customization & Warning Applications

Each Page in Section 1 and 2 describes the AWIPS functionality for the corresponding PUP functionality as documented in PUP job sheets. For additional information on AWIPS radar procedures, the on-line AWIPS User's Guide is linked for each section where functionality is documented. Section 3 contains some base and derived product comparisons. Section 4 refers to some excellent presentations on customization of warning applications (WARNGEN) and a presentation on using AWIPS Workstation in the Warning Decision Making process.

For any questions on the PUP to AWIPS web site, contact Brad Grant at 366-6560 ext. 4273 or at bgrant@osf.noaa.gov.

Brad Grant
OSF Operations Training Branch

Reflectivity Error Check

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additional ways to prevent dissemination of the bull's eye pattern in the future.

Mark Albertelly
OSF Operations Branch

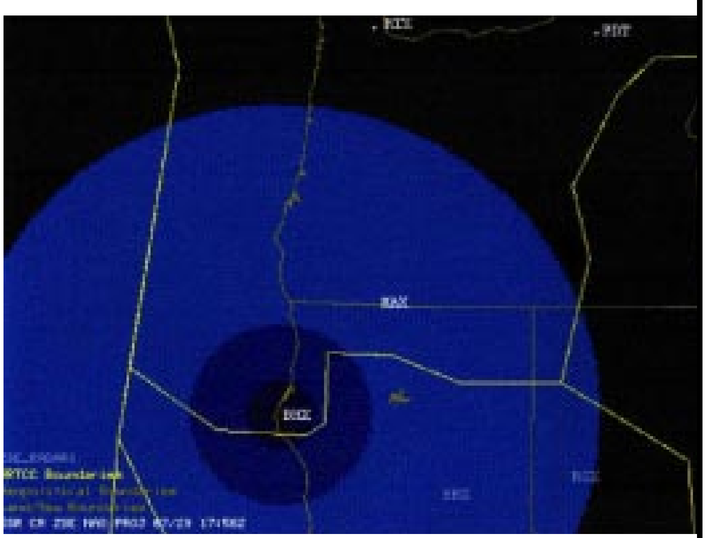

Figure 2 - Test pattern on FAA Air Route Traffic Control Center (ARTCC) "smart" situational display, Display System Replacement (DSR).

Air Force UCPs Move to NWS Forecast Offices

The Director of the National Weather Service (NWS) and the Director of Air Force Weather (HQ USAF/XOW) have agreed to shift operation of WSR-88D Unit Control Positions (UCP) that control Air Force WSR-88Ds to nearby National Weather Service forecast offices (NWSFO). This decision follows a successful demonstration of transferring the Altus Air Force Base (AFB) UCP to the Norman, OK NWSFO. Air Force personnel will continue to maintain the Air Force WSR-88D RDAs and RPGs.

Table 1 contains the list of Air Force and NWS sites that will be included in the UCP transfer. Vandenberg AFB, CA and four overseas Air Force WSR-88D sites will retain control over their UCPs.

The OSF will prepare a Time Compliance Technical Order (TCTO)/Mod Note to direct the transfer of UCPs to the appropriate NWS forecast offices. The TCTO/Mod Note will be kit proofed while moving the Moody AFB UCP (South Stockton WSR-88D) to NWSFO Jacksonville, FL in mid November 1999. The TCTO/Mod Note will be published in December with the UCP transfers to take place starting 2 January 2000. (The transfer of the Andersen AFB UCP to NWSFO Guam will take place after the new NWSFO is completed in March 2000.)

In preparation for this transfer and upon receipt of the TCTO/Mod Note by the Air Force and NWS offices, a special local URC meeting should be convened by the current URC. At this meeting, arrangements for UCP transfer, changes in URC leadership (the URC chairperson role is at the site where the UCP is located), local procedures for use of the new UCP by the NWSFO, agreement as to when the UCP will physically be transferred, and new Air Force maintenance procedures should be discussed. The Air Force is preparing a boilerplate memorandum of agreement to be signed by the NWSFO and maintenance organization outlining policy and instructions on maintaining the WSR-88D and associated issues.

Unit Control Position communication lines are being ordered between the affected forecast offices and radar sites. The Jacksonville - South Stockton circuit is to be installed by 1 November 1999 and the other circuits (except Guam) by 15 December 1999.

Table 1

Current UCP Location (Air Force)	**Future UCP Location** (NWS)
Andersen AFB, Guam	Guam NWSFO
Altus AFB, OK	Norman, OK (Completed)
Beale AFB, CA	Sacramento, CA
Cannon AFB, NM	Albuquerque, NM
Columbus AFB, MS	Jackson, MS
Dover AFB, DE	Wakefield, VA
Dyess AFB, TX	San Angelo, TX
Edwards AFB, CA	Las Vegas, NV
Eglin AFB, FL	Mobile, AL
Fort Campbell, KY	Paducah, KY
Fort Drum, NY	Burlington, VT
Fort Hood, TX	Fort Worth, TX
Fort Polk, LA	Lake Charles, LA
Fort Rucker, AL	Tallahassee, FL
Holloman AFB, NM	El Paso, TX
Laughlin AFB, TX	San Antonio, TX
Maxwell AFB, AL	Birmingham, AL
Minot AFB, ND	Bismarck, ND
Moody AFB, GA	Jacksonville, FL
Robins AFB, GA	Atlanta, GA
Vance, AFB, OK	Norman, OK

The TCTO/Mod Note will include instructions for checking the circuit prior to moving the UCP equipment (as specified in the TCTO/Mod Note) to the NWSFO.

Tim Crum
OSF Operations Branch, Chief

Optimizing Clutter Suppression

Over the years, after several papers and articles, understanding and implementing effective clutter suppression remains one of those topics which continue to be problematic for several sites. In an attempt to ease this pain, this article will discuss what constitutes "good" clutter suppression, discuss some basics of how clutter suppression works, and finally, give some simple advice on how to mitigate 95% of your clutter problems with minimum effort.

Don't Bypass Your Bypass Map - The simplest thing you can do to optimize your system is keep a current Bypass Map. If your map wasn't generated within the last six months, then that's the first thing you should do. Pick a good weather day and allow the technicians to have the equipment for a couple of hours. When they're finished, you'll have a current Bypass Map and be ready to continue.

Now, assuming you've got a current Bypass Map, go ahead and invoke clutter suppression using ONLY the Bypass Map by utilizing Operator Select Code 1. The UCP command is **AD,password1,CL,C,<VCP>** where <VCP> is one of the four allocated clutter suppression region files (11,21,31,32). Ensure all of the other lines in the chosen file are zeroed out (deleted). See Figure 1 below for an example of the entries.

Allow your system to run for a couple of volume scans, and then request a Clutter Filter Control (CFC) product at the PUP. On the right margin of the product, you'll see "BM" and a date and "NWM" and a date. These are the dates on which your Bypass Map (BM) and your Notch Width Map (NWM) were generated. As stated earlier, the BM date should not be more than 6 months old and the NWM should be very current (reflects the last time you downloaded a clutter suppression regions file). Your Bypass Map should be predominantly yellow indicating those range bins in which the system did not detect clutter. The bins which contained clutter are identified by the red pixels and their shape should very closely resemble the "high terrain" or tall objects around your site.

Once you determine your Bypass Map is okay, you're ready to set up your clutter suppression region files in such a way that day-to-day clutter mitigation will be very simple.

Regionalize Your Regions - Optimizing Your Clutter Suppression Region Files - There are as many ways of using the clutter suppression

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Region	Start Range	Stop Range	Start Azimuth	Stop Azimuth	Elev Seg Number	Operator Sel Code	Channel D	Width S
1	2	510	0	360	1	1	2	2
2	2	510	0	360	2	1	2	2
3	0	0	0	0	0	0	0	0

Figure 1

NEXRAD Now

Optimizing Clutter Suppression

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region files as there are NEXRAD radar focal points. Some are extremely effective and we applaud those of you who've had time to work out effective clutter suppression plans. For those of you who just haven't had the time or who would like some ideas, read on.

In order to make the daily duty of optimizing your system's clutter suppression as simple as possible, the OSF has some recommendations on using your four available "clutter files." The following steps will be accomplished at the UCP in the **AD,password1,CL,C,<VCP>** screen (where VCP is the file number of choice).

1) File 11: We recommend setting this up for Bypass Map usage only as shown in Figure 1. This is the "default" with which the WSR-88D should be operated day in and day out. Obviously, you should tweak and adjust your system for your local conditions.

Set up the file this way, and never change it. You should never have to since all other contingencies will be covered using the other files.

2) File 21: Set up this file to do maximum clutter suppression in ALL bins. You'll use Operator Select Code (OSC) 2 as shown in Figure 2.

Running this file in this configuration will result in the suppression of EVERY returned pulse whose radial velocity is less than ±10 kts from the lowest two elevation angles. Using this file will result in "The Big Gray Circle" on the CFC product.

We don't recommend you use this file definition often, especially if winds are fairly weak because you could lose a good deal of data. However, we recognize the utility of this mode at certain times, within certain weather regimes (e.g., strong nocturnal inversion resulting in widespread anomalous propagation).

3) File 31: Most sites we've visited have clutter problems they must deal with fairly routinely and generally, they can tell you where the clutter is likely to occur. It may be an area to your southeast where the terrain slopes downward significantly and along which early morning anomalous propagation (AP) is a big problem. It may be an area to the northwest in which rain-

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Figure 2

Region	Start Range	Stop Range	Start Azimuth	Stop Azimuth	Elev Seg Number	Operator Sel Code	Channel D	Width S
1	2	510	0	360	1	2	3	3
2	2	510	0	360	2	1*	3	3
3	0	0	0	0	0	0	0	0

* In areas where very strong superrefractive conditions frequently occur, this file may also need to invoke forced suppression (OSC 2) for the second elevation segment. Caution is warranted when selecting a notch width value for elevation segment 2; a notch width of 3 for the batch cuts will result in an effective notch width of ± 15 kts for all elevations above 2 degrees.

Optimizing Clutter Suppression

(Continued from page 5)

cooled air pools and causes AP. Regardless of your situation, we recommend you set up a file to help mitigate problems which are unique to your location. For example, lets assume that every morning AP is observed to the southeast of your radar. In the worst case scenario, the problem is so bad that the system actually accumulates precipitation on the AP. Then you could set up this file as shown in Figure 3.

Region	Start Range	Stop Range	Start Azimuth	Stop Azimuth	Elev Seg Number	Operator Sel Code	Channel D	Width S
1	2	510	0	360	1	1	3	3
2	2	510	0	360	2	1	3	3
3	30	190	100	160	1	2	3	3

Figure 3

Notice that lines one and two still invoke the Bypass Map. This will take care of all of your routine, site-specific clutter. The figure shows an increase in notch width for lines 1 and 2. Line 3 is for the situation-specific clutter or AP. It will suppress an area from 100 to 160 degrees, from 30 to 190 kilometers out, at maximum suppression. It may also be necessary, under extreme conditions, to increase your nominal clutter area somewhat to prevent your system from accumulating precipitation on any residual AP. Remember! You should always use clutter filtering FIRST!!!

4) File 32: Finally, we recommend that you use this file for everything else. It may be for training or it may be used for building very situation-specific clutter suppression regions. Regardless, this file is a "catch-all."

Setting up your regions as suggested (or similarly) will allow you to, in just a few keystrokes, download the file of interest without having to first determine which file you want to use. For example, suppose there is no significant clutter and you feel the site should be running with the Bypass Map in control. No problem! Don't even spend the time to request a CFC product and wonder if it was current. Just type **AD,password1,CL,C,11**<return> then, **DO** <return> and continue your business. Your clutter map will be in control. Its four-thirty in the morning and you just noticed the formation of that area of AP which has been out there every morning for the last two weeks. Just type **AD,password1,CL,C,31** <return> then, **DO** <return>. After a volume scan, the AP-induced clutter will be greatly reduced.

And, as always, if you have questions about the above procedure, or anything else WSR-88D-related for that matter, contact the WSR-88D Hotline at 1-800-643-3363.

Tony Ray
CIMMS/OSF Operations Branch

The Kansas City Connection

Every now and then, we in Kansas City hear about parts shipped out of the NRC, or sites sending items to the warehouse for credit. Although the National Reconditioning Center (NRC) and the National Logistics Support Center (NLSC) share the same building in Kansas City, we have truly separate and distinct functions.

The NRC is a branch under Engineering Division in the NWS Office of Systems Operations. Our mission is to inspect and repair nationally supported program equipment. New items coming in for stock in the NLSC are first transferred to the NRC for inspection. Inspection can be checking the paperwork to ensure the parts received are what was ordered, bench testing, or installation in a live system. This is done for all NWS systems supported on a national basis. This includes NEXRAD, Automated Surface Observing System (ASOS), Console Replacement System (CRS), Wind Profiler, Upper Air equipment, Rain and River Gauges, Test Equipment, Data Collection, and many other miscellaneous consumable and repairable parts. New parts are either sampled, with the percentage sampled based on historical data. Items with a good quality history may only have a 10% sample inspected, where items with a poor history might all be inspected. All repairs, whether contractor or in-house, are inspected prior to going back to the NLSC for stocking.

Repairs are performed either in-house or by contractor. The shop responsible for the equipment analyzes each Lowest Replaceable Unit (LRU) for the best method of repair. The repair method is chosen based on NRC capabilities, contractor capabilities, cost, turn-around time, obsolescence, stock levels, and available manpower. Approximately 40% of our repairs are done by contractor. The in-house repairs are accomplished using bench top equipment, simple Automated Test Equipment such as a Huntron Tracker, all the way up to a multi-million dollar Consolidate Automated Support System that uses specialized fixtures and software to help troubleshoot and repair complex equipment.

Parts returned from the field come to the NRC, where they are logged in and return credit is given to the site. It is important that the site return the pre-printed H14 form with the failed part. The form carries the information needed to correctly and quickly give the credit to the site. The NRC historically processes 15,000 to 16,000 parts a year, no small feat with less than 60 total employees. Parts are tracked using a database, where site information, serial number, failures found, parts replaced, and many other parameters are tracked. This data comes in useful for calculating repair prices and identifying failure trends that can be used for modification development.

The NLSC is an organization which is operated by NOAA Office of Finance and Administration through its Central Administrative Support Center (CASC). The NWS is one of the NLSC's customers along with other NOAA organizations and several agencies of the Department of Agriculture. The primary role of NLSC is to stock, store, and issue supplies as a redistribution center, and to operate and maintain the Consolidated Logistics System (CLS). NLSC packages all stock for shipment and arranges for transportation. The choice of supplies and the quantities stocked in the NLSC is up to the NWS, not the NLSC. NLSC operates 24 hours per day, seven days a week. After hours, they provide support through a CLS call back program where employees are carrying cell phones for quick access. The normal hours of operation are Monday through Friday 0700 to 1630.

The NRC and NLSC work closely together. NRC monitors all backorders generated by requisitions entered into the CLS, and adjusts its repair schedules to accommodate emergency requirements when there is zero stock at the NLSC. We

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GOING DIGITAL!
A New Receiver for NEXRAD

The WSR-88D receiver is a classic analog design consisting of a low-noise amplifier, mixer preamplifier, automatic gain control, IF amplifier, synchronous detector, and analog to digital converter. The receiver has a dynamic range of over 96 dB, noise level of -112 dBm, and calibration capability to less than 1 dB. In general, the existing receiver provides good service. However, the receiver design and hardware was "frozen" in the early 1980's and thus some hardware is becoming obsolete and difficult to maintain. In the past year, several receiver components including the analog to digital converter and transistors in the IF amplifier had to be replaced by special procurement or by substitution of comparable devices. A solicitation for purchase of additional automatic gain control subsystems resulted in a "no bid" from the original manufacturer. The OSF anticipates that most of the existing receiver IF components will not be available in the next few years. Many manufacturers are abandoning analog IF components in favor of newer digital technology. This is evidenced by the proliferation of high speed A/D converters and "digital down converter" products on the market. The era of the so called "soft radio", or software intensive radio, is upon us.

The present system also requires complex manual calibrations and the analog components tend to change characteristics over time. Receiver calibration takes considerable effort and needs to be done regularly. In addition to having these support and logistics problems, the present design is not optimum for supporting the proposed enhancements of the WSR-88D system such as dual polarization and random phase coding. These techniques will significantly improve the meteorological capability of the radar by providing better rainfall estimation, hail and scatterer phase state recognition, as well as significant mitigation of echo obscuration due to

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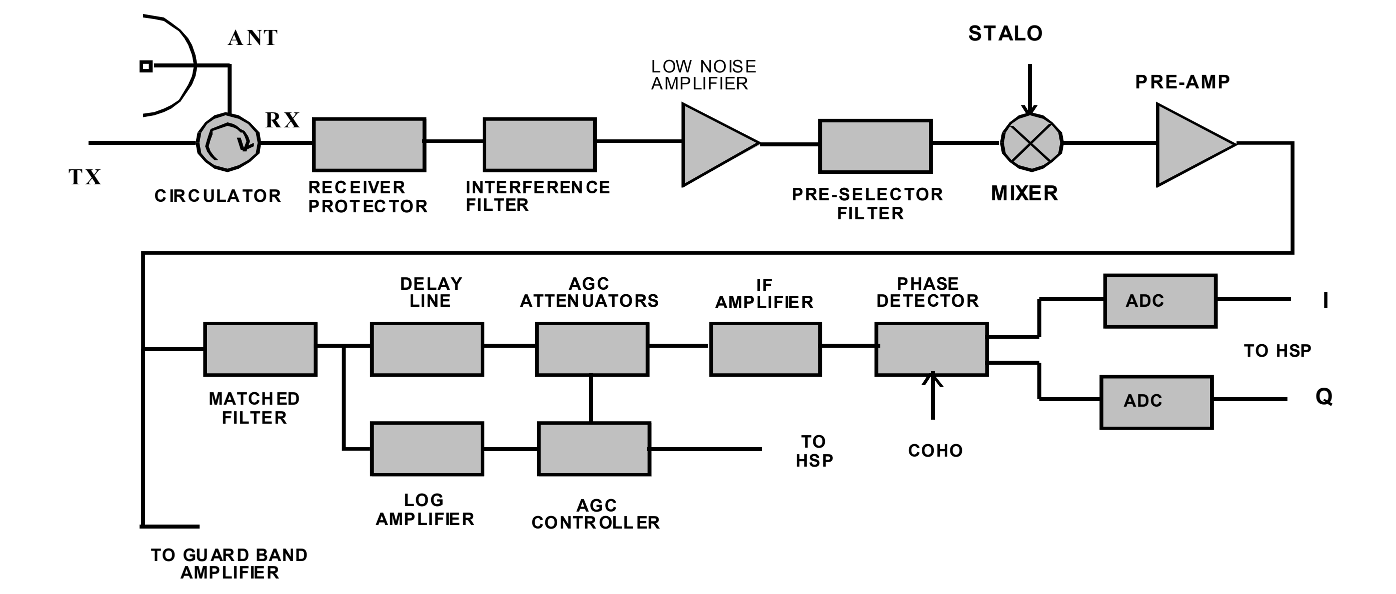

Figure 1: WSR-88D Analog Receiver

Going Digital!

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range folding. The simultaneous dual polarization scheme in particular will require two receivers with transfer characteristics matched to less than 1 dB. This will be challenging with the existing hardware.

Considering the radar system maintenance requirements and the need for support of identified radar system enhancements, the OSF has undertaken development of a digital IF receiver for the WSR-88D. This new technology will address these needs and provide the capability for substantial improvements in the radar signal detection as well as adjunct processing for possible elimination of velocity aliasing.

The present analog receiver used in the WSR-88D is a mid 1980's design and incorporates analog microwave components. The final component in the receiver chain is an analog to digital converter assembly which digitizes the I- and Q- components of the return signal along with the output of the logarithmic receiver channel. Figure 1 depicts a simplified block diagram of the receiver main signal paths. The built-in test and calibration functions are not shown.

The digital receiver modification will replace everything that is past the output of the Mixer/Preamplifier, including all elements from the matched filter through the analog to digital converters (ADC's). A key feature of the modification is elimination of the troublesome automatic gain control (AGC) and phase detectors. The digital receiver will handle any gain control requirements internally and will also eliminate the need for the signal processor to provide AGC pre-scaling and bias offset adjustments. The signal processor design for the Open Radar Data Acquisition System (ORDA) could then be simplified. By omitting analog components beyond the preamplifier, many manual path loss measurements and gain adjustments can be eliminated from the maintenance procedures, reducing staff hour requirements in the field and at the repair depots.

Our present plan for this project is to take advantage of commercially available technology. The OSF and the Central Administrative Support Center (CASC) completed formal market surveys to determine current industry capabilities. The engineering team evaluated the many industry responses and determined the most viable candidates for further evaluation. We obtained formal quotations for delivery of test units that would meet WSR-88D requirements and have placed an order with one company for a prototype. The team hopes to obtain and evaluate additional prototypes in the next fiscal year as funds allow. The prototype phase will result in a solid engineering specification that the OSF can use to develop a production acquisition package and procurement strategy. Present plans are for deployment of the digital receiver either concurrent with, or shortly after the deployment of ORDA.

Rich Ice, STA/Systems Engineering

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The KC Connection

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also collaborate on changes to packing for special needs. Examples are improved packing and "tip-n-tell" indicators used on Archive II units, or desiccant packs now installed in plastic bags for NEXRAD wave-guide switches. Both organizations work hard to take care of our customers in the field. We know getting a quality part, when you need it, is vital to keeping systems operating and allows the NWS to perform its mission of protecting life and property. The NRC phone number is (816) 926-3217, and the NLSC phone number is (816) 926-3990.

Charles Maples

National Reconditioning Center

Common Clutter Suppression Fallacies

Implementing good clutter suppression is difficult and time-consuming. Under certain circumstances, optimizing clutter suppression may not be as simple as we would like, but for 95% of the cases, you'll find that just a few keystrokes are all that are necessary. This is especially true if you've configured your files in the manner discussed in the related article "Optimizing Clutter Suppression."

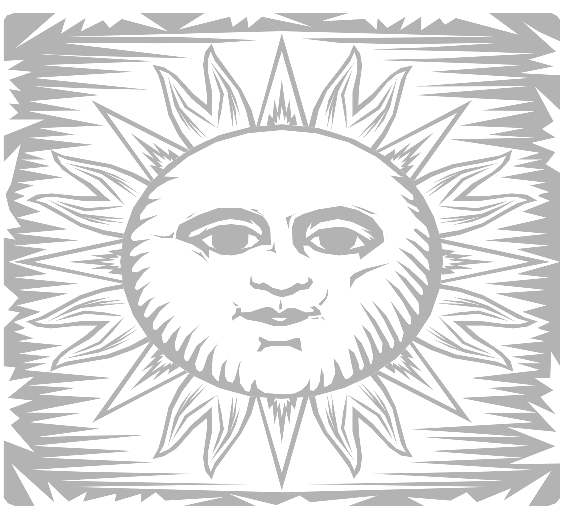
Using clutter suppression degrades rainfall estimates. We've heard this often, but when clutter suppression is used correctly there's no basis for the concern. If fact, appropriate clutter suppression can improve rainfall estimates by reducing power from ground returns in the reflectivity data prior to processing by the precipitation accumulation algorithm.

Remember, clutter suppression does remove power, but it removes power ONLY when two very specific criteria are met.

Criteria 1: First, power is removed from returns in specifically identified range bins. Bins must be identified in one of the following two ways:

(1) Bin identified as "clutter contaminated" on the Bypass Map (Suppression invoked by Operator Select Code 1); and

(2) Bin encompassed by operator-defined Clutter Suppression Region (Suppression invoked by Operator Select Code 2).



Criteria 2: Within an identified range bin, the velocity of the returned pulse must fall within the specified notch width. For the lowest two elevation angles, this will generally range between ±3 and ±10 knots, depending on the notch width being used. For the "middle elevations" (batch cuts), the range is between ±6 and ±15 knots.

This is one reason why it is not a good idea to routinely invoke "total coverage" clutter suppression. When you do so, you are automatically fulfilling one of the conditions (you're identifying the bin). Once the range bins are identified, power is removed from those pulses with a radial velocity below the threshold you set (notch width). You will lose meteorological information if you select complete coverage (OSC 2 for all bins) during a stratiform event.

Clutter suppression will remove thunderstorms which are stationary. Absolutely not true. The radar does not collect information on storms, but on the scatterers within the storm. The thermodynamics which go into generating a thunderstorm require that these scatterers are moving, most with high speeds. So, even if the storm propagation speed is zero, the scatterers within the storm are moving rapidly. The only power returns that are removed are those with near zero radial velocity: either calm air or flow perpendicular to the beam.

Clutter suppression is not necessary. This a false statement. If clutter contaminates your base data, then the base products and all downstream products are adversely affected. Moreover, once the data are stored at NCDC, it is entirely possible that the "contaminated data" may later be used in scientific studies or for other reasons. So, clutter suppression is very, very important.

Without clutter suppression, your system averages the high reflectivity return from nonmeteorological targets with the generally weaker weather returns. You end up with a reflectivity estimate which is too "hot." Likewise, your system averages the zero velocity of a mountain or stationary AP target with the valid velocities of scatterers. You can see

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Clutter Suppression Fallacies

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that when you average zero with anything you get really bad estimates of what's going on at that particular range bin.

Running with your system by utilizing a current Bypass Map and then applying operator-defined clutter suppression when needed is the most efficient way to ensure data quality.

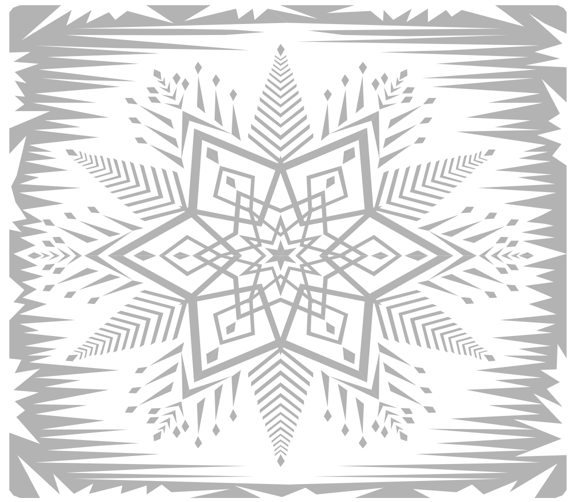
You can "double" your clutter suppression effectiveness by running your bypass map simultaneously overlaid with OSC 2 regions. It's understandable that one would believe this happens, but due to the way the algorithm is written, it doesn't work that way.

Data is processed through the signal processor one returned pulse at a time. The system will perform clutter suppression on individual return pulses in bins which are identified by either of the two options under Criteria 1, above. Even though the bin may be identified twice (meet both options) each pulse from an identified bin is only processed though the filter once.

If I am using clutter suppression, then I should be able to mitigate all clutter. Unfortunately, this isn't true. At best, the system can only remove about 55 dB of clutter. If you notice a significant increase in the intensity of the clutter you're accustomed to seeing, or if your clutter pattern appears stronger in one direction from the radar than another direction (and the terrain is generally flat,) it is possible there is an antenna/pedestal problem and this should be discussed with site technicians.

I am running with my clutter suppression maxed out, but it has no effect. This is a very common statement. To prove to yourself whether or not your system is actually suppressing clutter, invoke OSC 0 which effectively turns the filtering off. You'll likely be surprised by what you see!

Each evening as the sun sets, the clutter around my radar site increases greatly, and no amount of clutter suppression helps the problem. In all likelihood, what you are seeing is not clutter. Look at a velocity product. If it shows a nice,



smooth, non-zero velocity pattern with a well-defined zero line, then you're not looking at clutter. The returns are moving, that's why your clutter filters aren't removing them. What you're seeing is an increase in return due to an increase in scatterers in the lower levels. Research shows that much of the increased return is due to the movement of insects which had remained dormant during the day. This is enhanced as the sun sets and the boundary layer depth decreases. This traps the particles which were within the elevated boundary layer in subsequently lower and lower levels. Additionally, as the boundary layer cools, the radar beam is slowly "bent" towards the surface holding it in the boundary layer longer where return from refractive index gradients are more likely. At some point, it is likely that you may begin to get significant beam bending (ducting) and some AP; however, velocity products will show these areas to have zero or near zero velocities.

HAPPY CLUTTER FILTERING!! If you have questions about the effects of clutter filtering, or anything else WSR-88D-related, contact the WSR-88D Hotline at 1-800-643-3363.

Tony Ray, CIMMS/OSF Operations Branch

Joe N. Chrisman, OSF Engineering Branch

Hail Detection Algorithm

The purposes of this article are to 1) provide warning forecasters with a graph and table of the probabilities for hail of different sizes given a Maximum Expected Hail Size (MEHS) from the Hail Detection Algorithm (HDA), (2) explain how these probabilities were determined, and 3) explain how to use these probabilities. MEHS is a prediction of the maximum hail size within the next 15 minutes. A probability-based component was derived to provide warning forecasters with probabilities of hail of various sizes. This article presents these probabilities in graphical and tabular form. In the future, the HDA will automatically output these probabilities, but this feature is not scheduled to be available until Open RPG Build 2.

The data used to determine the probabilities are 168 hail reports from 40 storm days listed in Table 1. In Figure 1 (Witt 1999) reported hail sizes are plotted versus the parent cell's Severe Hail Index (SHI) which is used to make predictions of MEHS (Witt et al. 1998). Figure 1 shows a clustering of hail sizes into three categories: 0.75 - 1.25 inches, 1.5 - 2 inches, and greater than 2.5 inches. Because of this clustering, probabilities were developed for categories of hail sizes greater than or equal to 1.5 inches and greater than or equal to 2.5 inches. HDA's Probability of Severe Hail (POSH) already makes predictions of hail greater than or equal to 0.75 inches. Since the data consist entirely of severe hail reports, these predictions will be *conditional* probabilities (i.e., it

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Table 1

Radar Site	**Date**	**NSH** Number of severe hailstorms analyzed	**MS** Maximum reported hail size (in inches)
Oklahoma City, OK (TLX)	2/11/92	3	1.00
Melbourne, FL (MLB)	3/6/92	1	1.75
Melbourne, FL (MLB)	3/25/92	4	3.00
Norman, OK (OUN)	4/12/92	2	2.75
Frederick, OK (FDR)	4/19/92	4	4.00
Frederick, OK (FDR)	4/28/92	14	2.75
Melbourne, FL (MLB)	5/28/92	1	1.75
Melbourne, FL (MLB)	6/2/92	2	0.75
Oklahoma City, OK (TLX)	6/18/92	13	2.75
Oklahoma City, OK (TLX)	6/19/92	6	1.75
Melbourne, FL (MLB)	8/20/92	1	0.75
Melbourne, FL (MLB)	9/1/92	1	1.00
Norman, OK (OUN)	9/2/92	2	4.00
Frederick, OK (FDR)	3/29/93	5	3.50
Frederick, OK (FDR)	5/2/93	2	3.50
Dodge City, KS (DDC)	5/5/93	7	2.75
Dodge City, KS (DDC)	6/2/93	7	3.00
St. Louis, MO (LSX)	6/30/93	6	4.00
Melbourne, FL (MLB)	7/9/93	4	1.50
Melbourne, FL (MLB)	8/9/93	2	1.00
Memphis, TN (NQA)	4/26/94	3	1.75
Memphis, TN (NQA)	4/27/94	21	1.75
Oklahoma City, OK (TLX)	7/8/94	1	1.75
Oklahoma City, OK (TLX)	7/14/94	1	2.00
Fort Worth, TX (FWS)	4/19/95	8	3.00
Granger, TX (GRK)	5/5/95	1	4.00
Denver, CO (FTG)	5/12/95	2	0.88
New York City, NY (OKX)	6/20/95	6	2.75
Denver, CO (FTG)	6/22/95	4	1.75

Hail Detection Algorithm

Table 1 (Cont.)

Milwaukee, WI (MKX)	7/15/95	2	3.00
Minneapolis, MN (MPX)	8/9/95	2	2.50
Milwaukee, WI (MKX)	8/9/95	2	1.75
Denver, CO (FTG)	5/22/96	3	4.50
Frederick, OK (FDR)	5/26/96	1	3.00
Missoula, MT (MSX)	7/2/96	3	2.75
Tucson, AZ (EMX)	7/25/96	2	1.75
Missoula, MT (MSX)	8/1/96	3	1.00
Pueblo, CO (PUX)	8/2/96	3	3.00
Tucson, AZ (EMX)	8/14/96	2	1.00
Green Bay, WI/ Milwaukee, WI (GRB/MKX)	7/16/97	11	4.50
Totals	40 days	168	

(Continued from page 12)

is assumed severe hail is occurring.)

Using the data shown in Figure 1, relative frequencies of maximum hail size greater than or equal to 1.5 inches and greater than or equal to 2.5 inches were determined for the MEHS values. These frequencies are shown in tabular form in Table 2 and in graphic form in Figure 2. With this information, one can determine the probability of hail of different size categories from the MEHS. For example, if the MEHS is 3.00 inches, there is a 79% probability of hail greater than or equal to 1.5 inches and a 47% probability of hail greater than or equal to 2.5 inches.

For now, to make use of these probabilities, warning forecasters should place a copy of Figure 2 or Table 2 near their radar display workstation. In the future, these probabilities will be automatically output by the version of HDA scheduled for release with Open RPG Build 2.

Continued on page 14

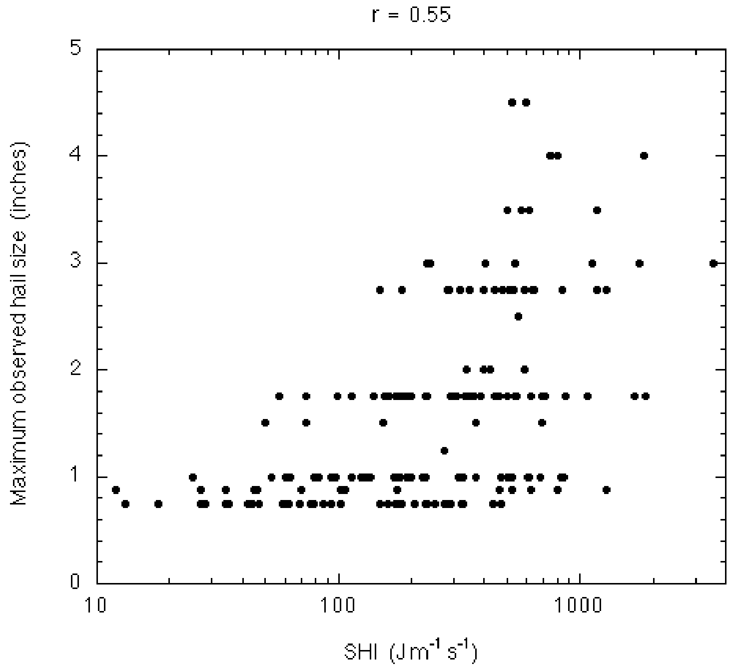

Figure 1 - Scatterplot of SHI vs maximum observed hail size for 168 severe hailstorms. The correlation coefficient (r) is shown at the top of the figure.

MEHS (inches)	Conditional probability of hail≥ 1.5 inches (%)	Conditional probability of hail≥ 2.5 inches (%)
0.50	1	0
0.75	19	0
1.00	31	1
1.25	41	10
1.50	49	18
1.75	55	25
2.00	61	30
2.25	66	35
2.50	71	40
2.75	75	44
3.00	79	47
3.25	82	51
3.50	85	54
3.75	88	57
4.00	91	60

Table 2 - Conditional probability of hail size greater than or equal to 1.5 inches and greater than or equal to 2.5 inches as a function of maximum expected hail size.

WSR-88D Tech Manual Accuracy

Who has the responsibility to keep WSR-88D technical manual (TM) information current and up to date? The answer is - all WSR-88D TM users.

Although the OSF System Support Branch Documentation Section publishes and updates the manuals, the corrections and changes come from the people who use the documents. There are several ways this information arrives at the OSF. The NWS uses a Publication Change Request (PCR) form sent directly to the OSF. The FAA uses a Case File and sends it to FAA AOS 250, Mike Monroney Aeronautical Center,

The DOD uses an AFTO Form 22 Technical Order Improvement Report and Reply and sends them to OC-ALC/TILDT,

through their major air command headquarters.

When these inputs are received by the OSF, they enter a change process that includes several steps. These steps are as follows:

1. All submitted TM change requests are entered into a database for tracking and management. At this time, all inputs are classified as PCRs.
2. The PCRs are then reviewed by OSF personnel for validity and either approved or disapproved. Approved PCRs are placed in the TM file to be published into the next TM update. Disapproved PCRs are filed in the TM file.
3. TM updates (revisions, changes) are developed on an as needed basis and include the approved PCRs. Emergency and Urgent changes are processed in an expeditious manner. These updates are sent to WSR-88D users to keep their TMs current.

PCR status can be viewed and tracked on the OSF homepage at http://www.osf.noaa.gov/ssb/sysdoc/pcrs/pcrmain.htm. The NWS PCR Form with mailing and email addresses can also be downloaded from the same address.

If you find an error in the WSR-88D TMs, please submit a change request through your agencies to the OSF. If you include an email address in your submission, we will keep you informed of your submission's progress. Together we can maintain the WSR-88D TMs as accurately as possible.

Danny G. Green
OSF System Support Branch

Hail Detection Algorithm

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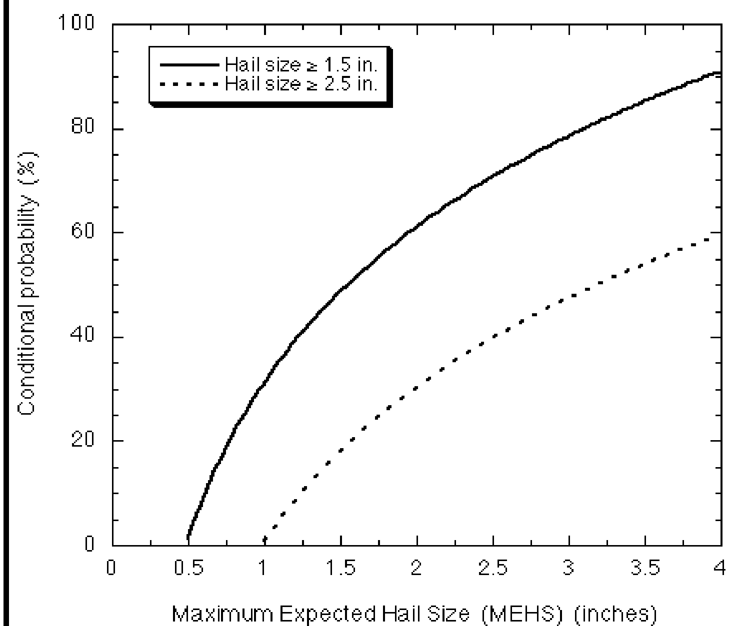

Figure 2 - Conditional probability of hail size greater than or equal to 1.5 inches and greater than or equal to 2.5 inches as a function of maximum expected hail size.

References -

• Witt, A., 1999: Probability-based predictions of maximum expected hail size using the WSR-88D hail detection algorithm. [Available on-line at http://www.nssl.noaa.gov/swat/MEHS and from the National Severe Storms Laboratory,

• Witt, A., M. D. Eilts, G. J. Stumpf, J. T. Johnson, E. D. Mitchell, and K. W. Thomas, 1998: An enhanced hail detection algorithm for the WSR-88D. Wea. Forecasting, 13, 286-303.

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Arthur Witt - National Severe Storms Laboratory
John Ferree - OSF Operations Training Branch

WSR-88D EMI Problem

The OSF recently investigated an unusual electro magnetic interference (EMI) problem at the WSR-88D site in Springfield, MO. Even though there is a preselect bandpass filter in the front end of the WSR-88D receiver, the weather products experienced an obvious interference strobe as seen in Figures 1 and 2.

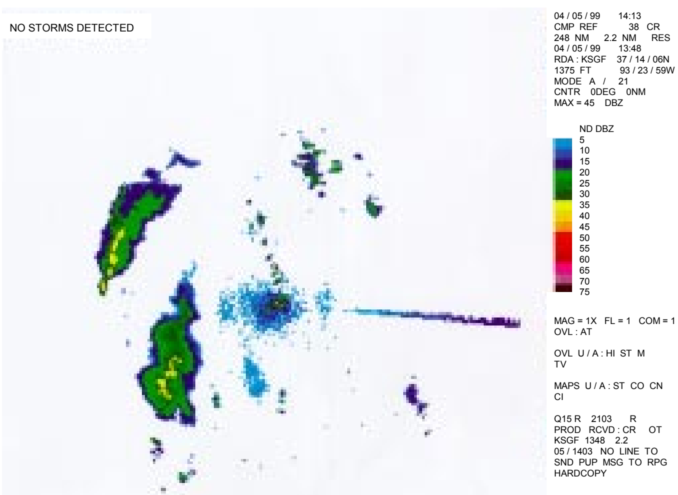

Figure 1 - Composite Reflectivity with interference on April 5, 1999.

The characteristics of the EMI signal measured at the output of the Low Noise Amplifier were:
Frequency of Interference: 2863 to 2867 MHz
Direction of Interference: 95 degree azimuth (East Southeast) and 0.5 degree elevation
Signal Strength (measured with Spectrum Analyzer): -50 dBm.
Signal Type: CW source and stationary
WSR-88D Site Frequency: 2865 MHz

The weather products were used to calculate an estimated field intensity of 3.3 micro volts per meter at the antenna input. All of the above characteristics were used in performing a database search for possible emitters of the EMI signal. The OSF tasked the Joint Spectrum Center (JSC) to perform the database search of the Government Master File (GMF) and Federal Communications Commission (FCC) frequency files. The search discovered numerous emitters along the 95 degree azimuth, but all the emitters were sub-harmonics of the WSR-88D site frequency.

To locate the unidentified emitter, the OSF teamed with the JSC to physically track down the EMI signal source. While searching in Springfield for the emitter, the team was led to a broadcasting tower. There were three broadcasting antennas on the tower radiating at 450 MHz (400 ft on tower), 400 MHz (450 ft on tower), and 95.5 MHz (500 ft on tower). The spectral search equipment led the team directly to the transmitter of the local FM radio station, broadcasting at 95.5 MHz.

The broadcasting station FM characteristics were frequency of 95.5 MHz, 8.8 miles from the WSR-88D, at 95.2 degree azimuth, 500 ft tower, 30th harmonic = 2865 MHz, transmitter power output = 15 KW, and antenna gain = 2 dB. Figure 3 is an illustration of how the broadcasting station and the WSR-88D are geographically related.

Apparently the broadcasting station's transmitter was creating a 30th harmonic signal at the WSR-88D frequency of 2865 MHz. This 30th harmonic signal appeared on the weather products as a continuous spoke beginning in September 1998. The radio station's chief engineer confirmed that in September 1998 their transmitter tube was replaced with another model. Normally a 30th harmonic emitter would not create enough energy to affect WSR-88D

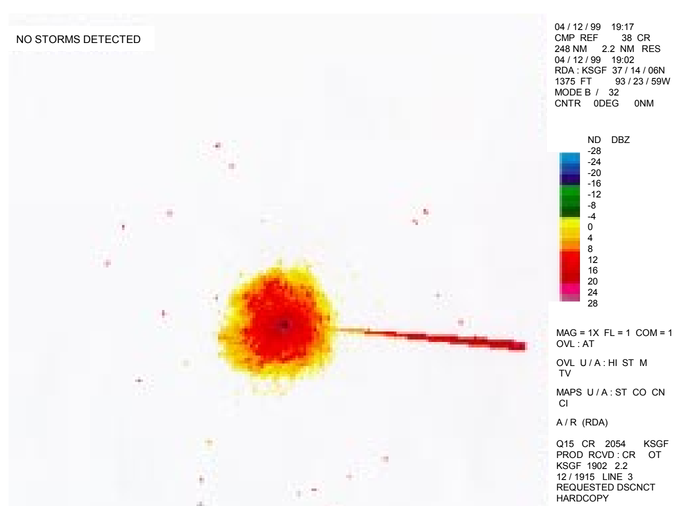

Figure 2 - Composite Reflectivity with interference on April 12, 1999.

WSR-88D EMI Problem

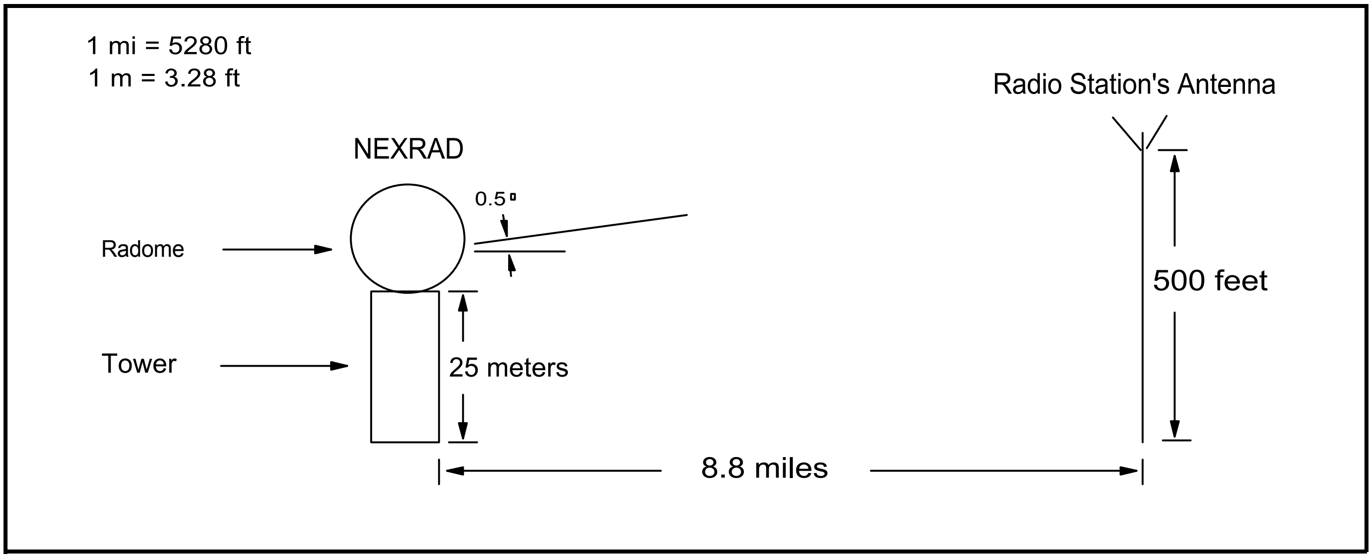

Figure 3 - The WSR-88D and Radio Station physical/geographical dimensions.

(Continued from page 15)

weather products, but this EMI problem was intensified due to the geometry of Springfield's WSR-88D and the broadcasting station's antenna. The FM broadcasting antenna was located directly in the NEXRAD 0.5 degree elevation line of sight.

The EMI signal produced a measured reflectivity of 10 dBz at 120 nmi which translates through the radar equation to an input power of -100 dBm at the antenna port. To further illustrate the low power level of the EMI signal and the sensitivity of the WSR-88D receiver, the input power of -100 dBm translates through the antenna effective area as a field density of $2.9(10^{-12})$ mW/m² (field intensity of 3.3 FV/m). A field density of $2.9(10^{-12})$ mW/m² translates through the broadcast station transmit equation to a 30th harmonic power source of 0.0047 mW. The broadcast station 30th harmonic emission was 90 dB below the carrier. The WSR-88D could see the above source to a range of 35 miles. If on the radar frequency and in the radar line of sight, the WSR-88D receiver can detect a 1 mW nondirectional source to a range of 414 miles or 666 km.

Since the WSR-88D receiver has a Minimum Detectable Signal (MDS) of as low as -114 dBm, it had no problem detecting the EMI signal of 3.3 micro volts per meter. As a temporary fix, the broadcasting station's chief engineer agreed to reduce their transmitter output power by 10 percent, until their transmitter tube harmonic is reduced with an engineering solution.

If you believe you have an active transmitter that is interfering with your WSR-88D, please contact the WSR-88D Hotline at 1-800-643-3363.

Patrick Massie
OSF Engineering Branch

NEXRAD Now is an informational publication of the WSR-88D Operational Support Facility published in February, June and October of each year.
We encourage our readers to submit articles for publication. Please note: *December 20th* is the deadline for submission of articles for the February, 2000 issue.
Please send all comments and articles, via email, to: **rjackson@osf.noaa.gov**
All previous issues of NEXRAD Now can be viewed on the OSF Home Page located at: **http://www.osf.noaa.gov**

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