Spring 2013
Issue 22

Dynamic Scanning

Due to hardware limitations during the first 20-year-span of life of the WSR-88D, volume scanning was governed by rigid Volume Coverage Pattern (VCP) definitions. WSR-88D VCPs were designed to automatically and continuously scan predefined elevation angles, in sequence, with a particular periodic update cycle that did not change, regardless of current meteorological conditions. The only way to change the update interval was to invoke a different VCP and accept its volume coverage characteristics and periodic update rate.

Fast-forward to today. Evolutionary RPG (Radar Product Generator) and RDA (Radar Data Acquisition) hardware upgrades, an on-going effort to migrate to modern processing software, along with a significant increase in available bandwidth have

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AVSET-Controlled Shortest VCP 11		AVSET-Controlled Shortest VCP 12		AVSET-Controlled Shortest VCP 212		AVSET-Controlled Shortest VCP 21	
Elevations	Time (sec)	Elevations	Time (sec)	Elevations	Time (sec)	Elevations	Time (sec)
0.5	19	0.5	17	0.5	17	0.5	32
0.5	19	0.5	14	0.5	21	0.5	32
1.5	19	0.9	17	0.9	17	1.5	32
1.5	19	0.9	14	0.9	21	1.5	32
2.4	22	1.3	17	1.3	17	2.4	32
3.4	20	1.3	14	1.3	21	3.4	32
4.3	20	1.8	15	1.8	15	4.3	32
5.3	21	2.4	14	2.4	15	6.0	32
6.2	21	3.1	14	3.1	14	9.9	25
		4.0	14	4.0	14		
		5.1	14	5.1	14		
		6.4	13	6.4	13		
Scan time	180 sec		177 sec		198 sec		281 sec

Table 1: Best case AVSET-controlled VCP completion times.

What's Inside?

Scanning

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allowed the Radar Operations Center (ROC) to begin implementing innovative dynamic scanning techniques.

AVSET (Automated Volume Scan Evaluation and Termination), implemented fleet-wide with Software Build 13.0, was the first of these new scanning techniques. AVSET reads the radar return on each elevation above 5 degrees and terminates the current volume scan when the available return does not meet reflectivity strength and coverage thresholds. The net effect of AVSET is to shorten the VCP completion time and reduce the product update interval when no significant data are available on the higher elevation tilts. See Table 1 for an example of best case AVSET-controlled VCP completion times.

Although AVSET can significantly reduce VCP competition times when storms are displaced from the RDA location, fast evolving meteorological events require more frequent low-level interrogation than AVSET can provide. The next innovative dynamic scanning technique, SAILS, was specifically designed to assist forecasters during these events. SAILS (Supplemental Adaptive Intra-Volume Low-Level Scan), scheduled for fielding with RPG Software Build 14.0, adds a supplemental 0.5° split cut scan to the existing severe weather VCPs 12 and 212. This new split cut scan will be inserted into the “middle” of the volume scan to evenly space the intervals between 0.5° data updates. The “middle” of the volume

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Elevation Angles (VCP 12)	VCP 12 Elevation Duration	Term Angle 19.5	AVSET Term Angle 15.6	AVSET Term Angle 12.5	AVSET Term Angle 10.0	AVSET Term Angle 8.0	AVSET Term Angle 6.4
0.5°	31 Sec	31 Sec	31 Sec	31 Sec	31 Sec	31 Sec	31 Sec
0.9°	31 Sec	31 Sec	31 Sec	31 Sec	31 Sec	31 Sec	31 Sec
1.3°	31 Sec	31 Sec	31 Sec	31 Sec	31 Sec	31 Sec	31 Sec
1.8°	15 Sec	15 Sec	15 Sec	15 Sec	15 Sec	15 Sec	15 Sec
0.5°						31 Sec	31 Sec
2.4°	14 Sec	14 Sec	14 Sec	14 Sec	14 Sec	14 Sec	14 Sec
0.5°				31 Sec	31 Sec		
3.1°	14 Sec	14 Sec	14 Sec	14 Sec	14 Sec	14 Sec	14 Sec
0.5°		31 Sec	31 Sec				
4.0°	14 Sec	14 Sec	14 Sec	14 Sec	14 Sec	14 Sec	14 Sec
5.1°	14 Sec	14 Sec	14 Sec	14 Sec	14 Sec	14 Sec	14 Sec
6.4°	14 Sec	14 Sec	14 Sec	14 Sec	14 Sec	14 Sec	14 Sec
8.0°	13 Sec	13 Sec	13 Sec	13 Sec	13 Sec	13 Sec	
10.0°	13 Sec	13 Sec	13 Sec	13 Sec	13 Sec		
12.5°	13 Sec	13 Sec	13 Sec	13 Sec			
15.6°	13 Sec	13 Sec	13 Sec				
19.5°	13 Sec	13 Sec					
Duration	243 Sec*	274 Sec*	261 Sec*	248 Sec*	235 Sec*	222 Sec*	209 Sec*
0.5 Elevation Update Times	243 Sec	136 Sec and 138 Sec*	136 Sec and 125 Sec*	122 Sec and 126 Sec*	122 Sec and 113 Sec*	108 Sec and 114 Sec*	108 Sec and 101 Sec*
* Plus Retrace Time							

Table 2: SAILS insert angle as a function of termination angle for VCP 12.

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scan is adaptive and determined in real-time since volume scan completion times vary due to change in termination angle when AVSET is active (see Table 2).

SAILS will significantly increase the low-level scan update rate, especially when AVSET is active and storms are displaced from the RDA location. Table 3 compares product availability with and without AVSET and SAILS executing.

For more information about AVSET, SAILS and other new WSR-88D operational improvements, please visit the "New Radar Technology" section on the ROC web page at http://www.roc.noaa.gov/WSR88D.

Joe N Chrisman
ROC Engineering Branch

VCP 12	0.5° Base Product Updates per Hour	Volume Product Updates per Hour
Standard Operation	14	14
AVSET	14 - 19	14 - 19
SAILS	24	12
AVSET and SAILS	24 - 32	12 - 16

VCP 212	0.5° Base Product Updates per Hour	Volume Product Updates per Hour
Standard Operation	13	13
AVSET	13 - 17	13 - 17
SAILS	22	11
AVSET and SAILS	22 - 28	11 - 14

Table 3: Product availability comparison.
Note: AVSET and SAILS are independent functions and may be executed separately.
AVSET – Automated Volume Scan Evaluation and Termination
SAILS – Supplemental Adaptive Intra-Volume Low-Level Scan

Newer and faster processors, and more flexible modern software enable the implementation of the real-time data analysis required to support dynamic volume scanning. These improvements also open the door for more automated operational radar control. The ROC and our tri-agency stakeholder partners are actively looking for innovations to automate and improve WSR-88D data collection, data processing and radar operation to better support the mission of forecasting and warning.

Update: Wind Farms and the WSR-88D

It's time for an update on the wind energy industry, a look at how successful/lucky we have been in preventing wind farms from getting too close to WSR-88D radar sites, and the Radar Operations Center's (ROC's) recent efforts to mitigate the potential impacts of wind turbine clutter (WTC) on the WSR-88D.

WIND ENERGY INDUSTRY UPDATE

Although the past three years have seen a decreased rate of wind industry expansion (Figure 1), the ROC continues to receive and evaluate a reduced but steady stream of proposed wind energy projects. As the economy revives, and if the federal Production Tax Credit (PTC) is renewed, annual wind farm installations will likely rebound to record levels, especially in states with renewable energy mandates.

Figure 2 shows the uneven distribution of wind farms across the country. The Great Plains states from Texas to North Dakota, and to a lesser extent the Great Lakes area, have vast wind resources and plenty of available land on which to build wind farms. The number of wind farms developed near WSR-88Ds is likely to increase, especially in those two geographic areas. Off-shore wind projects are being planned in the New England and Mid-Atlantic area, from Massachusetts to Virginia, with the first project, called Cape Wind, recently approved south of Rhode Island. For the foreseeable future, off-shore wind projects should be confined to the northern portion of the Atlantic coastline. The ROC does not anticipate any off-shore development on the west or Gulf coasts.

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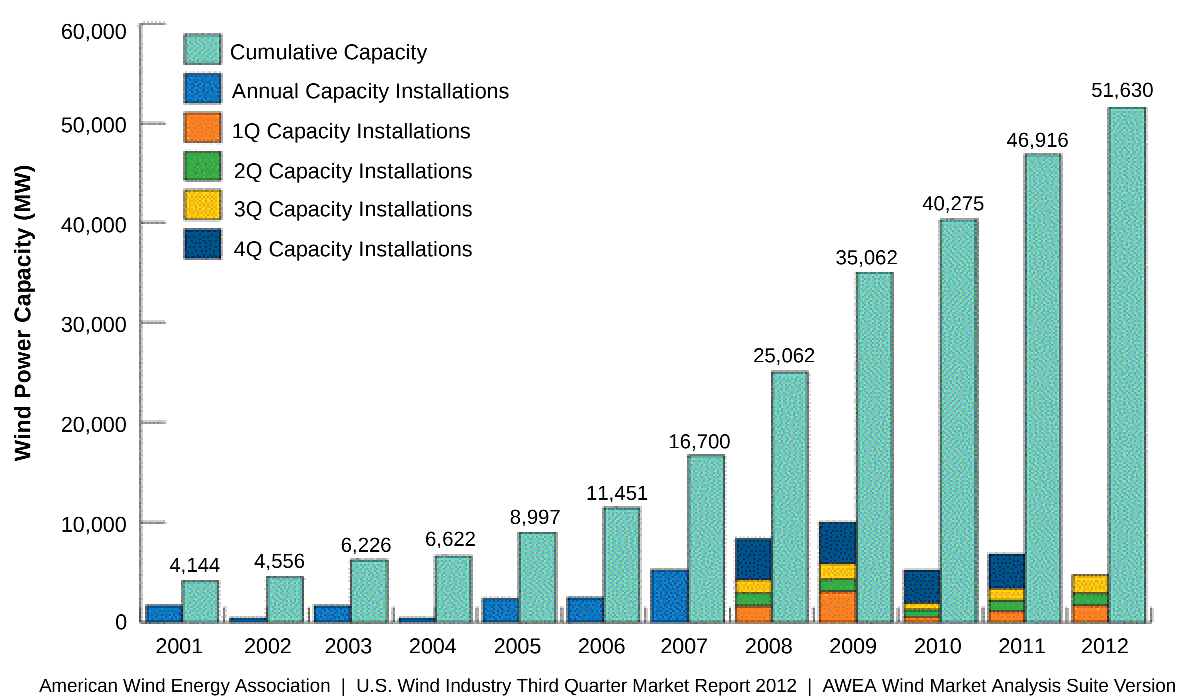

Figure 1: Annual wind turbine installations peaked in 2009 and are slowly recovering. (Source: American Wind Energy Association (AWEA) 3rd Quarter 2012 Market Report.)

Wind Farms

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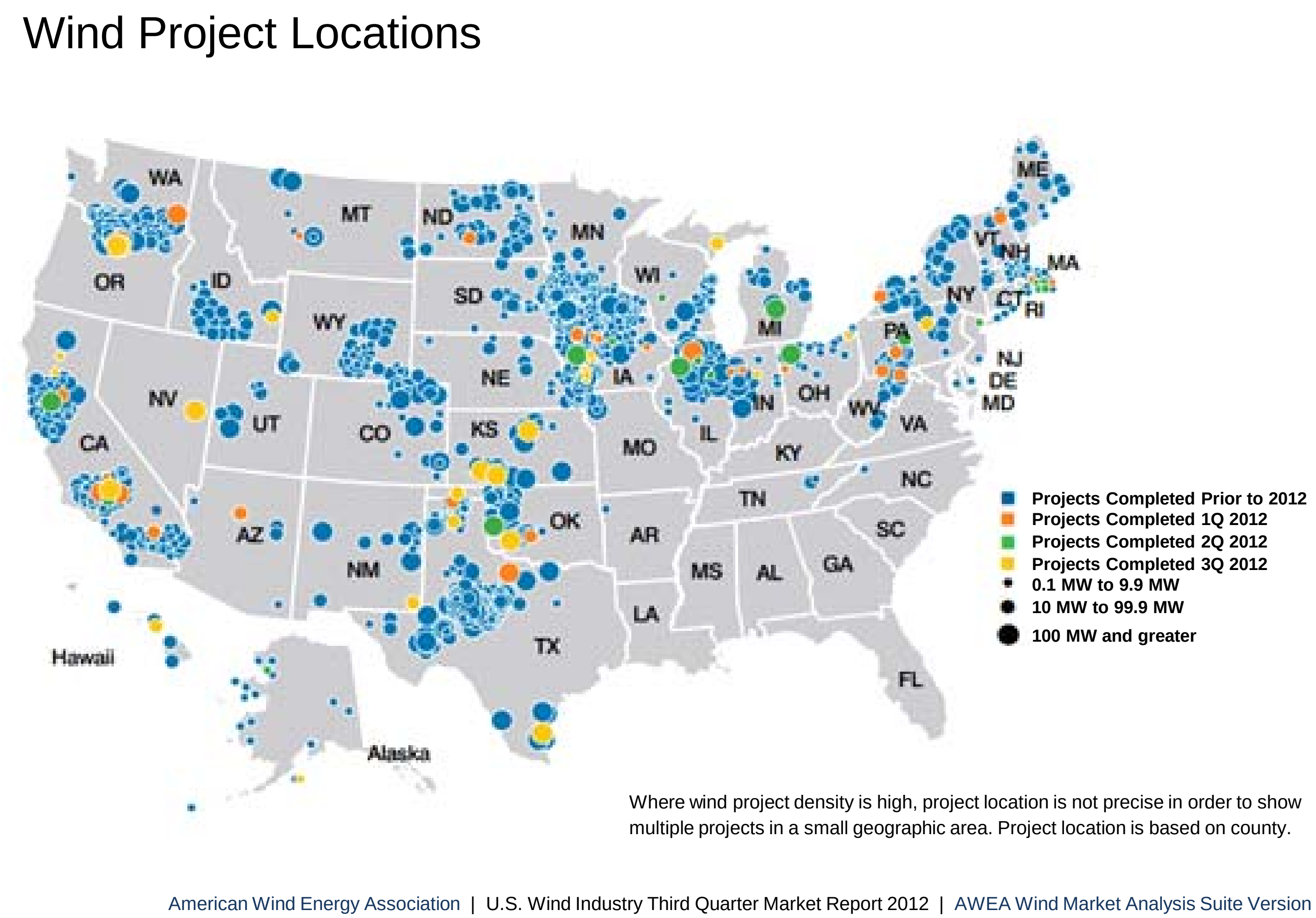

Figure 2: Wind Energy Project locations and project size (by Megawatt capacity) as of September 2012. (Source: American Wind Energy Association (AWEA) 3rd Quarter 2012 Market Report.)

HOW SUCCESSFUL HAVE WE BEEN AT PREVENTING WIND FARM INSTALLATIONS TOO CLOSE TO WSR-88D SITES?

Currently, the closest wind farm is 4km from the Ft Drum, NY WSR-88D. That wind farm causes significant clutter from multipath scattering out to 15—20km from the radar over approximately 120 degrees of azimuth and impacts the 3 lowest elevation scans (through 1.5 degrees).

When the ROC receives proposals that would be very close to a WSR-88D, including single-turbine projects within 3km, we make an effort to engage the developer to ensure they understand the potential impacts on the radar, and forecast and warning operations. We place greater emphasis on proposed wind farms with the potential for high and moderate impacts (i.e., those within 3km and 18km of a WSR-88D). Those developers

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Wind Farms

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proposing wind farms within 3km - and we have had a handful of those - get serious attention. Fortunately, the vast majority of wind farm developers want to do the right thing and we have been successful, with the help of local WFOs, in convincing several developers to not build within 3km of a WSR-88D. Some close projects are still in the works, but have not yet been built.

Unfortunately, with respect to the few that want to build on private land very close to a WSR-88D, the federal government has no land-use authority over private land. Other federal agencies with Doppler radar assets, including the FAA, DHS, and DOD, also do not have land-use authority, despite the potential risks to aviation safety and national security. An additional hurdle is the federal Anti-Lobbying Act (18 US Code § 1913) which bars federal employees and agencies from lobbying or influencing any other government official at any level (federal, state, or local) to favor or oppose "any legislation, law, or appropriation." This would include trying to get city or county planning board officials to change their permitting regulations for siting wind turbines so that they don't impact the WSR-88D radars. However, according to the NOAA General Counsel office, the Act does not prohibit NOAA employees from presenting city or county officials factual information about the impacts of a wind farm on the WSR-88D.

RECENT ROC INITIATIVES

In most WTC situations, forecasters can "work around" the impacts without influencing severe weather forecast/warning operations, just as they do for other clutter issues, such as those caused by anomalous propagation, terrain blockage, migratory birds, etc. With the on-going deployment of dual-polarization (D-P), the ROC has taken a preliminary look at some data and, so far, D-P does not appear to reduce WTC. However, the ROC has several on-going initiatives for both forecasters and wind project developers to work-around or mitigate wind turbine clutter impacts.

1. Updated AWIPS geographic information system (GIS) wind farm files were uploaded in July 2012 onto the NOAA1 server for WFOs/RFCs to download and create overlays of wind farms. Two types of files are available--polygons of wind farm locations (Figure 3, right) based on long-accumulation (12-month) radar-QPE data developed by NSSL (Figure 3, left), and individual turbine locations from the FAA and ROC databases. These GIS wind-farm overlays are particularly useful for distant wind farms that intermittently appear in the radar data. Forecasters should consider setting up Exclusion Zones to prevent known areas of WTC from contaminating precipitation products.

2. The Warning Decision Training Branch (WDTB) has a Commerce Learning Center course, released in 2011, that provides initial training on identifying wind farms on radar products, some mitigation strategies, and ROC outreach efforts. NWS Forecasters can access this course (and bypass the search requirement) by clicking the following link: Login for National Weather Service LearnCenter. NWS partners and others can access the course at the following link: National Weather Service - Warning Decision Training Branch.

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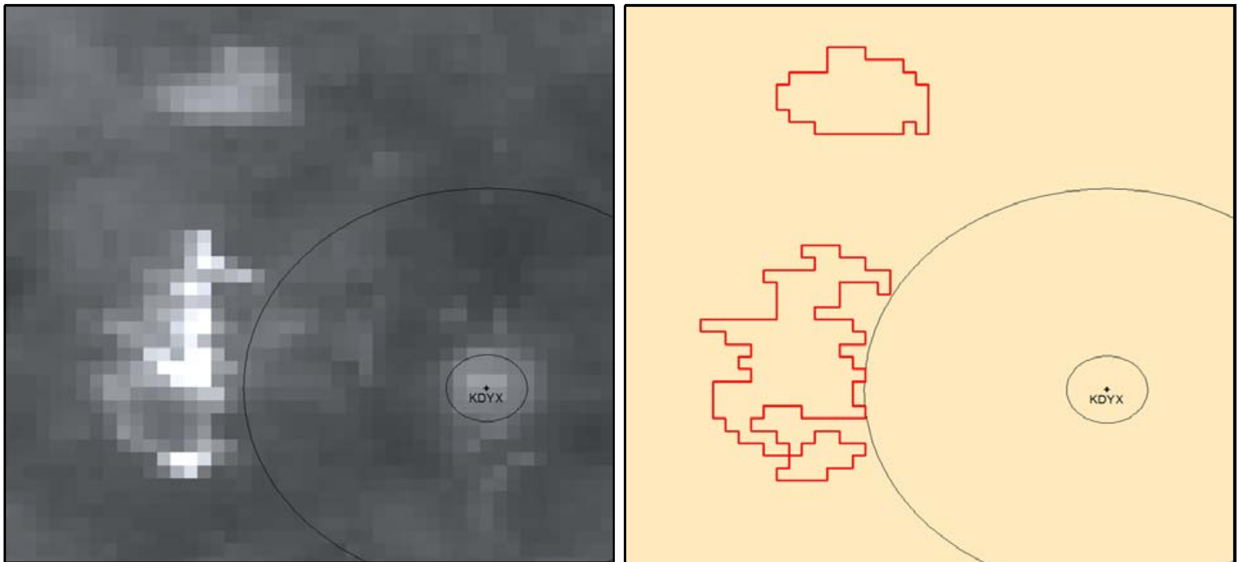

Figure 3: Left Image - 12-month Q2 QPE showing bright "hot spots" west of Dyess AFB, TX WSR-88D (KDYX) with 3- and 18-km range rings. Right Image - NSSL-generated polygons outlining QPE "hot spots."

3. To help developers avoid placing off-shore wind projects too close to our coastal radars, the ROC is working with NOAA's National Ocean Service (NOS) Coastal Services Center to place GIS maps of WSR-88D turbine impact zones on the joint NOS-Bureau of Ocean Energy Management (BOEM) Marine Cadastre web site.

4. This year the ROC was successful in coordinating the first signed agreements, technically called Letters of Intent (LOIs), between two WFOs and three wind farm developers/owners to voluntarily curtail operation of wind turbines under certain severe weather situations. These operational curtailment LOIs give the WFOs a way to eliminate the wind turbine clutter in critical weather situations by asking the wind farm operator for a temporary shut down of part or all of the wind farm causing the WTC.

5. The ROC was also recently successful in coordinating the first individual wind farm-WFO data sharing agreement, whereby the wind farm would share wind, and other meteorological data if available, from its 80-meter meteorological towers with the local WFO. It should also be noted that NOAA/NWS recently signed major data sharing agreements with two wind energy companies, Iberdrola Renewables LLC and NextEra Energy Resources LLC, to provide proprietary company-wide (all wind farms) data to NOAA for inclusion in numerical weather prediction models. Hopefully this agreement will result in NOAA getting better model initialization, and wind energy

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companies getting better wind forecasts in return.

THE ROC NEEDS YOUR HELP

While NOAA supports renewable energy development, we must ensure we preserve our ability to issue accurate and timely severe weather warnings and forecasts using radar data. To that end, the ROC is still looking for the support of field offices to better define the impacts of wind turbines on the WSR-88D and warning operations, and to convincingly make the case for those impacts. If a site is already dealing with WTC and encountering cases that impact forecast and/or warning operations, especially significant cases related to missed or delayed weather warnings, the ROC wants to hear about them. As a further step, WFOs may want to develop and document a "climatology" of the clutter (e.g., how often it occurs, under what conditions, products that are affected, etc.).

If site personnel learn about a proposed wind farm that would be located close to a WSR-88D, including single turbines within 3 km, please notify the wind energy team at the ROC by sending an email to wind.energy.matters@noaa.gov. The wind energy team will follow up.

To learn more about the WTC issue please visit previous *NEXRAD Now* articles (http://www.roc.noaa.gov/WSR88D/NNOW/NNOW.aspx) and/or the Wind Farm Interaction section on the ROC web site (Radar Operations Center - WindFarm Index). We have posted several posters, papers and briefings on this web page.

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NEXRAD Now is an informational publication of the
WSR-88D Radar Operations Center (ROC).

We encourage our readers to submit articles for publication.
Please email all articles and comments to:

ruth.e.jackson@noaa.gov

All previous issues of NEXRAD Now can
be viewed on the ROC Home Page at:

http://www.roc.noaa.gov/WSR88D/NNOW/NNOW.aspx

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Uncovering the Storm

The (elevation-based) Auto PRF (Pulse Repetition Frequency) algorithm has been in the WSR-88D baseline since the radar's inception. This algorithm selects the Doppler PRF that results in the least amount of range-folded (purple) data for the entire area within a 230 km radius of the radar. The Auto PRF algorithm works very well; however, it simply minimizes the area of range-folded data without consideration for the importance of any individual storm. To address this limitation, the Radar Operations Center (ROC) has developed a Storm-Based Auto PRF function to augment the original Auto PRF algorithm.

The initial concept behind the Storm-Based Auto PRF function is to identify an individual storm and select the PRF that results in the least amount of range-folded data affecting that storm. Using this starting point, RPG (Radar Product Generator) code was implemented and tested. Early testing revealed three shortcomings that needed to be addressed prior to proceeding. First, the storm's propagation had to be accounted for so the PRF applied to the next volume scan would address the storm's "new" location. Second, it quickly became apparent that multiple storm consideration would make this feature far more useful. Third, and probably most importantly, the need for an automatic storm selection process would be required to make this feature usable in an operational environment.

To tackle the first problem (storm propagation), code was developed that matches the selected storm to the closest Storm Cell Identification and Tracking (SCIT) algorithm-identified storm. The Storm-Based Auto PRF function uses the SCIT forecast track to project the location of this storm for the next volume scan. Using this forecast location, the Storm-Based Auto PRF function calculates a 20 km diameter "storm circle" centered on the projected storm centroid location. Then, the range-folded area within the storm circle is calculated for each Doppler PRF and the

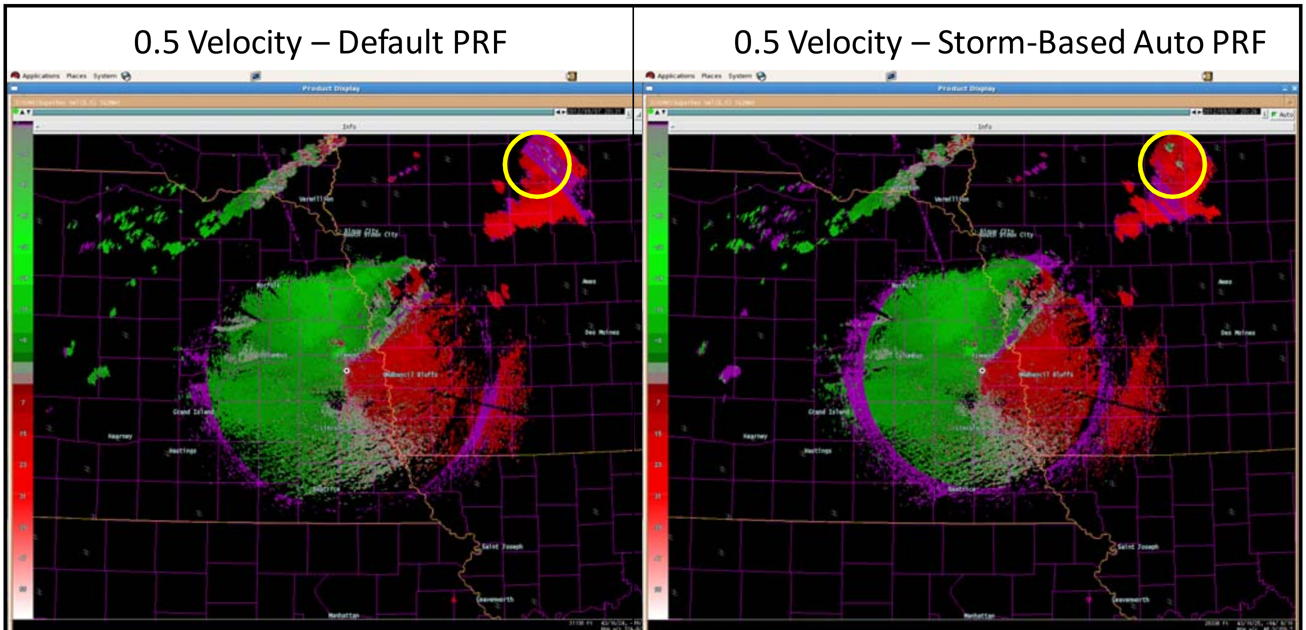

Figure 1: The benefit of Storm Based Auto PRF.

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PRF that results in the smallest area is selected for the next volume scan.

Using this as a building block, the software was modified and an adaptation parameter was added to support the identification and processing of multiple storms (second shortcoming). Several test cases were processed and the results showed that, when multiple storms were present, using three storms as a basis for determining the optimum PRF had the best overall performance.

Now with two of the three main shortcomings addressed, ROC Engineering focused its attention on the third problem of automating the storm selection process. One of the main criteria for the storm selection parameter was that it had to work at all ranges within 230 km. That single criteria excluded many automated severe weather indicators, such as TVS (Tornadic Vortex Signature) and MESO (Mesocyclone). Consequently, it became obvious that of the severe weather indicators derived by the RPG that are reliably associated with individual storms, that are easily sortable and rankable, and that provide consistent performance for all ranges within the Doppler coverage umbrella, Cell-Based VIL (Vertically Integrated Liquid) was the best available choice. This being the case, and not wanting the PRF to jump around when there are only towering cumulus (TCU) popping up and dying out, only cells with a Cell-Based VIL greater than 15 kg/m^2 (adaptable) are considered storms.

The Storm-Based Auto PRF function has now evolved into supporting two options: Automated Multi-Storm and Selected (Single) Storm. The Multi Storm-Based Auto PRF option automatically tracks (up to) the 3 most significant storms (based on the Cell-Based VIL) and assigns the PRF that results in the smallest area of range-obscured data for those storms. These two options are designed to work together and augment the current (elevation-based) Auto PRF algorithm to better automate the PRF control function.

When the Multi Storm-Based Auto PRF option is invoked, it will continuously track the top cells until all cells dissipate or move beyond 230 km. When this occurs, the Multi Storm-Based Auto PRF option will be automatically suspended and the Auto PRF (current elevation-based) algorithm will be used. At such time that a new convective cell meeting the minimum Cell-Based VIL (>15 kg/m^2) is identified by the SCIT algorithm, the Multi Storm-Based Auto PRF option will be automatically reactivated.

If the operator chooses to invoke the Selected (Single) Storm Auto PRF option, it will track the operator-selected storm of interest and assign the best PRF for that storm until that storm dissipates, is re-identified with a different Cell ID, or moves beyond 230 km. When any of these situations occur, the Selected (Single) Storm Auto PRF option will be automatically disabled and the Multi Storm-Based Auto PRF option will be activated.

Accordingly, in Software Build 14.0 there will be three Modes within the WSR-88D PRF control function: the current (elevation-based) Auto PRF Mode, Manual PRF Mode, and the new Storm-Based Auto PRF Mode. There are two options within the Storm-Based Auto PRF Mode - the (default) Multi Storm-Based Auto PRF option that automatically tracks up to three cells to determine the optimum PRF, and the (operator) Selected (Single) Storm Auto PRF option that ensures the smallest area of range-obscured data over a single operator-selected storm. These two new Storm-

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ROC Stars

After income and insurance, employee recognition may be the most important attribute to any job. Here at the Radar Operations Center (ROC) we are proud of our employees and all of their accomplishments, and are delighted to recognize the following employees for their hard work.

2013 Bronze Medal Award Winners:

Olen Boydstun, Steven Smith, Richard Ice, Dave Zittel, and **Richard Murnan** for excellence organizing and executing an operational assessment demonstrating the effectiveness of dual polarization data for warning and forecast operations.

2012 NOAA Administrator's Award Winner:

Russ Cook for outstanding management of the G-IV Tail Doppler Radar project, enhancing NOAA's weather forecasting and research capability.

NOAA Employee of the Month (September 2012) Winner:

Terrell "B: Ballard for outstanding leadership and expertise in restoring the NEXRAD radar to operation.

2013 Oklahoma Federal Executive Board Employee of the Year Nominees:

Technical, Professional & Administrative, GS-9 & Above, (Civilian) – **Zach Jing**
Technical, Professional & Administrative, GS-9 & Above, (DOD) – **Richard Ice**
Technical, Professional & Administrative, GS-8 & Below, (Civilian) – **Michael Fielden**
Technical, Professional & Administrative, GS-8 & Below, (DOD) – **Ssgt Josue Diaz**
Clerical/Administrative Assistant (Civilian) – **Kelly Thomason**
Outstanding Customer Service – **Robert Lane**
Outstanding Community Service – **Richard Murnan**
Supervisory (Civilian) – **Michael Miller**
Supervisory (DOD) – **Scott Saul**
Outstanding Team Effort – **Edward Berkowitz, James (Marty) Williams, Timothy Crum, Frank Hewins, Jeffery Turner, Donna Kitchell, Chris Hunt**

ROC Employee of the Quarter – FY13

1st Quarter – **Rich Murnan** (Applications Branch)

ROC Employee of the Quarter – FY12

1st Quarter – **Michael Prather** (Engineering Branch)
2nd Quarter – **SSgt Josue Diaz** (DOD)
3rd Quarter – **Jessica Schultz** (Applications Branch)
4th Quarter – **Kelly Thomason** (Applications Branch)

ROC Team Member of the Quarter – FY12

1st Quarter – **Scott Ganson** (Team Centuria)
2nd Quarter – **Gordon Jim** (Team Centuria)
4th Quarter – **Michelle Collier** (Team Centuria)

Janice Page
ROC Director's Office

Uncovering

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Based Auto PRF options, augmenting the current (elevation-based) Auto PRF Mode, should help ensure operators can always uncover the storm.

Joe N Chrisman
ROC Engineering Branch

PRF Modification Now Available for SZ-2 VCPs

The Sachidananda-Zrnić-2 (SZ-2) velocity data processing technique, which is able to recover weak trip velocity returns and thereby reduce range folding, was introduced into the WSR-88D baseline with the addition of Volume Coverage Patterns (VCPs) 212, 211 and 221. SZ-2 works by transmitting a known, repeating sequence of phase shifted pulses then using a strict set of decision rules, the SZ-2 algorithm separates the strong trip from the weak trip returns resulting in reduced range-folded data.

The SZ-2 algorithm requires 64 pulses per radial and uses a repeating sequence of 8 phase codes. To accommodate these requirements, the pulse repetition frequency (PRF) for all SZ-2 VCPs is currently hard-coded. The hard-coded PRFs result in the second trip clutter induced range folded bins to always be at a constant range for each SZ-2 VCP. While in most circumstances this is a manageable issue, under some conditions the inability to change the location of the second trip clutter-induced range folded data can have a detrimental impact on the forecast and warning process.

Recognizing this shortcoming in the implementation of the SZ-2 VCPs, Radar Operations Center (ROC) Software Engineering set out to implement the capability to manually specify the PRF used to collect Doppler data for VCPs 211, 212 and 221. Additionally, if possible, ROC Engineering wanted to develop an automated PRF selection method suitable for use with SZ-2 velocity data processing and integrate this new method into the Radar Product Generator's (RPG's) PRF control function.

Implementing manual PRF selection for the SZ-2 VCPs was reasonably straightforward. The RPG code was changed to automatically modify the antenna rotation rate based on the specified PRF. This was done to ensure that 64 pulses per radial are collected to support SZ-2 processing. Now, manually specifying the active PRF for SZ-2 VCPs is essentially the same as for all other VCPs, except PRF Sectors are not allowed as SZ-2 must have 64 pulses per radial.

Implementing an automated PRF selection method to emulate SZ-2 processing posed a bigger challenge. Unlike the current Auto PRF algorithm which relies solely on comparative power magnitude to determine overlaid return, SZ-2 processing also examines other return characteristics to separate the return from different trips. Therefore, an algorithm that uses information available at the RPG to emulate the SZ-2 decision factors was developed. The output from this algorithm is used to select the optimum PRF and as input into the Storm-Based Auto PRF function when either VCP 212, VCP 211 or VCP 221 are active. (See related article; Uncovering the Storm, on Page 9 of this publication.)

The new SZ-2 PRF control software complements the current PRF control functions (manual PRF selection and Auto PRF algorithm), as well as, the new Storm-Based Auto PRF function. Now, the SZ-2 VCP PRFs can be controlled, either manually or automatically, just like the other VCPs; the only notable difference stems from the SZ-2 requirement for 64 pulses per radial. Changing the active PRF will cause the SZ-2 VCP completion times to vary slightly, e.g., VCP 212 execution times are approximately 10 seconds faster with PRF 8 and approximately 5 seconds slower for PRF 5. The SZ-2 PRF control software modifications are currently under test and are scheduled for inclusion in RPG Software Build 14.0.

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