

7.3 DYNAMIC SCANNING FOR THE NATIONAL WEATHER RADAR TESTBED

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1. INTRODUCTION

The National Weather Radar Testbed (NWRT) Phased Array Radar (PAR) in Norman, Oklahoma is a research tool that is being used to demonstrate the benefits of phased array technology versus conventional mechanically scanned radars (i.e., WSR-88D). Heinselman et al (2007) analyzed data collected by the PAR from 3 different severe weather events during 2006 and described the benefits of increased temporal resolution in the detection and interpretation of severe weather phenomenon. In each of the events, different scanning strategies were chosen based on the type, size and location of the storms. Smith et al (2007) describe how the PAR was used to observe the characteristics of microburst events during the summer of 2006, again using different scanning strategies from those used by Heinselman et al. These studies illustrate the benefits of being able to change scanning strategies in response to a particular weather phenomenon.

In this paper, changes to the NWRT software which allow “adaptable scanning” of weather events are discussed. We choose not to use the term “adaptive scanning” here since these changes still require interaction from a human operator even though one could argue that they are adaptive. However, as will be mentioned in the following sections, the framework is being developed to allow algorithms, in addition to a human operator, to adaptively change various scan properties.

2. SYSTEM OVERVIEW

A system level overview was reported by Priegnitz and Forsyth (2006, 2007) and will not be repeated here. The software modifications that are being implemented to support adaptable scanning primarily affect the Real Time Control (RTC) and Radar Control Interface (RCI) subsystems. The RTC communicates directly with the radar

hardware, accepting input via a network connection from the RCI server. Human operators communicate with the RCI server via an RCI client. Command messages are then relayed from a single controlling RCI client to the RTC and processed.

Changes have been made to the RTC software that allow newly developed messages to support changing scan properties while the radar is active (i.e., transmitting and receiving pulses). Although relayed from a human operator, these messages could very well originate from an automated algorithm.

3. SCAN CONTROL TABLE

In the legacy RTC, (defined here as the version of the RTC software that was delivered with the original system) a single scan strategy, or “super stimulus”, is selected from the controlling RCI client and passed to the RTC by the RCI server. A repeat count can be specified so the super stimulus can run multiple times without the operator having to restart it each time it completes. However, in order to load a new super stimulus, an operator must either wait for an active scan to complete or stop it by command.

The legacy RTC requires that scan control files, or stimulus files, defined in the super stimulus by filename, be pre-built and loaded on the RTC disk so the RTC software can read them when a new super stimulus is defined. A major drawback in this design is that many stimulus files need to be created to cover all of the expected scanning scenarios. For example, during the 2006 season, a number of VCP12 type stimulus files were created, differing only by the width of the azimuth sector. The stimulus properties for all beam positions at a given elevation angle were the same; only the azimuth angle differed. In order to increase temporal resolution it would have been advantageous to be able to limit the number of elevation cuts and reduce the azimuth sector width when scanning isolated distant storms. In the future, with each new project/user, a unique scanning strategy would be needed, resulting in an

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increasingly unmanageable number of stimulus files.

To address the aforementioned issues, a new scan control scheme has been developed that eliminates the need to pre-build stimulus files and copy them to the RTC disk. A new high level scan strategy format has been developed which is more compact and less redundant than the legacy stimulus format. Scan strategies using the new format are created using the “Stimulus Wizard” software tool described by Priegnitz and Forsyth (2007) and stored on the RCI server disk. An operator chooses a scan strategy from a menu which is then loaded into a scan control table residing at the RTC. Currently, the scan control table holds up to 10 scan strategies and can be managed from a controlling RCI client. Any non-controlling RCI client views the scan control table. However, only one controlling RCI client can edit it at any given time.

In this case, since the repeat count for all active scan strategies is 2, each is repeated twice (i.e., DARE61 + DARE61 + DARE62 + DARE62 + DARE63 + DARE63 + DARE64 + DARE64).

Other items in the NWRT Scan Strategy Control window include the antenna azimuth position (Pos column), the azimuth sector (Az1 and Az2 columns), the azimuth interval (Azint column), the number of elevation cuts (Elevs column), the upper elevation cut to process (ElevT column), and the scan completion time (Time column). The operator can save the table to a file so it can be restored at a later time allowing several predefined sets of scanning strategies for different scenarios. Saved scan control tables are stored by the RCI server.

Scan table properties are editable by first selecting a table item and then selecting the “Properties” button, at which time the NWRT

Index	Scan Strategy Name	Rep...	Pos	Azi1	Azi2	Azint	Elevs	ElevT	Time
1	90 degree sector up to 41 degrees (storms < 100km)	0	0.0	-45.0	45.0	1.0	32	41.0	29.038
2	VCP12 - 90 Degree sector	0	0.0	-45.0	43.99	1.0	14	19.5	57.544
3	VCP12 - Lowest 5 Cuts	0	0.0	-45.0	45.0	1.0	5	2.4	30.281
4	DARE61: Multicells within 75km - undersamples all elev.	2	225.0	-45.0	45.0	1.0	11	30.0	59.494
5	DARE62: Multicells within 75km - undersamples all elev.	2	225.0	-45.0	45.0	1.0	21	30.0	111.709
6	DARE63: Multicells within 75km - undersamples all elev.	2	225.0	-45.0	45.0	1.0	33	30.0	173.629
7	DARE64: Multicells within 75km - undersamples all elev.	2	225.0	-45.0	45.0	1.0	43	30.0	233.315
8	PASSES1: Supercells within 100km - oversamples low el.	0	0.0	-45.0	45.0	1.0	8	5.6	30.285
9	PASSES2: Supercells within 100km - oversamples low el.	0	0.0	-45.0	45.0	1.0	8	5.6	58.24
10	PASSES2: Supercells within 225km - oversamples low el.	0	0.0	-45.0	45.0	1.0	8	5.6	58.968

Repeat List: 1

Buttons: Properties, Save Table, Restore Table, Refresh, Close

Figure 1: NWRT Scan Strategy Control menu.

Each scan strategy can be modified by the controlling RCI client, eliminating the need to have numerous flavors of a given scan strategy just to change azimuth and/or elevation properties. In addition, these modifications can be made while scanning is active so that the operator no longer waits for a scan to complete before sending a new scan strategy to the RTC.

Figure 1 shows a sample NWRT Scan Strategy Control window in which a scan control table is displayed. Different scan strategies have been loaded into all 10 scan control table positions. When scanning is activated, the scan strategies with a non-zero repeat count (“Rep” column) are executed. In the scan control table, active scan strategies are displayed with a green background color.

Scan Strategy Properties menu is displayed. A sample NWRT Scan Strategy Properties menu is presented in Figure 2.

For a selected scan table position, if a scan strategy has not yet been defined, or if the operator wants to change the scan strategy, it can be chosen from a list by selecting the “Scan Strategy” button. Sector azimuth width is defined by a pair of angles (“Azimuth 1” and “Azimuth 2”) relative to the array face. The largest sector width that can be defined is 90 degrees (-/+ 45 degrees). The number of beam positions in an elevation cut is defined by the sector width divided by the azimuth interval (“Interval”). Since the NWRT consists of a single array face, it is necessary to position the antenna (“Antenna Pos”) to a particular compass direction before starting

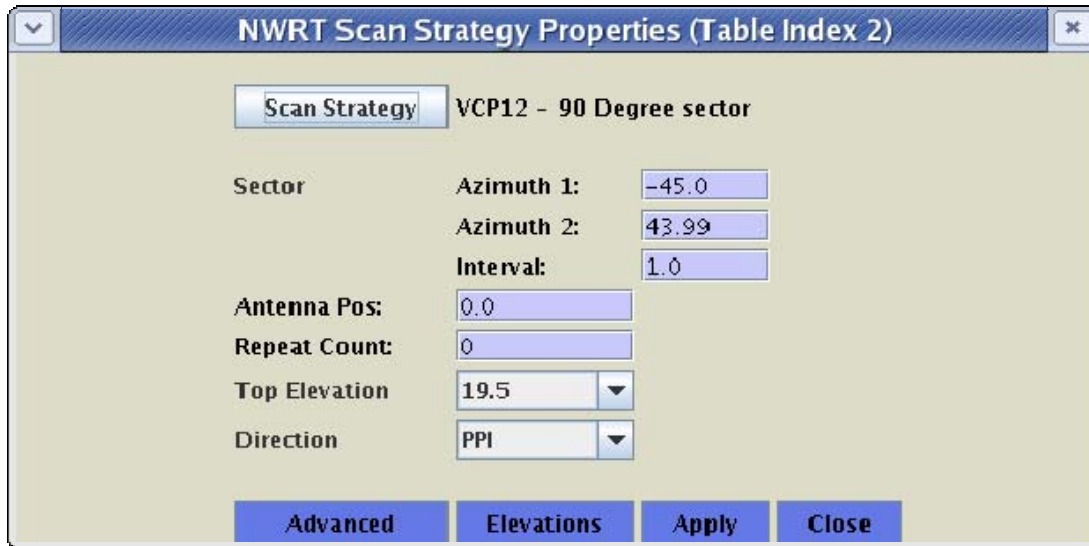


Figure 2: NWRT Scan Strategy Properties Menu

scan processing. Since scanning is processed from the first to the last elevation cuts defined in the scan strategy, the operator can use the "Top Elevation" item to define the last elevation cut to be processed in the scan. For instance, this can be useful in situations where storms are located far from the radar. The scan strategy can be repeated ("Repeat Count" > 0) or deactivated ("Repeat Count" = 0). The scan direction ("Direction") can be defined as PPI (horizontal) or RHI (vertical).

Elevation cut properties may be modified by selecting the "Elevations" button. This activates the NWRT Scan Strategy Elevation Control menu. A sample NWRT Scan Strategy Elevation Control menu is presented in Figure 3.

A simple table is presented with properties for the first elevation cut at the top and properties for the last elevation cut at the bottom of the table. Although in this example the elevations are defined in increasing value from lowest to highest, there is no requirement for elevation cuts to be ordered any particular way. Below the table are menu selections to either insert a new cut ("Insert Cut") or delete an existing cut ("Delete Cut") from the table. Within the table the operator can define the elevation angle, waveform (short: 1.57 μ s, or long: 4.71 μ s), mode (single, split cut, batch, staggered pulse repetition time), start range, stop range, and up to 5 different pulse repetition time/pulse count combinations.

SCAN PROCESSING

When the operator at the controlling RCI client starts scan processing, the following happens at the RTC. If no scan control table entries are active (repeat count set to 0), nothing happens. If active scan control table entries are present, processing is performed from the first active scan table entry to the last. Each individual scan table entry is repeated based on its repeat count.

When a scan table entry is processed for the first time, or when modifications have been made since the last time it was processed, a stimulus template is created. The template sets up the internal command structure that is passed to the various system components for execution. Before data is collected, the stimulus template is modified as defined by the scan strategy (i.e., azimuth and elevation angles, pulse properties).

As mentioned previously, entries in the scan table can be modified while scanning is active. However, if changes are made to a scan table entry while it is active, modifications do not take effect until the next time the scan is processed (at which time its stimulus template is updated).

SUMMARY

A new scan control method has been designed for the NWRT PAR that allows an operator to run multiple scan strategies in sequence and make modifications while scanning is active. Currently, changes to the

NWRT Scan Strategy Elevation Control																
Cut	Elev	Waveform	Mode	Rng1	Rng2	PRT1	Pulses	PRT2	Pulses	PRT3	Pulses	PRT4	Pulses	PRT5	Pulses	
1	0.51	S10r	Split Cut	2.49	463.68	3107	15	898	44	0	0	0	0	0	0	
2	0.9	S10r	Split Cut	2.49	463.68	3107	15	898	44	0	0	0	0	0	0	
3	1.3	S10r	Split Cut	2.49	463.68	3107	15	898	44	0	0	0	0	0	0	
4	1.8	S10r	Split Cut	2.49	463.68	3107	15	898	44	0	0	0	0	0	0	
5	2.4	S10r	Split Cut	2.49	333.75	2240	3	898	33	0	0	0	0	0	0	
6	3.1	S10r	Split Cut	2.49	333.75	2240	3	898	33	0	0	0	0	0	0	
7	4.0	S10r	Split Cut	2.49	333.75	2240	3	898	33	0	0	0	0	0	0	
8	5.1	S10r	Split Cut	2.49	230.79	1553	3	898	33	0	0	0	0	0	0	
9	6.4	S10r	Split Cut	2.49	230.79	1553	3	898	33	0	0	0	0	0	0	
10	8.0	S10r	Single	2.49	122.58	831	42	0	0	0	0	0	0	0	0	
11	10.0	S10r	Single	2.49	117.945	800	43	0	0	0	0	0	0	0	0	
12	12.5	S10r	Single	2.49	117.945	800	43	0	0	0	0	0	0	0	0	
13	15.6	S10r	Single	2.49	117.945	800	43	0	0	0	0	0	0	0	0	
14	19.5	S10r	Single	2.49	117.945	800	43	0	0	0	0	0	0	0	0	

Insert Cut: Delete Cut: Scan Time: 57.544 seconds

Figure 3: NWRT Scan Strategy Elevation Control menu.

scan control table are made by a human operator. However, in the future, algorithms could be used to modify them. One challenge in implementing a scheme that runs a variety of scanning strategies is that the beam properties from one scanning strategy may be significantly different from another (temporally and spatially). Algorithms processing the data will have to account for these differences.

The scan control method presented here assumes that scan processing is performed by running one scanning strategy followed by another. However, one major advantage of phased array technology is the ability to track fast moving objects such as aircraft without physically moving the antenna. A new scheme will need to be implemented which interlaces scan strategies based on a well defined priority scheme. This will be integrated into the scan control scheme presented in this paper.

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