4B.5 Use of the Management Information and Retrieval System to Produce Radar Coverage Maps

Joe Facundo and Michael Carelli, Office of Operational Systems,

Silver Spring, Maryland

1. INTRODUCTION

The National Weather Service's (NWS) Management Information and Retrieval System (MIRS) contain metadata on the NWS radar network using a Geographical Information System (GIS). Information from MIRS was used to define theoretical radar beams from the NWS WSR-88D radars. Beams can be defined for any antenna elevation angle for any radar. The theoretical beams were superimposed on 30-meter resolution terrain maps to depict radar coverage for individual radar sites for different antenna elevation angle. This paper is an extension of the American Meteorological Society extended abstract J11.3, presented at the AMS IIPS meeting in 2006.

2. BACKGROUND

The GIS approach for determining radar beam coverage has been described before in AMS extended abstracts (see references). The technique estimates the height of the centroid of the radar beam above the geoid along a radial for an antenna elevation angle. Radar beam propagation is determined by the characteristics of the radar and atmospheric parameters.

The height of the centroid of the beam is determined by:

$h = (r^2 \cos^2 e/2aR_e) + r \sin e$[1]

Where:

h – Height of the centroid of the beam above local radar level
r – Horizontal range
e – Antenna elevation angle
a – Effective earth radius factor
R_e – Radius of the earth

Estimates of the height of the bean centroid are determined for each location (latitude and longitude) along each radial. The GIS approach uses a digital elevation model to determine the terrain elevation at each location. The terrain field is added to the height of the beam centroid. The percent of obstruction of the half power beam is determined for each radial. The lowest height of the unobstructed beam is also determined. The radar coverage determined by this method is then overlaid on the terrain map. Figure 1 below illustrates this technique.

This method has been applied to the NWS WSR-88D radars, but could also be applied to other radar systems as well.

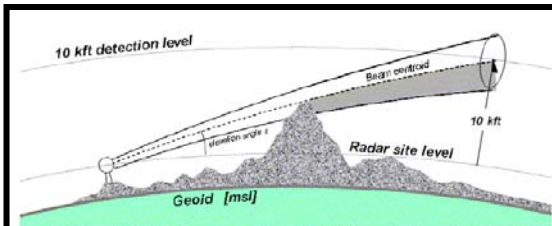

Figure 2 – Theoretical WSR-88D beam propagation path for initial beam elevation angle ε. The radar beam power distribution is assumed to be symmetric about the beam centroid. The lowest detectable height is defined by the bottom of the beam, which in this paper is called the "Floor". When the occultation criterion is set to Power < 50%, then the Floor is defined by the beam centroid after that centroid grazes an obstacle. The SRI method (Leone et al., 1989) defines the maximum detectable range when the lowest possible beam centroid reaches 10 kft ARL (Above Radar Level), and radar beam elevation angles are presumed to vary continuously. The vertical scale is greatly exaggerated.

Figure 1. Graphic from AMS paper J11.3, 22 IIPS 2006.

3. CASE STUDIES

3.1 MOVING A RADAR

One of the uses of this technique from a GIS perspective is with respect to radar moves, whether it is in the vicinity of the old radar location or much farther away. For example, the NWS is planning to relocate its WSR-88D radar at WFO LWX from its current location in Sterling, Virginia at the Sterling Research and Development Center to another location at the

[1] From AMS J11.3 extended abstract, see Section 7 for details.

same facility in the northwest quadrant. The distance between the two may turn out to be around 4000 ft (see arrow in Figure 2). Using the Google ™ Professional Trial Mode as shown in Figure 2, the relative distance and direction of the move is delineated.

The question then becomes, what is the impact of the move on the radar pattern? Note, for purposes of this example, other radars in the vicinity of the Sterling where not included in the re-mapping, although extending the technique to more than one radar is not difficult from a GIS perspective.

Figure 2. Potential move of LWX Radar.

Figure 3a is the GIS view of the current LWX radar location in terms of the Volume Coverage Pattern (VCP-11) radar coverage in yellow shading, although the technique applies to any VCP, e.g., VCP-21, one wish's to analyze. The coverage ring patterns illustrate the beam mapped on a surface plane at 10,000 ft above the radar. For this reason, the concentric circles cover smaller areas as the radar beam elevates its angle overhead. Note the beam blockage at the 0.5-degree elevation angle as the radar sweeps across the mountains to the west of the site. For this analysis, a 30-meter GIS resolution background was used in order to portray the terrain more clearly and identify actual points where the radar intersects with the mountains.

The question then becomes: If the radar is moved to its new location how will this affect the coverage patterns for VCP-11 in this case? The GIS tool uses the new coordinates for the new location and recalculates all the points along the beam trajectory for each angle as described above.

The outstanding feature of this process is that it costs nothing to recalculate different locations in a hypothetical way as opposed to hiring staff to physically map the terrain using radio interference patterns to estimate the blockage, which can be costly.

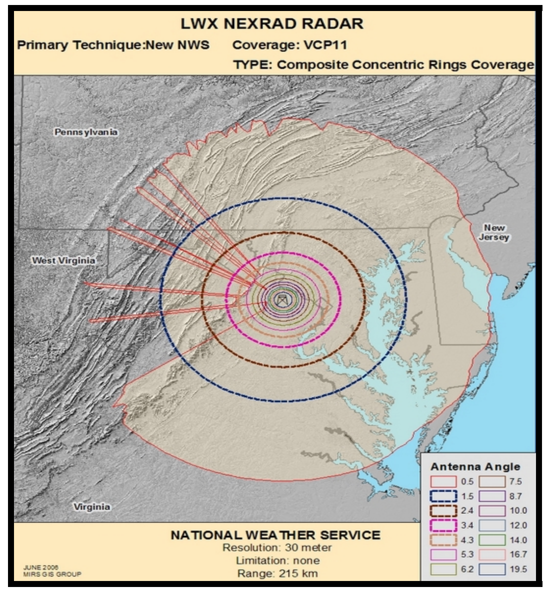

Figure 3a – Coverage of the Sterling, VA, WSR-88D with the radar at its current location.

The re-mapped VCP-11 for the projected new location is shown in Figure 3b. If this were the actual location, the coverage pattern for the lowest elevation angles would improve even without knowing about the coverage patterns from other radars in the vicinity. The actual GIS maps will be drawn when the final determinations on location are made.

With this technique and GIS tools, one can understand the coverage pattern better and also verify if the pattern is actually accurate, since the 30-m GIS terrain mapping is itself accurate and the radar beam solution has been calculated, independently; thus, the two need to match well or some registration problem may exist. With some good tools on the market, one can zoom-in on the terrain and determine if this is indeed the case.

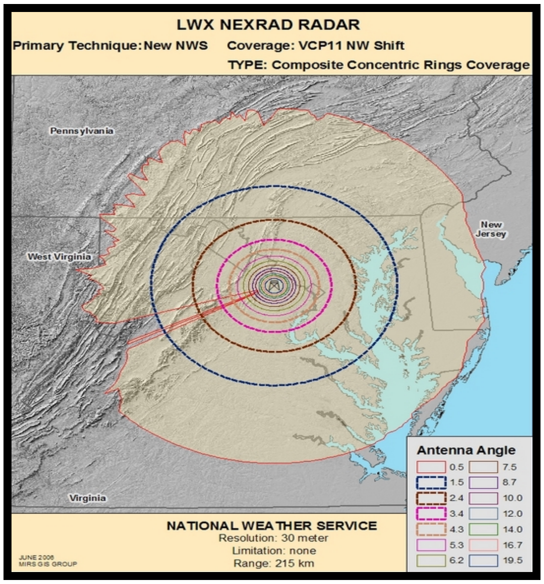

Figure 3b – Coverage of the Sterling, VA, WSR-88D with the radar moved 4000 feet toward the west-northwest.

3.2. EVALUATING NEW RADAR PATTERNS

Another use of this technique having great promise is with respect to experimentation and evaluating new coverage patterns well before they are actually utilized by an NWS office. In this case, a couple of examples were selected illustrating this concept and its utility to radar meteorology.

The first example is a calculation of the radar beam pattern at an angle of –0.5-degrees in elevation. Now, it would not be prudent to try this with an actual radar until one could see what the affects are in terms of its intersection at ground level. Why point a radar towards this angle? The reason is because some radars are placed at higher altitudes which can overshoot the lower layers of weather and thus not depict the atmosphere as well. Figure 4a illustrates this point by selecting an elevated radar in the Salt Lake City vicinity which could then be pointed down, theoretically. Scrutinizing the coverage with the 30-meter GIS background, one can see there is good consistency between the radar beam blockage where the mountains exist and good coverage where no mountains exist to the extent of the radar beam intersecting the ground. This means the technique for calculating the radar intersecting points agrees well with the GIS terrain, as one would expect. Extending this technique further, one could then move the coordinates of a *hypothetical* radar to any location in a given mountain region and point the radar to any reasonable negative number or zero elevation and see exactly what pattern is defined by the algorithm with a high degree of confidence. This too can be very cost effective in ascertaining key information about the radar's performance before it is installed.

Returning to the Sterling radar again, the next example illustrates the concept of adding new radar elevation angles and assessing their affects on the radar coverage as a result. Figure 4b delineates the application of this technique by adding new radar coverage angles, hypothetically, and then viewing the results before any decisions are made, since adding a new coverage pattern has a significant affect on radar processing.

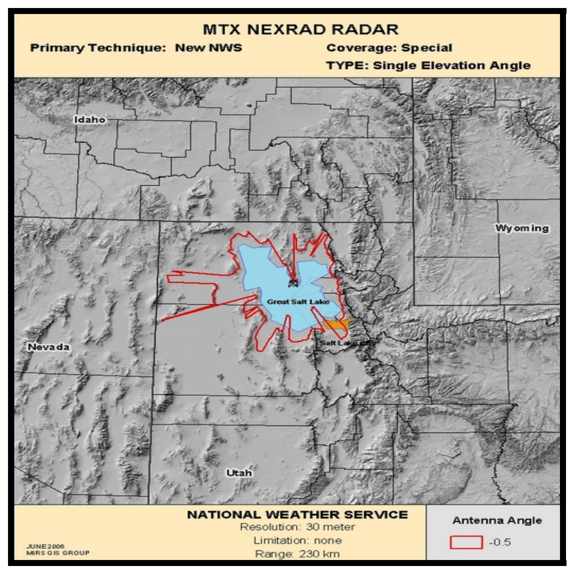

Figure 4a – Coverage of the Salt Lake City, UT, WSR-88D with the antenna set at a -0.5 degree elevation angle.

In this example, the LWX at its current location was used, but elevation angles at 0.50, 0.75, 1.00, 1.25, 1.50, and 19.5 degrees were incorporated into a "special" radar coverage pattern with the intent being to improve the coverage where there is beam blockage at the

0.5-degree angle towards the west from the site. In this case, one can see significant improvement in the coverage (yellow shading) by simply adding these angles into the mix. With this technique, field offices could experiment with different elevation angles to improve their radar's performance and possibly eliminate areas of beam blockage, recognizing there are trade-offs in radar processing to established products.

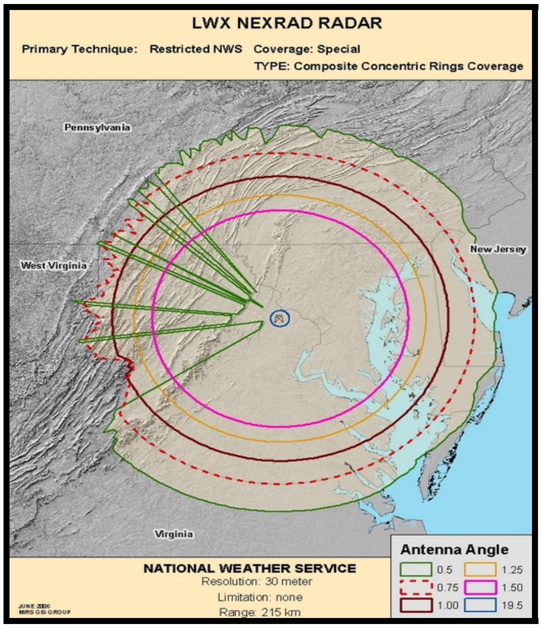

Figure 4b – Coverage of the Sterling, VA, WSR-88D with several antenna elevation angles added.

4. FURTHER WORK

Certainly the GIS mapping becomes more complicated with multiple radars overlapping each other. Nevertheless, NWS will look at these types of regional mappings to see if any trends or interesting features result. The goal is to make this tool available through the MIRS GIS portal to NWS offices for their use and applications.

5. CONCLUSIONS

The intent of this paper was to inform the community on how the NWS-developed technique briefed in previous extended abstracts could be integrated with 30-meter resolution GIS backgrounds along with the mapping of radar coverage. These coverage patterns can then be manipulated either through the movement of radar locations, hypothetically adding a new radar location somewhere, or changing VCPs to meet new and changing requirements. The end result is this new tool will allow users to make sound decisions or convey new information as needed.

6. ACKNOWLEDGEMENT

The authors of this extended abstract wish to share their appreciation to the authors of the references below for their outstanding work in developing the GIS technique for radar coverage mapping contained in this document. Also work conducted by S. Del Greco of NOAA's NESDIS/NCDC and Yekaterina Shkolnikova (Katya) have also contributed to this effort. Without their work, this paper would not have been possible.

7. REFERENCES

J11.3 GIS Tools for Radar Siting and Analysis, Scott T. Shipley, Ira A. Graffman, Robert E Saffle, and Joseph Facundo, Environmental Resource Technologies, National Weather Service, Mitretek Systems, and George Mason University
Silver Spring, Maryland

6.6 GIS Module for the National Weather Service's Management Information Retrieval System, John P. Kozimor, QSS Group, Inc., Silver Spring, MD

P2.4 National Weather Service Management Information Retrieval System Online Map Gallery and Interactive Map Viewer, John P Kozimor**,** NOAA/NWS, Silver Spring, MD