5B.8 Investigation of point echoes from GPS-enabled aircraft to detect anomalous propagation

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Abstract – Point echoes are normally removed from weather radar data to reduce noise associated with small targets such as aircraft. Most aircraft now carry GPS instrumentation and are reporting their positions {lon, lat, height, time} with great accuracy. Such information may be correlated with point echoes observed in individual range cells of a weather radar return. This paper examines the possibility that weather radar point echoes can be correlated to targets with known position, and if so, whether this information can be used to provide useful information on anomalous radar beam propagation.

1. Meteorological Value of Point Echoes – Point echoes in weather radar returns are generally considered to be noise and are typically removed. According to FMH-11:
"Targets capable of independent flight, such as aircraft and birds that are not tracers of the wind, provide little useful information to the meteorologist. The WSR-88D system has the capability to remove these types of returns from the data field by logic based on the target radar cross section and range extent (Point Clutter Rejection)." – FMH 11, Part B, Doppler Radar Theory and Meteorology, FCM-H11B-2005, Appendix B, Point Targets and Clear Air Returns (page B-3).

With the advent of Automated Aircraft Reports (ACARS) and their availability to the meteorological community through the Meteorological Assimilation Data Ingest System (MADIS), it may now be possible to correlate point echoes with actual aircraft positions given information on aircraft longitude, latitude and height, as well as bearing and ground speed. Once positively identified and correlated with radar point echoes at specific beam elevation angles, it should be possible to determine the departure of beam refraction from standard propagation models, to within the limits of the radar vertical beam width. This paper addresses the detectability of aircraft point echoes, and our

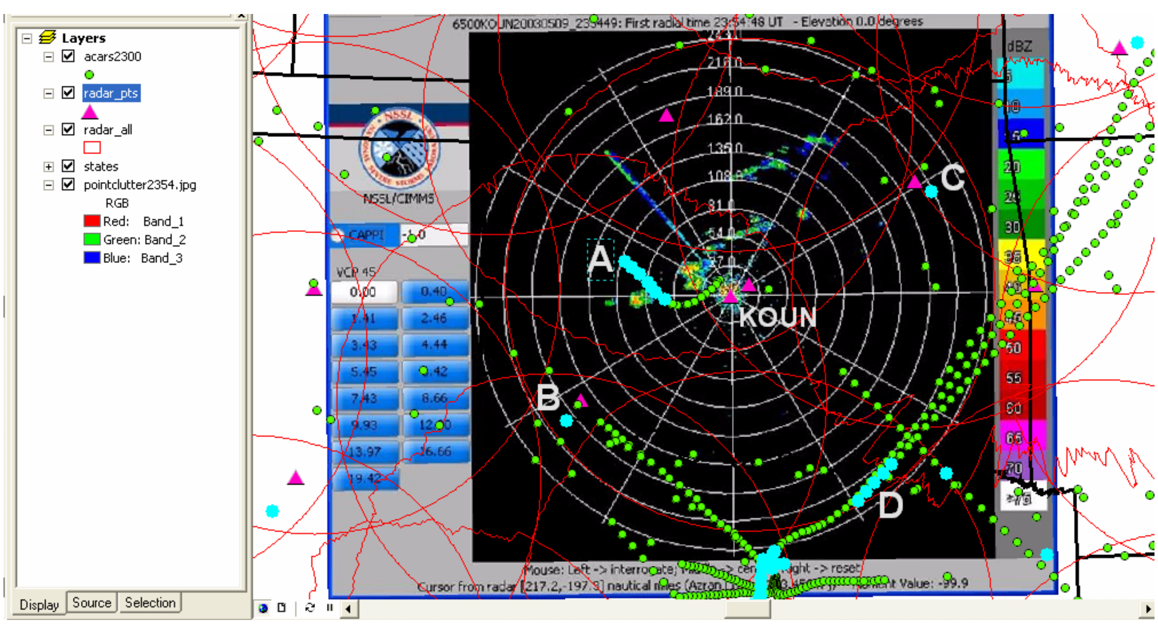

Figure 1 – Simultaneous and collocated ACARS reports for the hour of 2300 UT, overlaid on Level II PPI depiction for the KOUN WSR-88D at 2354 UT on 9 May 2003, using ESRI ArcMap. ACARS reports occurring during the 5-minute volume scan starting 2354 UT are highlighted (cyan).

ability to correlate them in space and time with ACARS aircraft positions. Preliminary results on a small data sample indicate that such identification can be accomplished. Given the increasing frequency of aircraft reports, this approach may eventually provide valuable information on anomalous propagation in real time. In addition, a statistical collection of aircraft point echo correlations may provide useful information on radar beam patterns when used as calibration targets. One issue to this study is that Level I data are normally processed to remove point echoes. This barrier was overcome by utilizing NSSL's KOUN Research RDA (RRDA) to process the Level I data and disabling the point clutter rejection processing.

2. Method – A test data set was identified from KOUN data archives and processed using the RRDA to produce NEXRAD Level II format data, resulting in ten volume scans starting at 2354 UT on 9 May 2003. Two versions of these data were provided, including the original with point processing (point echoes removed), and a new version without point processing. ACARS data were acquired from MADIS (the cooperation of Patricia Miller of NOAA/ESRL is greatly appreciated). These data were decoded into formats compatible with ESRI ArcGIS, and GIS procedures were used to overlay and correlate the radar and ACARS point echoes in a PPI format, as shown in Figure 1. An additional range-time data depiction was used for detailed correlation of these data sets, allowing radial by radial examination for aircraft point echoes. Confirmation was sought for multiple echoes from the same aircraft, which would confirm aircraft identity by consistent motion through the radar sample volume.

3. Detection probability – Four correlation events were examined for the 5-minute period starting at 2354 UT on 9 May 2006. These four events are labeled A, B, C, D in Figure 1. Events B and C were isolated reports of aircraft position and could not provide confirmation by multiple strikes on the same aircraft. Event D was eliminated due to the presence of precipitation echoes in the vicinity of the aircraft position. The remaining event A provided a positive correlation (probable detection) with two strikes at the correct location and time in two sequential elevation scans (RDA 6 = 4.30 degrees and RDA 7 = 5.25 degrees). The ACARS and point echo data for event A are listed in Table 1. A vertical cross section for these events showing the correlation of aircraft position with beam elevation angle is shown in Figure 2 (adapted from FCM-H11C-1991 figure 5-3).

This is a preliminary result. Additional data must be examined to develop confidence in the correlation of ACARS and WSR-88D point echoes. Please keep in mind that point echoes are removed in the operational WSR-88D radars when processing Level I data, and should not be expected in routine Level II archives.

Acknowledgments – We gratefully acknowledge the provision of archived Automated Aircraft Reports (ACARS) data by MADIS, especially the efforts of Patricia Miller/ Information Systems Branch, NOAA Earth System Research Laboratory. We also appreciate the availability of online tools for NEXRAD data manipulation provided by NCDC. This effort was supported in part by NWS Contract GS35F0041N, with the NWS Office of Science and Technology, Systems Engineering Center.

Table 1 – ACARS data intersecting KOUN for the five-minute time period starting 2355 UT on 9 May 2003, event A only.

	alt (m)	alt (kft)	heading	minute	second	range (km)	range (nau.mi.)	azimuth	RDA elev#	detection
A	6100	20013	297	55	na	61	32.9	267.0	6	na
A	6705	21998	310	56	na	70	37.8	273.1	6	na
A	7011	23002	-999	56	na	74	39.9	276.7	6	na
A	7317	24006	319	57	na	79	42.6	279.9	6 & 7	na
A	7623	25010	-999	57	na	88	47.5	283.4	7	strike
A	7928	26010	312	58	na	96	51.8	286.3	7	strike
A	8235	27017	309	59	na	104	56.1	288.0	7	na

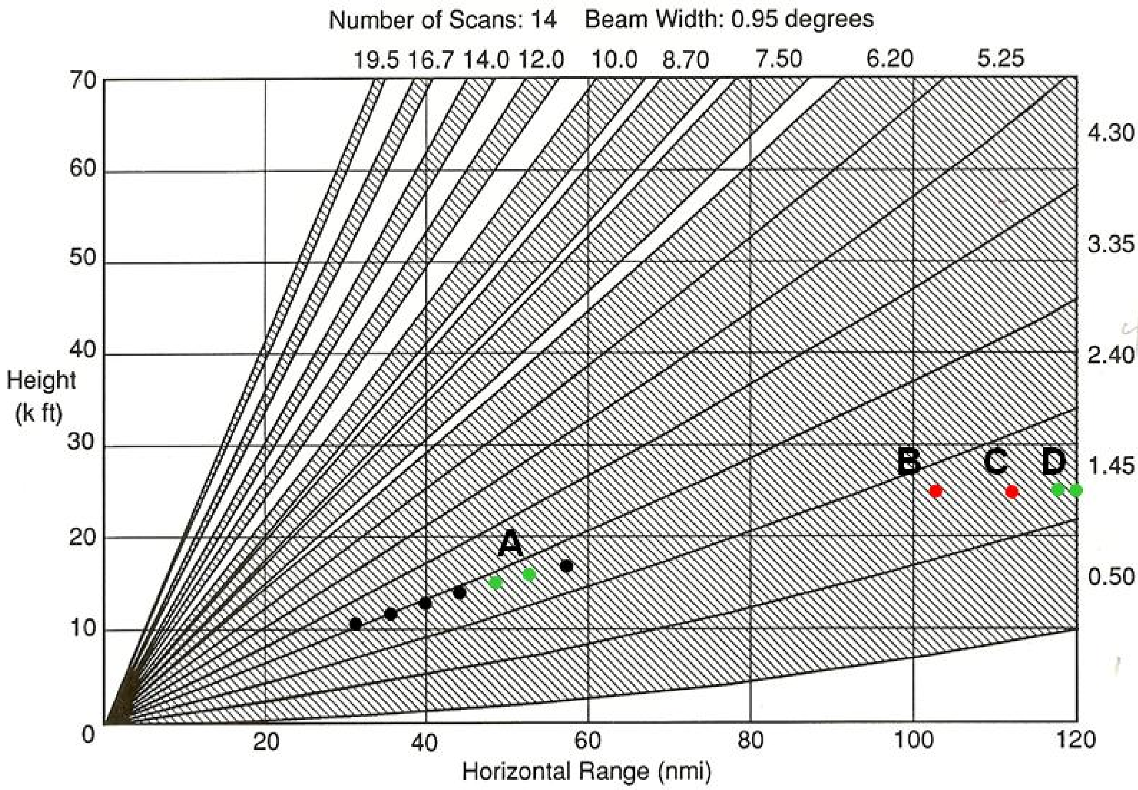

Figure 2 – Precipitation/Severe Weather Scan Volume Coverage Pattern (from FMH-11 Part C, figure 5-1, 1991). ACARS positions overlaid for KOUN collocation during the 5-minute period starting 2355 UT on 9 May 2003. Color code indicates probable positive identification (green) and ambiguous results (red).

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