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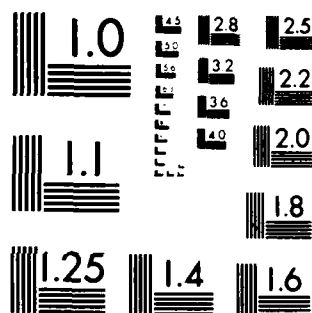
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An Evaluation of an Automatic Cell Detection and Tracking Algorithm

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3 November 1982

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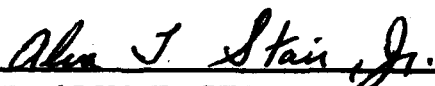
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20. ABSTRACT (Continue on reverse side if necessary and identify by block number) A storm tracking algorithm designed to detect and track fine structure in digitized radar data is evaluated. These fine structures are defined by regions containing values within 3 dB of peaks in reflectivity factor. The algorithm describes storm structure and evolution by correlating these peak regions in time and space. The evaluation consists of a comparison of the algorithm output with raw data and with output from an AFGL algorithm which detects and tracks three-dimensional reflectivity weighted centroids defined by a preselected threshold.		

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It is concluded that the algorithm cannot reliably detect and track significant structures within storms when applied to data sets with a temporal resolution of ~6 min and a spatial resolution of 1.0° in azimuth and 0.7° in elevation. The significance of tracking 3 dB peaks is questioned and the implication of defining a larger peak threshold is discussed. The algorithm does track the large features of storms with results similar to the AFGL algorithm. However, it does not run in real time and is not modular, unlike the AFGL algorithm.

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An Evaluation of an Automatic Cell Detection and Tracking Algorithm

I. INTRODUCTION

The large amount of data available from Doppler weather radar systems (for example, reflectivity, radial velocity, and velocity variance fields) make it nearly impossible for an operational forecaster to observe, interpret, and integrate all the data into a forecast product. Many of the algorithms developed for the NEXRAD software package will automate the analysis of Doppler weather radar data in real time and provide useful, easy to interpret products for the operational meteorologist.

As the Technical Evaluation Facility (TEF) for the NEXRAD project, the Air Force Geophysics Laboratory's (AFGL) Ground Based Remote Sensing Branch is developing and evaluating proposed algorithms for the NEXRAD system. In this report we present an evaluation of the Automatic Cell Detection and Tracking Algorithm proposed and developed by Crane^{1,2,3,4,5} and Gustafson and Crane,^{6,7} as an operational tool.

(Received for publication 3 November 1982)

The Next Generation Weather Radar (NEXRAD) is a joint agency program to develop and acquire a surveillance Doppler weather radar system for the Departments of Commerce (DOC), Defense (DOD), and Transportation (DOT). The NEXRAD system will replace aging DOC and DOD weather radars, and improve severe weather detection capabilities.

(Due to the large number of references cited above, they will not be listed here. See References, page 29.)

We have based the evaluation on an analysis of the timing, accuracy, and limitations of the algorithm assuming:

- a 5-6 min elevation angle sequence (volume scan) repeat time;
- and
- products will be useful to at least a range of 230 km.

The analysis consists of checks of the algorithm products against both raw data and output from the Automated Real-Time Storm Analysis and Storm Tracking (WEATRK) developed by Bjerkaas and Forsyth.⁸

All the data used in this analysis were archived during the 1979 Joint Doppler Operational Project (JDOP) (Donaldson and Glover⁹) by AFGL's 5-cm radar located at the Doppler Radar Facility of the National Severe Storms Laboratory near Norman, Oklahoma.

2. THE AUTOMATIC CELL DETECTION AND TRACKING ALGORITHM

2.1 Algorithm Overview

The Automatic Cell Detection and Tracking Algorithm (ACDT) was designed to detect and track certain features of precipitation echoes observed in weather radar data. These features are:

- 3 dB peaks defined by contours of reflectivity 3 dBZ below individual peaks in the reflectivity field,
- Volume cells consisting of vertically correlated 3 dB peaks,
- Contour regions defined by one fixed reflectivity value (for example, 30 dBZ) at the lowest available elevation angle,
- Clusters defined as groups of volume cells within a single contour, and with spacings less than some minimum distance.

2.2 Storm Attributes

The following is a discussion of the various attributes which are computed for each of the features listed above.

8. Bjerkaas, C.J., and Forsyth, D.E. (1980) An Automated Real-Time Storm Analysis and Storm Tracking Program (WEATRK), AFGL-TR-80-0316, AD A100236.

9. Donaldson, R.J., Jr., and Glover, K.M. (1980) Joint Agency Doppler Technology Tests, AFGL-TR-80-0357, AD A100208.

2.2.1 3 dB PEAKS AND VOLUME CELLS

3 dB peaks are characterized by the attributes listed in Table 1.

These peaks are detected and attributes, compiled and stored for each elevation angle. After a volume scan* is completed the 3 dB peaks are vertically correlated to build three-dimensional structures called volume cells.

The algorithm produces a hierarchy of volume cell types, removes false volume cells, and identifies significant volume cells. Significant cells are characterized as having a high degree of vertical continuity or having high reflectivity and some vertical continuity. Specifically these criteria for significance are:

(1) detection on more than 50% of all azimuth scans in a volume scan and more than 70% of the scans below 6 km; or (2) average reflectivity greater than 40 dBZ in more than 30% of the azimuth scans in a volume scan, with some portion below 6 km.

According to Crane,⁴ several types of volume cells are evident in the output from this algorithm. These are large mature (significant) cells, young growing cells, and ground clutter which is typically identified by cells that do not move and are close to the surface.

2.2.2 CONTOURS

Since contours are defined as regions enclosed by a preselected reflectivity threshold, they may encompass more than one volume cell. The attributes tallied for each contour region are listed in Table 1.

The motions of the volume cells enclosed by a contour are used to establish tracks for the contour regions, and to provide a directory for the mergers and splits of the contour regions. Estimates of liquid water flux averaged over the area of a fixed contour are useful for a relative evaluation of the contoured regions. The algorithm computes the total water mass flux rates only for observations at the lowest elevation angle to avoid contamination by ice.

2.2.3 CLUSTERS

Closely spaced volume cells are associated as belonging to a cluster, each cluster is tracked and attributes are compiled describing its structure and behavior. The cluster attributes are listed in Table 1. Crane and Hardy¹⁰ state that, at short ranges where the radar beam is sufficiently narrow to resolve the volume cells in a cluster, the cluster will represent active convection. However, at longer ranges, the volume cells in a cluster may not be resolved, in which case the convective element will be detected as a significant cell.

*A complete elevation angle sequence from lowest to highest elevation is called a volume scan.

10. Crane, R.K., and Hardy, K.R. (1980) The Hiplex Program in Colby-Goodland Kansas: 1976-1980, Final Report, Document P1552-F. Environmental Research & Technology, Inc., Concord, Massachusetts.

Table 1. List of Attributes Compiled From the Automatic Cell Detection and Tracking Algorithm (after Crane⁴)

Function	3 dB Peak	Volume Cell	Cluster	Fixed Contour	Volume Scan Summary
Intensity	• Avg. Reflectivity	• Avg. Reflectivity • Reflectivity at Lowest Ht. • Reflectivity at summit • Peak reflectivity	• Avg. Reflectivity • Peak Reflectivity	• Avg. Reflectivity • Peak Reflectivity	
	• Avg. Tangential Shear	• Avg. Tangential Shear • Peak Tangential Shear	• Avg. Tangential Shear • Peak Tangential Shear		
Location	• Centroid Position	• Centroid Position	• Centroid Position	• Water Flux • Reflectivity Centroid • V. Cell Centroid[*] • Sig. Cell Centroid	• Water Flux
Motion		• Velocity of Centroid	• Velocity of Centroid • Velocity of V. Cells	• Velocity of Centroid • Velocity of V. Cells • Velocity of Sig. Cells	
Size	• Area	• Area at Lowest Ht. • Area at Peak Volume		• Area	• Area
Height	• Elevation Angle	• Lowest Height • Height Base • Height Peak • Height Top • Height Summit	• Highest Summit Height	• Highest Summit Height • Avg. Height First Echoes	

Table 1. List of Attributes Computed From the Automatic Cell Detector and the Sample-Age Determination (Crane⁵)
(Contd)

Function	3 dB Peak	Volume Cell	Cluster	Fixed Contour	Volume Scan Summary
Star-type	• Contour Identity	• Contour Identity • Cluster Identity • Spread of Cell • Centroids	• Contour Identity • Spread of V. Cell Centroids • Correlation of V. Cell Centroids • Orientation of V. Cell Centroids† • No. of V. Cells	• Complex Identity • No. of V. Cells • No. of Clusters • No. of Sig. Cells and Clusters • Spread of V. Cells • Spread of Clusters • Spread of Sig. Cells • Orientation of V. Cells • Orientation of Clusters • Orientation of Sig. Cells • Correlation of V. Cells • Correlation of Clusters • Correlation of Sig. Cells	• No. of Contours • No. of V. Cells • No. of Sig. Cells and Clusters

*V. Cells are Volume Cells

Sig. Cells are Significant Cells

†Correlation of X location (east) vs Y location (north)

3. AN AUTOMATED REAL-TIME STORM ANALYSIS AND STORM TRACKING PROGRAM (WEATRK)

3.1 Algorithm Overview

The following is an abbreviated description of the Automated Real Time Storm Analysis and Storm Tracking Program (WEATRK).

The WEATRK algorithm defines a storm cell as any region contained within a predetermined reflectivity contour. The storm attributes tabulated by this algorithm include:

- Storm volume,
- Storm mass,
- Mass-weighted centroid,
- Maximum reflectivity and its height,
- Maximum radial velocity at the lowest elevation angle, and
- Maximum spectral variance and its height.

Radar data for this algorithm is acquired via a series of azimuth scans over a volume scan. Reflectivity segments along each radial exceeding a predetermined threshold are identified and correlated azimuthally to define two-dimensional storm cells. After the completion of a volume scan the storm cells are correlated in the vertical to define a three-dimensional storm. Any single level feature that is not correlated with any other in the vertical is removed from consideration. The volume centroid is then computed in three dimensions using a mass-weighted algorithm. The maximum reflectivity and height are computed using a three-dimensional squares fit technique to the reflectivity data.

4. CASE STUDIES

The first case study was a severe weather event that occurred on 12 May 1984 in the central United States. The event was characterized by a strong low-level jet, a deep moist layer, and a strong surface inversion. The event was characterized by a strong low-level jet, a deep moist layer, and a strong surface inversion.

Comparison of the ACDP output with the output of the WEATRK algorithm was performed to verify the accuracy of the WEATRK algorithm. The output of the WEATRK algorithm was compared with the output of the ACDP algorithm for the same event. The output of the WEATRK algorithm was compared with the output of the ACDP algorithm for the same event.

4.1 Case Study No. 1

The first case study consists of four volume scans recorded between 1555 and 1621 CST on 2 May 1979. These four volume scans are a subset of an eleven volume scan run of the algorithm, and are assessed to be representative of the algorithm's behavior.

The data, for this case, reveals two well-defined storms northwest of the radar (ranges from 120 to 200 km). A cursory glance at Figures 1, 2, 3, and 4 reveals some internal structure in each. The centroid locations of the ACDT contour regions (numbered) and those of the WRAFRD storm cells (lettered) are marked on each plot.

Output from the ACDT for Case Study No. 1 can be seen in Tables 2, 3, 4, and 5. The output consists of five parts:

- (1) Volume Scan Header Information,
- (2) Fixed Contour Header Attributes,
- (3) Contour Cell Attributes,
- (4) Cluster Attributes, and
- (5) Volume Scan Summary.

The attributes for parts 2-5 are listed in Table 1. For a more comprehensive discussion of these attributes and their derivation, see Gustafson and Crane.⁷

From the fixed contour output of Table 2 it can be seen that the ACDT has identified two storms (1 and 2) at the lowest elevation angle (0.4°) along with one other very small feature (3) 217 km from the radar. Six minutes later (Table 3) these same three contours are found along with a new one (4) which is identified as a split from 1 (last column on right). However, with the next sequence (Table 4) the algorithm has declared that contour 4 has merged back with 1 (second to last column on right), and has identified a new cell (5) at a range of 203 km. In the last sequence to be presented here we see that 2 has merged with 1 (Table 5 and Figure 4) and 6 has split from 3.

Although some of the merging and splitting may seem a little artificial (that is, contour region 1 and 4), it is a function of the threshold (30 dBz) used to define the contour regions and the perturbations around that value. Contour region 4 is not readily apparent in Figure 2 due to the smoothing in our contouring routine. It is, however, apparent in the raw data, where two adjacent range gates with reflectivities of 28 and 29 dBz separate two areas of reflectivity greater than 30 dBz. The contoured region between contour regions 1 and 2 (marked x in Figure 1) does not contain a 3 dB peak and is therefore not listed by the algorithm.

CONTOURS OF DBZ

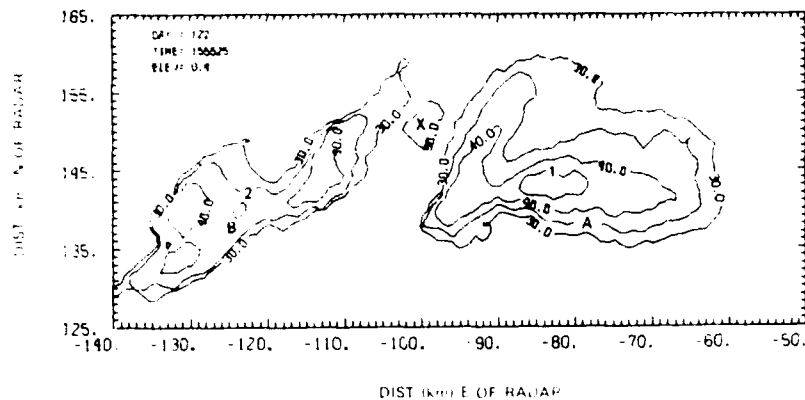


Figure 1. Reflectivity Contour Plot for Volume Scan Beginning at 1555

CONTOURS OF DBZ

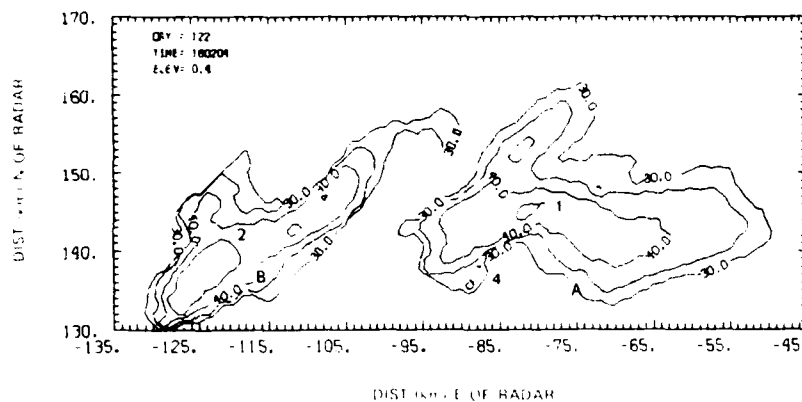


Figure 2. Reflectivity Contour Plot for Volume Scan Beginning at 1601

The contour region centroid locations are determined by averaging the centroid locations of the volume cells enclosed by the contour region. The contour region centroids appear to be located in the correct positions judging from the concurrent lowest elevation contour maps. The peak reflectivities enclosed by the contour regions, and the contour region's speed and direction seem to be reasonable within the resolution of our analysis.

CONTOURS OF DBZ

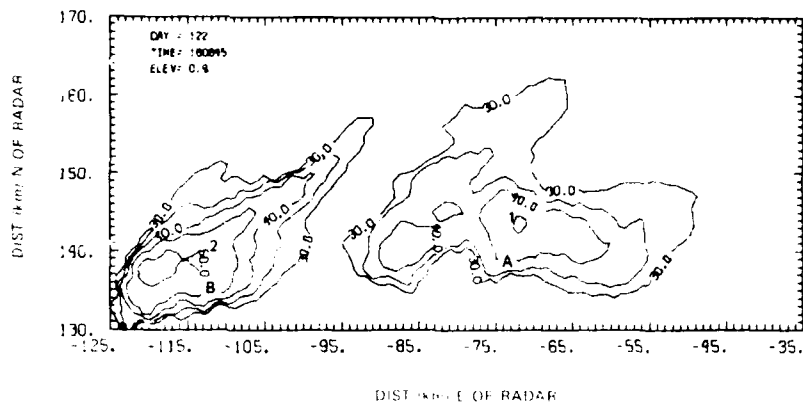


Figure 4. Reflectivity Contour Plot for Volume Scan Beginning at $t = 0_s$.

CONTOURS OF DBZ

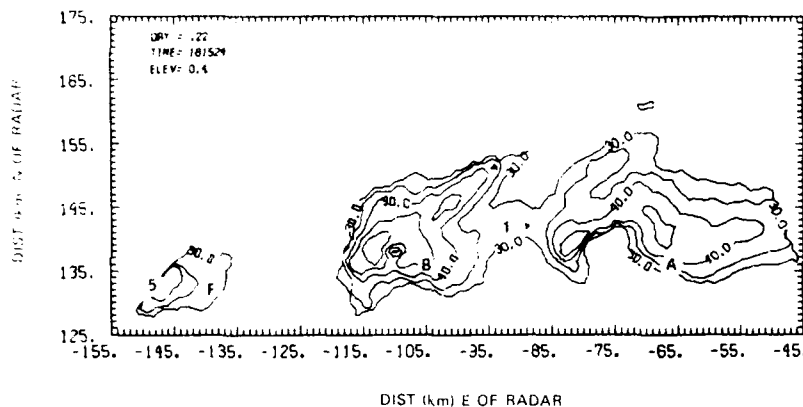


Figure 4. Reflectivity Contour Plot for Volume Scan Beginning at 1015

4.1.1 ACIDT-WEATRK PRODUCT COMPARISON

The output statistics for WEATRK storm cells identified in the four volume scans of this case study, and the closest corresponding contour regions from the ACDF are presented in Table 6. The same threshold value was used for determining the WEATRK storm cells and the ACDF contour regions.

Table 2. ACD1 Volume Scan Output for Volume Scan No. 1

SCAN TIME 122 155507 - 160107 VOL SCAN 1: A2 -137.1 TO 119.8 (DEG)
 TRACK REF TIME 1555 7 - 155507 AZM SCAN 10/C EL - 0.4 TO 6.5 (DEG)

NFA = 10, NVMA = 18

FIXED CONTOUR OUTPUT

CENTROID		AV	CELL	Z	N	N	K	SPR	SPR	C	WTR	AREA	VELOCITY	NEAR	MX	PR	SP			
TRK	AZM	RNG	AZM	RNG	AV	PK	V	S	C	X	L	R	FLUX	XSCN	AV	CELL	CIST	HT	ID	ID
NO	DEG	KM	DEG	KM	DB	DB	C	C	L	KM	KM	T	M/M	K/M2	DEG	M/S	KM	KM	NO	NO
1	330	167	329	164	42	47	6	2	1	3.4	9.6290		4.77	0.61	999	999	6.9	12	C	C
2	319	188	320	188	43	46	4	2	1	3.0	9.2	62	2.54	0.37	999	999	0.0	10	C	C
3	329	217	329	217	44	44	1	0	C	0.0	0.0	C	0.61	0.08	999	999	0.0	6	C	C

VOLUME CELL OUTPUT

CENTROID		-	Z	-	HGT	VBAR	CELL	SPACIAL	(TAN)	CCP	RAC	RAC	CS	CK	D	R							
TRK	FST	NDR	AV	PK	LW	HI	L	M	H	EM/S	AM/S	SPRD	A	(SHR)	SPD	VEL	SPC	TR	TR	C	E	E	
NO	KM	KM	DB	DB	DB	DB	W	N	I			CLD	ID	KM	KM2	(PSK)	PSK	M/S	M/S	NO	NO	P	P
1	-131	142	42	43	43	43	5	5	5	11.8	2.1	0.00	9.2	1.4	0.0	-9.5	4.6	0	2	1	1	1	
2	-128	136	39	43	40	32	4	6	10	11.8	2.1	0.78	16.7	3.4	0.0	0.2	1.0	0	2	7	4	1	
3	-114	143	46	46	46	46	4	4	4	11.8	2.1	0.00	3.5	1.7	0.0	-9.1	3.3	0	2	2	1	1	
5	-112	148	41	44	44	36	4	5	6	11.8	2.1	0.00	7.7	0.0	0.0	-14.0	0.3	1	2	0	2	1	
6	-95	139	40	42	34	42	4	6	7	11.8	2.1	0.00	6.0	1.7	0.0	-7.3	4.3	2	1	3	3	1	
7	-99	143	43	44	44	42	4	4	5	11.8	2.1	0.00	8.1	0.0	0.0	-14.0	0.7	2	1	0	2	1	
8	-112	185	44	44	44	44	6	6	6	11.8	2.1	0.00	10.2	0.0	0.0	-14.2	0.0	0	3	0	1	1	
9	-83	149	43	47	47	37	4	4	7	11.8	2.1	0.00	18.3	2.0	0.0	-8.9	3.9	0	1	7	3	1	
14	-67	137	36	38	35	38	3	4	4	11.8	2.1	0.00	3.3	1.7	0.0	-4.8	3.5	0	1	4	1	1	
15	-80	137	44	44	44	44	5	5	5	11.8	2.1	0.00	11.5	2.3	0.0	-2.7	4.4	0	1	3	1	1	
17	-89	137	42	45	45	31	5	7	12	11.8	2.1	1.43	9.2	1.7	0.0	-5.4	6.9	2	1	5	5	1	

CLUSTER OUTPUT

CENTROID		Z	N	SPR	SPR	ORT	CNT	VELOCITY	SPEAR	MX	PR	SP	CELL	CELL	NO
TRK	AZM	RNG	AV	PK	V	X	L	ANG	ID	AV	CELL	MSKM	HT	ID	ID
NO	DEG	KM	DB	DB	C	KM	KM	DEG		EM/S	NM/S		KM	NO	NO
1	323	186	41	44	1	0.0	0.0	C	2	0.0	0.0	0.0	6	C	C
2	326	169	42	45	3	1.4	3.6	316	1	0.0	0.0	1.0	12	C	C

VOL	NNM	AREA	WFLUX	NEAR	NEIGHBOR	ACT	NO	NO	VELOCITY	TRK	CLS	CNT	C	CVER
SCAN	K/M2	KNT/H	CELL	CLST	CONT	VCL	CS	FC	EM/S	NM/S	NO	CTR	CTR	C
1	1999	1.2	10.12	9.4	0.0	0.0	11	4	3	11.8	2.1	18	2	3

Table 3. ACDD Volume Scan Output for Volume Scan No. 2

-----SCAN TIME 122-160149 - 160745 VOL SCAN 2 #2 -169.23 TO 160.77 (CELL)-----
 TRACK REF TIME 16 1 2 - 160149 21# SCAN 10/0 EL - 0.4 TO 6.3 (21#)

NFA = 10, NVMX = 21

FIXED CONTOUR OUTPUT

CENTROID		AV	CELL	2	N	N	N	SPR	SPR	0	WTR	AREA	VELOCITY	NEAR	MX	MR	SP			
TRK	AZM	RNG	AZM	RNG	AV	FA	V	S	C	X	L	R	FLUX	ASCA	AV	CELL	DIST	HT	IC	IC
NO	DEG	KM	DEG	KM	DB	GB	C	C	C	KM	KM	F	MFM	KMM2	DEG	M/S	KM	KM	NO	NO
2	320	185	321	184	43	49	5	2	0	4.0	8.1	49	4.41	0.36	158	15	0.0	9	0	0
4	327	163	328	160	43	49	2	2	1	0.0	0.0	0	0.05	0.01	214	12	0.0	10	0	0
3	331	217	330	217	44	44	1	0	0	0.0	0.0	0	0.70	0.10	218	17	0.0	4	0	0
1	332	165	329	169	44	45	2	0	0	0.0	0.0	0	4.63	0.04	243	10	0.0	3	0	0

VOLUME CELL OUTPUT

CENTROID		-	-	2	-	HGT	VBAR	CELL	SPACIAL	(TAN)	CCP	RAC	RAC	CL	CL	R	F				
TRK	EST	NDR	AV	PR	EW	MI	L	M	M	EM/S	NM/S	SPKD	#	(SMR)	SPD	VEL	SPE	TP	TR	CL	CL
NO	KM	KM	DB	DB	DB	DB	W	N	I	CLD	IC	KM	KM2	(PSF)	MSK	M/S	M/S	NO	NO	F	F
1	123	145	40	40	40	3	3	3	3	17.0	5.3	0.0011.4	0.0	0.0	13.0	0.0	0	2	0	1	2
2	123	137	46	49	49	38	3	5	9	12.8	2.3	5.0011.6	2.2	0.0	-3.1	6.5	0	2	5	4	1
3	109	144	44	44	44	44	3	3	3	10.9	2.8	0.0019.4	2.0	0.0	-3.2	3.0	0	2	4	1	2
5	106	148	42	45	45	34	3	4	7	13.6	0.8	0.007.7	1.2	0.0	-9.2	5.4	0	2	1	2	2
6	87	135	43	49	36	34	2	5	10	17.4	-5.4	0.6510.7	2.1	0.0	-6.8	4.0	2	4	5	4	2
7	90	145	44	44	44	44	3	3	3	10.3	3.0	0.0010.1	1.5	0.0	-9.7	3.2	0	1	1	1	1
8	107	189	44	44	44	44	4	4	4	13.2	0.1	0.005.0	0.0	0.0	-13.5	6.0	0	3	0	1	2
9	82	145	45	45	45	45	2	2	2	7.6	3.4	0.0010.3	0.5	0.0	-5.0	4.3	0	1	1	1	2
14	66	138	36	36	36	36	4	4	4	6.5	1.6	0.002.9	1.0	0.0	-2.4	5.1	0	-1	5	0	2
15	81	135	43	47	43	39	4	6	8	2.8	-3.0	0.679.5	2.3	0.0	-4.8	3.7	0	-1	1	2	1
17	86	139	35	35	35	35	4	4	4	9.2	4.1	0.006.4	2.4	0.0	-4.5	0.0	0	-1	1	0	2
20	120	132	40	43	43	32	7	7	8	11.8	2.1	0.0011.6	2.2	0.0	-2.3	7.4	0	2	2	0	1

CLUSTER OUTPUT

CENTROID		2	N	SFR	SPR	ORT	CNT	VELOCITY	SHEAR	MX	MR	SP	CELL	CELL	NO		
TRK	AZM	RNG	AV	PR	V	X	L	ANG	IC	AV	CELL	MSKM	HT	IC	IC		
NO	DEG	KM	DB	GB	C	KM	KM	DEG	EM/S	NM/S	KM	NO	NO	MSKM	HT		
2	327	161	43	49	1	0.0	0.0	0	4	21.1-10.5	2.1	10	0	0	0.00	0.00	0

VOL	MMH	AREA	WFLUX	NEAR	NEIGH	ECR	ACT	NO	NO	VELOCITY	TRK	CLS	CNT	G	OVER
SCAN	MMH2	KM2	KM2	CELL	CLST	CGNT	VOL	CS	FC	EM/S	NM/S	NO	CTR	CTR	C
2	1601	1.3	12.19	9.6	0.0	0.0	12	4	3	11.8	2.1	21	2	4	0

Table 4. ACDF Volume Scan Output for Volume Scan No. 3

--- SCAN TIME 122 160827 - 161321 VBL SCAN 3 #2 -145.4 TO 144.3 (DEG)
 TRACK REF TIME 16 742 - 160827 AZM SCAN 8/C EL - 0.4 TO 5.8 (CEL)

NFN = 8, NVMA = 34

FIXED CONTOUR OUTPUT

CENTROID		AV	CELL	Z	N	N	SFR	SPR	C	WTR	AREA	VELOCITY	NEAR	MX	MR	SP				
TRK	AZM	RNG	AZM	RNG	AV	PK	V	S	C	X	L	F	FLUX	ACN	AV	CELL	DIST	HT	ID	IC
NO	DEG	KM	DEG	KM	DB	DB	C	C	L	KM	KM	T	MT/H	KM2	DEC	M/S	KM	KM	NO	NO
2	321	181	322	179	45	51	5	2	C	3.5	8.0	42	6.73	0.37	257	8	7.4	5	0	0
5	310	203	310	203	36	41	2	C	C	0.0	0.0	C	0.40	0.08	999	999	0.0	7	0	0
3	332	216	333	217	37	38	2	C	C	0.0	0.0	C	0.48	0.11	274	15	0.0	6	0	0
4	333	162	331	161	42	49	8	3	1	5.3	5.3	44	4.08	0.60	258	10	4.0	9	4	0

VOLUME CELL OUTPUT

CENTROID		-	-	Z	-	HCT	VBAR	CELL	SPACIAL	(TAN)	CCP	RAC	RAC	CS	ON	C	R	A			
TRK	EST	NDR	AV	PK	LW	HI	L	M	EM/S	NM/S	SPRD	A	(SHR)	SFD	VEL	SPD	TR	TR	C	E	
NO	KM	KM	DB	DB	DB	DB	W	W	I	CLD	IC	KM	KM2	(M/K)	MSK	M/S	M/S	NO	NO	P	E
1	-115	144	31	31	31	6	6	6	18.1	0.6	0.00	3.5	2.4	0.0	-11.1	0.0	0	-2	4	0	2
2	-119	138	47	51	51	40	4	5	9	11.3	2.9	0.26	10.5	1.9	0.0	-7.2	2.6	0	2	5	4
3	-110	145	44	44	44	4	4	4	4.2	1.5	0.00	3.4	2.5	0.0	-1.5	3.5	0	2	2	0	
5	-101	149	39	41	41	32	4	5	7	13.4	1.1	0.00	3.7	1.7	0.0	-5.4	2.9	0	2	3	2
6	-83	137	31	31	31	31	3	3	12.4	1.1	0.00	1.5	1.3	0.0	1.9	0.0	0	1	1	0	
7	-83	148	38	38	38	36	4	4	14.2	5.2	0.00	12.0	1.9	0.0	-4.1	5.3	0	1	2	1	
8	-100	188	38	38	38	36	5	5	14.5	1.8	0.00	15.2	0.0	0.0	-13.6	0.0	0	-3	0	1	
9	-73	146	42	44	44	40	4	4	15.2	2.4	0.00	7.3	1.9	0.0	-7.8	3.8	3	1	3	2	
14	-80	139	37	37	37	37	4	4	11.5	3.1	0.00	4.3	1.8	0.0	-6.0	1.8	0	-1	2	0	
15	-79	134	46	49	49	38	5	6	9	3.9	-2.5	1.02	6.9	2.1	0.0	-5.0	4.1	0	1	1	
17	-86	139	43	46	44	38	4	6	9	4.6	1.4	1.64	6.7	1.4	0.0	-9.4	4.8	0	1	3	
20	-118	133	42	43	43	42	6	6	8.0	2.5	0.00	5.0	1.2	0.0	-0.6	3.8	0	-2	2	0	
21	-157	130	38	41	41	31	5	7	11.8	2.1	0.00	2.3	0.0	0.0	-14.4	0.5	0	5	0		
22	-113	139	50	50	50	50	4	4	11.8	2.1	0.00	10.6	1.7	0.0	-3.8	6.4	0	2	1		
23	-98	196	37	37	37	37	6	6	11.8	2.1	0.00	4.1	0.0	0.0	-14.0	0.0	0	3	0		
24	-71	144	45	45	45	45	3	3	11.8	2.1	0.00	7.6	1.8	0.0	-8.9	0.6	0	1	1		
25	-151	131	34	36	36	31	5	7	11.8	2.1	0.00	4.4	1.4	0.0	-3.8	3.8	0	5	1		
27	-113	130	37	40	35	34	5	7	11.8	2.1	0.00	14.7	1.4	0.0	-5.1	6.4	0	2	2		
30	-73	131	36	38	38	35	4	6	9	11.8	2.1	0.00	10.0	1.6	0.0	-5.9	7.6	0	1	4	
32	-76	140	36	38	38	35	6	7	8	11.8	0.1	0.00	6.8	1.7	0.0	-5.8	5.4	0	1		
33	-59	132	32	32	32	32	5	5	11.8	2.1	0.00	7.1	2.1	0.0	-4.8	0.9	0	0	2		

CLUSTER OUTPUT

CENTROID		Z	N	SFR	SPR	DRT	CNT	VELOCITY	SHEAR	MX	MR	SE	CELL	CELL	NO
TRK	AZM	RNG	AV	PK	V	X	L	ANG	ID	AV	CELL	MSKM	HT	ID	IC
NO	DEG	KM	DB	DB	C	KM	KM	DEC	EM/S <td>NM/S</td> <td>KM</td> <td>NO</td> <td>NO</td> <td>MSKM</td> <td>MSKM</td>	NM/S	KM	NO	NO	MSKM	MSKM
3	333	164	42	44	1	0.0	0.0	C	1	20.2	1.6	1.9	5	C	C

VBL	NMPP	AREA	WFLUX	NEAR	NEIGHBOR	ACT	NO	NO	VELOCITY	TRK	CLS	CNT	6	OVER
SCAN	KM2	KMT/H	CELL	CLST	CCNT	VCL	CS	FC	EM/S	NM/S	NO	CTR	CTR	C
3	1607	1.3	13.52	6.0	13.7	0.0	21	5	4	11.0	1.8	34	3	5

Table 5. ACDT Volume Scan Output for Volume Scan No. 4

SCAN TIME 122 161506 - 162103 VOL SCAN 4 AZ -141.5 TO 110.0 (DEG)
 TRACK REF TIME 1613 3 - 161506 AZM SCAN S/C EL - 0.3 TO 6.6 (DEG)

NFN = 9, NVMX = 44

FIXED CONTOUR OUTPUT

CENTROID		AV CELL		Z		N N N		SPR SPR		C		WTR AREA		VELOCITY		NEAR		MX PR SP	
TRK	AZM	RNG	AZM	RNG	AV	PK	V	X	L	R	FLX	XSCN	AV	CELL	DIST	HT	ID	ID	
NO	DEG	KM	DEG	KM	DB	DB	C	C	L	KM	KM	T	MT/H	KM2	DEG	M/S	KM	KM	NO
5	311	199	310	202	39	45	2	1	1	0.0	0.0	C	0.97	0.14	271	6	0.0	7	0
6	332	212	332	212	34	34	1	0	0	0.0	0.0	C	0.06	0.02	297	7	0.0	5	0
1	326	170	326	168	44	52	18	3	3	7.5	18.1	65	11.55	1.08	250	13	4.6	11	2
3	335	221	335	221	35	35	1	0	0	0.0	0.0	C	0.06	0.02	237	17	0.0	6	0

VOLUME CELL OUTPUT

CENTROID		Z		HGT		VBAR		CELL		SPACIAL		(TAN)		CCP		RAC		CS		CN		C		R		F	
TRK	EST	NOR	AV	PK	LV	HI	L	M	H	EM/S	NM/S	SPRD	A	(SHR)	SFD	VEL	SPE	TR	TR	E	E	E	E	E	E	E	E
NO	KM	KM	DB	DB	DB	DB	W	N	I	OLD	ID	KM	KM2	(MSK)	MSK	M/S	M/S	NO	NO	P	P	P	P	P	P	P	P
2	-114	139	48	52	52	47	4	5	8	11.7	2.6	0.00	10.2	1.9	0.0	-7.0	7.9	4	1	1	3	2					
3	-104	147	40	40	40	4	4	4	4	5.5	3.6	0.00	9.5	4.3	0.0	-3.4	0.0	0	1	1	0	2					
5	-93	152	32	32	32	6	6	6	17.5	5.3	0.00	9.2	0.0	0.0	-14.5	0.0	0	1	0	1	2						
6	-80	140	47	51	51	44	3	4	6	10.3	4.0	0.00	5.5	3.0	0.0	-4.2	3.6	5	1	4	3	2					
7	-76	153	36	36	36	36	4	4	17.4	9.2	0.00	15.0	0.0	0.0	-13.6	0.0	0	1	0	1	2						
8	-98	187	34	34	34	34	5	5	5	5.7	-1.3	0.00	3.8	0.0	0.0	-13.9	0.0	0	6	0	1	2					
9	-71	149	40	43	43	36	4	4	5	10.0	5.2	0.00	2.1	0.0	0.0	-12.6	1.8	0	1	0	2						
15	-75	136	44	48	48	33	5	6	10	8.4	1.7	0.69	7.4	1.9	0.0	-5.4	5.8	5	1	7	5	2					
17	-83	141	40	41	39	41	5	6	7	6.3	4.3	0.00	4.2	0.0	0.0	-14.1	0.2	5	1	0	2						
20	-114	135	41	42	42	42	4	4	4	8.5	3.5	0.00	3.7	4.2	0.0	-0.5	0.0	0	1	1	0	2					
22	-109	137	49	49	49	49	4	5	5	11.6	-2.3	0.00	8.9	2.1	0.0	-4.8	6.6	4	1	1	2						
23	-92	200	35	35	35	35	6	6	13.5	6.5	0.00	5.5	0.0	0.0	-14.5	0.0	0	3	0	1	2						
24	-63	144	41	41	41	41	3	3	16.1	0.3	0.00	4.0	1.9	0.0	-11.6	0.0	0	1	1	0	2						
25	-149	131	42	45	45	34	5	5	7	8.5	0.7	0.00	9.7	1.6	0.0	-8.7	3.2	6	5	2	2						
27	-109	133	47	49	46	49	5	7	10.2	5.2	0.00	2.6	2.5	0.0	-4.1	3.9	7	1	5	2	2						
30	-69	135	39	39	39	39	4	4	11.5	6.5	0.00	4.1	2.0	0.0	-5.9	1.2	0	1	2	0	2						
32	-70	142	39	39	39	39	3	3	13.7	3.0	0.00	2.7	2.5	0.0	-6.3	2.5	0	1	2	0	2						
33	-57	132	33	33	33	33	6	6	6	6.7	2.2	0.00	2.7	3.8	0.0	-7.4	0.0	0	0	1	0	2					
34	-161	127	33	34	24	33	5	6	7	11.0	1.8	0.00	8.9	0.0	0.0	-7.1	7.1	0	5	0	2	1					
35	-113	129	39	39	39	39	4	4	11.0	1.8	0.00	3.6	0.0	0.0	-15.3	0.0	0	1	0	1	1						
36	-101	147	47	47	47	47	4	4	11.0	1.8	0.00	3.4	2.7	0.0	-6.9	0.0	0	1	0	1	1						
37	-97	141	34	34	34	34	4	4	11.0	1.8	0.00	6.5	2.5	0.0	-6.5	2.3	0	1	3	0	1						
38	-157	123	32	32	22	32	7	7	11.0	1.8	0.00	6.3	0.0	0.0	-14.4	0.0	0	0	0	1	1						
40	-108	132	46	50	50	36	5	6	10	11.0	1.8	0.09	9.4	1.9	0.0	-6.3	4.6	7	1	2	4	1					
42	-114	137	42	45	45	33	7	8	11.0	1.8	0.00	9.9	0.0	0.0	-9.2	6.6	4	1	0	3	1						
44	-65	132	36	39	39	32	7	7	8	11.0	1.8	0.00	6.4	2.1	0.0	-4.6	5.4	0	1	4	2	1					

CLUSTER OUTPUT

CENTROID		Z		N SPR		SPR		ORT		CNT		VELOCITY		SPEAR		MX		PR		SP		CELL		CELL		NO	
TRK	AZM	RNG	AV	PK	V	X	L	ANG	ID	AV	CELL	MSKM	HT	ID	ID	ROT.	DIV.	RD									
NO	DEG	KM	DB	DB	C	KM	KM	DEG		EM/S	NM/S	KM	NE	NO	MSKM	MSKM	ES										
4	321	178	47	52	3	0.9	2.5	291	1	11.7	-1.4	1.8	11	C	C	0.00	0.00	2									
5	330	161	45	51	3	0.2	4.1	304	1	9.2	5.5	2.3	10	C	C	-0.47	4.79	3									
6	311	199	42	45	1	0.0	0.0	C	5	6.3	-0.1	1.6	7	C	C	0.00	0.00	C									
7	321	172	47	50	2	0.0	0.0	C	1	9.0	7.2	2.3	10	C	C	0.00	0.00	C									

VOL HMMF AREA WFLUX NEAR NEIGHBOR ACT NO NO VELOCITY TRK CLS CNT C OVER
 SCAN KKM2 KMT/H CELL CLST CONT VCL CS FC EM/S NM/S NO CTR CTR C
 -4 1613 1.5 15.71 5.0 0.0 0.0 26 4 -2 11.3 3.0 44 7 0 0 0 0 0 0

Table 6. ACDT-WEATRK From 1 Comparison for Case Study No. 1

Algorithm	Contour Region No. or Start Cell No.	Azimuth	Range (km)	Max Height (km)	Centroid Direction	Speed (M/S)	Max. up- Reflectivity	Average Reflectivity
<u>Time 1555</u>								
ACDT	1	330	167	12	-	-	47	50
WEATRK	1	330	160	10.4	-	-	51	
ACDT	2	319	188	10	-	-	46	
WEATRK	2	318	186	9.6	-	-	46	46
WEATRK	3	324	184	9.5	-	-	46	
ACDT	3	329	217	6	-	-	44	48
WEATRK	4	330	214	4.6	-	-	48	
<u>Time 1601</u>								
ACDT	4	237	163	10	314	12	49	
ACDT	1	332	165	3	296	12	55	57
WEATRK	1	331	156	10.4	243	10	52	
ACDT	2	320	185	9	258	15	47	
WEATRK	2	320	180	10.2	284	22	53	
ACDT	3	331	217	4.9	238	17	44	
WEATRK	4	332	214	4	236	20	53	
<u>Time 1608</u>								
ACDT	1	333	162	9	258	10	49	56
WEATRK	1	331	154	10.0	288	9	51	
ACDT	2	321	181	9	257	8	51	
WEATRK	2	321	176	9.8	279	14	54	
ACDT	3	332	216	6	274	15	36	49
WEATRK	4	333	212	4.9	243	16	40	
ACDT	5	310	203	7	-	-	41	43
WEATRK	5	311	200	4.4	-	-	42	

Table 6. ACDT-WEATRK Product Comparison for Case Study No. 1 (Contd)

Algorithm	Contour Region No. or Storm Cell No.	Azimuth °	Range (km)	Max Height (km)	Centroid Direction	Speed (M/S)	Maximum Reflectivity	Verified Reflectivity
ACDT	1	326	170	11	250	13	52	
WEATRK	2	322	170	11.1	286	16	55	55
WEATRK	1	334	152	9.8	277	10	54	
ACDT	5	311	199	7	271	6	45	
WEATRK	5	309	202	7.2	44	12	42	46
WEATRK	6	313	194	3.9	-	-	46	
ACDT	3	335	221	6	327	17	35	
ACDT	6	332	212	7	297	7	34	

Before the data are compared, it is necessary to discuss the differences in the algorithms' processing schemes. Since WEATRK tracks three-dimensional storm cells, that are large relative to the volume cells tracked by ACDT, the centroid position of the storm cell will be different from that of the contour region given by ACDT.

The centroid locations of the various ACDT contour regions, and WEATRK storm cells are plotted in Figures 1, 2, 3, and 4. Although the centroid locations of the WEATRK storm cells and the ACDT contour regions are derived differently they both represent three-dimensional reflectivity-weighted entities, and are hard to locate on two-dimensional single elevation angle plots. In viewing these figures it must be noted that the contoured data field is slightly smoothed by the coordinate conversion and plotting routines.

Table 6 reveals that the maximum reflectivity values reported by WEATRK are slightly higher than those from ACDT. This is due to the two range gate averaging performed by the ACDT.

The maximum echo heights reported by the ACDT are generally close to those reported by WEATRK. There are, however, some differences of more than 1.5 km (that is, contour region No. 1 at 1555, contour region No. 5 at 1608). These might be explained by the ACDT finding a 3-dB peak in the next higher elevation azimuth scan that does not exceed the WEATRK criterion of reflectivity above threshold in 14 contiguous range gates.

The velocity difference between the ACDT contour region centroids and the WEATRK storm cell centroids shows a bias of +11.8° and -1.7 m/sec. These are acceptable since the centroid positioning error for this data is ± 1.5 km.

The net effect of these differences is negligible as both the contour regions and the storm cells propagate in approximately the same direction. Figure 5 is the contour plot for the first volume scan of this case study, with the centroid locations of the ACDT contour regions and WEATRK storm cells for all four volume scans labeled. It is interesting to note the apparent reversal in the motion of contour region 1 at 1615. This is obviously due to the merging of contour regions 1 and 2.

4.1.2 SPATIAL CORRELATIONS

Further analysis of the ACDT output reveals that an average 52% of all volume cells are detected at only one height. Out of the nine volume cells tracked over all four volume scans, only volume cell 2 was detected at more than one height at all times.

Some of these "single height" volume cells appear to be oriented in such a way as to suggest that they might be vertically correlated with neighboring "single height" cells (for example, cells 9 and 15 at 1601, 6 and 17 at 1608). This might imply we have reason to doubt the validity of the vertical correlation function used in the

algorithm. The following comments from Gustafson and Crane, ⁷ page 7, concur with this reasoning: "Relaxation of the height separation criteria of the association logic to accommodate large elevation steps could cause invalid associations such as that of an immature cell at a mid-level with the cirrus overhang from a nearby mature storm. Clearly a trade-off is required; thus, the weight of the height component of the association function is defined such that a separation of between 2.5 and 3.0 km will make an association difficult (that is, require close agreement between the other components), and a separation greater than 3 km will cause the association to be rejected."

CONTOURS OF DBZ

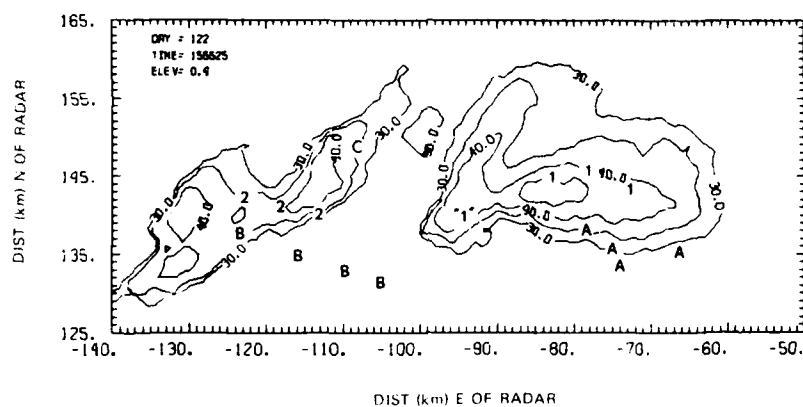


Figure 5. ACDDT Contour Region (numbered) and WEATRK Storm Cell (lettered) Centroid Locations for Volume Scans 1-4. Motion is from left to right, location marked "1" is centroid location of merged contour regions 1 & 2 in Volume Scan No. 4

The data were collected at 0.7° elevation angle steps; thus by using the 4:3 earth beam refraction correction we find the height difference between elevation angles is 2.5 km at a range of 150 km and 4.0 km at 230 km.

Another factor that may be contributing to the vertical correlation problem is that the height computations for some features appear to be wrong. Although most of the heights are correct within the resolution of the algorithm (1 km), there are a few cases where the height given for a volume cell is in error even when truncated to the nearest kilometer. Table 7 illustrates this discrepancy.

In studying the cluster output for this case it is apparent that 83% of the clusters are not correlated in time, and no single cluster is tracked throughout the entire 4 volume scans.

Table 7. Comparison of Height Estimates of Selected Volume Cells From ACDT and 4/3 Earth Correction for the Lowest Two Elevation Angles (α)

Cell No.	Volume Scan No.	Range	ACDT Height	4/3 Earth $\alpha = 0.4^\circ$	4/3 Earth $\alpha = 1.3^\circ$
1	1	194	5	3.9	6.9
9	1	167	4	3.1	5.6
9	2	167	2	3.1	5.6

Figure 6 is a plot of the positions and trajectories of the volume cells in contour No. 1 starting with volume scan No. 1. These volume cell tracks all look plausible, although it is interesting to note the movement of volume cell 16 around 17 and the almost complete reversal of direction of cell 15.

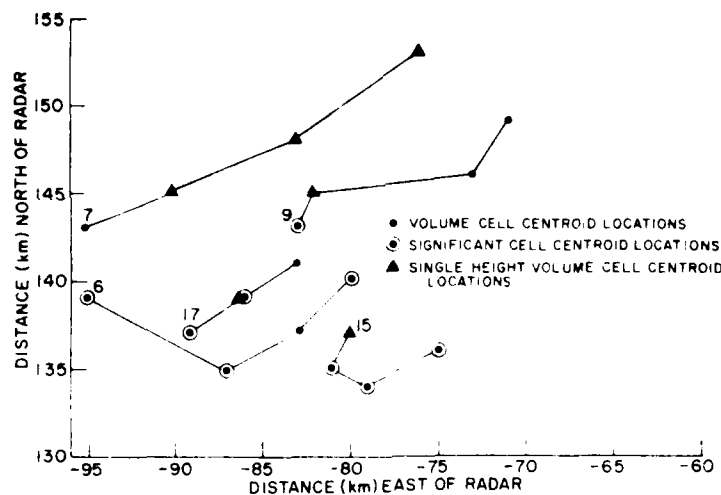


Figure 6. ACDT Volume Cell Centroid Trajectories for Contour Region No. 1. For volume scans 1-4

Figure 7 is a plot of the vertical extent of selected volume cells throughout the period of interest. This diagram illustrates the rapid structural changes in several volume cells. Cells 6 and 17 seem to alternately lose and gain their significance in volume scans 2 through 4. Cells 7 and 9 behave erratically between volume scans 1 and 2, going from a multi-height entity to a single height entity at

a lower elevation. Volume cell No. 5 is an example of a short lived significant cell, one which does not decay the way one might expect, that is, with reflectivity gradually lowering in time. The behavior of volume cell 20 on the other hand might be indicative of a decaying cell. Volume cell numbers 1, 3, 8 are examples of single height cells that are tracked over several volume scans. Volume cell No. 2 is an example of a relatively long lived significant cell. Volume cell 15 could be an example of a growing storm cell.

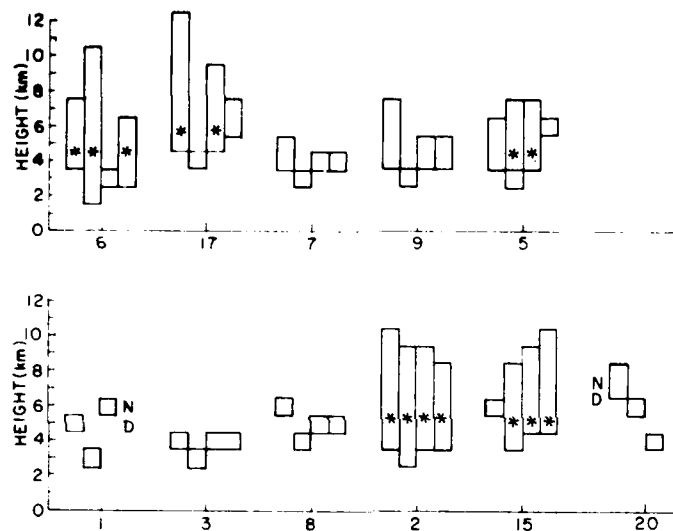


Figure 7. Volume Cell Vertical Extent for Volume Scans 1-4.
(* signifies significant cells, ND - Volume Cell not defined)

4.1.3 TEMPORAL CORRELATIONS

One check of the reliability of a tracking algorithm is the examination of the ratio of the nearest neighbor distance between cells and the distance each cell travels between observation times. This ratio should be greater than 1 to have any meaningful significance. Another parameter to consider is the ratio of the nearest neighbor distance and the average cell diameter to give another indication of possible cell overlap. These ratios were computed for all the nearest neighbor volume cells within a contour region.

Table 3 contains a listing of these ratios for all the nearest neighbor cells that had a lifetime of more than two volume scans (~ 12 min).

Table 8. Compilation of Volume Cell Overlap Ratios,
for Nearest Neighbor Cells

Time	Contour	Cell Group	d/st	$d/2r$
1601	2	1-2	1.5	2.2
	2	*2-20	1.2	1.5
	2	*3-5	1.2	1.2
	1	*7-9	2.1	2.2
	4	*6-15	1.7	1.7
1608	1	*7-9	0.3	0.4
	1	*6-17	1.1	1.9
	1	6-15	2.2	2.4
	2	*3-5	2.0	2.5
	2	*1-20	2.1	3.7
1615	1	*2-20	2.2	1.3
	1	*6-17	0.9	1.3
	1	*30-32	1.4	0.1
	1	15-32	1.9	3.1
	1	24-30	2.0	4.8
	1	*22-27	0.9	1.4
	1	*9-32	1.6	4.1
	1	*7-9	1.1	1.9
	1	3-22	2.8	3.2
			$\overline{\frac{d}{st}} = 1.4$	$\overline{\frac{d}{2r}} = 1.9$

* Cell groups are counted twice in overall average (that is, is, cell No. 2 is the nearest neighbor to cell No. 20 and vice versa)

The following variables are used to compute these ratios:

- d = Nearest neighbor separation distance (km),
- $\bar{s}$ = Average cell speed over the volume scan (km/s),
- t = Volume scan time (s),
- r = Average cell radius (km).

The overall average for the nearest neighbor distance over the distance each cell travels between observation times ($\frac{d}{st}$) is 1.4, the overall average for the ratio of nearest neighbor distance to cell diameter ($\frac{d}{2r}$) is 1.9. The error in determining cell position due to the radar beam width is ± 1.5 km at a range of 175 km. This positioning error results in an uncertainty of ± 3.0 in $\frac{d}{st}$ and ± 1.8 $\frac{d}{2r}$. Considering these uncertainties, it is obvious that the above ratios are not large enough to demonstrate that the algorithm can distinguish between adjacent volume cells in subsequent volume scans.

4.2 Case Study No. 2

The second case study consists of four volume scans, recorded from 1534-1557 CST on 10 April 1979. The thunderstorm observed at this time extended in a complex band from the northeast to southwest of the radar. Figure 8 is a contour plot of a small section of this band. The closest identifiable 30-dBz contour was at a range of 20 km.

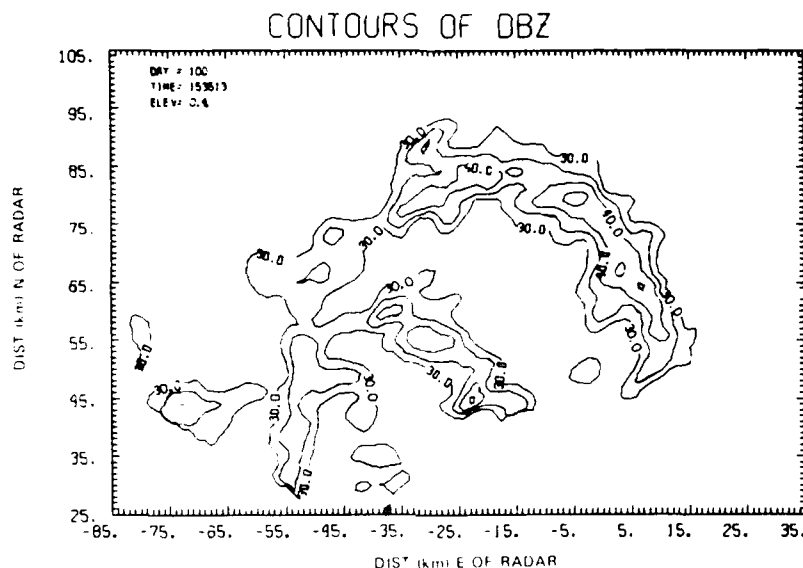


Figure 8. Reflectivity Contour Plot for Volume Scan Beginning at 1534

A synopsis of the ACDT output (Appendix A) can be seen in Table 9. The high number of contours and volume cells in Table 6 confirms the complex nature of the storm system on this day. The number of fixed contour regions for the time period of interest never drops below 33, yet only three of these are correlated throughout all four volume scans. On the average 77% of all contour regions are not temporally correlated.

The number of volume cells detected for each volume scan is also very large. It was found that on average 49% of all volume cells were uncorrelated in time and 55% were uncorrelated vertically (that is, detected at only one height). There were 21 volume cells that were followed for the entire time, yet only four of these (numbers 42, 53, 126, 131) had vertical continuity at all times. Considering this it is not surprising that 56% of the clusters in this case showed no temporal continuity. This case was run again with 35 dBz as a threshold; the effect of which was

to reduce the number of contour regions from 39 to 32 without changing significantly the number of volume cells that were uncorrelated in time. In comparison, when the WEATRK algorithm was run with a 35-dBz threshold over the same data, it detected 12 storm cells, and tracked 8 of these throughout this time period. It must be noted, that WEATRK only lists the attributes for what it determines to be the 12 most significant storm cells.

In addition, ACDT appears to have difficulties in identifying and tracking significant cells in this case. There are 40 significant cells identified over the period of interest, yet only one of these (number 126) is detected in all four volume scans. Over all, 88% of the significant cells are not correlated in time.

Table 9. Synopsis of the ACDT Algorithm Output for 1534-1557 (CST) on 10 April 1979

Volume Scan No.	No. of Contour Regions		No. of Volume Cells		No. of Clusters	
	Total	New	Total	New	Total	New
1	39	-	148	-	24	-
2	37	27	148	77	19	8
3	34	24	113	51	18	11
4	33	29	140	72	23	15

5. SUMMARY AND CONCLUSIONS

The ACDT behaves as designed, that is, it locates 3 dB peaks, defines contours, groups clusters, and tracks these entities. Although not all of the individual 3 dB peaks can be identified in the contour plots presented in this report, they can be located in the higher resolution raw data.

It is apparent that the algorithm is experiencing several problems when applied to our data sets; it has however, proved to yield good results using 3 to 5 min volume scan repeat time with greater vertical resolution (Crane and Hardy,¹⁰ Crane¹¹). It is thought that several of the problems in this analysis such as, uncorrelated volume cells, single height cells, and uncorrelated significant cells are due to inadequate temporal (6-min volume scan repeat time) and/or inadequate vertical resolution (as much as 2.8 km at ranges of 230 km).

11. Crane, R. K. (1976) Radar Detection of Thunderstorm Hazards for Air Traffic Control, Vol. I Storm Detection, Project Report ATC-67, Vol. I, MIT Lincoln Laboratory, Lexington, Massachusetts, FAA-RD-76-52; AD A032732.

Previous studies have only been concerned with data out to 150 km (Crane and Hardy¹⁰). Gustafson¹² concurs with these speculations regarding possible areas of algorithm breakdown.

An average 50% of the volume cells detected by the ACDT are not correlated with another volume cell in the next volume scan. Yet, at the same time the ACDT tracked some single height volume cells over the entire four volume scans of case study No. 1 (that is, cells 3 and 8).

The association of volume cells of considerable vertical extent (that is, > 4 km) in one volume scan to those of little vertical extent (that is, < 1 km) in the next volume scan (that is, 6, 17, 9, 5 in Figure 7) causes us to question the ability of the algorithm to vertically correlate the 3-dB peaks and to adequately track these volume cells.

The ratio of the nearest neighbor distance to the distance an average volume cell travels between observation times is shown to be small when compared to the relative error in determining the volume cell positions. This might explain the difficulties that the ACDT had with cell tracking.

The fact that ACDT sometimes detected higher storm cell peaks is not thought to be a significant advantage over WEATRK as these higher peaks are small (less than 14 range gates) in horizontal extent.

Crane³ found the average lifetime for a significant cell to be approximately 30 minutes. We found the average significant cell to have a lifetime close to 10 minutes.

Crane and Hardy¹⁰ state that the volume cell clusters may be the most important feature for analyzing storm structure. In our analysis 69% of the clusters were uncorrelated in time, suggesting that they may not be quite as important here. This is obviously a product of the difficulties the ACDT has with the elements within the clusters, namely the volume cells.

Finally, a few comments on the software itself. It was found that the subroutines for the ACDT contain a substantial amount of residual developmental code. The subroutines are not modular, hence it is difficult to make changes to the processing scheme without altering the code in several subroutines. The algorithm currently runs at approximately two times real time for the simple case and three times real time for the more complex case. However, if this algorithm were to be used operationally, an entirely new software package would be needed; preferably a modular one designed for speed and efficiency.

12. Gustafson, G. B. (1982) Personal communication.

It is apparent that more work must be done to determine what radar data processing methods would yield the best results for a given meteorological scale. WEATRK tracks the large scale features of a storm complex, while ACDT tracks much smaller entities to presumably yield a description of the internal structure of a storm complex. The ACDT was initially developed to process up to 512 volume cells at one time. It is obvious that processing this amount of data is not possible in a real-time environment. To rectify this problem, Crane³ recommends that the subroutines for cell detection and tracking be maintained while the number of cells be reduced by increasing the reflectivity threshold and by incorporating the tangential shear information in the decision process for saving the most important 12 to 16 cells. It would be more consistent with algorithm development to specify a larger peak size, since raising the threshold level would tend to eliminate growing volume cells.

Since it may well be useful to identify elements within storms, such as significant cells, one might consider an algorithm with resolution capabilities between the two algorithms discussed herein. Perhaps if ACDT were modified to track 6 to 10 dBz peaks, or WEATRK were modified to operate with several thresholds, storm structure would be more readily apparent. If the reflectivity peak processing method were to be explored further it would be prudent to write an algorithm in which the peak size would be an input variable. This would enable the researcher to specify a peak size (feature size) that was consistent with the spatial and temporal resolution of the data set. This type of algorithm could be run repeatedly over the same data altering the peak size to first, observe the large scale features of the storm, then to detect and track the feature of interest, and lastly to determine when the algorithm breaks down (that is, no longer can correlate its derived features).

In reviewing our case studies one can see that it might be necessary to either fine tune the ACDT contour region threshold for each case study, or specify a permissible reflectivity range around the threshold. This would eliminate extraneous contour regions, and eliminate insignificant merges and splits of contour regions due to small fluctuations of the reflectivity field.

The Automatic Cell Detection and Tracking algorithm (ACDT) developed by Crane^{1,2,3,4} has been evaluated by carefully examining two case studies taken from the 1979 JDOP program. The output products from the ACDT were compared to raw data and to the products from the AFGL storm tracking algorithm WEATRK. We found that the ACDT performs unsatisfactorily when constrained to a 5 to 6 min volume scan repeat time, and when it is required to perform out to a range of 230 km. Therefore, we do not recommend its inclusion in the NEXRAD system at this time.

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12. Gustafson, G. B. (1982) Personal communication.

Appendix A

ACDT Algorithm Output

Table A1. ACDT Volume Scan Output for Volume Scan No. 1, Case Study No. 2

SCAN TIME 100 153447 - 154005 VOL SCAN 1 AZ - 39.3 TO 31.9 (DEG)																								
TRACK REF TIME 153447 - 153447 AZM SCAN 11/0 EL * 0.4 TO 11.8 (DEG)																								
FIXED CONTROL OUTPUT																								
CENTROID AV CELL 2																								
TRK	AZM	RNO	AZM	RNO	AV	FX	V	S	C	X	L	R	FLX	X	CON	AV	CELL	DIST	HT	ID	ID	SE	SE	SE
NO	DEG	KM	DEG	KM	DEG	DE	C	C	L	KM	KM	I	MT/E	KM2	DEG	M/S	KM	KM	AC	AC	AC	AC	AC	AC
1	60	146	59	147	30	34	0	0	0	0.0	0.0	0	0.27	0.10	559	999	0.0	2	0	0	0	0	0	
2	67	19	68	29	30	32	1	0	0	0.0	0.0	0	0.07	0.01	559	999	0.0	0	0	0	0	0	0	
3	292	54	292	65	37	40	2	1	1	4.5	4.4	34	2.05	0.49	559	999	9.2	2	0	0	0	0	0	
4	44	126	44	127	34	34	1	0	0	0.0	0.0	0	0.28	0.09	559	999	0.0	1	0	0	0	0	0	
5	51	97	51	100	35	35	3	1	1	0.2	4.5	61	0.18	0.04	559	999	0.0	2	0	0	0	0	0	
6	60	53	61	90	37	32	1	0	0	0.0	0.0	0	0.12	0.03	559	999	0.0	1	0	0	0	0	0	
7	244	237	243	267	37	37	1	0	0	0.0	0.0	0	0.17	0.04	559	999	0.0	4	0	0	0	0	0	
8	62	122	62	123	32	32	1	0	0	0.0	0.0	0	0.15	0.05	559	999	0.0	1	0	0	0	0	0	
9	40	152	42	180	31	31	1	0	0	0.0	0.0	0	0.04	0.02	559	999	0.0	3	0	0	0	0	0	
10	55	121	55	121	31	43	2	1	1	8.7	3.7	16	0.24	0.32	559	999	7.6	5	0	0	0	0	0	
11	69	129	69	129	33	32	1	0	0	0.0	0.0	0	0.03	0.01	559	999	0.0	1	0	0	0	0	0	
12	71	200	71	200	31	31	1	0	0	0.0	0.0	0	0.05	0.02	559	999	0.0	4	0	0	0	0	0	
13	72	214	72	214	31	31	1	0	0	0.0	0.0	0	0.07	0.01	559	999	0.0	4	0	0	0	0	0	
14	167	16	153	15	16	34	1	0	0	0.0	0.0	0	0.14	0.03	559	999	0.0	0	0	0	0	0	0	
15	233	266	234	267	41	44	4	2	2	0.0	0.0	0	1.10	0.17	559	999	0.0	7	0	0	0	0	0	
16	236	139	235	194	35	44	4	2	2	2.8	7.5	65	2.22	0.53	559	999	0.0	6	0	0	0	0	0	
17	249	201	249	201	32	32	1	0	0	0.0	0.0	0	0.17	0.06	559	999	0.0	4	0	0	0	0	0	
18	245	48	245	48	33	32	1	0	0	0.0	0.0	0	0.21	0.00	559	999	0.0	0	0	0	0	0	0	
19	304	60	302	61	40	51	25	5	7	7.9	4.5	42	3.00	0.54	559	999	4.5	7	0	0	0	0	0	
20	252	153	253	152	31	31	1	0	0	0.0	0.0	0	0.08	0.03	559	999	0.0	2	0	0	0	0	0	
21	256	124	257	103	34	37	0	1	1	0.0	0.0	0	0.31	0.10	559	999	0.0	3	0	0	0	0	0	
22	252	143	243	122	32	32	1	0	0	0.0	0.0	0	0.41	0.11	559	999	0.0	2	0	0	0	0	0	
23	269	108	268	105	36	41	0	1	0	1.4	10.5	15	1.30	0.33	559	999	0.0	6	0	0	0	0	0	
24	292	75	291	74	32	32	1	0	0	0.0	0.0	0	0.21	0.00	559	999	0.0	0	0	0	0	0	0	
25	309	24	316	25	36	40	1	0	0	0.0	0.0	0	0.10	0.02	559	999	0.0	1	0	0	0	0	0	
26	314	37	322	37	39	47	13	3	3	3.6	7.7	17	0.55	0.16	559	999	7.6	8	0	0	0	0	0	
27	306	53	306	51	32	32	1	0	0	0.0	0.0	0	0.01	0.00	559	999	0.0	0	0	0	0	0	0	
28	305	28	305	25	31	21	1	0	0	0.0	0.0	0	0.04	0.01	559	999	0.0	1	0	0	0	0	0	
29	316	61	312	53	35	35	0	1	1	0.0	0.0	0	0.07	0.02	559	999	0.0	5	0	0	0	0	0	
30	312	54	311	54	32	34	2	1	1	0.0	0.0	0	0.06	0.02	559	999	0.0	1	0	0	0	0	0	
31	319	91	319	91	34	34	1	0	0	0.0	0.0	0	0.08	0.02	559	999	0.0	1	0	0	0	0	0	
32	357	51	357	50	34	35	0	1	1	0.0	0.0	0	0.04	0.02	559	999	0.0	0	0	0	0	0	0	
33	0	51	359	54	32	32	1	0	0	0.0	0.0	0	0.00	0.00	559	999	0.0	3	0	0	0	0	0	
34	347	83	341	78	39	47	15	1	11.6	9.13	2	53	4.27	0.69	559	999	6.5	6	0	0	0	0	0	
35	17	59	18	59	31	31	1	0	0	0.0	0.0	0	0.01	0.00	559	999	0.0	0	0	0	0	0	0	
36	11	43	13	44	44	45	1	0	0	0.0	0.0	0	0.18	0.03	559	999	0.0	0	0	0	0	0	0	
37	20	45	20	44	33	33	1	0	0	0.0	0.0	0	0.01	0.00	559	999	0.0	0	0	0	0	0	0	
38	5	67	8	68	60	45	16	3	7	5.6	8.4	120	2.68	0.29	559	999	4.7	7	0	0	0	0	0	
39	26	96	26	95	38	38	1	0	0	0.0	0.0	0	0.13	0.04	559	999	0.0	1	0	0	0	0	0	

Table A1. ACDT Volume Scan Output for Volume Scan No. 1, Case Study No. 2
(Cont'd)

VOLUME CELL DATA																			
TRK	ACM	PAG	AV	PK	LR	HI	LN	H	W	W	W	W	W	W	W	W	W	W	W
NO.	NO.	NO.	NO.	NO.	NO.	NO.	NO.	NO.	NO.	NO.	NO.	NO.	NO.	NO.	NO.	NO.	NO.	NO.	NO.
1	41	92	37	37	37	37	1	1	1	1	1	1	1	1	1	1	1	1	1
2	42	132	31	31	31	31	2	2	2	2	2	2	2	2	2	2	2	2	2
3	43	123	32	32	32	32	1	1	1	1	1	1	1	1	1	1	1	1	1
4	44	127	34	34	34	34	1	1	1	1	1	1	1	1	1	1	1	1	1
5	47	131	34	34	34	34	2	2	2	2	2	2	2	2	2	2	2	2	2
6	48	22	32	32	32	32	2	2	2	2	2	2	2	2	2	2	2	2	2
7	50	95	33	33	33	33	1	1	1	1	1	1	1	1	1	1	1	1	1
8	51	113	34	34	34	34	1	1	1	1	1	1	1	1	1	1	1	1	1
9	52	122	40	42	42	34	1	2	2	2	2	2	2	2	2	2	2	2	2
10	56	122	38	38	38	38	1	1	1	1	1	1	1	1	1	1	1	1	1
11	56	123	39	42	42	36	1	2	2	2	2	2	2	2	2	2	2	2	2
12	56	142	34	34	34	34	2	2	2	2	2	2	2	2	2	2	2	2	2
13	59	121	42	43	43	42	1	2	2	2	2	2	2	2	2	2	2	2	2
14	60	125	37	38	38	36	1	3	3	3	3	3	3	3	3	3	3	3	3
15	61	123	35	36	36	36	1	1	1	1	1	1	1	1	1	1	1	1	1
16	61	151	31	31	31	31	2	2	2	2	2	2	2	2	2	2	2	2	2
17	69	128	33	33	33	33	1	1	1	1	1	1	1	1	1	1	1	1	1
18	71	222	31	31	31	31	4	4	4	4	4	4	4	4	4	4	4	4	4
19	72	214	31	31	31	31	4	4	4	4	4	4	4	4	4	4	4	4	4
20	153	15	34	34	34	34	2	2	2	2	2	2	2	2	2	2	2	2	2
21	234	227	41	44	44	38	4	5	7	11	6	2	1	0	0	0	0	0	0
22	235	192	36	36	36	36	3	3	3	3	3	3	3	3	3	3	3	3	3
23	236	205	42	44	44	40	4	4	4	4	4	4	4	4	4	4	4	4	4
24	236	194	38	38	38	38	3	3	3	3	3	3	3	3	3	3	3	3	3
25	243	227	37	37	37	37	4	4	4	4	4	4	4	4	4	4	4	4	4
26	245	49	33	33	33	32	0	0	0	0	0	0	0	0	0	0	0	0	0
27	249	201	33	33	33	33	4	4	4	4	4	4	4	4	4	4	4	4	4
28	253	152	31	31	31	31	2	2	2	2	2	2	2	2	2	2	2	2	2
29	253	142	37	37	37	37	2	2	2	2	2	2	2	2	2	2	2	2	2
30	256	126	32	34	34	31	1	2	2	2	2	2	2	2	2	2	2	2	2
31	257	120	35	37	37	34	1	2	2	2	2	2	2	2	2	2	2	2	2
32	263	109	39	41	35	36	1	2	4	11	6	2	1	0	0	0	0	0	0
33	276	102	36	36	36	36	1	1	1	1	1	1	1	1	1	1	1	1	1
34	282	32	34	34	34	34	1	1	1	1	1	1	1	1	1	1	1	1	1
35	296	66	33	33	33	33	0	0	0	0	0	0	0	0	0	0	0	0	0
36	296	90	38	38	38	38	0	0	0	0	0	0	0	0	0	0	0	0	0
37	290	64	33	36	36	32	0	1	4	11	6	2	1	0	0	0	0	0	0
38	291	74	32	32	32	32	0	0	0	0	0	0	0	0	0	0	0	0	0
39	293	82	36	37	37	35	1	1	1	1	1	1	1	1	1	1	1	1	1
40	294	87	40	42	42	37	1	1	2	11	6	2	1	0	0	0	0	0	0
41	294	91	36	36	36	36	1	1	1	1	1	1	1	1	1	1	1	1	1
42	301	62	37	39	35	34	0	1	2	11	6	2	1	0	0	0	0	0	0
43	302	64	39	39	39	39	0	0	0	0	0	0	0	0	0	0	0	0	0
44	302	86	39	39	39	39	1	1	1	1	1	1	1	1	1	1	1	1	1
45	305	98	33	33	33	33	1	1	1	1	1	1	1	1	1	1	1	1	1
46	306	52	32	32	32	32	0	0	0	0	0	0	0	0	0	0	0	0	0
47	307	66	36	36	36	32	0	1	4	11	6	2	1	0	0	0	0	0	0
48	311	31	40	40	40	40	0	0	0	0	0	0	0	0	0	0	0	0	0
49	313	39	39	40	40	39	0	0	0	0	0	0	0	0	0	0	0	0	0
50	311	56	32	32	32	32	0	0	0	0	0	0	0	0	0	0	0	0	0

Table A1. ACDT Volume Scan Output for Volume Scan No. 1, Case Study No. 2
(Cont'd)

51	312	52	33	34	34	32	C	C	1	11.3	2.1	C	0.00	4.7	5.0	C	C	9.0	0.8	6	30	1	2	1	
52	316	25	36	40	40	34	C	C	1	11.3	2.1	C	0.00	2.1	1.4	C	C	6.8	1.3	0	25	0	3	1	
53	316	74	38	40	40	34	C	2	6	11.8	2.1	C	0.08	6.1	1.9	C	C	-4.6	3.2	8	19	1	5	1	
54*	317	42	40	41	40	40	C	1	1	11.6	2.1	C	0.00	3.6	2.7	C	C	10.1	3.3	7	26	3	3	1	
55	318	61	34	35	35	33	C	C	1	11.3	2.1	C	0.00	5.1	3.9	C	C	8.5	2.1	9	29	0	2	1	
56	319	67	35	37	37	34	C	1	1	11.3	2.1	C	0.00	4.7	1.6	C	C	-1.8	10.9	10	19	0	2	1	
57	318	91	34	34	34	34	1	1	1	11.8	2.1	C	0.00	6.1	0.0	C	C	-2.5	0.0	0	31	0	1	1	
58	321	40	33	33	33	33	C	C	0	11.3	2.1	C	0.00	6.9	3.0	C	C	-1.6	3.9	6	34	5	1	1	
59	322	74	35	35	35	35	C	C	0	11.3	2.1	C	0.00	2.2	1.2	C	C	-8.0	0.9	0	19	1	1	1	
60	323	64	33	35	35	32	1	2	5	11.3	2.1	C	0.00	3.7	1.3	C	C	-2.3	4.1	8	34	1	3	1	
61	327	68	37	37	37	37	1	1	1	11.6	2.1	C	0.00	1.7	0.0	C	C	-1.8	0.0	0	34	0	1	1	
62	328	82	33	33	33	33	1	1	1	11.3	2.1	C	0.00	3.1	1.4	C	C	-4.7	0.4	0	34	2	1	1	
63	329	71	42	43	43	43	C	C	0	11.3	2.1	C	0.00	4.9	1.3	C	C	-11.2	1.6	0	19	1	1	1	
64	331	65	44	44	44	44	C	C	2	11.3	2.1	C	0.00	7.7	1.0	C	C	-12.4	1.5	11	15	1	1	1	
65*	334	65	49	45	44	47	C	1	4	11.6	2.1	C	0.00	6.3	3.3	C	C	-0.5	9.0	11	19	4	3	1	
66*	336	53	53	51	50	49	C	2	4	11.8	2.1	C	0.00	6.1	2.7	C	C	8.2	2.6	12	19	4	5	1	
67	339	86	41	44	44	33	1	1	3	11.3	2.1	C	0.00	3.2	1.6	C	C	-7.3	4.9	0	34	4	2	1	
68	341	95	39	40	40	35	1	1	2	11.6	2.1	C	0.00	9.4	1.4	C	C	-6.0	0.4	0	34	2	2	1	
69	355	51	34	34	34	34	C	0	0	11.5	2.1	C	0.00	3.0	2.3	C	C	-2.7	8.2	13	32	1	1	1	
70	337	62	46	47	47	46	C	1	1	11.3	2.1	C	0.00	4.7	3.2	C	C	-2.0	8.3	14	34	4	2	1	
71	359	77	42	43	43	43	C	C	0	11.3	2.1	C	0.00	2.9	2.5	C	C	10.8	0.0	15	34	0	1	1	
72	359	73	35	35	35	35	C	C	0	11.3	2.1	C	0.00	2.1	3.4	C	C	-5.1	0.0	15	34	0	1	1	
73	359	50	35	35	35	35	C	C	0	11.3	2.1	C	0.00	1.9	0.0	C	C	-11.4	0.0	13	32	0	1	1	
74	359	67	37	37	37	37	C	C	0	11.3	2.1	C	0.00	3.2	2.8	C	C	-10.6	1.1	16	34	1	1	1	
75	C	59	34	36	36	34	C	1	3	11.3	2.1	C	0.00	3.3	1.2	C	C	-3.4	5.2	16	34	0	3	1	
76	359	54	32	32	32	32	C	2	3	11.3	2.1	C	0.00	2.0	0.0	C	C	-3.6	4.6	13	33	0	3	1	
77	1	61	39	39	39	39	C	C	0	11.3	2.1	C	0.00	4.5	0.0	C	C	-12.1	0.0	16	38	0	1	1	
78	1	76	45	45	45	45	C	C	0	11.3	2.1	C	0.00	6.4	5.4	C	C	3.0	5.9	15	38	2	1	1	
79*	3	60	40	45	45	33	C	1	4	11.3	2.1	C	0.00	4.5	2.5	C	C	-2.3	4.1	16	38	2	3	1	
80	8	67	44	45	45	43	C	1	1	11.3	2.1	C	0.00	5.7	4.4	C	C	-2.4	3.1	16	38	3	2	1	
81*	12	57	42	45	42	39	C	1	4	11.3	2.1	C	0.00	4.0	1.6	C	C	-6.7	5.6	17	38	2	4	1	
82	11	52	40	40	40	40	C	C	0	11.3	2.1	C	0.00	4.1	1.5	C	C	-9.4	0.4	17	38	1	1	1	
83	13	44	44	45	43	45	C	C	0	11.3	2.1	C	0.00	2.8	1.4	C	C	-1.3	6.7	0	36	1	2	1	
84	18	58	31	31	31	31	C	C	0	11.3	2.1	C	0.00	2.1	3.1	C	C	-2.0	4.7	0	35	2	1	1	
85	20	44	33	33	33	33	C	C	0	11.3	2.1	C	0.00	1.8	2.4	C	C	-10.6	0.0	0	37	0	1	1	
86	26	95	38	38	38	38	1	1	1	11.3	2.1	C	0.00	3.3	0.0	C	C	-5.3	0.0	0	39	0	1	1	
87	51	101	33	34	33	34	1	1	2	11.3	2.1	C	0.00	2.1	1.1	C	C	-2.0	2.0	18	5	1	1	1	
88*	339	56	41	46	34	40	C	4	7	11.3	2.1	C	0.00	3.4	2.3	C	C	5.4	3.5	12	19	6	4	1	
89	344	50	38	40	35	40	C	0	0	11.3	2.1	C	0.00	2.6	2.8	C	C	5.4	0.7	0	19	2	1	1	
91	350	80	34	34	34	34	C	C	0	11.3	2.1	C	0.00	3.0	2.4	C	C	-10.8	0.0	0	34	1	0	1	
93	39	81	31	31	31	31	1	1	1	11.3	2.1	C	0.00	7.6	3.3	C	C	1.3	0.2	0	C	1	1	1	
94	40	92	32	32	32	32	2	2	2	11.3	2.1	C	0.00	8.1	1.7	C	C	5.2	0.2	0	C	1	1	1	
95	129	12	33	33	33	33	C	C	0	11.3	2.1	C	0.00	4.7	1.0	C	C	-14.8	0.0	19	0	0	1	1	
96	126	17	36	37	36	36	C	1	1	11.3	2.1	C	0.00	2.4	2.4	C	C	-1.6	8.9	19	0	1	1	1	
97	228	34	31	31	31	31	C	C	0	11.3	2.1	C	0.00	1.7	1.8	C	C	-4.8	0.0	0	0	0	1	1	
98	234	185	33	33	33	33	5	5	5	11.3	2.1	C	0.00	30.8	0.0	C	C	C	C	0	0	16	0	1	1
99	294	61	34	34	34	34	1	1	1	11.3	2.1	C	0.00	3.0	0.0	C	C	-6.3	0.0	3	19	0	1	1	
100	301	80	32	32	32	32	1	1	1	11.3	2.1	C	0.00	4.0	0.0	C	C	-6.4	0.0	0	0	0	1	1	
101	305	61	36	36	36	36	1	1	1	11.3	2.1	C	0.00	1.9	4.3	C	C	-8.2	3.1	5	19	1	1	1	
102	312	68	39	39	35	39	1	1	1	11.3	2.1	C	0.00	4.0	2.4	C	C	-7.3	4.3	0	19	2	1	1	
103	329	17	35	39	31	39	C	1	2	11.3	2.1	C	0.00	1.8	1.1	C	C	9.6	1.4	0	C	0	3	1	
104	321	64	32	35	32	32	1	3	5	11.3	2.1	C	0.00	2.7	2.0	C	C	6.8	2.7	10	19	0	4	1	
105*	323	36	44	47	33	47	C	2	2	11.3	2.1	C	0.00	1.9	1.8	C	C	9.8	2.9	20	26	1	3	1	
106	326	40	34	34	34	34	C	C	0	11.3	2.1	C	0.00	1.5	1.4	C	C	9.7	2.1	20	26	2	1	1	

Table A1. ACCT Volume Scan Output for Volume Scan No. 1, Case Study No. 2
(Cont D)

107	330	63	76	39	39	31	1	2	4	11.8	2.1	0.00	7.8	1.4	0.0	-4.9	3.1	0	34	2	2	1
108	333	75	35	32	35	31	1	1	4	11.8	2.1	0.00	5.2	1.1	0.0	-1.7	7.9	0	19	0	4	1
109	344	85	31	31	31	31	1	1	1	11.8	2.1	0.00	7.5	1.6	0.0	-0.6	0.1	0	0	1	1	1
110	350	89	32	42	40	33	2	2	3	11.8	2.1	0.00	3.5	2.0	0.0	-4.9	1.5	0	36	1	2	1
111	352	57	32	32	31	32	1	1	1	11.8	2.1	0.00	1.2	0.0	0.0	3.9	0.0	0	0	0	1	1
112	352	58	38	42	42	36	1	1	3	11.8	2.1	0.00	4.2	3.2	0.0	-1.4	7.0	1	38	3	2	1
113	352	57	36	39	39	33	1	1	1	11.8	2.1	0.00	5.1	3.0	0.0	-0.1	4.6	0	28	4	0	1
114	352	57	31	42	42	38	1	1	1	11.8	2.1	0.00	3.5	3.7	0.0	-2.2	6.4	1	38	3	2	1
115	352	57	32	40	40	41	1	1	1	11.8	2.1	0.00	6.0	2.3	0.0	-5.0	5.2	17	39	4	1	1
116	352	57	32	32	32	32	1	1	2	11.8	2.1	0.00	2.2	0.0	0.0	0.0	0.0	18	5	2	1	1
120	355	116	33	33	33	33	5	5	5	11.8	2.1	0.00	4.9	0.0	0.0	4.7	0.0	0	0	0	1	1
121	356	35	32	34	31	34	1	1	5	11.8	2.1	0.00	2.5	5.0	0.0	-2.1	3.3	0	0	2	3	1
122	365	104	33	35	35	32	4	1	6	11.8	2.1	0.00	3.4	0.0	0.0	-0.9	1.3	0	23	0	2	1
123	319	56	77	38	38	34	2	1	5	11.8	2.1	0.00	3.6	5.2	0.0	5.5	3.8	9	29	3	4	1
124	321	45	36	33	34	35	1	4	5	11.8	2.1	0.00	0.8	4.7	0.0	6.5	5.4	21	26	2	5	1
125	321	30	42	42	42	42	1	1	1	11.8	2.1	0.00	3.1	1.5	0.0	10.4	1.1	20	26	0	2	1
126	337	69	41	44	44	34	2	4	7	11.8	2.1	0.00	5.4	1.5	0.0	2.7	0.7	22	19	1	3	1
127	340	64	43	45	45	43	2	1	1	11.8	2.1	0.00	2.5	1.4	0.0	1.1	1.8	23	19	2	3	1
128	347	61	31	31	31	31	2	2	3	11.8	2.1	0.00	0.1	1.1	0.0	-0.4	0.9	24	0	1	2	1
129	352	83	31	31	31	31	1	4	5	11.8	2.1	0.00	8.8	0.0	0.0	-1.5	1.0	0	0	0	2	1
130	352	12	76	39	37	33	3	4	6	11.8	2.1	0.00	1.9	1.7	0.0	-4.6	0.1	16	38	0	3	1
131	319	78	35	32	32	35	1	4	6	11.8	2.1	0.00	4.1	4.1	0.0	1.7	4.5	8	34	4	3	1
132	352	57	74	38	38	38	3	3	1	11.8	2.1	0.00	3.0	1.2	0.0	1.3	0.5	16	38	1	1	1
133	334	27	32	33	32	33	1	2	4	11.8	2.1	0.00	2.1	1.1	0.0	7.1	1.4	20	26	0	4	1
134	328	34	40	43	40	41	2	4	7	11.8	2.1	0.00	0.1	2.2	0.0	8.3	2.7	20	26	2	6	1
135	316	49	34	34	34	34	2	2	1	11.8	2.1	0.00	1.4	4.4	0.0	8.6	0.0	21	26	0	1	1
136	325	29	36	36	36	36	1	1	1	11.8	2.1	0.00	1.7	0.0	0.0	10.5	0.0	20	26	0	1	1
137	320	49	37	37	37	37	1	2	2	11.8	2.1	0.00	0.5	1.8	0.0	-1.1	0.4	0	0	1	1	1
138	347	55	33	34	34	32	4	5	5	11.8	2.1	0.00	0.5	1.0	0.0	1.2	0.3	24	19	0	2	1
139	332	62	35	37	37	33	5	4	7	11.8	2.1	0.00	3.7	1.6	0.0	-5.2	0.5	16	38	2	2	1
140	342	14	67	36	36	36	5	5	5	11.8	2.1	0.00	1.6	1.7	0.0	-6.3	0.0	16	38	0	1	1
141	342	16	61	42	44	44	5	5	5	11.8	2.1	0.00	4.1	2.2	0.0	-5.0	2.5	0	28	2	2	1
142	334	68	34	34	34	34	5	5	5	11.8	2.1	0.00	1.9	1.4	0.0	4.7	0.0	22	19	0	1	1
143	341	63	36	36	36	36	5	5	5	11.8	2.1	0.00	1.5	0.0	0.0	0.5	0.0	23	19	0	1	1
144	315	73	33	33	33	33	6	6	6	11.8	2.1	0.00	4.7	1.0	0.0	-5.5	0.0	16	38	0	1	1
145	325	47	34	35	35	32	4	5	6	11.8	2.1	0.00	3.5	1.6	0.0	11.1	0.7	21	26	0	2	1
146	340	51	37	37	37	37	6	6	6	11.8	2.1	0.00	3.0	4.6	0.0	5.7	1.7	0	19	2	1	1
147	344	18	35	37	34	36	2	3	7	11.8	2.1	0.00	1.9	1.4	0.0	5.3	1.0	0	0	0	3	1
148	325	40	39	39	39	39	8	8	8	11.8	2.1	0.00	2.8	3.9	0.0	0.9	0.0	0	26	0	1	1

Table A1: ACDT Volume Scan Output for Volume Scan No. 1, Case Study No. 2 (Contd)

CLUSTER OUTPUT																							
CENTROID																							
TRK	AZM	RNG	AV	PK	V	X	L	AN	IC	AV	CELL	MSKM	MT	IC	IC	RCT	DIV	RC					
NO	DEG	KM	50	50	C	KM	KM	DEG		SM/S	NM/S	MM	MT	IC	IC	MSKM	MSKM	CS					
1	60	125	39	43	2	0.0	3.6	53	10	0.0	0.0	0.7	5	C	C	0.00	0.00	C					
2	257	123	34	37	2	0.0	0.0	0	21	0.0	0.0	0.0	3	C	C	0.00	0.00	C					
3	290	63	33	36	2	0.0	3.6	47	15	0.0	0.0	0.5	4	C	C	0.00	0.00	C					
4	293	87	37	42	2	0.0	3.6	102	1	0.0	0.0	1.0	2	C	C	0.00	0.00	C					
5	303	62	37	39	2	1.1	2.5	54	19	0.0	0.0	1.9	2	C	C	0.00	0.00	C					
6	310	53	32	34	2	1.6	2.3	37	30	0.0	0.0	4.5	1	C	C	0.00	0.00	C					
7	315	40	39	41	2	0.0	0.0	0	24	0.0	0.0	2.3	1	C	C	0.00	0.00	C					
8	320	79	36	40	4	0.0	5.2	6	15	0.0	0.0	2.8	6	C	C	0.00	0.00	C					
9	318	53	35	38	2	0.0	1.0	0	24	0.0	0.0	4.5	5	C	C	0.00	0.00	C					
10	320	66	34	37	2	0.0	0.0	0	15	0.0	0.0	1.9	5	C	C	0.00	0.00	C					
11	332	65	43	45	2	0.0	0.0	0	15	0.0	0.0	2.4	4	C	C	0.00	0.00	C					
12	333	54	47	51	2	0.0	0.0	0	15	0.0	0.0	2.6	7	C	C	0.00	0.00	C					
13	358	51	33	35	2	1.0	1.9	46	32	0.0	0.0	0.8	3	C	C	0.00	0.00	C					
14	353	83	44	47	2	0.0	0.0	0	34	0.0	0.0	2.2	3	C	C	0.00	0.00	C					
15	0	75	42	45	2	1.0	1.7	36	36	0.0	0.0	4.2	0	C	C	0.00	0.00	C					
16	0	63	38	46	11	3.4	7.4	55	31	0.0	0.0	2.7	7	C	C	0.00	0.00	C					
17	12	57	40	45	2	0.4	4.1	15	31	0.0	0.0	1.9	4	C	C	0.00	0.00	C					
18	52	103	32	34	2	0.0	0.0	0	5	0.0	0.0	0.6	2	C	C	0.00	0.00	C					
19	127	15	34	37	2	0.0	0.0	0	0	0.0	0.0	2.0	1	C	C	0.00	0.00	C					
20	326	33	40	47	2	1.5	4.9	314	26	0.0	0.0	1.6	7	C	C	0.00	0.00	C					
21	321	47	34	38	2	1.1	0.5	53	26	0.0	0.0	2.9	6	C	C	0.00	0.00	C					
22	335	63	39	44	2	0.0	0.0	0	19	0.0	0.0	1.3	7	C	C	0.00	0.00	C					
23	340	64	41	45	2	0.0	0.0	0	19	0.0	0.0	1.2	5	C	C	0.00	0.00	C					
24	347	53	32	34	2	0.0	0.0	0	19	0.0	0.0	1.0	5	C	C	0.00	0.00	C					
VOL HMM AREA WFLX NEAR NEIGHBOR ACT NO NO VELOCITY TRK CLS CNT G OVER																							
SCAN	KMM2	KMT/H	CELL	CLST	CONT	VCL	CS	FC	EM/S	NM/S	NC	CTR	CTR	C									
1	1534	5.0	27.08	7.0	13.6	0.0	143	25	13	11.8	2.1	148	24	39	C	0	C	C	C	C	C	C	C

Table A2. ACDT Volume Scan Output for Volume Scan No. 2, Case Study No. 2

SCAN TIME 100 154044 - 154703										VCL SCAN 2 A2 - 71.1 TC 70.6 (DEG)											
TRACK REF TIME 101930 - 154044										AZM SCAN 10/1 EL - 0.0 TC 6.5 (DEG)											
FIXED CONTIGUR OUTPUT																					
CENTROID AV CELL 2										WTR AREA VELOCITY NEAR MX MR SP											
TRK	AZM	RNG	AZM	RNG	AV	PK	V	D	A	SPR	TPR	D	FLUX	ACCN	AV	CELL	DIST	HT	IC	IC	
NO	DEG	KM	DEG	KM	CH	DE	C	C	L	KM	KM	I	M/T/H	K/M2	DEG	M/S	KM	NO	NO	NO	
40	100	16	100	15	35	35	2	0	0	0.0	0.0	0	0.05	0.01	217	19	0.0	0	0	0	
17	242	194	242	194	31	31	1	0	0	0.0	0.0	0	0.02	0.01	258	19	0.0	4	0	0	
41	161	31	159	30	36	38	1	0	0	0.0	0.0	0	0.06	0.01	999	999	0.0	1	0	0	
42	147	33	144	32	31	32	1	0	0	0.0	0.0	0	0.03	0.01	999	999	0.0	1	0	0	
16	236	194	235	184	39	45	4	1	0	1.3	10.3	49	3.18	0.53	135	16	0.0	7	0	0	
43	259	118	260	116	32	33	2	0	0	0.0	0.0	0	0.21	0.07	999	999	0.0	2	0	0	
44	240	26	242	24	33	35	1	0	0	0.0	0.0	0	0.02	0.01	999	999	0.0	0	0	0	
15	233	21	232	219	43	48	2	1	0	0.0	0.0	0	4.57	0.44	249	14	0.0	9	0	0	
45	242	226	242	227	37	38	1	0	0	0.0	0.0	0	0.42	0.09	999	999	0.0	6	0	0	
46	244	217	244	217	31	31	1	0	0	0.0	0.0	0	0.25	0.04	999	999	0.0	5	0	0	
47	252	158	251	159	36	37	1	0	0	0.0	0.0	0	0.40	0.12	999	999	0.0	4	0	0	
48	253	146	255	146	32	32	1	0	0	0.0	0.0	0	0.07	0.03	999	999	0.0	2	0	0	
49	274	71	276	70	31	32	1	0	0	0.0	0.0	0	0.02	0.01	999	999	0.0	3	0	0	
23	269	103	268	102	37	46	5	2	1	2.4	8.9	28	1.41	0.37	215	22	0.1	6	0	0	
50	271	92	272	92	30	34	1	0	0	0.0	0.0	0	0.02	0.01	999	999	0.0	1	0	0	
51	280	75	280	75	31	31	1	0	0	0.0	0.0	0	0.02	0.01	999	999	0.0	1	0	0	
52	286	92	286	91	32	32	0	0	0	0.0	0.0	0	0.06	0.02	225	14	0.0	1	0	3	
53	280	73	281	77	34	35	1	1	1	0.0	0.0	0	0.03	0.01	999	999	0.0	1	0	0	
26	312	26	312	25	38	38	1	1	1	0.0	0.0	0	0.03	0.01	102	17	0.0	0	0	0	
3	290	82	299	88	36	41	5	1	1	8.1	7.7	35	1.75	0.43	238	16	0.2	2	24	0	
54	303	76	304	76	33	34	1	0	0	0.0	0.0	0	0.02	0.01	262	15	0.0	1	0	0	
55	311	99	311	99	34	34	1	0	0	0.0	0.0	0	0.04	0.01	999	999	0.0	1	0	0	
56	341	67	343	69	41	52	14	4	4	5.1	7.7	117	1.96	0.26	257	15	4.0	6	19	34	
57	322	81	323	81	31	31	1	0	0	0.0	0.0	0	0.02	0.01	252	23	0.0	1	0	34	
58	359	32	359	63	34	34	1	0	0	0.0	0.0	0	0.05	0.01	999	999	0.0	0	0	0	
57	356	92	348	93	41	45	6	3	2	3.3	11.6	229	2.05	0.27	263	21	0.2	3	0	34	
34	321	60	323	60	39	48	31	3	3	9.9	14.4	310	3.48	0.61	246	13	4.1	7	19	0	
60	333	91	332	92	35	37	1	0	0	0.0	0.0	0	0.12	0.03	999	999	0.0	2	0	0	
19	338	53	337	54	26	36	1	0	0	0.0	0.0	0	0.01	0.00	177	6	0.0	5	0	0	
61	2	63	2	63	32	32	1	1	1	0.0	0.0	0	0.03	0.02	200	13	0.0	0	0	34	
62	33	99	34	95	35	37	2	0	0	0.0	0.0	0	0.08	0.08	999	999	0.0	1	0	0	
63	9	74	12	73	39	45	12	2	1	3.5	11.9	230	3.71	0.50	250	14	0.2	6	38	34	
64	48	113	49	114	32	34	1	0	0	0.0	0.0	0	0.03	0.01	999	999	0.0	3	0	0	
65	51	135	51	134	39	38	1	0	0	0.0	0.0	0	0.27	0.26	999	999	0.0	2	0	0	
66	52	122	52	122	31	32	1	1	1	0.0	0.0	0	0.01	0.01	999	999	0.0	7	0	0	
67	52	132	52	132	35	42	1	1	1	0.0	0.0	0	0.57	0.09	999	999	0.0	8	0	0	
10	59	121	60	121	35	35	1	0	0	0.0	0.0	0	0.07	0.02	327	4	0.0	2	0	0	

Table A2. ACPI Volume Scan Output for Volume Scan No. 2, Case Study No. 2
(continued)

ACPI Volume Scan Output		Volume Scan No. 2		Case Study No. 2	
Line	Time	Time	Time	Time	Time
101	101	101	101	101	101
102	102	102	102	102	102
103	103	103	103	103	103
104	104	104	104	104	104
105	105	105	105	105	105
106	106	106	106	106	106
107	107	107	107	107	107
108	108	108	108	108	108
109	109	109	109	109	109
110	110	110	110	110	110
111	111	111	111	111	111
112	112	112	112	112	112
113	113	113	113	113	113
114	114	114	114	114	114
115	115	115	115	115	115
116	116	116	116	116	116
117	117	117	117	117	117
118	118	118	118	118	118
119	119	119	119	119	119
120	120	120	120	120	120
121	121	121	121	121	121
122	122	122	122	122	122
123	123	123	123	123	123
124	124	124	124	124	124
125	125	125	125	125	125
126	126	126	126	126	126
127	127	127	127	127	127
128	128	128	128	128	128
129	129	129	129	129	129
130	130	130	130	130	130
131	131	131	131	131	131
132	132	132	132	132	132
133	133	133	133	133	133
134	134	134	134	134	134
135	135	135	135	135	135
136	136	136	136	136	136
137	137	137	137	137	137
138	138	138	138	138	138
139	139	139	139	139	139
140	140	140	140	140	140
141	141	141	141	141	141
142	142	142	142	142	142
143	143	143	143	143	143
144	144	144	144	144	144
145	145	145	145	145	145
146	146	146	146	146	146
147	147	147	147	147	147
148	148	148	148	148	148
149	149	149	149	149	149
150	150	150	150	150	150
151	151	151	151	151	151
152	152	152	152	152	152
153	153	153	153	153	153
154	154	154	154	154	154
155	155	155	155	155	155
156	156	156	156	156	156
157	157	157	157	157	157
158	158	158	158	158	158
159	159	159	159	159	159
160	160	160	160	160	160
161	161	161	161	161	161
162	162	162	162	162	162
163	163	163	163	163	163
164	164	164	164	164	164
165	165	165	165	165	165
166	166	166	166	166	166
167	167	167	167	167	167
168	168	168	168	168	168
169	169	169	169	169	169
170	170	170	170	170	170
171	171	171	171	171	171
172	172	172	172	172	172
173	173	173	173	173	173
174	174	174	174	174	174
175	175	175	175	175	175
176	176	176	176	176	176
177	177	177	177	177	177
178	178	178	178	178	178
179	179	179	179	179	179
180	180	180	180	180	180
181	181	181	181	181	181
182	182	182	182	182	182
183	183	183	183	183	183
184	184	184	184	184	184
185	185	185	185	185	185
186	186	186	186	186	186
187	187	187	187	187	187
188	188	188	188	188	188
189	189	189	189	189	189
190	190	190	190	190	190
191	191	191	191	191	191
192	192	192	192	192	192
193	193	193	193	193	193
194	194	194	194	194	194
195	195	195	195	195	195
196	196	196	196	196	196
197	197	197	197	197	197
198	198	198	198	198	198
199	199	199	199	199	199
200	200	200	200	200	200

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Table A2. ACPT Volume Scan Output for Volume Scan No. 2, Case Study No. 2
(Cont'd)

185	165	41	34	34	34	0	0	0	11.8	2.1	0.00	1.1	1.1	0.0	-5.7	0.0	27	58	0	1	1
187	215	171	33	33	33	0	0	0	11.8	2.1	0.00	1.1	1.1	0.0	0.2	0.0	0	16	0	1	1
188	354	131	31	31	31	0	0	0	11.8	2.1	0.00	1.1	1.1	0.0	0.0	0.0	0	0	0	1	1
189	362	34	33	33	33	0	0	0	11.8	2.1	0.00	1.1	1.1	0.0	2.6	4.7	0	0	0	1	1
190	261	108	38	38	38	0	0	0	11.8	2.1	0.00	1.1	1.1	0.0	1.5	0.0	0	23	0	1	1
191	225	88	32	32	32	0	0	0	11.8	2.1	0.00	1.1	1.1	0.0	1.6	0.0	0	0	0	1	1
192	279	98	32	32	32	0	0	0	11.8	2.1	0.00	1.1	1.1	0.0	1.2	0.0	0	0	0	1	1
193	347	133	32	32	32	0	0	0	11.8	2.1	0.00	1.1	1.1	0.0	1.1	0.0	0	0	0	1	1
194	317	68	36	36	36	0	0	0	11.8	2.1	0.00	1.1	1.1	0.0	-1.9	6.8	25	34	0	1	1
195	327	62	37	37	37	0	0	0	11.8	2.1	0.00	1.1	1.1	0.0	5.4	3.4	25	34	0	1	1
197	36	36	33	33	33	0	0	0	11.8	2.1	0.00	1.1	1.1	0.0	3.8	0.7	0	0	0	1	1
198	51	132	32	32	32	0	0	0	11.8	2.1	0.00	1.1	1.1	0.0	0.0	0.0	0	0	0	1	1
199	350	217	34	34	34	0	0	0	11.8	2.1	0.00	1.1	1.1	0.0	0.5	0.0	0	0	0	1	1
200	357	207	34	34	34	0	0	0	11.8	2.1	0.00	1.1	1.1	0.0	0.1	0.0	0	0	0	1	1
201	27	107	33	33	33	0	0	0	11.8	2.1	0.00	1.1	1.1	0.0	1.7	1.3	0	23	0	1	1
202	321	27	34	34	34	0	0	0	11.8	2.1	0.00	1.1	1.1	0.0	4.7	0.1	35	34	1	1	1
203	324	34	33	33	33	0	0	0	11.8	2.1	0.00	1.1	1.1	0.0	1.9	1.7	25	34	0	1	1
204	330	22	36	36	36	0	0	0	11.8	2.1	0.00	1.1	1.1	0.0	6.7	1.1	25	34	0	1	1
205	337	61	36	36	36	0	0	0	11.8	2.1	0.00	1.1	1.1	0.0	1.4	1.1	21	34	0	1	1
206	43	33	32	32	32	0	0	0	11.8	2.1	0.00	1.1	1.1	0.0	5.8	0.1	25	34	0	1	1
207	34	34	33	33	33	0	0	0	11.8	2.1	0.00	1.1	1.1	0.0	1.3	1.7	22	56	2	4	1
208	342	21	35	35	35	0	0	0	11.8	2.1	0.00	1.1	1.1	0.0	3.0	1.4	22	56	3	5	1
209	34	34	33	33	33	0	0	0	11.8	2.1	0.00	1.1	1.1	0.0	-0.9	0.7	0	0	0	1	1
210	338	14	31	31	31	0	0	0	11.8	2.1	0.00	1.1	1.1	0.0	-3.7	0.6	0	0	0	2	1
211	34	34	33	33	33	0	0	0	11.8	2.1	0.00	1.1	1.1	0.0	1.0	1.7	34	34	0	3	1
212	34	34	33	33	33	0	0	0	11.8	2.1	0.00	1.1	1.1	0.0	4.1	1.1	25	34	0	4	1
213	34	34	33	33	33	0	0	0	11.8	2.1	0.00	1.1	1.1	0.0	-1.5	0.4	0	0	0	2	1
214	242	24	32	32	32	0	0	0	11.8	2.1	0.00	1.1	1.1	0.0	1.2	1.3	22	56	0	3	1
215	323	69	33	33	33	0	0	0	11.8	2.1	0.00	1.1	1.1	0.0	-0.3	0.2	25	34	1	1	1
216	17	26	34	34	34	0	0	0	11.8	2.1	0.00	1.1	1.1	0.0	-2.5	1.7	16	63	2	2	1
217	354	25	41	41	41	0	0	0	11.8	2.1	0.00	1.1	1.1	0.0	0.9	0.0	29	0	0	1	1
218	279	61	31	31	31	0	0	0	11.8	2.1	0.00	1.1	1.1	0.0	3.5	0.0	0	0	0	1	1
219	359	47	44	44	44	0	0	0	11.8	2.1	0.00	1.1	1.1	0.0	3.5	1.2	25	34	3	3	1
220	342	44	46	46	46	0	0	0	11.8	2.1	0.00	1.1	1.1	0.0	4.6	1.1	25	34	2	2	1
221	345	40	41	41	41	0	0	0	11.8	2.1	0.00	1.1	1.1	0.0	0.9	1.8	0	34	2	2	1
222	150	24	31	31	31	0	0	0	11.8	2.1	0.00	1.1	1.1	0.0	11.4	0.0	0	0	0	1	1
223	195	25	31	31	31	0	0	0	11.8	2.1	0.00	1.1	1.1	0.0	-3.1	0.0	0	0	0	1	1
224	345	67	45	45	45	0	0	0	11.8	2.1	0.00	1.1	1.1	0.0	3.3	0.9	22	56	2	2	1
225	338	50	47	47	47	0	0	0	11.8	2.1	0.00	1.1	1.1	0.0	3.3	0.0	25	34	0	2	1
226	136	30	35	35	35	0	0	0	11.8	2.1	0.00	1.1	1.1	0.0	8.9	0.0	0	0	0	1	1
227	342	50	31	31	31	0	0	0	11.8	2.1	0.00	1.1	1.1	0.0	6.2	0.0	12	56	0	1	1

Table A2. ACDT Volume Scan Output for Volume Scan No. 2, Case Study No. 2 (Cont'd)

CLUSTER OUTPUT																			
CENTROID																			
TRK	ACM	PK	AV	PK	V	F	AV	PK	AV	PK	AV	PK	AV	PK	AV	PK	AV	PK	AV
NO	DES	AV	DES	AV	DES	AV	DES	AV	DES	AV	DES	AV	DES	AV	DES	AV	DES	AV	DES
3	290	59	290	49	1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
4	301	80	301	41	0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
25	320	61	320	48	25	0.0	10.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
26	312	55	312	38	1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
8	332	51	332	34	1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
11	334	65	334	31	1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
27	1	64	35	17	3	1.0	0.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
16	15	68	39	45	10	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
12	345	60	45	50	4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
28	232	38	48	37	1	1.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
20	340	77	38	44	2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
22	346	72	40	47	5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
29	353	64	41	43	2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
32	272	95	33	46	3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
31	231	76	33	35	2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
32	340	56	36	43	2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
33	354	61	44	43	3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
34	52	102	31	32	1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
35	326	66	33	35	2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
VOL	H-MM	AREA	W-FLX	NEAR	NE-TH	DE	ACT	PC	NO	VELOCITY	TRK	CLS	CNT	C	OVER				
SCAN	KMM2	SMT/H	CELL	CLST	CNT	VOL	CS	PC	EM/S	MM/S	AC	CTR	CTF	C					
2	1539	4.5	27.56	3.5	16.0	0.0	147	25	12	13.5	3.9	229	35	67	0	0	0	0	0

Table A3. ACDT Volume Scan Output for Volume Scan No. 3, Case Study No. 2

SCAN TIME 100 154708 - 155150 WGL SCAN 3 A2 - 22.9 TC 18.5 (DEG)																				
TRACK REF TIME 154523 - 154703 AZM SCAN 9/C EL - 0.9 TC 6.5 (DEG)																				
FIXED CONTROL OUTPUT																				
CENTROID AV CELL 2 A X A SPR SER 0 WTS AREA VELOCITY NEAR MX MR SF																				
TRK	AZM	RNG	AZM	RNG	AV	FX	V	S	C	X	L	P	FLCP	XSCN	AV	CELL	DIST	HT	IC	IC
NO	DEG	KM	DEG	KM	DE	DE	C	C	L	KM	KM	T	MT/F	KKM2	CFG	M/S	KM	KM	AC	AC
62	31	109	32	106	37	40	2	0	0	0.0	0.0	0	0.44	0.10	257	16	0.0	2	0	0
63	31	77	31	72	31	72	1	0	0	0.0	0.0	0	0.02	0.01	559	999	0.0	5	0	0
69	37	56	37	56	33	33	1	0	0	0.0	0.0	0	0.01	0.00	559	999	0.0	0	0	0
70	42	58	44	41	34	32	1	0	0	0.0	0.0	0	0.04	0.01	559	999	0.0	5	0	0
71	50	130	50	131	33	35	1	0	0	0.0	0.0	0	0.03	0.01	559	999	0.0	6	0	0
67	56	141	57	140	39	44	2	0	0	0.0	0.0	0	0.72	0.11	258	16	0.0	6	0	0
72	56	130	57	130	32	33	1	0	0	0.0	0.0	0	0.06	0.02	559	999	0.0	3	0	0
73	126	28	120	29	37	40	1	0	0	0.0	0.0	0	0.05	0.02	559	999	0.0	2	0	0
74	135	23	135	23	32	32	1	0	0	0.0	0.0	0	0.01	0.00	559	999	0.0	0	0	0
15	233	215	233	215	41	45	3	1	1	0.0	0.0	27	4.18	0.50	272	12	0.0	7	0	0
75	241	221	240	223	37	37	1	0	0	0.0	0.0	0	0.52	0.13	559	999	0.0	5	0	0
76	252	149	250	149	39	42	1	0	0	0.0	0.0	0	0.70	0.11	559	999	0.0	4	0	0
16	236	183	236	186	42	47	5	1	1	1.3	7.3	56	5.61	0.64	241	6	4.7	6	0	0
77	258	123	257	120	34	35	1	0	0	0.0	0.0	0	0.12	0.04	559	999	0.0	3	0	0
78	258	54	261	53	32	33	1	0	0	0.0	0.0	0	0.01	0.00	559	999	0.0	3	0	0
43	259	110	260	109	35	37	1	1	1	0.0	0.0	0	0.09	0.02	277	13	0.0	2	0	0
79	264	75	264	74	32	32	1	0	0	0.0	0.0	0	0.01	0.00	559	999	0.0	1	0	0
80	268	16	268	16	31	31	1	0	0	0.0	0.0	0	0.00	0.00	559	999	0.0	0	0	0
81	285	69	286	67	35	38	1	1	1	0.0	0.0	0	0.18	0.05	559	999	0.0	3	0	0
82	270	83	270	82	33	35	1	0	0	0.0	0.0	0	0.01	0.00	559	999	0.0	4	0	0
53	290	78	282	78	31	32	1	0	0	0.0	0.0	0	0.01	0.00	189	5	0.0	4	0	0
23	270	97	272	97	34	44	4	1	1	3.2	8.7	23	0.88	0.19	226	15	0.0	5	0	0
83	282	65	284	64	33	34	1	0	0	0.0	0.0	0	0.03	0.01	220	15	0.0	4	0	0
84	294	73	294	72	32	33	1	0	0	0.0	0.0	0	0.13	0.04	215	13	0.0	1	0	3
85	296	67	296	67	31	31	1	0	0	0.0	0.0	0	0.01	0.00	559	999	0.0	0	0	0
86	298	61	300	60	33	36	1	0	0	0.0	0.0	0	0.03	0.01	559	999	0.0	3	0	0
3	306	82	306	80	35	37	3	2	2	4.5	4.9	42	0.47	0.14	254	16	0.0	2	0	0
87	331	34	331	34	32	32	1	0	0	0.0	0.0	0	0.01	0.00	559	999	0.0	0	0	0
88	340	104	341	104	36	38	1	0	0	0.0	0.0	0	0.09	0.02	559	999	0.0	2	0	0
89	343	87	344	84	31	32	2	1	1	0.0	0.0	0	0.02	0.01	218	10	0.0	4	0	0
90	358	101	358	101	38	41	3	1	1	0.5	4.1	81	0.31	0.05	559	999	0.0	2	0	0
34	339	63	337	64	39	48	33	5	5	9.0	16.4	53	4.79	0.83	253	13	4.0	7	56	0
91	5	35	6	39	41	46	5	1	1	1.3	5.7	336	0.27	0.03	559	999	5.1	5	0	0
63	14	78	17	79	39	45	8	2	2	4.5	5.9	121	1.47	0.24	235	14	5.1	8	0	0

Table A3. ACFT Volume Scan Output for Volume Scan No. 3, Cast Study No. 2
(Cont'd)

VOLUME CELL OUTPUT																			
IDENT	IC	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
LINE	ACFT	RM	AV	PA	LA	MI	LA	MI	LA	MI	LA	MI	LA	MI	LA	MI	LA	MI	LA
NO	150	151	152	153	154	155	156	157	158	159	160	161	162	163	164	165	166	167	168
150	150	150	150	150	150	150	150	150	150	150	150	150	150	150	150	150	150	150	150
151	151	151	151	151	151	151	151	151	151	151	151	151	151	151	151	151	151	151	151
152	152	152	152	152	152	152	152	152	152	152	152	152	152	152	152	152	152	152	152
153	153	153	153	153	153	153	153	153	153	153	153	153	153	153	153	153	153	153	153
154	154	154	154	154	154	154	154	154	154	154	154	154	154	154	154	154	154	154	154
155	155	155	155	155	155	155	155	155	155	155	155	155	155	155	155	155	155	155	155
156	156	156	156	156	156	156	156	156	156	156	156	156	156	156	156	156	156	156	156
157	157	157	157	157	157	157	157	157	157	157	157	157	157	157	157	157	157	157	157
158	158	158	158	158	158	158	158	158	158	158	158	158	158	158	158	158	158	158	158
159	159	159	159	159	159	159	159	159	159	159	159	159	159	159	159	159	159	159	159
160	160	160	160	160	160	160	160	160	160	160	160	160	160	160	160	160	160	160	160
161	161	161	161	161	161	161	161	161	161	161	161	161	161	161	161	161	161	161	161
162	162	162	162	162	162	162	162	162	162	162	162	162	162	162	162	162	162	162	162
163	163	163	163	163	163	163	163	163	163	163	163	163	163	163	163	163	163	163	163
164	164	164	164	164	164	164	164	164	164	164	164	164	164	164	164	164	164	164	164
165	165	165	165	165	165	165	165	165	165	165	165	165	165	165	165	165	165	165	165
166	166	166	166	166	166	166	166	166	166	166	166	166	166	166	166	166	166	166	166
167	167	167	167	167	167	167	167	167	167	167	167	167	167	167	167	167	167	167	167
168	168	168	168	168	168	168	168	168	168	168	168	168	168	168	168	168	168	168	168
169	169	169	169	169	169	169	169	169	169	169	169	169	169	169	169	169	169	169	169

Table A3. ACDT Volume Scan Output for Volume Scan No. 3, Case Study No. 2 (Cont'd)

170	14	72	32	33	32	32	4	4	11.3	3.9	0.00	7.4	0.0	0.0	-3.0	1.0	0	0	0	1
171	152	71	35	26	33	32	3	7	11.3	3.9	0.00	7.4	1.0	0.0	-1.0	0.0	0	0	0	1
172	334	51	36	18	31	32	1	1	11.3	3.9	0.00	7.4	1.0	0.0	-0.7	1.4	16	0	2	4
173	334	51	49	46	46	44	2	7	11.3	3.9	0.00	7.4	1.0	0.0	-0.5	1.0	18	34	0	0
174	17	32	41	40	40	41	1	1	11.3	3.9	0.00	7.4	1.0	0.0	-0.7	1.4	16	0	2	4
175	324	72	33	33	32	32	7	4	11.3	3.9	0.00	7.4	1.0	0.0	-1.0	3.8	39	34	1	2
180	17	72	34	34	34	34	4	4	11.3	3.9	0.00	7.4	1.0	0.0	-0.7	0.0	16	0	0	0
176	243	93	32	32	32	32	3	3	11.3	3.9	0.00	7.4	1.0	0.0	-0.3	0.0	0	0	0	1
177	1	47	73	32	33	33	3	3	11.3	3.9	0.00	7.4	1.0	0.0	-0.0	1.7	0	0	0	1
178	121	21	27	27	27	27	1	1	11.3	3.9	0.00	7.4	1.0	0.0	-0.5	0.1	16	0	0	1
179	47	65	34	34	34	34	3	3	11.3	3.9	0.00	7.4	1.0	0.0	-1.0	0.0	0	0	0	1
183	331	34	34	34	34	34	3	3	11.3	3.9	0.00	7.4	1.0	0.0	-0.1	0.0	16	0	0	0
186	265	50	32	32	32	32	3	3	11.3	3.9	0.00	7.4	1.0	0.0	-0.1	1.0	0	0	0	1
187	446	1	34	34	34	34	3	3	11.3	3.9	0.00	7.4	1.0	0.0	-5.0	1.1	0	0	0	1
191	305	76	31	31	31	31	1	1	11.3	3.9	0.00	7.4	1.0	0.0	-0.0	0.0	0	0	0	1
192	12	41	41	42	42	41	1	1	11.3	3.9	0.00	7.4	1.0	0.0	-1.0	0.0	42	0	0	0
193	304	41	31	31	31	31	3	3	11.3	3.9	0.00	7.4	1.0	0.0	-0.0	0.0	0	0	0	1
197	346	0	0	0	0	0	0	0	11.3	3.9	0.00	7.4	1.0	0.0	-0.0	0.0	0	0	0	1
198	346	0	0	0	0	0	0	0	11.3	3.9	0.00	7.4	1.0	0.0	-0.0	0.0	0	0	0	1
199	210	61	31	32	32	32	1	1	11.3	3.9	0.00	7.4	1.0	0.0	-0.5	0.1	39	35	0	0
199	315	57	41	41	41	41	1	1	11.3	3.9	0.00	7.4	1.0	0.0	-4.0	1.3	39	34	1	1
199	231	79	37	38	38	38	1	1	11.3	3.9	0.00	7.4	1.0	0.0	-0.5	4.1	22	34	6	2
199	117	64	40	43	40	43	1	1	11.3	3.9	0.00	7.4	1.0	0.0	-11.7	0.0	16	63	1	0
199	226	82	34	35	35	36	2	3	11.3	3.9	0.00	7.4	1.0	0.0	-1.0	1.7	0	23	2	2
199	350	72	45	46	46	46	1	1	11.3	3.9	0.00	7.4	1.0	0.0	-0.0	1.5	22	34	0	2
199	349	56	41	45	42	45	3	5	11.3	3.9	0.00	7.4	1.0	0.0	-2.0	2.0	12	34	2	2
199	357	57	36	36	36	36	4	4	11.3	3.9	0.00	7.4	1.0	0.0	-0.3	0.0	12	34	1	0
199	11	59	36	36	36	36	1	1	11.3	3.9	0.00	7.4	1.0	0.0	-3.0	4.9	0	63	4	0
199	15	79	35	36	36	37	1	1	11.3	3.9	0.00	7.4	1.0	0.0	-7.7	0.0	44	63	0	0
199	347	81	40	41	40	41	1	1	11.3	3.9	0.00	7.4	1.0	0.0	-3.0	5.9	63	34	2	2
199	16	83	41	40	40	40	1	1	11.3	3.9	0.00	7.4	1.0	0.0	-4.7	5.0	44	63	1	1
199	16	76	37	37	37	37	1	1	11.3	3.9	0.00	7.4	1.0	0.0	-2.0	0.0	0	63	1	0
199	20	77	42	45	37	37	1	1	11.3	3.9	0.00	7.4	1.0	0.0	-2.0	1.7	16	63	5	3
199	136	176	33	33	33	32	5	5	11.3	3.9	0.00	7.4	1.0	0.0	-0.2	0.0	36	16	0	1
199	260	109	35	37	37	37	1	0	11.3	3.9	0.00	7.4	1.0	0.0	-0.1	0.0	45	43	1	2
199	232	73	31	32	31	31	1	0	11.3	3.9	0.00	7.4	1.0	0.0	-0.3	0.4	0	53	0	4
199	232	72	33	34	34	32	1	3	11.3	3.9	0.00	7.4	1.0	0.0	-2.2	0.3	0	0	0	2
199	311	35	35	37	37	37	1	1	11.3	3.9	0.00	7.4	1.0	0.0	-3.1	2.8	0	3	1	2
199	35	104	33	34	34	33	1	2	11.3	3.9	0.00	7.4	1.0	0.0	-1.7	4.4	0	62	2	2
199	59	116	34	37	37	31	2	2	11.3	3.9	0.00	7.4	1.0	0.0	-0.8	3.0	0	67	1	2
199	303	75	34	34	34	34	1	1	11.3	3.9	0.00	7.4	1.0	0.0	-5.0	0.2	46	3	1	1
199	232	94	32	32	32	32	1	1	11.3	3.9	0.00	7.4	1.0	0.0	-1.0	0.0	0	23	0	1
199	319	66	34	35	35	35	2	3	11.3	3.9	0.00	7.4	1.0	0.0	-0.3	0.0	39	34	2	3
199	232	268	40	40	40	40	5	5	11.3	3.9	0.00	7.4	1.0	0.0	-1.0	0.0	0	15	0	1
199	273	102	36	36	36	36	1	1	11.3	3.9	0.00	7.4	1.0	0.0	-2.9	0.0	41	23	0	1
199	329	87	32	32	32	32	2	2	11.3	3.9	0.00	7.4	1.0	0.0	-2.3	0.2	35	34	2	0
199	335	75	34	37	37	32	1	3	11.3	3.9	0.00	7.4	1.0	0.0	-6.3	2.8	25	34	3	2
199	336	62	37	37	37	37	0	0	11.3	3.9	0.00	7.4	1.0	0.0	-11.7	0.0	0	34	1	0
199	342	69	41	43	43	41	0	3	11.3	3.9	0.00	7.4	1.0	0.0	-6.0	4.1	12	34	2	3
199	344	82	31	31	31	31	4	4	11.3	3.9	0.00	7.4	1.0	0.0	-3.0	0.0	28	89	0	1

Table A3. ACDT Volume Scan Output for Volume Scan No. 3, Case Study No. 2 (Cont'd)

207	342	80	33	33	33	33	1	1	1	10.0	6.0	0.00	3.0	1.2	C.C	-6.6	0.0	22	34	1	1	2
208	352	71	40	40	40	40	1	1	1	12.1	3.4	0.00	1.8	4.0	C.C	-8.2	5.3	22	34	2	C	2
209	26	71	36	36	36	36	3	3	3	10.3	6.4	0.00	1.6	C.C	C.C	-2.6	0.0	0	C	0	1	2
211	329	84	36	40	34	33	2	4	6	13.5	2.6	1.42	6.1	2.2	C.C	3.3	5.1	35	34	3	3	2
213	16	86	35	35	35	35	3	4	4	8.3	6.4	0.00	4.2	1.4	C.C	-1.9	0.8	44	63	4	2	2
214	353	72	36	36	36	36	1	1	1	14.7	-1.0	0.00	5.2	1.5	C.C	4.8	0.0	22	34	1	0	2
215	308	65	31	32	31	32	1	2	2	14.9	4.3	0.00	4.6	1.7	C.C	-7.3	0.7	39	34	1	2	2
216	22	81	37	38	37	38	1	3	4	16.7	4.7	0.00	4.1	1.8	C.C	-3.9	3.3	16	63	5	3	2
218	284	64	33	34	34	31	0	2	4	10.6	7.9	2.42	4.1	1.0	C.C	2.1	1.4	37	83	C	5	1
219*	350	51	46	42	45	46	0	2	4	16.3	12.2	3.90	3.4	1.3	C.C	0.5	1.4	12	34	6	5	1
224	347	66	38	40	40	35	0	2	5	8.5	0.3	4.32	3.9	1.4	C.C	4.7	3.4	22	34	6	6	1
227*	346	59	41	44	44	39	2	3	5	10.6	4.2	3.73	3.2	1.2	C.C	1.9	1.1	12	34	1	4	1

CLUSTER OUTPUT																						
TRK	AZM	RNG	AV	PK	V	X	L	ANG	IC	AV	CELL	MSKM	HT	IC	IC	RECT	DIV	RT				
NO	DEG	M	DB	DE	C	MM	KM	DEG		EM/S	NM/S		KM	AC	NC	MSKM	MSKM	CS				
36	236	178	38	41	2	0.0	0.0	C	16	1.5	3.7	1.0	5	C	C	C.00	0.00	0				
37	285	65	34	38	2	0.0	0.0	C	81	9.8	11.7	1.0	4	C	C	C.00	0.00	C				
38	233	219	42	45	2	0.0	0.0	C	15	14.4	6.6	C.C	7	C	C	C.00	0.00	C				
39	314	64	35	40	8	1.7	10.1	19	34	7.7	2.7	2.8	4	C	25	-2.01	3.67	6				
28	344	84	31	32	2	0.0	0.0	C	89	6.4	8.2	C.6	4	C	C	C.00	0.00	0				
40	359	102	39	41	2	0.0	0.0	C	90	0.0	C.C	1.7	2	C	C	C.00	0.00	C				
41	271	99	38	44	2	0.0	0.0	C	23	13.4	13.7	C.9	5	C	C	C.00	0.00	C				
42	7	39	43	46	3	1.9	1.9	44	91	0.0	C.C	1.1	4	C	C	C.00	0.00	C				
4	303	82	37	37	1	0.0	0.0	C	3	13.1	13.0	1.2	1	C	C	C.00	0.00	C				
25	338	69	36	41	4	1.9	4.4	309	34	14.1	9.3	1.9	4	11	C	-0.86	4.53	3				
43	329	74	37	41	2	1.1	5.3	316	34	16.4	5.1	2.9	3	C	25	-0.24	4.69	3				
22	351	72	39	46	8	3.1	4.3	322	34	16.1	3.0	1.8	7	C	C	-1.13	4.58	6				
12	342	55	43	48	8	2.1	4.7	308	34	13.7	3.6	1.4	6	25	C	-1.12	4.15	6				
16	19	76	39	45	6	1.2	5.9	39	63	15.2	7.6	2.3	8	C	C	1.04	4.51	4				
44	16	83	38	40	3	0.0	2.7	30	63	9.5	6.9	1.2	4	C	16	3.17	4.88	3				
45	260	109	35	37	1	0.0	0.0	C	43	13.4	-1.5	1.1	2	C	C	C.00	0.00	C				
46	303	75	34	34	1	0.0	0.0	C	3	14.3	-3.5	1.3	1	C	4	C.00	0.00	0				
35	329	86	35	40	2	0.0	0.0	C	C	12.9	1.9	2.3	6	C	C	C.00	0.00	C				

VOL	HHMM	AREA	WFLUX	NEAR	NEIGHBOR	ACT	NC	NC	VELOCITY	TRK	CLS	CNT	G	OVER
SCAN		KMP2	KMT/H	CELL	CLST	CNT	VCL	CS	FC	EM/S	NM/S	NC	CTR	CTR
3	1545	3.5	21.83	6.0	19.6	C.0	113	18	10	12.5	4.6	284	46	91 C 0 C C C 0

Table A4. AC/DT Volume Scan Output for Volume Scan No. 4, Case Study No. 2

SCAN TIME 100 155022 - 155745 VOL SCAN 14.41 - 40.3 TO 39.4 (DEG)									
TRACK REF TIME 155115 - 155227 42" SCAN 970 EL - 0.4 TO 0.5 (DEG)									
FIXED CONTROL OUTPUT									
TRK	AZM	RNG	AZM	RNG	AV	SP	V	S	C
NO	DEG	KM	DEG	KM	TS	TS	0	0	0
92	57	115	50	111	34	36	1	0	0
93	47	123	43	126	32	32	1	0	0
94	48	135	43	135	32	32	1	0	0
95	50	157	53	155	31	31	1	0	0
96	105	29	106	22	33	33	1	0	0
97	241	215	241	214	43	43	1	0	0
16	234	123	235	124	33	33	1	0	0
27	255	144	253	142	41	41	1	0	0
98	247	183	247	183	32	32	1	0	0
99	315	102	316	102	30	30	1	0	0
100	250	12	222	1	21	21	1	0	0
101	261	117	261	116	30	30	1	0	0
102	270	49	276	48	34	36	1	0	0
103	276	32	277	31	32	32	1	0	0
23	274	95	269	96	35	28	1	0	0
34	340	69	339	69	39	46	1	0	0
104	301	29	301	28	31	31	1	0	0
3	300	75	295	72	34	39	1	0	0
105	309	52	310	51	31	31	1	0	0
106	340	106	341	107	30	35	1	0	0
107	338	100	338	100	34	26	1	0	0
108	347	111	346	111	32	22	1	0	0
109	343	24	343	24	31	31	1	0	0
89	348	26	348	26	31	31	1	0	0
110	345	92	343	91	31	31	1	0	0
90	358	107	358	105	35	41	1	0	0
111	28	89	29	85	34	34	1	0	0
63	17	84	19	89	40	47	1	0	0
112	7	46	6	49	38	42	1	0	0
113	1	108	2	107	33	33	1	0	0
62	33	115	34	114	33	33	1	0	0
114	29	121	29	119	36	36	1	0	0
115	38	112	33	112	32	32	1	0	0
116	41	68	42	72	36	40	1	0	0

Table A4. ACDT Volume Scan Output for Volume Scan No. 4, Case Study No. 2 (Contd)

VOLUME CELL OUTPUT																								
CENTROID - - - 2 - - - - - HCL VEAR CELL SPACIAL (TAN) CFF RAC RAD CS CN C R R																								
TRA	AZM	RNG	AV	PK	LA	HI	L	M	F	EM/S	AM/S	SPPC	A	(SFR)	SPC	VEL	SPD	TR	TR	O	E	E	E	E
NO	DEG	KM	DB	DB	SS	DB	A	A	A	10	10	EM	AMZ	(MSK)	MSK	M/S	M/S	NO	NO	P	E	E	E	E
230	34	114	33	33	33	33	1	1	1	20.2	3.4	0.00	4.7	0.0	0.0	-3.9	0.0	0	62	0	1	2		
235	55	147	45	45	45	45	2	2	2	11.9	10.0	0.00	5.2	1.3	0.0	1.3	3.9	47	67	3	2	2		
238	129	28	35	35	35	35	1	1	1	10.0	-0.6	0.00	1.5	1.2	0.0	5.1	0.0	0	0	0	1	2		
239	237	173	41	41	41	41	2	2	2	5.5	8.7	0.00	9.2	1.7	0.0	-0.4	6.0	0	16	3	0	2		
240	240	217	45	45	45	45	4	4	4	16.5	7.0	0.00	5.5	0.0	0.0	0.1	0.0	0	75	0	1	2		
285	48	126	32	32	32	32	1	2	3	12.5	4.6	0.00	5.9	0.2	0.0	0.0	0.0	0	93	0	2	1		
247	291	66	36	36	36	36	0	1	3	10.0	11.8	4.62	9.8	1.2	0.0	-3.4	1.5	37	3	2	4	1		
249	300	61	31	32	31	32	2	2	3	16.9	4.5	0.00	5.6	1.3	0.0	-6.9	0.7	48	0	0	3	2		
21	233	208	46	46	46	46	4	4	4	17.9	9.5	0.00	16.2	0.0	0.0	0.1	0.0	38	16	0	1	2		
23	235	188	44	47	47	38	5	5	9	16.6	5.3	0.00	7.5	0.0	0.0	-0.1	0.5	0	16	0	2	2		
24	237	186	44	44	44	44	3	3	3	4.6	5.5	0.00	26.6	1.6	0.0	3.9	1.5	49	16	1	1	2		
250	317	67	35	37	33	38	0	1	3	16.8	2.2	0.00	5.6	2.3	0.0	-5.3	7.1	39	34	3	3	2		
266	49	135	32	32	32	32	2	2	2	12.5	4.6	0.00	9.1	0.0	0.0	0.3	0.0	0	94	0	1	1		
253	348	66	31	31	31	31	1	1	1	17.2	5.6	0.00	12.6	1.6	0.0	-7.3	0.0	0	29	1	1	2		
254	356	104	34	34	34	34	1	1	1	10.7	5.0	0.00	3.3	1.2	0.0	-4.1	0.0	0	90	1	0	2		
32	271	94	37	37	37	37	2	2	2	12.5	12.7	0.00	12.3	0.0	0.0	1.1	0.0	0	23	0	1	2		
267	50	118	34	35	31	36	1	3	4	12.5	4.6	0.00	5.3	0.0	0.0	0.1	0.1	0	92	0	2	1		
268	53	166	31	31	31	31	2	2	2	12.5	4.9	0.00	14.6	0.0	0.0	-0.3	0.0	0	55	0	1	1		
289	60	148	34	34	34	34	2	2	2	12.5	4.6	0.00	16.2	0.0	0.0	1.4	0.0	0	67	0	1	1		
290	106	26	33	33	33	33	0	0	0	12.5	4.6	0.00	2.5	1.0	0.0	15.8	0.0	0	56	0	1	1		
38	297	65	35	37	37	34	2	3	4	15.8	-0.5	0.00	5.5	1.7	0.0	-4.1	1.1	48	0	3	3	2		
291	222	6	21	31	31	31	0	0	0	12.5	4.9	0.00	2.1	1.5	0.0	-0.5	0.0	0	100	0	1	1		
40	306	93	39	39	39	39	1	1	1	5.0	13.6	0.00	5.2	0.0	0.0	-0.3	0.0	0	3	0	1	2		
292	247	188	38	38	38	38	1	3	3	12.5	4.6	0.00	4.5	0.0	0.0	0.3	0.0	0	98	0	1	1		
42	303	61	34	37	37	31	0	0	1	3.9	5.0	0.00	6.7	0.0	0.0	-6.7	4.2	39	34	1	2	2		
293	255	143	40	41	41	40	2	2	3	10.5	4.6	0.00	5.6	0.0	0.0	2.1	1.0	50	97	0	2	1		
294	2	116	32	34	34	31	1	2	2	12.5	4.6	0.00	5.2	0.0	0.0	0.0	0.0	0	101	0	2	1		
295	264	106	35	37	37	34	1	1	2	12.5	4.6	0.00	2.5	0.0	0.0	1.3	1.1	51	23	0	2	1		
296	262	100	32	32	32	32	1	1	2	12.5	4.6	0.00	7.4	0.0	0.0	0.1	0.1	51	23	0	2	1		
299	272	62	34	37	37	32	0	1	3	12.5	4.6	0.00	3.2	1.1	0.0	0.3	2.8	0	3	0	3	1		
262	283	81	31	31	31	31	1	1	1	10.9	1.2	0.00	5.2	0.0	0.0	-0.9	0.0	52	0	0	1	2		
53	323	68	36	39	39	33	0	1	3	2.7	-2.2	0.00	5.5	1.5	0.0	-6.1	7.6	0	34	2	2	2		
263	2	107	33	33	33	33	1	1	1	12.3	10.8	0.00	5.6	1.2	0.0	-10.1	0.0	0	113	1	0	2		
297	277	81	32	33	32	31	1	1	1	12.5	4.6	0.00	6.8	1.0	0.0	-0.9	1.6	0	103	0	2	1		
298	287	72	34	36	34	32	0	1	1	12.5	4.6	0.00	5.4	0.0	0.0	-3.1	0.4	37	3	0	2	1		
58	337	70	36	36	36	36	0	0	0	26.0	2.7	0.00	2.9	9.7	0.0	-4.5	0.0	0	34	1	0	2		
299	285	87	33	33	33	33	1	1	1	12.5	4.6	0.00	19.6	0.0	0.0	-0.3	0.0	0	23	0	1	1		
265*	354	66	42	45	42	36	2	4	7	12.5	-0.1	2.16	6.1	1.8	0.0	0.7	2.7	12	34	5	5	1		
300	288	77	32	33	33	31	0	1	1	10.5	4.6	0.00	4.5	0.0	0.0	-1.7	1.1	37	3	0	2	1		
63	341	73	40	40	40	40	0	0	0	9.3	5.3	0.00	13.1	0.0	0.0	-15.0	0.0	0	34	0	1	2		
64	344	65	39	39	39	39	0	0	0	15.7	5.9	0.00	1.8	9.3	0.0	8.5	0.0	0	34	1	0	2		
301	296	82	34	34	34	34	1	1	1	12.5	4.6	0.00	1.6	0.0	0.0	-1.7	0.0	0	3	0	1	1		
268	301	26	31	31	31	31	0	0	0	12.5	4.6	0.00	1.9	0.3	0.0	10.2	0.0	0	104	0	1	1		
302	301	74	36	38	38	35	0	1	1	12.5	4.6	0.00	16.2	1.1	0.0	-5.1	1.5	0	3	1	2	1		
270	17	95	33	34	33	34	4	5	5	15.4	6.1	0.00	13.5	1.0	0.0	1.7	0.6	53	63	0	2	2		
271	358	70	32	32	32	32	5	5	5	17.8	1.2	0.00	2.7	0.0	0.0	-2.5	0.0	12	34	0	1	2		

Table A4. ACDT Volume Scan Output for Volume Scan No. 4, Case Study No. 2
(Cont'd)

303	310	51	31	31	31	31	0	0	0	12.5	-4.6	0.00	2.1	7.9	0.0	-4.1	0.0	0105	0	1	1
304	310	56	36	36	36	36	1	1	1	12.5	-4.6	0.00	2.1	7.9	0.0	-3.8	0.0	0	3	0	1
372	21	52	37	37	37	37	1	1	1	12.5	-4.6	0.00	2.1	7.9	0.0	-3.2	1.4	16	63	0	3
373	1	54	38	38	38	38	0	0	0	12.5	-4.6	0.00	2.1	7.9	0.0	-0.5	0.0	12112	0	1	2
374	14	43	41	42	42	42	0	0	0	12.5	-4.6	0.00	2.1	7.9	0.0	2.4	0.9	42112	1	1	2
375	326	71	33	33	33	33	0	0	0	12.5	-4.6	0.00	2.1	7.9	0.0	-10.6	0.0	0	34	1	0
305	316	102	32	32	32	32	1	1	1	12.5	-4.6	0.00	2.1	7.9	0.0	-3.2	0.3	0	99	1	1
306	320	74	36	36	36	36	1	1	1	12.5	-4.6	0.00	2.1	7.9	0.0	-9.7	1.3	0	34	1	1
307	330	74	40	40	40	40	1	1	1	12.5	-4.6	0.00	2.1	7.9	0.0	-13.3	0.0	0	34	0	1
377	3	51	32	32	32	32	0	0	0	12.5	-4.6	0.00	2.1	7.9	0.0	-2.0	0.0	0	112	1	0
378	4	56	36	36	36	36	0	0	0	12.5	-4.6	0.00	2.1	7.9	0.0	-7.0	0.0	54	67	0	1
379	43	71	37	40	40	40	0	0	0	12.5	-4.6	0.00	2.1	7.9	0.0	-0.9	5.0	0	116	1	5
380	271	48	38	38	38	38	1	1	1	12.5	-4.6	0.00	2.1	7.9	0.0	1.7	5.0	55100	5	3	2
381	308	77	44	44	44	44	1	1	1	12.5	-4.6	0.00	2.1	7.9	0.0	-8.7	2.2	0	34	1	1
92	7	47	39	39	39	39	0	0	0	12.5	-4.6	0.00	2.1	7.9	0.0	-7.1	0.0	42112	1	0	1
383	348	66	33	33	33	33	0	0	0	12.5	-4.6	0.00	2.1	7.9	0.0	-6.6	0.0	0	34	1	0
308	336	101	36	36	36	36	1	1	1	12.5	-4.6	0.00	2.1	7.9	0.0	-3.1	0.0	0	107	0	1
309	340	101	38	38	38	38	1	1	1	12.5	-4.6	0.00	2.1	7.9	0.0	-4.9	0.0	0	107	0	1
310	341	107	35	35	35	35	1	1	1	12.5	-4.6	0.00	2.1	7.9	0.0	-3.6	0.0	0	106	0	1
311	343	94	31	31	31	31	1	1	1	12.5	-4.6	0.00	2.1	7.9	0.0	-4.6	0.0	0	109	0	1
312	346	111	32	32	32	32	1	1	1	12.5	-4.6	0.00	2.1	7.9	0.0	-7.6	0.0	0	108	0	1
301	314	62	32	32	32	32	0	0	0	12.5	-4.6	0.00	2.1	7.9	0.0	-1.6	5.7	39	34	0	2
313	349	91	31	31	31	31	1	1	1	12.5	-4.6	0.00	2.1	7.9	0.0	-4.7	0.0	0	110	0	1
314	359	124	41	41	41	41	1	1	1	12.5	-4.6	0.00	2.1	7.9	0.0	-5.5	0.1	0	90	1	1
315	29	85	34	34	34	34	1	1	1	12.5	-4.6	0.00	2.1	7.9	0.0	-1.4	1.4	0	111	1	1
316	29	119	36	36	36	36	1	1	1	12.5	-4.6	0.00	2.1	7.9	0.0	-0.4	0.0	0	114	0	1
317	38	112	32	32	32	32	1	1	1	12.5	-4.6	0.00	2.1	7.9	0.0	0.8	0.2	0	115	1	1
318	241	212	39	41	41	37	4	4	4	12.5	-4.6	0.00	2.1	7.9	0.0	3.6	2.9	0	75	1	1
109	353	79	38	38	38	38	1	1	1	12.5	-4.6	0.00	2.1	7.9	0.0	0.8	0.3	22	34	0	2
320	48	141	32	32	32	32	3	3	3	12.5	-4.6	0.00	2.1	7.9	0.0	0.7	0.0	0	0	0	1
321	52	150	35	35	35	35	3	3	3	12.5	-4.6	0.00	2.1	7.9	0.0	1.8	0.0	0	67	0	1
322	102	31	39	41	41	38	0	0	0	12.5	-4.6	0.00	2.1	7.9	0.0	1.5	7.9	0	0	0	2
323	231	194	37	37	37	37	5	5	5	12.5	-4.6	0.00	2.1	7.9	0.0	2.9	0.0	0	0	0	1
324	236	157	32	32	32	32	4	4	4	12.5	-4.6	0.00	2.1	7.9	0.0	1.0	0.0	0	0	0	1
117	235	178	42	43	43	43	4	4	4	12.5	-4.6	0.00	2.1	7.9	0.0	1.1	0.0	0	0	0	1
118	307	21	33	33	33	33	1	1	1	12.5	-4.6	0.00	2.1	7.9	0.0	-10.5	0.0	0	3	0	1
119	285	68	34	36	36	32	1	2	4	12.5	-4.6	0.00	2.1	7.9	0.0	-0.9	3.7	37	3	0	2
325	254	140	42	45	45	32	3	3	6	12.5	-4.6	0.00	2.1	7.9	0.0	-0.1	1.3	50	97	1	2
326	265	102	33	33	33	33	2	2	2	12.5	-4.6	0.00	2.1	7.9	0.0	0.0	0.0	51	23	0	1
122	263	98	37	37	37	37	2	2	2	12.5	-4.6	0.00	2.1	7.9	0.0	1.6	0.0	51	23	0	1
327	289	71	32	32	32	32	1	1	1	12.5	-4.6	0.00	2.1	7.9	0.0	-3.9	0.0	37	3	0	1
328	276	47	33	36	36	36	0	2	3	12.5	-4.6	0.00	2.1	7.9	0.0	5.6	0.7	55102	1	5	1
329	38	116	31	31	31	31	4	4	4	12.5	-4.6	0.00	2.1	7.9	0.0	-0.1	0.0	0	0	0	1
126	349	71	38	42	42	32	0	3	7	12.5	-4.6	0.00	2.1	7.9	0.0	-1.2	4.0	22	34	2	4
129	12	93	38	38	38	38	1	1	1	12.5	-4.6	0.00	2.1	7.9	0.0	-5.1	0.2	0	63	2	0
131	331	80	37	41	41	31	0	1	4	12.5	-4.6	0.00	2.1	7.9	0.0	1.6	5.5	43	34	1	3
132	19	85	38	39	39	38	1	2	4	12.5	-4.6	0.00	2.1	7.9	0.0	-3.5	2.7	16	63	2	3
330	34	73	35	35	35	35	2	2	2	12.5	-4.6	0.00	2.1	7.9	0.0	3.2	0.0	0	116	0	1
331	54	154	32	32	32	32	8	8	8	12.5	-4.6	0.00	2.1	7.9	0.0	2.7	0.0	0	0	0	1
332	248	81	32	33	33	32	1	4	4	12.5	-4.6	0.00	2.1	7.9	0.0	-3.3	0.3	0	0	1	2
334	262	84	32	32	32	32	3	3	3	12.5	-4.6	0.00	2.1	7.9	0.0	-7.9	0.0	0	0	1	1
335	278	62	33	35	32	35	2	3	4	12.5	-4.6	0.00	2.1	7.9	0.0	4.2	0.2	56	0	0	1

Table A4. ACDT Volume Scan Output for Volume Scan No. 4, Case Study No. 2
(Cont'd)

139	18	79	47	47	47	47	0	0	0	12.7	4.5	0.00	7.1	0.0	1.0	-9.7	0.0	57	63	0	1	2
334*	312	34	34	35	35	32	2	3	5	12.5	4.5	1.75	2.4	5.7	0.0	1.9	5.1	58	0	3	5	1
337	329	70	32	32	32	30	1	3	3	12.5	4.5	0.00	0.5	0.0	0.0	5.4	0.0	0	0	0	1	1
338	334	72	33	33	32	33	3	4	4	12.5	4.5	0.00	2.4	0.0	0.0	3.3	0.5	43	34	0	2	1
339	344	75	32	32	32	32	1	3	3	12.5	4.5	0.00	0.2	1.3	0.0	1.4	1.5	0	0	0	1	1
340	356	36	36	32	32	32	4	4	6	12.5	4.5	0.00	3.3	1.1	0.0	2.5	2.9	0	34	2	4	1
341*	7	55	40	41	41	40	0	3	4	12.5	4.5	0.00	3.4	1.2	0.0	-1.5	1.1	59	0	5	2	1
342*	14	50	42	46	46	46	2	4	4	12.5	4.5	0.00	0.5	1.2	0.0	-0.2	1.0	0	0	2	2	1
343	19	96	34	34	34	34	4	4	4	12.5	4.5	0.00	1.9	1.3	0.0	-0.3	0.3	53	63	1	1	1
344	29	94	32	32	32	32	4	4	4	12.5	4.5	0.00	0.0	0.0	0.0	1.1	0.2	0	0	0	1	1
345	34	71	32	33	33	32	3	4	4	12.5	4.5	0.00	3.3	0.0	0.0	0.4	1.0	0	0	0	2	1
346*	0	62	45	46	46	45	0	4	5	12.5	4.5	0.00	3.5	1.5	0.0	-4.5	2.0	13	34	5	4	1
152	237	178	40	40	40	40	4	4	4	12.1	4.5	0.00	5.5	2.3	0.0	-9.5	0.0	0-16	1	0	2	
347	266	56	32	32	32	32	2	2	2	12.5	4.5	0.00	0.6	3.3	0.0	-8.5	0.0	0	0	0	1	1
348	318	05	31	31	31	31	1	1	1	12.5	4.5	0.00	1.7	4.0	0.0	13.5	0.0	0	0	0	1	1
349	335	51	32	32	32	32	5	5	5	12.5	4.5	0.00	1.0	2.0	0.0	2.4	0.0	0	0	0	1	1
350	19	47	42	43	43	42	2	2	2	12.5	4.5	0.00	4.0	2.0	0.0	-1.1	1.5	0	0	1	1	1
351	276	67	33	33	33	33	3	3	4	12.5	4.5	0.00	2.5	1.1	0.0	2.2	0.2	56	0	0	2	1
352	44	74	35	35	35	35	5	5	5	12.5	4.5	0.00	4.3	1.1	0.0	-0.4	0.0	0116	0	1	1	
152	252	104	31	31	31	31	2	2	2	12.2	-2.3	0.00	4.6	1.1	0.0	3.3	0.0	0	0	0	1	2
353	280	46	32	32	32	32	1	4	4	12.5	4.5	0.00	2.9	1.8	0.0	5.4	0.5	60102	0	3	1	
354	356	65	41	42	42	42	4	4	4	12.5	4.5	0.00	1.9	0.0	0.0	1.3	0.2	12	34	0	1	1
355	6	09	37	38	38	36	4	5	7	12.5	4.5	0.00	3.1	1.3	0.0	-1.4	1.0	59	0	0	2	1
356	318	52	31	31	31	31	4	4	4	12.5	4.5	0.00	4.5	4.3	0.0	-8.5	0.0	53	0	1	1	1
165	282	69	32	33	32	33	1	3	3	12.5	1.7	0.00	4.3	1.0	0.0	-0.3	1.5	37	3	0	3	2
357	0	65	39	39	39	39	7	7	7	12.5	4.5	0.00	5.1	2.0	0.0	-0.1	0.3	0	0	1	1	1
358	279	50	38	39	38	38	5	5	5	12.5	4.5	0.00	1.9	1.1	0.0	6.3	0.7	60108	0	1	1	
168	310	20	35	35	35	35	1	1	1	11.5	-5.5	0.00	2.3	0.0	0.0	-7.1	0.0	0	-3	0	1	2
193	56	140	36	36	36	36	2	2	2	12.5	10.5	0.00	5.3	1.7	0.0	-2.5	1.2	0	67	2	0	2
194	304	69	31	31	31	31	0	0	0	14.0	-5.4	0.00	2.1	1.2	0.0	-6.3	0.0	0	3	1	0	2
192	279	91	38	38	38	38	1	1	1	12.7	-1.5	0.00	5.0	0.0	0.0	-0.2	0.0	0	0	0	1	2
199	232	205	45	45	45	45	5	5	5	7.1	7.6	0.00	4.3	0.0	0.0	-1.7	0.0	38	16	0	1	2
203	341	76	40	40	40	40	0	0	0	17.1	11.5	0.00	0.5	1.3	0.0	-13.6	0.1	0	34	1	1	2
206	343	81	32	32	32	32	0	0	0	13.0	0.3	0.00	5.1	1.2	0.0	-7.6	0.2	0	34	1	1	2
207	351	78	35	35	36	32	0	3	6	11.9	0.7	0.00	4.7	1.3	0.0	-4.0	4.9	22	34	2	5	1
211	324	84	34	34	34	34	1	1	1	11.9	0.5	0.00	0.6	1.2	0.0	-9.1	0.0	43	34	1	0	2
213	19	99	33	33	33	33	4	4	5	12.5	5.5	0.00	2.3	1.1	0.0	-1.1	1.2	16	63	1	2	2
215	312	61	32	32	32	31	0	1	3	15.4	0.1	0.00	4.5	1.3	0.0	-7.2	2.1	39	34	1	2	2
216	24	84	39	39	39	39	4	4	4	14.5	4.7	0.00	1.8	1.1	0.0	-3.0	0.2	54	63	1	1	2
219	357	53	46	46	46	46	0	1	2	13.5	10.7	0.00	3.6	1.7	0.0	-0.1	2.7	12	34	1	2	2
224	351	65	39	39	39	39	2	0	2	11.9	-0.1	0.00	1.9	1.4	0.0	-0.3	0.0	61-34	1	0	2	
227	351	60	42	42	42	42	0	0	0	14.3	5.0	0.00	13.5	5.3	0.0	7.9	0.7	61	34	1	1	2

Table A4. ACFT Volume Scan Output for Volume Scan No. 1, Case Study No. 2 (Cont'd)

CLUSTER OUTPUT																			
CENTROID		2		3		4		5		6		7		8		9		10	
TRK	AZM	RVG	AV	PA	V	A	S	AN	DEG	VEL	CL	TRK	CL	TRK	CL	TRK	CL	TRK	CL
47	55	147	45	48	1	1.4	14.4	14.4	14.4	14.4	14.4	14.4	14.4	14.4	14.4	14.4	14.4	14.4	14.4
37	287	70	33	33	1	1.4	3.3	3.3	3.3	3.3	3.3	3.3	3.3	3.3	3.3	3.3	3.3	3.3	3.3
48	299	61	33	33	1	1.4	3.3	3.3	3.3	3.3	3.3	3.3	3.3	3.3	3.3	3.3	3.3	3.3	3.3
38	230	007	45	48	1	1.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
49	237	126	44	44	1	1.4	2.4	2.4	2.4	2.4	2.4	2.4	2.4	2.4	2.4	2.4	2.4	2.4	2.4
39	313	63	34	37	4	1.1	4.1	4.1	4.1	4.1	4.1	4.1	4.1	4.1	4.1	4.1	4.1	4.1	4.1
50	255	142	41	45	1	1.4	14.2	14.2	14.2	14.2	14.2	14.2	14.2	14.2	14.2	14.2	14.2	14.2	14.2
51	264	100	34	37	4	1.5	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
52	293	91	31	31	1	1.4	3.1	3.1	3.1	3.1	3.1	3.1	3.1	3.1	3.1	3.1	3.1	3.1	3.1
12	358	60	42	42	6	2.1	5.2	5.2	5.2	5.2	5.2	5.2	5.2	5.2	5.2	5.2	5.2	5.2	5.2
53	18	96	33	34	1	1.4	3.3	3.3	3.3	3.3	3.3	3.3	3.3	3.3	3.3	3.3	3.3	3.3	3.3
16	20	85	36	39	1	1.4	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9
46	10	45	40	40	1	1.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
54	24	35	37	39	1	1.4	3.7	3.7	3.7	3.7	3.7	3.7	3.7	3.7	3.7	3.7	3.7	3.7	3.7
55	273	42	33	36	1	1.4	3.3	3.3	3.3	3.3	3.3	3.3	3.3	3.3	3.3	3.3	3.3	3.3	3.3
22	351	76	37	40	1	1.4	4.4	4.4	4.4	4.4	4.4	4.4	4.4	4.4	4.4	4.4	4.4	4.4	4.4
43	334	81	35	41	1	1.4	3.1	3.1	3.1	3.1	3.1	3.1	3.1	3.1	3.1	3.1	3.1	3.1	3.1
56	277	64	33	35	1	1.4	3.3	3.3	3.3	3.3	3.3	3.3	3.3	3.3	3.3	3.3	3.3	3.3	3.3
57	12	73	47	47	1	1.4	4.7	4.7	4.7	4.7	4.7	4.7	4.7	4.7	4.7	4.7	4.7	4.7	4.7
53	318	53	32	35	1	1.4	3.2	3.2	3.2	3.2	3.2	3.2	3.2	3.2	3.2	3.2	3.2	3.2	3.2
59	6	57	39	41	1	1.4	3.9	3.9	3.9	3.9	3.9	3.9	3.9	3.9	3.9	3.9	3.9	3.9	3.9
60	200	48	36	38	1	1.4	3.6	3.6	3.6	3.6	3.6	3.6	3.6	3.6	3.6	3.6	3.6	3.6	3.6
61	351	62	41	43	1	1.4	4.1	4.1	4.1	4.1	4.1	4.1	4.1	4.1	4.1	4.1	4.1	4.1	4.1
OVER																			
VOL	HHMM	AREA	WFLUX	NEAR	NEAR	NEAR	NEAR	NEAR	NEAR	NEAR	NEAR	NEAR	NEAR	NEAR	NEAR	NEAR	NEAR	NEAR	NEAR
SCAN		KKM2	KYT/H	CELL	CLST	CCAT	VOL	IS	FL	LM/S	AN/S	NO	CTR	CTR	CTR	CTR	CTR	CTR	CTR
4	1551	5.2	31.29	6.6	17.0	0.0	140	24	10	10.0	5.1	358	67	116	C	C	C	C	C