DEPARTMENT OF TRANSPORTATION
FEDERAL AVIATION ADMINISTRATION

ASR-9
TARGETS-OF-OPPORTUNITY
PERFORMANCE BASELINE

TEST REPORT

Tech Note # CTTN022

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TABLE OF CONTENTS

	Page
EXECUTIVE SUMMARY	viii
1.0 INTRODUCTION	1
1.1 Purpose	1
1.2 Background	1
1.3 Scope of Report	2
2.0 REFERENCE DOCUMENTS	3
3.0 SYSTEM DESCRIPTION	3
3.1 Test Configuration	3
3.2 Definitions	7
4.0 TEST AND EVALUATION DESCRIPTION	8
4.1 Probability of Detection and Overall Reinforcement Rates	8
4.2 Low Angle Coverage	16
4.3 Beacon False Target Analysis	22
4.4 Primary Radar False Target Rates	25
4.5 Quality Filtering Assessment	46
5.0 SUMMARY OF RESULTS	52
6.0 RECOMMENDATIONS	53

APPENDICES

A Site 1 – Performance
B Site 2 – Clear Conditions
C Site 2 – Intense Weather
D Site 3 – Results
E Site 4 – Results
F Site 5 – Results
G Site 6 – Results: (9-PAC Phase 2 Site)

LIST OF ILLUSTRATIONS

Figure		Page
4.1-1	Site 1 – Range Height Indicator Display	12
4.1-2	Site 2 – Clear Conditions – Range Height Indicator Display	12
4.1-3	Site 2 – Intense Weather and AP – Range Height Indicator Display	13
4.1-4	Site 3 – Range Height Indicator Display	13
4.1-5	Site 4 – Range Height Indicator Display	14
4.1-6.	Site 5 – Range Height Indicator Display	14
4.1-7.	Site 6 – Range Height Indicator Display	15
4.2-1.	Range Height Indicator Display – Low Angle Coverage	18
4.2-2.	Site 2 – Clear Conditions – Range Height Indicator Display Low Angle Coverage	18
4.2-3.	Site 2 – Intense Weather and AP – Range Height Indicator – Low Angle	19
4.2-4.	Site 3 – Range Height Indicator Display – Low Angle Coverage	19
4.2-5.	Site 4 – Range Height Indication Display – Low Angle Coverage	20
4.2-6.	Site 5 – Range Height Indicator Display – Low Angle Coverage	20
4.2-7.	Site 6 – Range Height Indicator Display – Low Angle Coverage	21
4.4-1.	Site 2a Weather During Maximum False Plot Occurrence	29
4.4-2.	Site 2a Weather During Maximum False Track Occurrence	29
4.4-3a	Site 1 – Target Counts with no Quality Filtering	30
4.4-3b	Site 1 – Target Counts with Quality 0 Filtering	30
4.4-4a	Site 2 – Clear Conditions – Target Counts with no Quality Filtering	31
4.4-4b	Site 2 – Clear Conditions – Target Counts with Quality 0 Filtering	31
4.4-5a	Site 2 – Intense Weather and AP – Target Counts with no Quality Filtering	32
4.4-5b	Site 2 – Intense Weather and AP – Targets with Quality 0 Filtering	32

LIST OF ILLUSTRATIONS (Continued)

Figure		Page
4.4-5c	Site 2 – Intense Weather and AP – Target Counts with no Quality Filtering	33
4.4-5d	Site 2 – Intense Weather and AP – Target Counts with Quality 0 Filtering	33
4.4-6a	Site 3 – Target Counts with no Quality Filtering	34
4.4.6b	Site 3 – Target Counts with Quality 0 Filtering	34
4.4-7a	Site 4 – Target Counts with no Quality Filtering	35
4.4-7b	Site 4 – Target Counts with Quality 0 Filtering	35
4.4-8a	Site 5 – Target Counts with no Quality Filtering	36
4.4-8b	Site 5 – Target Counts with Quality 0 Filtering	36
4.4-9a	Site 6 – Target Counts with no Quality Filtering	37
4.4-9b	Site 6 – Target Counts with Quality Filtering Zero Filtering	37
4.4-10a	Site 1 – False Tracks – no Quality Filtering	38
4.4-10b	Site 1 – False Tracks – Quality 0 Filtering	38
4.4-11a	Site 2 – Clear Conditions – False Tracks	39
4.4-11b	Site 2 – Clear Conditions – False Tracks with Quality Zero Filtering	39
4.4-12a	Site 2 – Intense Weather and AP – False Tracks	40
4.4-12b	Site 2 – Intense Weather and AP – False Tracks	40
4.4-12c	Site 2 – Intense Weather and AP – False Tracks w/Quality Zero Filtering	41
4.4-12d	Site 2 – Intense Weather and AP – False Tracks w/Quality Zero Filtering	41
4.4-13a	Site 3 – False Tracks No Quality Filtering	42
4.4-13b	Site 3 – False Tracks with Quality 0 Filtering	42
4.4-14a	Site 4 – False Tracks no Quality Filtering	43
4.4-14b	Site 4 – False Tracks – Quality Zero Filtering	43

LIST OF ILLUSTRATIONS (Continued)

Figure	Page
4.4-15a Site 5 – False Tracks no Quality Filtering	44
4.4-15b Site 5 – False Tracks – Quality Zero Filtering	44
4.4-16a Site 6 – False Tracks	45
4.4.16b Site 6 – False Tracks Quality Zero Filtering	45

LIST OF TABLES

Table		Page
3.1-1a	Test Configurations	5
3.1-1b	Test Configurations	6
4.1-1	Summary of Probability of Detection and Reinforcement Rates for all sites	11
4.2-1	Reinforcement Rates Versus Elevation Angle	17
4.3-1	Beacon False Target Summary Analysis for ASR-9 Sites	24
4.3-2	Beacon Target Distribution	24
4.4-1	False Track and False Plot Summaries for Sites 1 thru 6	28
4.5-1	Target Quality Distribution – Site 1	49
4.5-2	Target Quality Distribution – Site 2	49
4.5-3	Target Quality Distribution – Site 2a	49
4.5-4	Target Quality Distribution – Site 3	49
4.5-5	Target Quality Distribution – Site 4	50
4.5-6	Target Quality Distribution – Site 5	50
4.5-7	Target Quality Distribution – Site 6	50
4.5-8	Distribution of Radar Correlated and Radar/Beacon Merge Targets	50
4.5-9	Quality Distribution of Total Target Population – Site 5with Merge Window set to Zero	51
4.5-10	Quality Distribution of Real Targets – Site 5 with merge window set to zero	51
4.5-10	Quality Distribution Had Radar Targets Been Able to Merge With Beacon Targets – Data Collection from Site 5 with Merge Window set to Zero	51
4.5-12	Percentage of Quality Zero Targets as a Function of Range and Azimuth – Site 5 With Merge Window set to Zero	51

EXECUTIVE SUMMARY

The Digital Airport Surveillance Radar (DASR) system is a Non-Developmental Item (NDI) S-Band Airport Surveillance Radar designated by the Federal Aviation Administration (FAA) as the Airport Surveillance Radar Model 11 (ASR-11). The United States Air Force (USAF) and the FAA are jointly procuring the ASR-11 as a direct replacement of existing radar and beacon equipment at terminal facilities. These radars are being replaced to: interface to new digital automation systems, improve aircraft detection in clutter, improve reliability, reduce support costs and provide National Weather Service (NWS) calibrated six level weather. The ASR-11 consists of a Moving Target Detector (MTD) Primary Surveillance Radar (PSR), integrated Air Traffic Control Radar Beacon System (ATCRBS) Monopulse Secondary Surveillance Radar (MSSR), external interfaces and facilities.

Operational Testing planned for the ASR-11 will include both dedicated flight tests and target-of opportunity tests. While the target-of-opportunity tests do not maintain the strict test controls needed to measure some specific specification test parameters, they do provide a measure of the operational performance that will be observed by air traffic controllers.

The ASR-9 is the only digital Moving Target Detector terminal radar currently fielded. ASR-9 and ASR-11 performance requirements are similar in the area of False Target Report Rates and Probability of Detection (P_D). The testing described in this document will quantify baseline performance for selected ASR-9 performance parameters using targets-of-opportunity test and analysis methods planned to be used during the ASR-11 Operational Test. These results will aid the PT in determining the operational effectiveness and suitability of the ASR-11 performance.

Summary of Results

Note: The following are based upon Targets-of-Opportunity Testing and as such are not appropriate for direct comparison with ASR-11 performance without considering specific radar site environments.

Beacon Pd - ASR-9 Beacon Pd ranged from 98.15% to 99.55% using RBAT analysis.

Radar Pd - The ASR-9 radar Pd ranged from 81.75 to 95.56% using RBAT analysis. Five of the six sites had a radar Pd over 90%. Site 3 whose radar Pd was 81.75% had over 55% of its air traffic at elevation angles less than 1 degree (based upon beacon reports).

Overall Reinforcement Rates - Overall reinforcement rates (all angles) ranged from 81.57 to 95.7%. Reinforcement rates at all sites were in excess of 90% with the exception of site 3, whose reinforcement rate was 81.57%. As stated above, over 55% of the air traffic at this site was at elevation angles less than one degree.

Reinforcement Rates vs. Elevation Angle - Reinforcement rates in the peak of the antenna beam (between 1 and 20 degrees elevation) ranged between 92.62 and 98.24%. Low angle

coverage at all sites was good. Reinforcement rates between .25 and .5 degrees ranged from 77.78 to 91.31 %.

Beacon False Targets - Observed beacon false target rates ranged from .004 to .236 false beacon targets per scan (averaged over the data recording duration).

False Track Report Rates - Maximum false track report rates ranged from 4 to 28 false track reports per scan averaged over 10 scans. The highest maximum false plot rate of 28 false tracks per scan (averaged over 10 scans) was observed at site 2 under severe weather conditions. The lowest maximum false track report rate of 4 tracks per scan was observed at site 6, the only 9-PAC phase 2 site analyzed. It was observed under conditions of level three weather with weather peaks up to level 5.

False Plot Report rates - Maximum false plot report rages ranges from 40 to 410 false plots per scan averaged over three scans without quality zero filtering. The maximum average of 410 false plots per scan (averaged over 3 scans) was observed at Site 2 under severe weather conditions. With the recommended ASR-9 target report quality zero filtering (simulated), the maximum average false plot rate of 136 false plots per scans was observed at this site. Note: there is no false plot requirement in the ASR-9 specification.

Quality Filtering - Enabling of quality zero filtering was found to result in the removal of 3.8-24.47% of true radar targets while removing an estimated 35-70% of false plots at 9-PAC phase 1 sites. Quality zero filtering could not be evaluated at the 9-PAC phase 2 site due to limits in the data collection. In general, quality zero targets report rates increase at lower angles and at greater distances from the radar.

Recommendations – It is recommended that total system performance requirements be considered when comparing these results to ASR-11 performance. All sites analyzed were operational radar sites optimized to meet operational user needs. All of the ASR-9 sites were optimized to achieve high reinforcement rates at low coverage angles. Low angle coverage achieved by a radar is a function of radar optimization. Trade-offs can be made between low angle coverage and primary radar false alarm rates.

Meaningful comparison with the baseline performance documented within this test report requires radar optimization to similar overall user needs.

1.0 Introduction

1.1 Purpose: The purpose of this report is to document the operational performance baseline of fielded ASR-9 sites using targets-of opportunity testing and the same analysis techniques planned for use in evaluating the ASR-11.

1.2 Background: The Digital Airport Surveillance Radar (DASR) system is a Non-Developmental Item (NDI) S-Band Airport Surveillance Radar designated by the Federal Aviation Administration (FAA) as the Airport Surveillance Radar Model 11 (ASR-11). The United States Air Force (USAF) and the FAA are jointly procuring the ASR-11 as a direct replacement of existing radar and beacon equipment at terminal facilities. These radars are being replaced to: interface to new digital automation systems, improve aircraft detection in clutter, improve reliability, reduce support costs and provide National Weather Service (NWS) calibrated six level weather. The ASR-11 consists of a Moving Target Detector (MTD) Primary Surveillance Radar (PSR), integrated Air Traffic Control Radar Beacon System (ATCRBS) Monopulse Secondary Surveillance Radar (MSSR), external interfaces and facilities.

Operational Testing planned for the ASR-11 will include both dedicated flight tests and target-of opportunity tests. While the target-of-opportunity tests do not maintain the strict test controls needed to measure some specific specification test parameters, they do provide a measure of the operational performance that will be observed by air traffic controllers.

The ASR-9 is the only digital Moving Target Detector terminal radar currently fielded. ASR-9 and ASR-11 performance requirements are similar in the area of False Target Report Rates and Probability of Detection (P_D). The testing described in this document will quantify baseline performance for selected ASR-9 performance parameters using targets-of-opportunity test and analysis methods planned to be used during the ASR-11 Operational Test. These results will aid the PT in determining the operational effectiveness and suitability of the ASR-11 performance.

1.3 Scope of Report: This report provides a record of target-of-opportunity performance for key parameters for the ASR-9 radar. It based upon analysis of targets-of opportunity data collected from six operational ASR-9 sites with varying clutter and environmental conditions. Each section contains: specification performance requirements for the ASR-9 and ASR-11 that are related to the target-of-opportunity test; a description of the test; the limitations in directly applying the results to the specification requirements; and a discussion of the target-of opportunity test results. Section 4.1 presents analysis of radar and beacon probability of detection and radar reinforcement rates. Section 4.2 provides an analysis of low angle radar coverage by measuring radar reinforcement rates versus the angle from the radar horizon. Section 4.3 looks at analysis of beacon false targets using the RBAT Beacon False Target Summary tool. Section 4.4 addresses radar false target report rates for both uncorrelated and correlated radar target reports. Section 4.5 provides an analysis of the effects of radar target quality filtering on false target reduction and the loss of true aircraft radar returns. Appendices A thru G provide summaries of site-by site performance.

2.0 Reference Documents

FAA Acquisition Management System Test & Evaluation Process Guidelines. Dated July 2001

NAS-SS-1000 NAS System Specification, Vol. I, II, III, and V. Dated: December 1986.

FAA-E-2079B Airport Surveillance Radar Model 9 (ASR-9). Dated: Oct 1, 1986

ICD SE007-4E External Interface Control Document for the ASR-9 SCIP to Terminal Computer. Dated: June 13, 1986.

Raytheon SSG708688 DASR System Specification REV-D. Dated: July 17 1999.

3.0 System Description

The ASR-9 is a low-Pulse Repetition Frequency (PRF) pulsed Doppler radar, Moving Target Detector (MTD), signal and data processing system. MTD is a digital signal processor employing coherent Doppler filtering and adaptive thresholding techniques. The ASR-9 is paired with a secondary surveillance radar (ATCBI-4, ATCBI-5 or Mode S) and provides for the integration of radar and beacon data prior to sending it to the automation system. It is designed to interface with Automated Radar Terminal System (ARTS)-II and ARTS-III automation equipment.

All fielded FAA ASR-9 radars are currently equipped with the 9-PAC Phase I modification. The 9-PAC Phase I only addresses beacon performance and was developed to reduce beacon target splits and control dynamic reflectors. The 9-PAC Phase II modification is currently fielded at a few key sites. It enhances the primary radar performance, improving the ability to accurately track turning targets, and reducing the effects of road traffic, weather and birds.

3.1 Test Configurations: Data analyzed within the scope of this report was collected from six operational radar and beacon systems certified in accordance with established procedures. Sites 1 thru 5 are all 9-PAC Phase 1 sites. Site 6 is a 9-PAC phase 2 site. Since two large data collections were made at site two under different weather conditions, a separate analysis was made for each data collection (Referenced as sites 2 and 2a throughout this report).

Tables 3.1-1a and 3.1-1b show radar conditions at each site. Determination of radar interference being observed was based upon interpretation of radar message confidence bits and strobes of radar targets on Plan Position Displays of radar targets.

Standard radar maintenance procedures were followed during the data collection period (Other than connection and disconnection of recording equipment, no special maintenance procedures were used – with the exception of a second recording at site 5 to gather information on radar report target quality).

During all data recordings, the ASR-9 radars were being used to control air traffic. Changes to the radar configuration (e.g. change between Circular Polarization (CP) and Linear Polarization (LP), etc.) were at the discretion of AT and are documented for the different data sets collected through the analysis of status messages provided by the ASR-9 radar.

Site	Hardware/ Software Configuration	Beacon Interrogator Type	Weather Environment	Ground Clutter Environment	Road Traffic Environment	Antenna Tilts	Radar Interference Observed	Scans/ Recording Duration
1	9-PAC Phase 1	ATCBI-4	Cloudy with some sun	15 miles from metropolitan area. Ground terrain is relatively flat over half of coverage area. Other half of coverage area has rolling hills starting at 10 miles rising up to 600 ft at outer edge of coverage	15 miles from interstate highway. Minor roads locally	Radar: 0° Beacon: 0°	No	2934 scans 3 hr, 45 min
2	9-PAC Phase 1	Mode-S	Clear and sunny	Major metropolitan area, sea clutter over portion of coverage area. Ground terrain is relatively flat	Between inner and outer beltways of major city (less than three miles from each), less than 2 miles from major interstate highway	Unknown	No	4338 scans 5 hr, 32 min
2a	9-PAC Phase 1	Mode-S	Rain with levels 2-6, Level 6 weather at end of recording	Major metropolitan area, sea clutter over portion of coverage area. Ground terrain is relatively flat	Between inner and outer beltways of major city (less than three miles from each), less than 2 miles from major interstate highway	Unknown	No	9572 scans 12 hr, 13 min
3	9-PAC Phase 1	Mode-S	Level 1 and 2 over most of the coverage volume with cells of level 3 and 4	Metropolitan area with some tall buildings, ground terrain is relatively flat	Less than 2 miles to major interstate highway	Unknown	Yes	6000 scans 10 hrs

Table 3.1-1a Test Configurations

Site	Hardware/ Software Configuration	Beacon Interrogator Type	Weather Environment	Ground Clutter Environment	Road Traffic Environment	Antenna Tilts	Radar Interference Observed	Scans/ Recording Duration
4	9-PAC Phase 1	Mode-S	Unknown	Near major metropolitan area,	Less than two miles from major city beltway and interstate	Radar: 0° Beacon: 0°	No	2422 scans 3 hr, 5 min
5	9-PAC Phase 1	Mode-S	Unknown	Urban area on edge of major metropolitan area Ground terrain is rolling hills of 200-300 feet	Less that two miles from beltway of major city and feeding interstate highway	Radar: 1° Beacon: unknown	No	2073 scans 2 hr, 39 min
6	9-PAC Phase 2	ATCBI-4	Level 2 increasing to level 3 with small areas up to level 5	Major metropolitan area. Ground terrain is rolling hills to 300 ft	Less than two miles from interstate. Several interstate highways within ten miles	Radar: 0° Beacon: 0°	No	5068 scans 6 hr 28 min

Table 3.1-1b Test Configurations

3.2 Definitions:

Anomalous Propagation (AP) – a bending of the radar beam downward caused by temperature inversions in the atmosphere

Beacon Only Target Report – A beacon report which did not combine with a radar report.

Beacon P_D – The probability an aircraft within the coverage volume of the Beacon interrogator is detected on a given scan. Plot – same a Radar Uncorrelated Report

Radar Correlated Report (RC) - A radar report which has been scan-to-scan correlated by the radar's tracker and exhibits a progression in range and azimuth consistent with a real aircraft's flight kinematics.

Radar Only Report (RO)– A Radar Uncorrelated report.

Radar P_D – The probability an aircraft within the coverage volume of the primary radar is detected on a given scan

Reinforced Target Report – A target report which represents the consolidation of a beacon report and a radar report which were determined to be close enough in proximity that they represent the same target.

Reinforcement Rate – The number of Reinforced Target reports divided by the sum of Reinforces Target reports plus the number of Beacon Only Target reports.

Radar Uncorrelated Report – A radar target report, unfiltered by the radar tracker, which was not combined with a beacon target by the radar processor on a given scan.

Total P_D – The probability an aircraft is detected by the primary radar and or the beacon interrogator on a given scan

4.0 Test and Evaluation Description

4.1 Probability of Detection and Overall Reinforcement Rates

4.1.1 Test Objective: Measure the overall probability of detection for both the primary and secondary radars for the ASR-9 using targets-of opportunity techniques. Measure the overall reinforcement rates for the ASR-9 using targets of opportunity techniques.

4.1.2 Specification Performance Related Requirements.

4.1.2.1 ASR-11 Related Performance Requirements:

The radar Pd requirement for the ASR-11 is as follows:

> **3.1.3.1** **Detection Performance in Clear.** In the clear, the PSR ***Shall [RSS-0318.0]*** detect a 1 m^2 (0 dBsm) Swerling 1 target anywhere within the detection volume with a single scan probability of detection (P_d) greater than or equal to 0.8 at a probability of false alarm (P_{FA}) of 10^{-6} over 92 percent of the radial velocities between -700 to +700 knots. Detection requirements (Figure 3-1) extend from:
>
> a. 0.5 nmi to 60 nmi on the nose of the beam
>
> b. Between 8000 and 24,000 feet altitude at 50 nmi
>
> c. The local radar horizon to 30° elevation angle

The MSSR Pd requirement for the ASR-11 is as follows:

> **3.2.2.4** **Probability of Detection (P_d).** The MSSR P_d ***Shall [RSS-0464.0]*** be 0.995 minimum for targets with a round reliability of 0.75 with three-fourths of the modes responding, in a steady state condition of 10,000 ATCRBS and 200 Mode-S false-replies unsynchronized-in-time (FRUIT) per second, of which 30 percent are in the mainbeam.

There is no specification requirement for reinforcement rates on the ASR-11. However, given that there is an ASR-11 requirement for Beacon False Targets not to exceed 1 false target per scan, the presence of a beacon report is a good indication that an aircraft is present at a given location. Therefore, reinforcement rates provide a good measure of the radars ability to detect real aircraft within the range coverage of the radar.

4.1.2.2 ASR-9 Related Performance Requirements:

The radar Pd requirement for the ASR-9 is as follows:

> **3.4.2 System Coverage** - The contractor shall prove the required maximum coverage by means of calculations. These calculations shall be furnished prior to acceptance of the first system. Calculations, utilizing measured system parameters except for the constants provided herein, shall be performed in accordance with NRL report 6930, "A Guide to Basic Pulse – Radar Maximum – Range Calculation," dated 23 December 1969. Such calculations shall indicate detection of a target of one square meter cross section with a probability of detection of 0.8 at a range of 55 nautical miles inbound and outbound. The target is assumed to be at the nose of the low-beam radiation pattern; the radar is assumed to be operating in linear polarization with the antenna mounted atop a 47 foot tower. Swerling Case 1 target fluctuation

and 10-6 false alarm probability shall be assumed.

The MSSR Pd requirement for the ASR-9 is as follows:

3.4.3.4.1 Probability of detection – The minimum probabilities of detection (Pd) on targets having round reliabilities of 0.5 and 0.75 are shown in the following tables :

Detection Requirements – Round Reliability = 0.5			
Total Interrogations	Modes Responding		
	All	Half	Three fourths
8	.640	--	.360
12	.900	.340	.700
16	.950	.460	.810
20	.980	.550	.890

Detection Requirements – Round Reliability = 0.75			
Total Interrogations	Modes Responding		
	All	Half	Three fourths
8	.970	.320	.830
12	.998	.810	.830
16	.999	.890	.970
20	.999	.940	.995

There is no specification requirement for reinforcement rates on the ASR-9.

4.1.3 Test Description: Data collected from six sites with diverse ground clutter conditions and varied environmental conditions was analyzed using the Surveillance Analysis utility of the Radar Beacon Analysis Tool (RBAT) tool set. RBAT Surveillance Analysis provides a measure of Beacon Pd, Search Pd and Reinforcement rate. Data is also analyzed and graphed with Integrated Radar Evaluation System (IRES) to show beacon coverage and the areas in range and elevation where beacon reports are being reinforced.

4.1.4 Limitations in applying results directly to related requirements: There is no verification or control of beacon transponder performance on the target aircraft. Aircraft executing turns are likely to fail to respond to beacon interrogations. Poor detection on the fringe on the beam (affecting round reliability) is not accounted for in the beacon analysis. No filtering is done for the adjust for differences in coverage volume of the primary and secondary radars. Increased coverage of the secondary radar at high and low elevation angles tends to lower reinforcement rates. There are no controls for aircraft radar cross section. The RBAT tracker can only initiate tracks on Beacon reports and therefore does not include data for aircraft without transponders.

4.1.5 Discussion/Results: Table 4.1-1 shows a summary of the results at all six ASR-9 sites. Sites 2 and 2a represent the same site in clear weather and severe weather conditions.

All ASR-9 sites show an overall Beacon Pd in excess 99% with the exception of site 2 which shows a beacon Pd of 98.15

All ASR-9 sites show an overall Radar Pd in excess of 90% with the exception of site 3 which had an overall search Pd of 81.75%. Investigation of site 3 performance shows that the difference in performance can be attributed to the nature of the air traffic at site 3. Over 55% of all traffic within the 60 nmi range of site 3 is at an elevation angle of less that 1 degree. The shape of the primary radar antenna pattern causes low angle targets to provide weaker return signals to the radar. As such, a lower Pd is expected for these targets. Section 4.2 of this report further addresses this issue by examining the relationship between reinforcement rate and

elevation angle. Data in section 4.2 shows reinforcement rates at the peak of the beam and at low angles for site 3 to be close to that of the other ASR-9 sites.

All sites show overall reinforcement rates in excess of 90% with the exception of site 3 which had an overall reinforcement rate of reinforcement rate of 81.57%. As explained above this can be accounted for by the nature of the air traffic at site 3.

Figures 4.1-1 thru 4.1-7 show range height indicator graphs of radar reinforcement for all six sites. Black dots represent reinforce targets. Blue dots represent Beacon Only targets. No altitude is provided in Radar Only and Radar Correlated target reports (and therefore they are not included in the figures). Altitudes shown are thousands of feet above Mean Sea Level (MSL) as reported by the target aircraft transponders. The angles shown on the right represent degrees from the radar horizon. Qualitative analysis shows good beacon coverage and radar reinforcement from above 30 degrees down to low elevation angles.

Site	Hardware/Software Configuration	Beacon Type	Target Category	Beacon Pd	Search Pd	Total Pd	Reinforcement Rate
1	9-PAC Phase 1	ATCBI-4	DISCRETE	99.39	91.53	99.71	91.76
			NON DISCRETE	98.13	86.91	99.22	87.44
			TOTAL	99.27	91.08	99.66	91.35
2	9-PAC Phase 1	Mode-S	DISCRETE	99.44	95.77	99.77	95.97
			NON DISCRETE	96.49	90.82	98.78	91.74
			TOTAL	**98.15**	93.6	99.34	94.15
2a	9-PAC Phase 1	Mode-S	DISCRETE	99.58	92.77	99.79	92.91
			NON DISCRETE	96.88	83.33	98.46	84.28
			TOTAL	98.94	90.55	99.48	90.92
3	9-PAC Phase 1	Mode-S	DISCRETE	99.1	87.46	99.61	87.06
			NON DISCRETE	97.4	77.29	98.84	77.2
			TOTAL	98.15	**81.75**	99.18	**81.57**
4	9-PAC Phase 1	Mode-S	DISCRETE	99.38	91.09	99.75	91.21
			NON DISCRETE	100	93.52	100	93.52
			TOTAL	99.39	91.10	99.75	91.22
5	9-PAC Phase 1	Mode-S	DISCRETE	99.56	95.53	99.84	95.5
			NON DISCRETE	97.39	93.16	99.35	93.65
			TOTAL	99.55	95.53	99.84	95.5
6	9-PAC Phase 2	ACTBI-4	DISCRETE	99.53	95.86	99.74	95.98
			NON DISCRETE	96.51	79.63	98.14	80.80
			TOTAL	99.48	95.56	99.71	95.70

TABLE 4.1-1. Summary of Probability of Detection and Reinforcement Rates for all sites

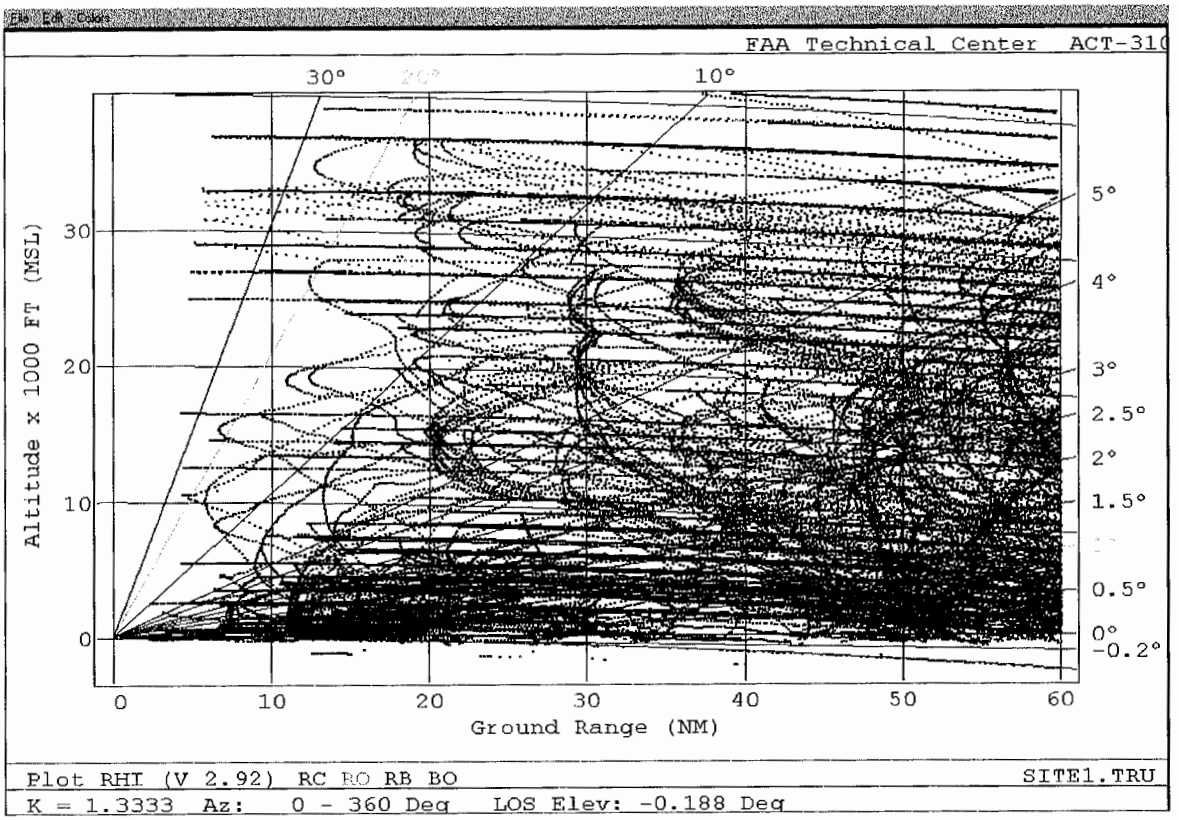


Figure 4.1-1. Site 1 – Range Height Indicator display

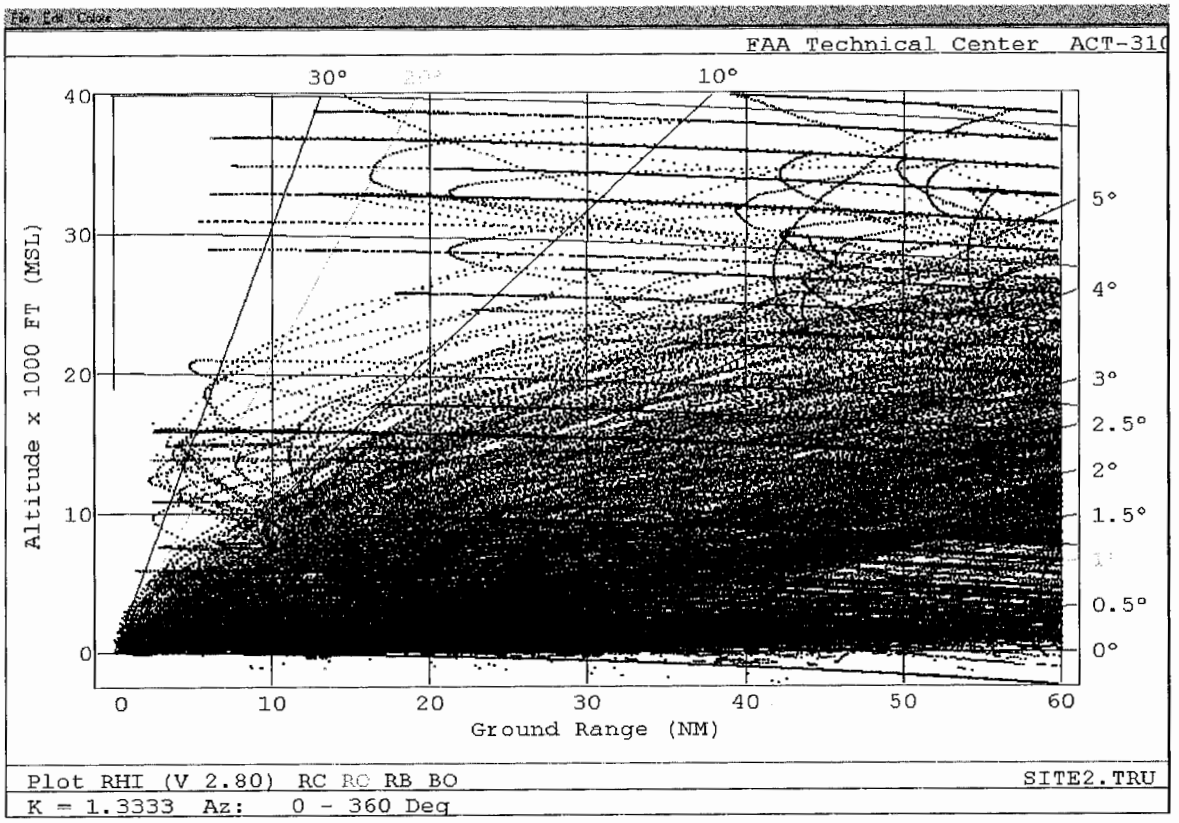


Figure 4.1-2. Site 2 – clear conditions – Range Height Indicator display

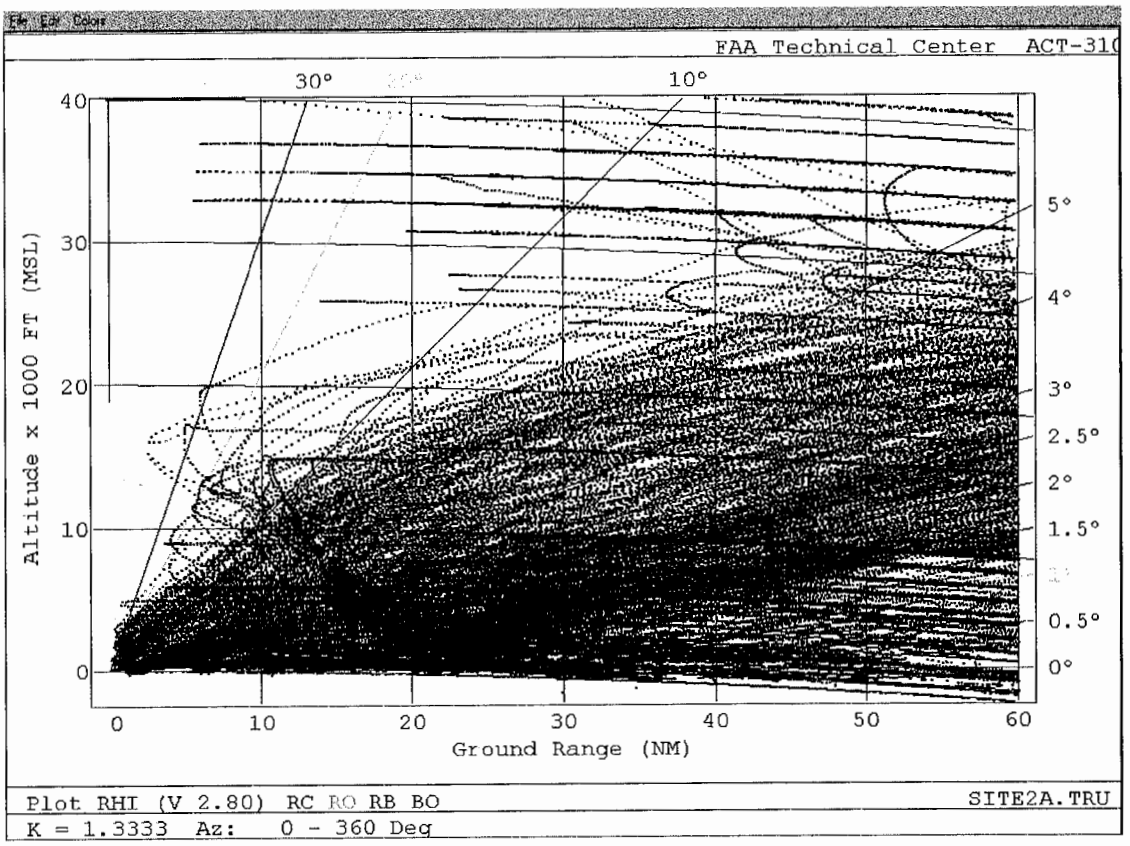


Figure 4.1-3. Site 2 – Intense weather and AP – Range Height Indicator display

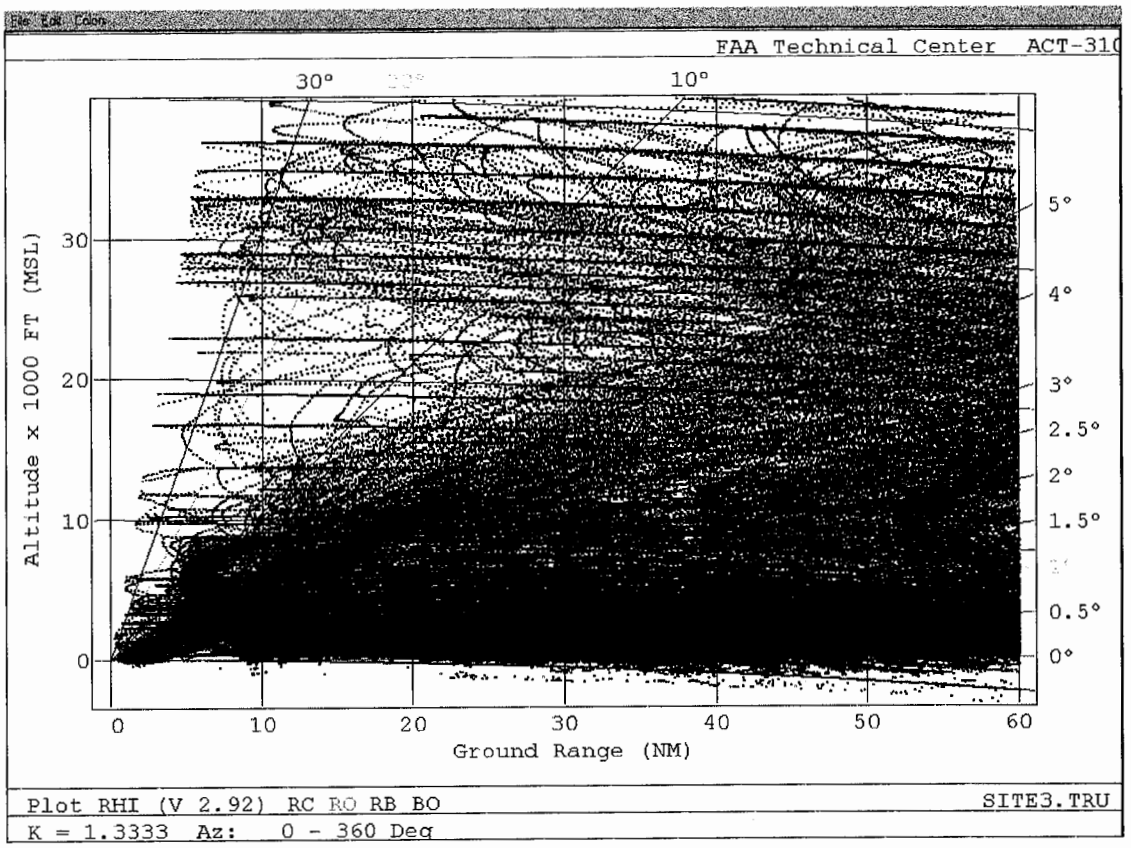


Figure 4.1-4. Site 3 - Range Height Indicator display

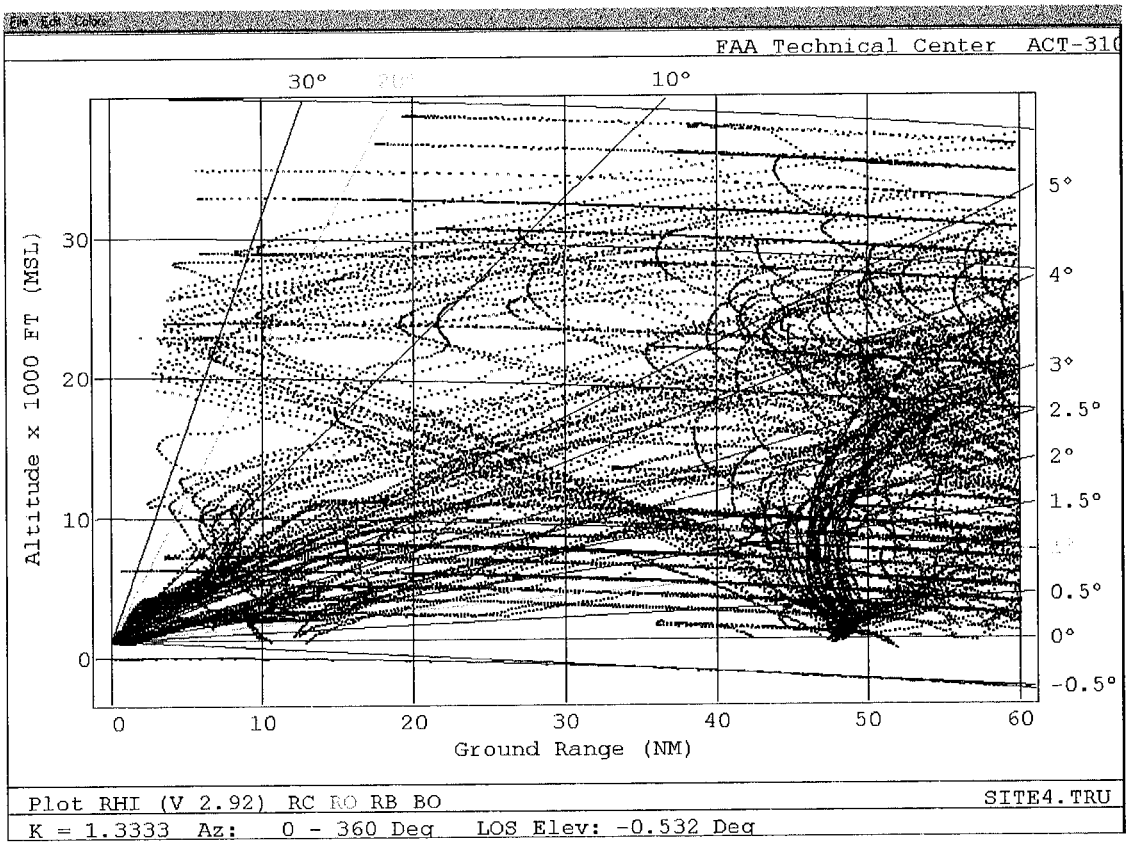


Figure 4.1-5. Site 4 - Range Height Indicator display

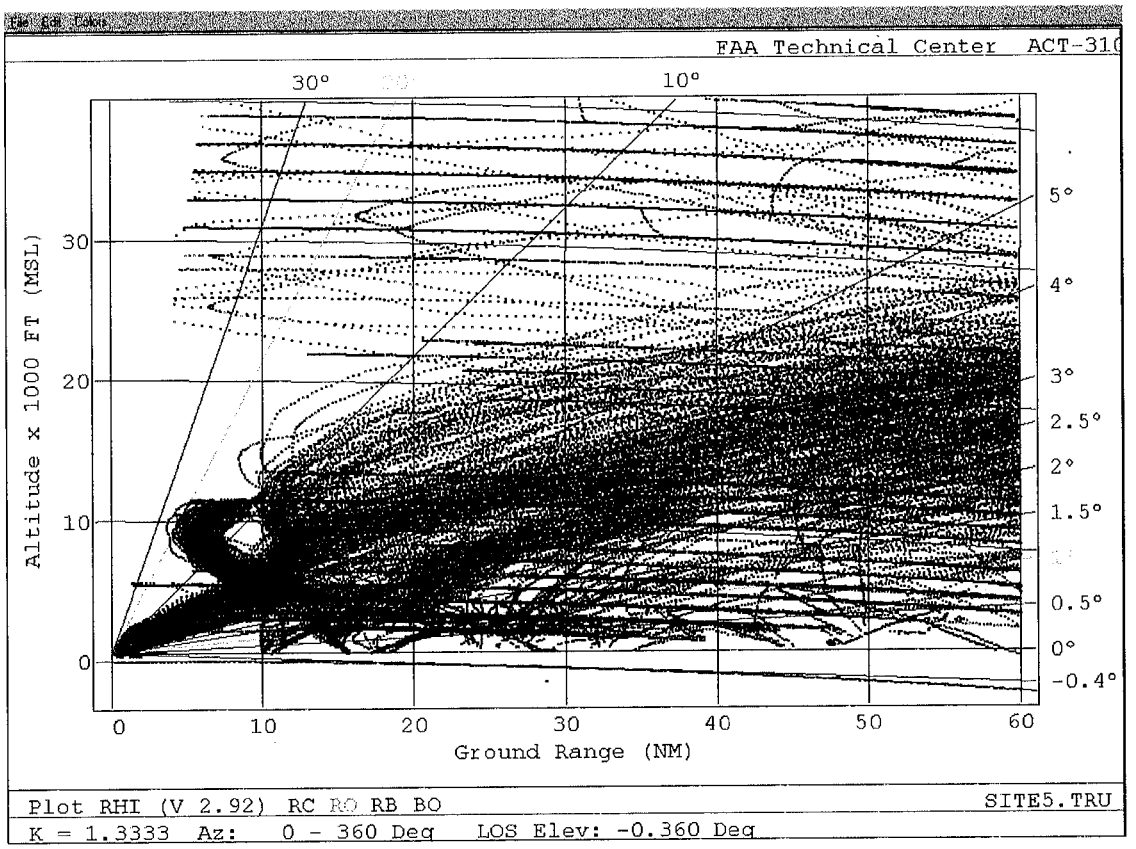


Figure 4.1-6. Site 5 - Range Height Indicator display

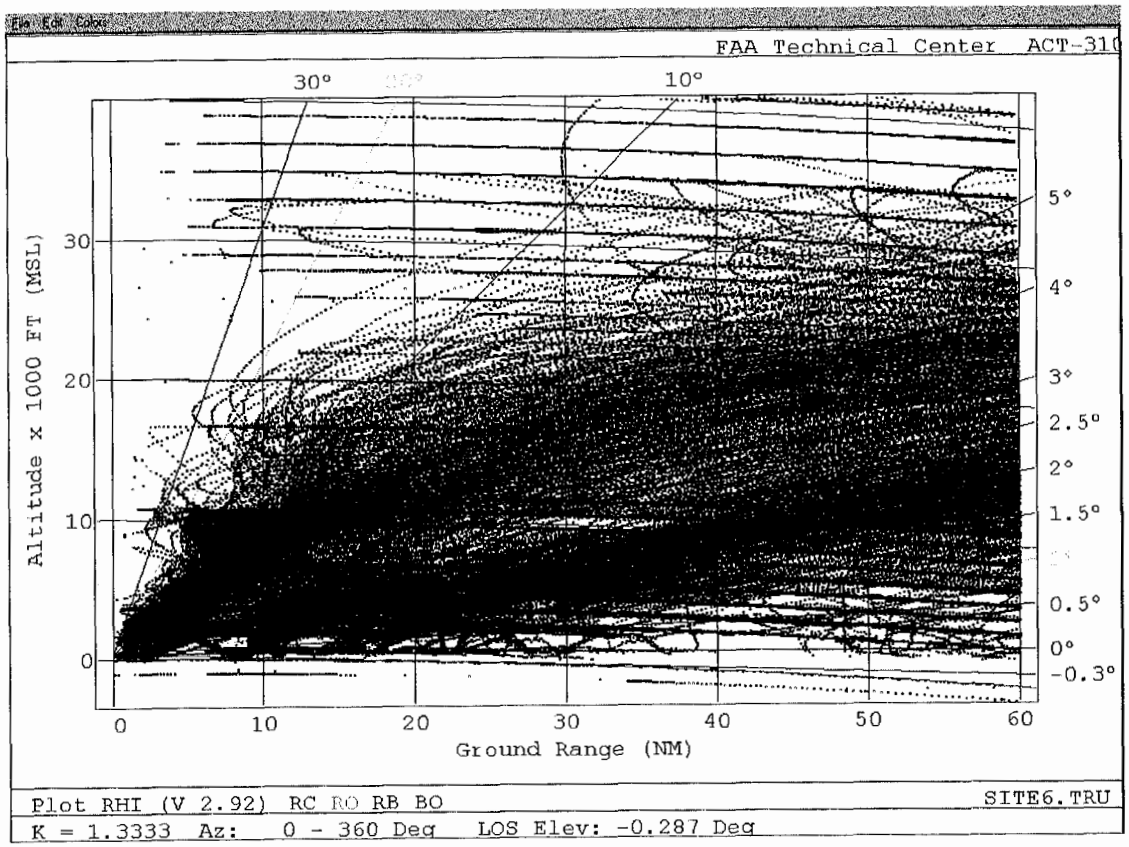


Figure 4.1-7. Site 6 - Range Height Indicator display

4.2 Low Angle Coverage Analysis

4.2.1 Test Objective: Measure the low angle coverage performance of the ASR-9 at operational sites using targets-of-opportunity.

4.2.2 Specification Performance Related Requirements

4.2.2.1 ASR-11 Related Performance Requirements:

The radar low angle coverage requirement for the ASR-11 is as follows:

> **3.1.1d.** From local radar horizon as determined by earth curvature, atmospheric refraction, and as further limited by terrain screening to 30° with respect to the horizontal plane at the radar antenna.

The MSSR low angle coverage requirement for the ASR-11 is as follows:

> **3.2.2.3d.** From 0.25° above local radar horizon as determined by earth curvature, atmospheric refraction and as further limited by terrain screening to 40° with respect to the horizontal plane at the radar antenna

4.2.2.2 ASR-9 Related Performance Requirements:

There are no specific low angle coverage requirements on the ASR-9.

4.2.3 Test Description: Data from each site is analyzed using IRES to determine reinforcement rate versus elevation angle.

4.2.4 4 Limitations in applying results directly to related requirements: Testing is conducted on targets of opportunity. There are no controls on aircraft radar cross section. Radars whose coverage areas have more small cross section aircraft would tend to have lower reinforcement rates. Overall reinforcement rates tend to be lower for radar coverage areas where aircraft are lower and further away.

4.2.5 Discussion/Results: Table 4.2-1 shows reinforcement rates versus angle for all six sites. Sites 2 and 2a represent the same site in clear and severe weather conditions. Figures 4.2-1 thru 4.2-7 show Range Height Indicator graphs depicting radar reinforcement versus angle. Black dots represent reinforce targets. Blue dots represent Beacon Only targets. No altitude is provided in Radar Only and Radar Correlated target reports (and therefore they are not included in the figures). Altitudes shown are thousands of feet above Mean Sea Level (MSL) as reported by the target aircraft transponders. The angles shown on the right represent degrees from the radar horizon. The level for zero degrees was determined by adding the antenna height above the runway to the mean altitude reported by aircraft on the runway. This is necessary to account for local barometric pressure effects on reported aircraft altitude. (Aircraft altitude is always reported against a standard pressure of 29.92 inches.)

All sites show good reinforcement rates down to low elevation angles. The lowest reinforcement rates were for site 3. Review of data for site 3 shows that 55% of air traffic is at elevation angles

of less than 1 degree and 7.2% is at distances greater than 55 nautical miles. Site 2 demonstrates the best low angle coverage with a 91.31% reinforcement rate at elevation angles between .25 and .5 degrees in elevation.

	Reinforcement Rate %						
Angle	Site 1	Site 2	Site 2a	Site 3	Site 4	Site 5	Site 6
1-20 degrees	94.82	98.17	95.46	92.62	95.6	97.47	98.24
.5- 1 degrees	89.45	96.77	92.67	82.63	91.83	92.29	94.26
.25-.5 degrees	86.87	91.31	87.95	77.78	86.91	82.05	82.57
0-.25 degrees	67.55*	81.92	75.24	58.53	77.97*	63.27*	79.10*
All angles	91.32	94.00	90.56	81.3	90.92	95.6	96.06

*small sample size due to length of data recording-

TABLE 4.2-1. Reinforcement Rates versus Elevation Angle

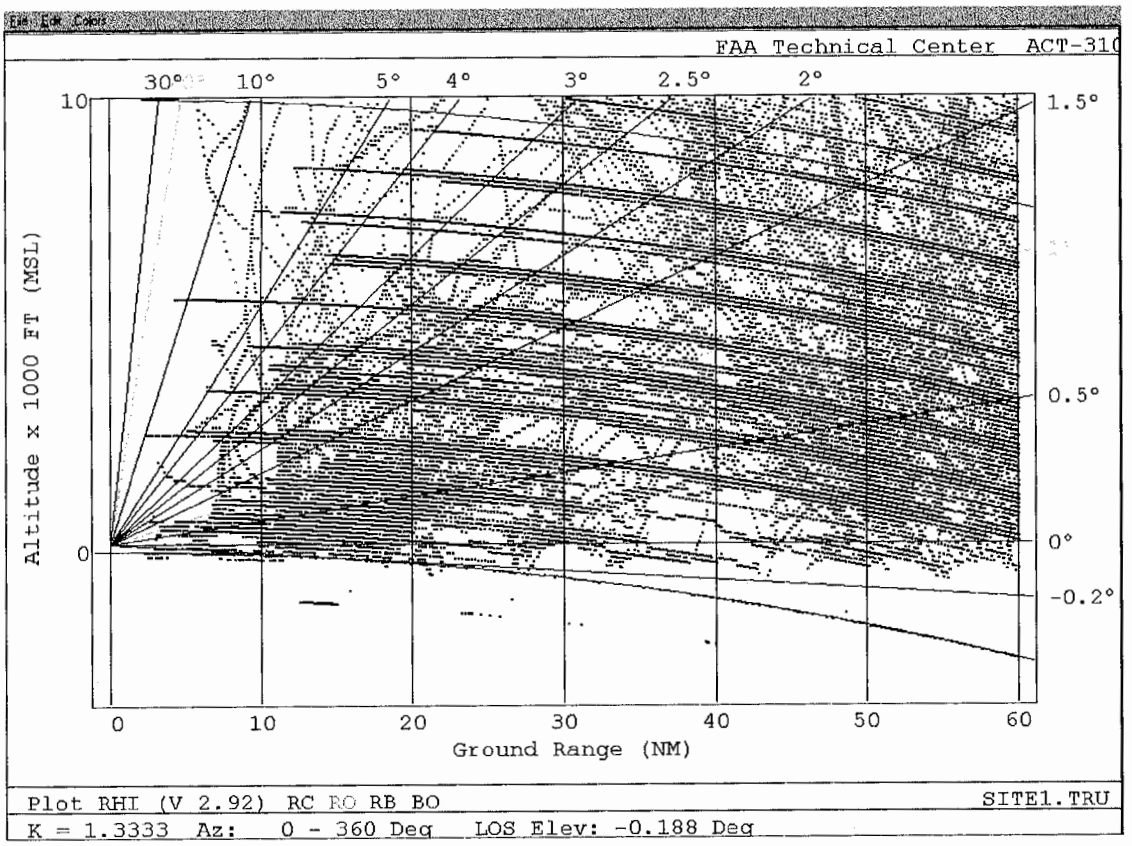


Figure 4.2-1. Range Height Indicator display – Low angle coverage

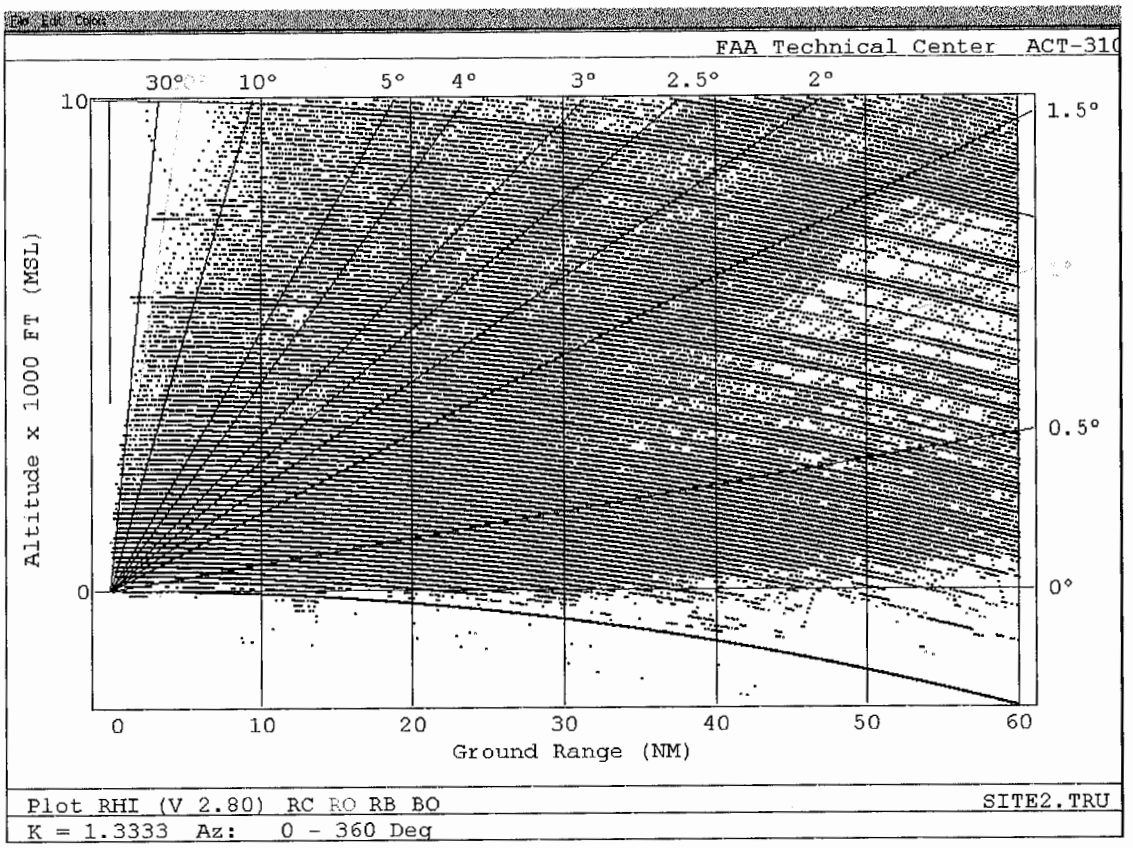


Figure 4.2-2. Site 2 – clear conditions – Range Height Indicator display low angle coverage

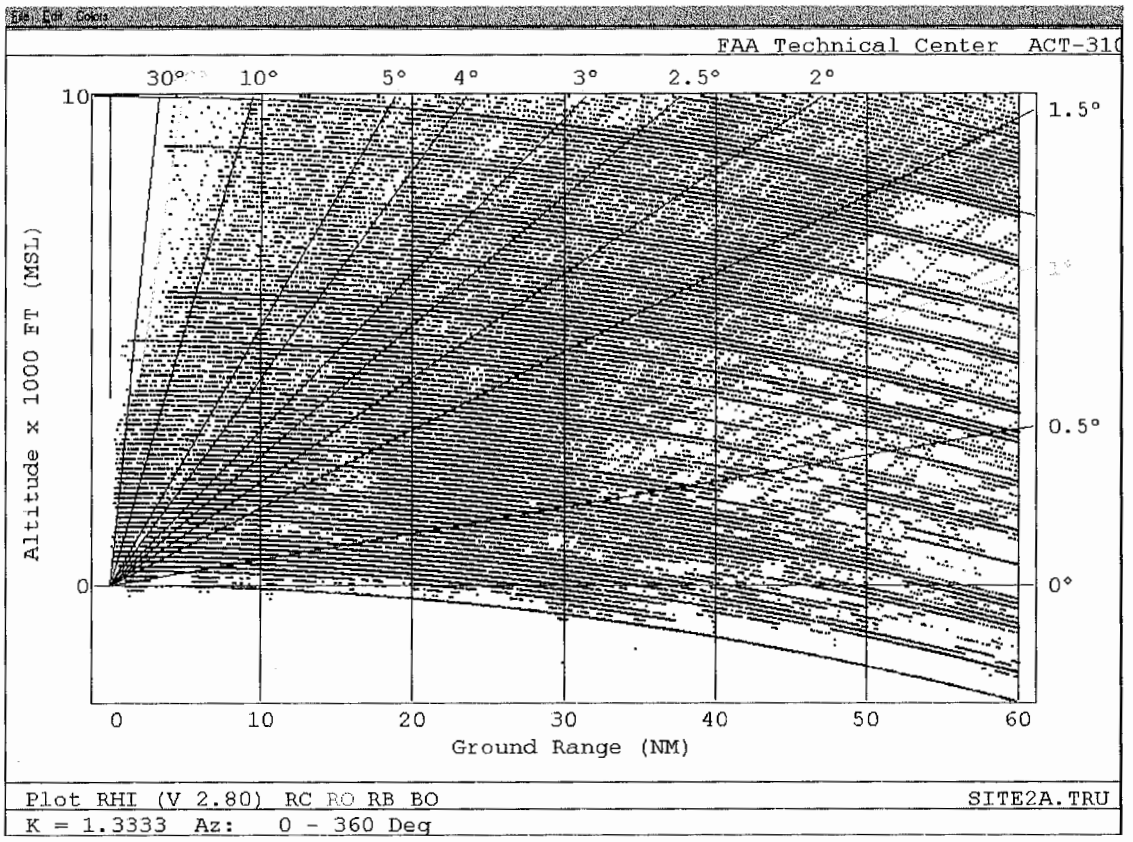


Figure 4.2-3. Site 2 – Intense weather and AP – Range Height Indicator – Low Angle

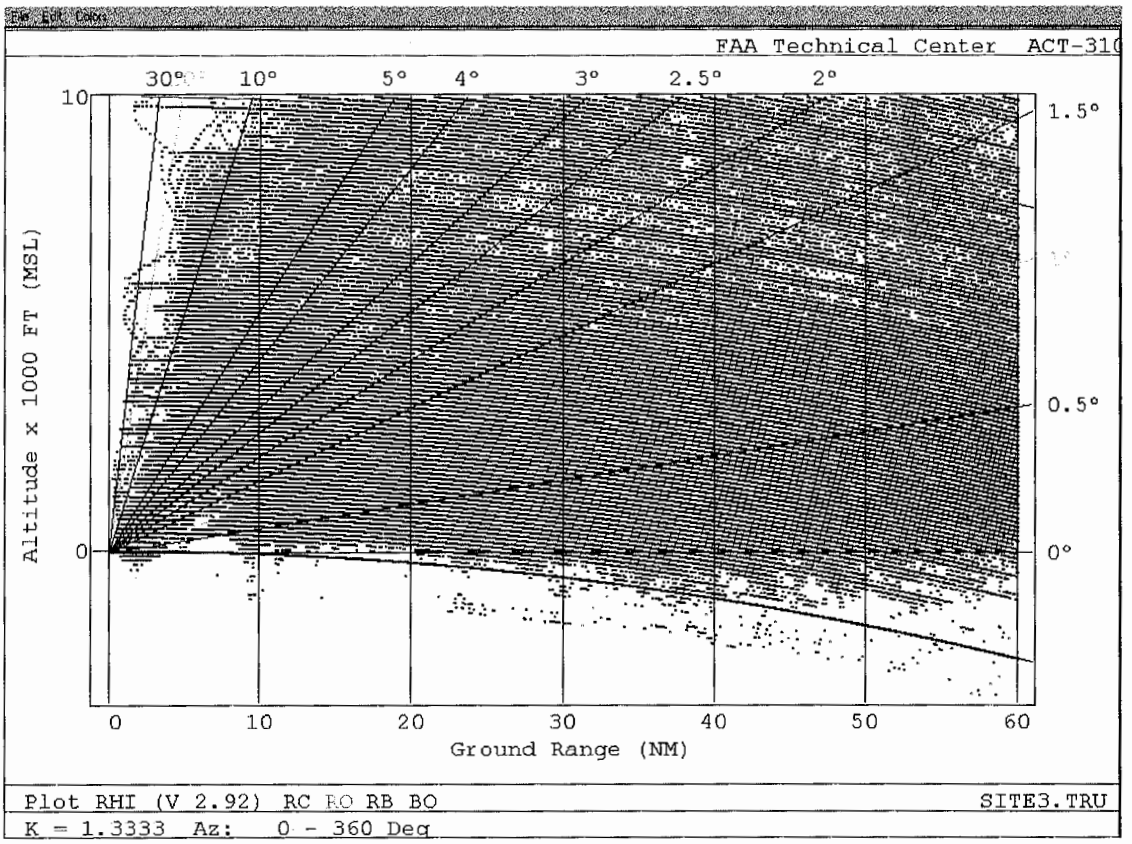


Figure 4.2-4. Site 3 – Range Height Indicator display – Low angle coverage

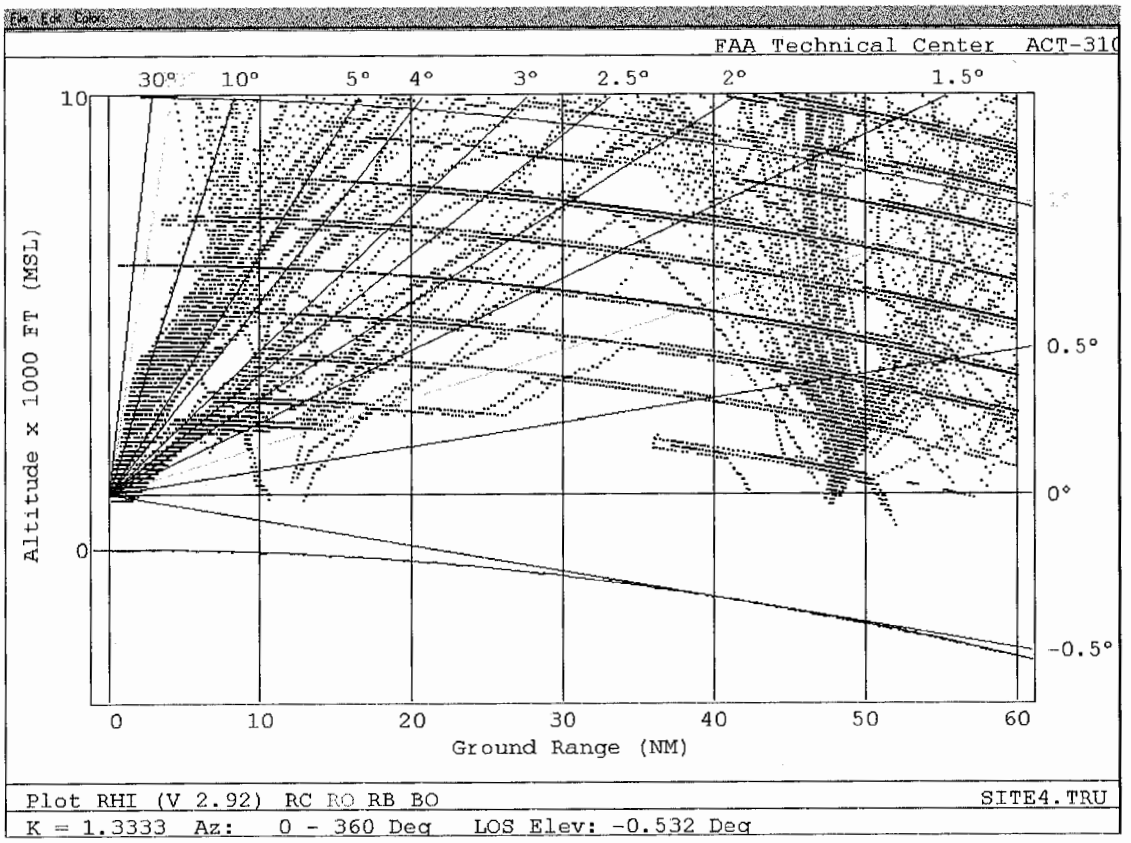


Figure 4.2-5. Site 4 – Rang Height Indication display – Low angle coverage

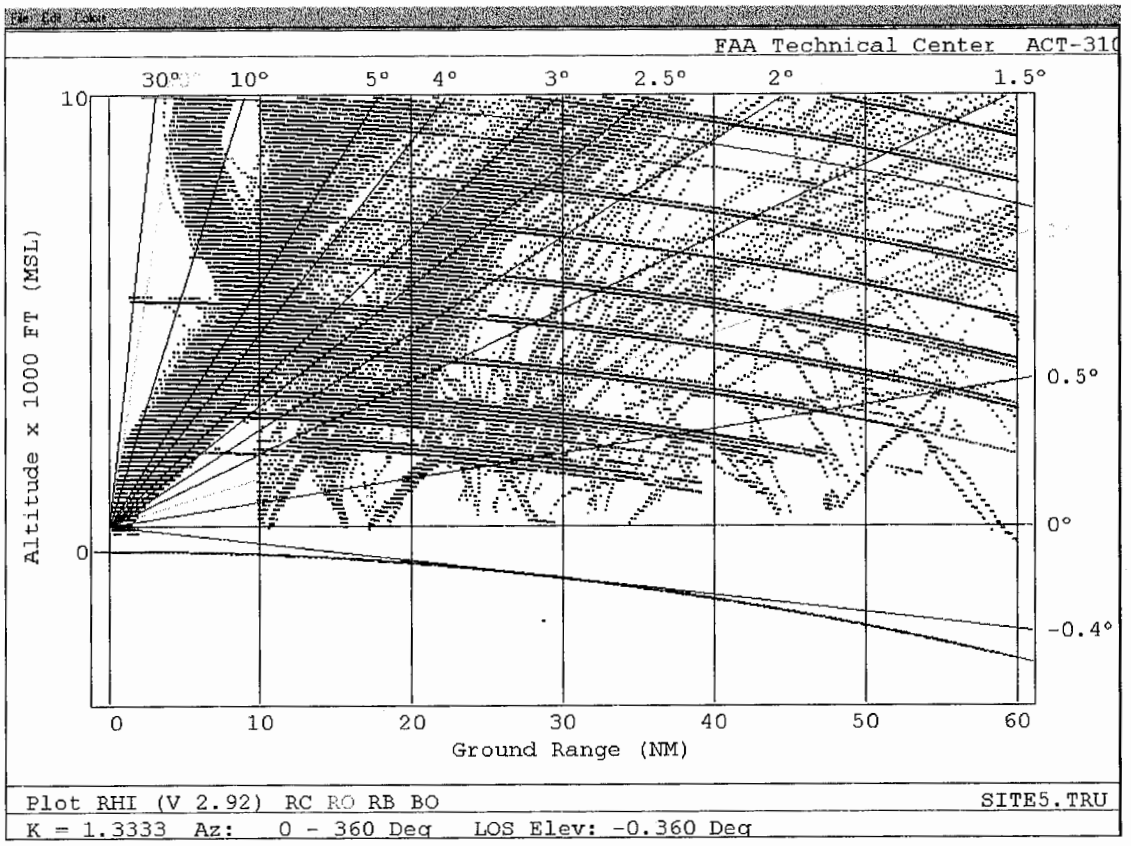


Figure 4.2-6. Site 5 - Range Height Indicator display – Low angle coverage

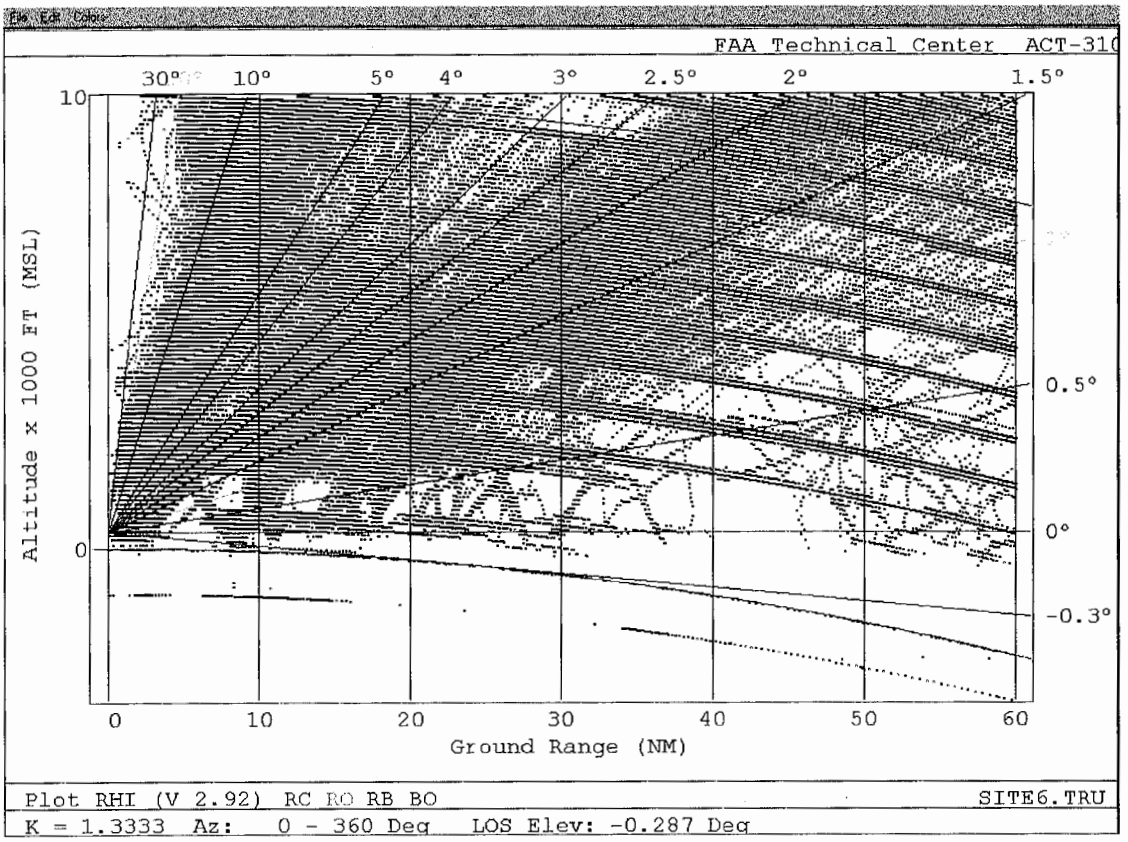


Figure 4.2-7. Site 6 – Range Height Indicator display – Low Angle Coverage

4.3 Beacon False Target Analysis

4.3.1 Test Objective: Measure the false target performance of the Secondary Surveillance Radars used with the ASR-9.

4.3.2 Specification Performance Related Requirements

4.3.2.1 ASR-11 Related Performance Requirements:

3.4.2.4 <u>MSSR False Target Report</u>

a. The MSSR ***Shall [RSS-0596.0]*** report no more than one false target report per scan when averaged over 15 minutes in the steady-state FRUIT condition of 10,000 ATCRBS and 200 Mode-S FRUIT per second of which 30% are in the mainbeam.

b. The MSSR ***Shall [RSS-0597.0]*** generate no more than one split target per scan when averaged over 15 minutes. This includes single aircraft beacon's discrete Mode 2 and Mode 3 replies and nondiscrete replies.

c. The MSSR ***Shall [RSS-0598.0]*** report no more than one false target report per scan averaged over 15 minutes due to reflections of the mainbeam caused by permanent or temporary reflecting objects.

4.1.2.2 ASR-9 Related Performance Requirements:

3.4.3.4.8 False Reports. - The BTD shall produce no more than one false target report per scan. This is an overall requirement and shall be met in the steady-state fruit condition of 10,000 fruit replies per second, with any or all target conditions permitted herein, other than a mix of aircraft in which the number of nondiscrete Mode 2 or 3/A aircraft exceeds 30 percent of the total of beacon-equipped aircraft. In addition, the BTD shall detect and report civil emergency Mode 3/A codes 7500, 7600, and 7700 and military emergency (four code train in trail) in a manner so that no more than one false emergency report is reported per 48 hours, averaged over a 30-day period during these same conditions.

4.3.3 Test Description: Data collected from six sites with diverse ground clutter conditions and varied environmental conditions was analyzed using the Beacon False Target Summary utility of the RBAT tool set. The Beacon False Target Summary provides a measure of beacon false targets in the environment classified by type of false target. It addresses only discrete beacon code aircraft and as such does not include false target data for non-discrete code false alarms. The total number of false targets is divided by the number of scans to determine the number of beacon false targets per scan. The number of discrete and non-discrete beacon targets is determined for each site assess whether or not the results can be applied to the target population which contains both discrete and non-discrete targets.

4.3.4 Limitations in applying results directly to related requirements: Data was collected using targets of opportunity. As such, there is no method of ensuring proper performance of the beacon transponders on the target aircraft. FRUIT environment is unknown. RBAT Beacon False Target summary bases its analysis on aircraft using discrete beacon codes. Values calculated represent the average false alarm rate rather than the peak of the false alarm rates averaged over 15 minutes.

4.3.5 Discussion/Results: The results of the Beacon False Target summary are provided in Table 4.3-1. Table 4.3-2 show the distribution of discrete and non-discrete targets for each site. The maximum false target rate per scan is at site 5 with a false target rate of .236 false targets per scan. At this site, 99.4% of the targets were discrete targets and therefore the results are representative of the total target population. The lowest false target rate was observed at site 1 with a false target rate of .004 false targets per scan. 94.7% of the targets were discrete at Site 1, thereby demonstrating results representative of the total target population.

	Site 1		Site 2		Site 2a		Site 3		Site 4		Site 5		Site 6	
Category	**Number**	**Percent**	**Number**	**Percent**	**Number**	**Percent**	**Number**	**Percent**	**Number**	**Percent**	**Number**	**Percent**	**Number**	**Percent**
Split	10	.01	159	.07	134	.06	264	.06	7	.02	75	.05	93	.03
Ringaround	0	.00	6	.00	17	.01	4	.00	13	.03	76	.05	49	.02
Down reflection	2	.00	10	.00	12	.01	15	.00	0	.00	23	.02	65	.02
PRF	0	.00	99	.04	271	.12	11	.00	0	.00	3	.00	1	0
Upreflection	0	.00	161	.07	480	.21	99	.02	12	.03	313	.21	69	.02
ATCRBS/ Mode S	0	.00	0	.00	0	.00	0	.00	0	.00	0	0	0	0
Other	0	.00	0	.00	0	.00	0	.00	0	.00	0	0	0	0
Total	12	.01	435	.18	914	.41	393	.09	32	.07	490	.32	277	.09
Overall Average False Targets per Scan	**.004**		**.102**		**.0954**		**.0655**		**.0132**		**.236**		**.054**	

TABLE 4.3-1. Beacon False Target Summary Analysis for ASR-9 sites

	Site 1		Site 2		Site 2a		Site 3		Site 4		Site 5		Site 6	
	Number	**Percent**	**Number**	**Percent**	**Number**	**Percent**	**Number**	**Percent**	**Number**	**Percent**	**Number**	**Percent**	**Number**	**Percent**
Discrete	133604	94.7	209293	65.8	145200	86.2	459503	54.1	43277	97.6	148971	99.6	324540	96.8
Non-Discrete*	7437	5.3	108867	34.2	23258	13.8	389846	45.9	1056	2.4	563	.4	10900	3.2

***Non-discrete based upon whether or not discrete bit was set in the target message**

TABLE 4.3-2. Beacon Target Distribution

4.4 Primary Radar False Target Rates

4.4.1 Test Objective: To determine the primary radar false plot and false track rates for operational ASR-9 radar sites using targets-of opportunity under varying ground clutter and weather conditions.

4.4.2 Specification Performance Related Requirements

4.4.2.1 ASR-11 Related Performance Requirements:

3.4.2.1 **PSR Scan-to-Scan Correlated Target Reports.** Scan-to-scan correlation ***Shall [RSS-0528.0]*** be used to reduce false alarms and assure a high confidence in reported aircraft targets with velocities of 25 to 700 knots and maneuvering up to 1g of centripetal or linear acceleration as follows:

a. Report no more than one false scan-to-scan correlated search report per scan averaged over 15 minutes under normal clutter conditions. Normal clutter conditions include thermal noise, terrain, stationary discretes, sea, and distributed rain.

b. Report no more than 10 false scan-to-scan correlated search reports per scan averaged over 10 scans when the clutter environment exceeds normal conditions. Excessive clutter conditions include surface vehicles, anomalous propagation, angels, and cellular rain.

3.4.2.3 **PSR Uncorrelated Target Reports.** The PSR ***Shall [RSS-0567.0]*** report targets prior to scan-to-scan correlation with a maximum of 100 false search reports per scan in three consecutive scans in normal and excessive clutter conditions.

4.1.2.2 ASR-9 Related Performance Requirements:

3.12.5 Surveillance Processor - ... The Surveillance Processor shall output fewer than 1.0 false scan correlated radar target reports per scan averaged over a 1 hour period, during normal operating conditions. The peak rate of display of false scan correlated radar targets shall be fewer than ten per scan averaged over one hour, under extreme conditions of "angel" activity or ducting

Note: There is no false plot requirement in the ASR-9 specification

4.4.3 Test Description: Data collected from six sites with diverse ground clutter conditions and varied environmental conditions is analyzed using the IRES tool set to determine the maximum number of false tracks per scan (averaged over 10 scans) and false plots per scan (averaged over three scans). Since the ASR-9 data is collected before the ASR-9 Surveillance and Communications Interface Processor (SCIP), it was not subjected to target report quality filtering by the SCIP. False plot and false track rates are also calculated with simulated quality zero filtering, as quality zero filtering of plots is a recommended filter setting for fielded ASR-9 systems (Re: Site Technical Bulletin STB-004). Total plot, track, reinforced and beacon only reports are graphed versus scan count. False track rates are graphed versus scan count.

4.4.4 4 Limitations in applying results directly to related requirements: Test method is the same that will be used during ASR-11 Operational Testing. False plot rates are averaged over three scans rather than finding the maximum for three scans.

4.4.5 Discussion/Results:

Table 4.4-1 shows a summary of false track rates and false plot rate estimates for all six sites. Site 2 and 2a represent the same site in clear weather and severe weather conditions respectively.

The worst false plot report rates were observed at site 2a under conditions of severe weather and anomalous propagation (AP). At this site, a maximum of 410 false plots per scan (averaged over three scans) were observed without quality zero filtering and 136 false plots per scan with quality zero filtering. Figure 4.4.5-1 shows weather conditions at the time of the worst false plot rate.

The best false plot rates were observed at site 1 under clear conditions with a maximum false plot report rate of 40 false plots per scan without quality zero filtering and 20 false plots per scan with quality zero filtering.

The worst false track report rates were observed at site 2a. Up to 28 false tracks per scan (averaged over 10 scans) observed during conditions of severe storms and anomalous propagation. Figure 4.4.5-2 shows weather conditions at the time the worst false plot rate occurred. Quality zero filtering has minimal effects on false track output at site 2, decreasing the maximum 10 scan average false track rate to 27 (Quality filtering of tracks was not recommended by STB-004).

Graphical representations of target report counts per scan are shown in figures 4.4-1a thru 4.4-7b. The graphs are shown with and without quality zero filtering active. All target report counts in these figures represent both true and false targets. Green dots represent plots (uncorrelated radar), black – reinforced beacon, blue – beacon only, red – radar correlated and yellow – 10 scan average of radar correlated. The graphs for sites 1-5 show that quality zero filtering dramatically helps false plot rates. In site 6 (the 9-PAC phase 2 site), quality filtering does not have as large an effect on false plots rates (quality 0 targets with confidence 0 are pre-filtered in the 9-PAC phase 2 data, therefore a direct comparison with the other sites cannot be made). Site 2a, shown in figures 4.4-3a thru 4.4-3d, represents the worst ASR-9 false plot performance observed.

Graphs of false tracks per scan are shown in figures 4.4-10a. thru 4.4-16b. Red dots represent false track rates per scan. Yellow dots indicate a ten scan average of false tracks. Figures 4.4-10a thru 4.4-10d show site 2a false track performance – the worst ASR-9 false track performance.

Since site 2 false plot and track performance was significantly worse than the other sites, its was evaluated further. Review of overall performance of site 2 shows that it has the best low angle coverage of all six sites (Low angle coverage is addressed in section 4.2 of this report). Site 2 was found to have a high number of aircraft flying without transponders and the highest number of small airports within its coverage volume. Based upon these facts it appears that an increase in false targets reports was accepted as a tradeoff for increased low angle coverage during radar optimization.

Review of site 6 performance shows the improvements of the 9-PAC phase 2 modification. Even though this site shows an output plot rate of up to 220 plot per scan (see figures 4.4-7a and 4.4-7b) , it has the lowest false track rate of all six sites analyzed hitting a maximum of 4 false tracks per scan averaged over 10 scans (see figures 4.4-14a and 4.4-14b). This performance was observed despite a weather environment of significant areas of level 3 weather with weather peaks up to level five. The 9-PAC phase 2 modification appears to achieve its intended function of improved tracker performance while also maintaining a high radar Pd (95.56% per section 4.1 of this report).

Site	Radar Configuration	Antenna Polarization	Weather	AP effects present in data recording	Maximum False Track Rate (10 scan Average)	Maximum False Track Rate with Quality Zero filtering (10 scan average)	Maximun False Plot Estimate (3 scan average)	Maximun False Plot Estimate with Quality Zero filtering (3 scan average)
1	9-PAC Phase 1	Linear	Sporadic level 1, visually observed as cloudy with some sun	No	6	5	40	20
2	9-PAC Phase 1	Linear	Clear and Sunny	No	**12**	**12**	**135**	65
2a	9-PAC Phase 1	Linear changing to circular during data recording	Significant thunderstorm activity over most of the coverage volume with level 6 intensity	Yes	**28**	**27**	**410**	**136**
3	9-PAC Phase 1	Circular	Unknown	No	10	9	64	36
4	9-PAC Phase 1	Circular then changing to linear during the data recording	Unknown	No	9.5	7	**128**	42
5	9-PAC Phase 1	Circular and linear both included during recording	Unknown	No	6	5	86	47
6	9-PAC Phase 2	Linear changing to circular during data recording	Level 2 at beginning of recording increasing to large areas of level three with small areas of intense weather up to level 5	No	4	3	**220**	**180**

TABLE 4.4-1. False Track and False Plot Summaries for Sites 1 thru 6

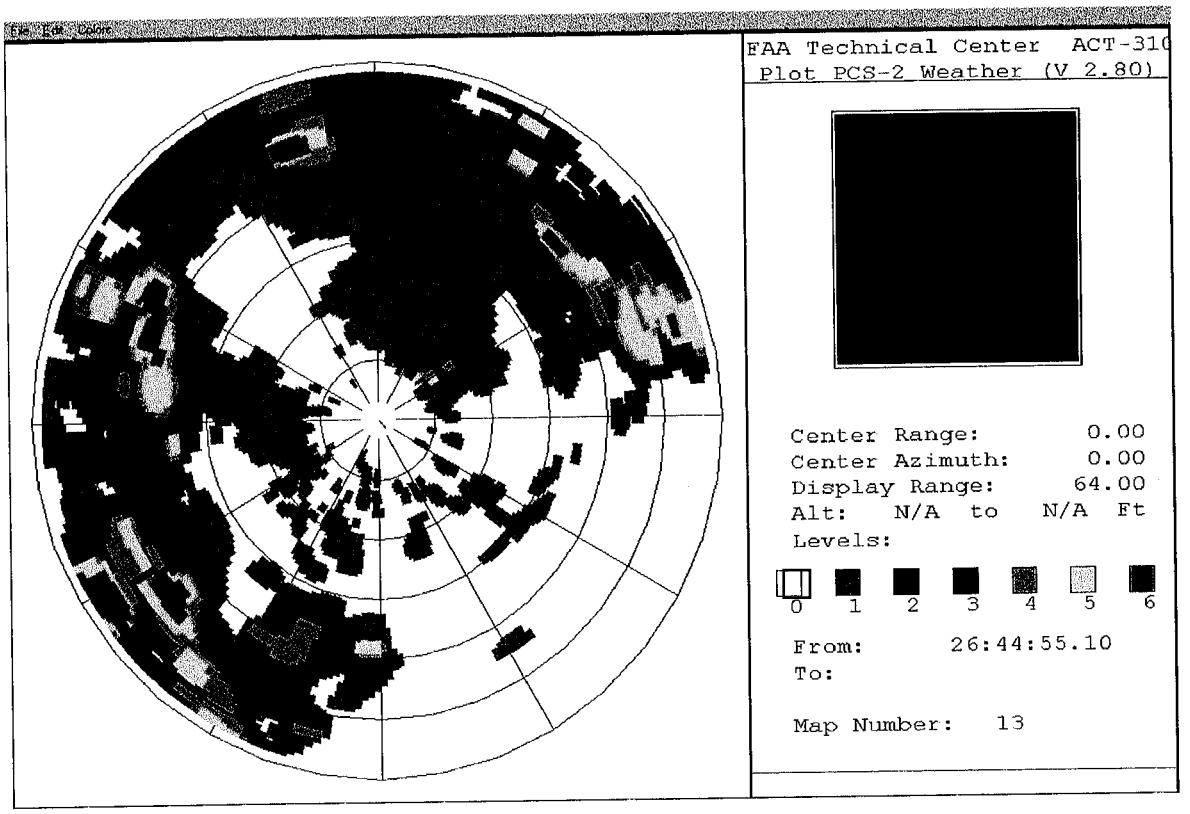


Figure 4.4-1 – Site 2a weather during maximum false plot occurrence

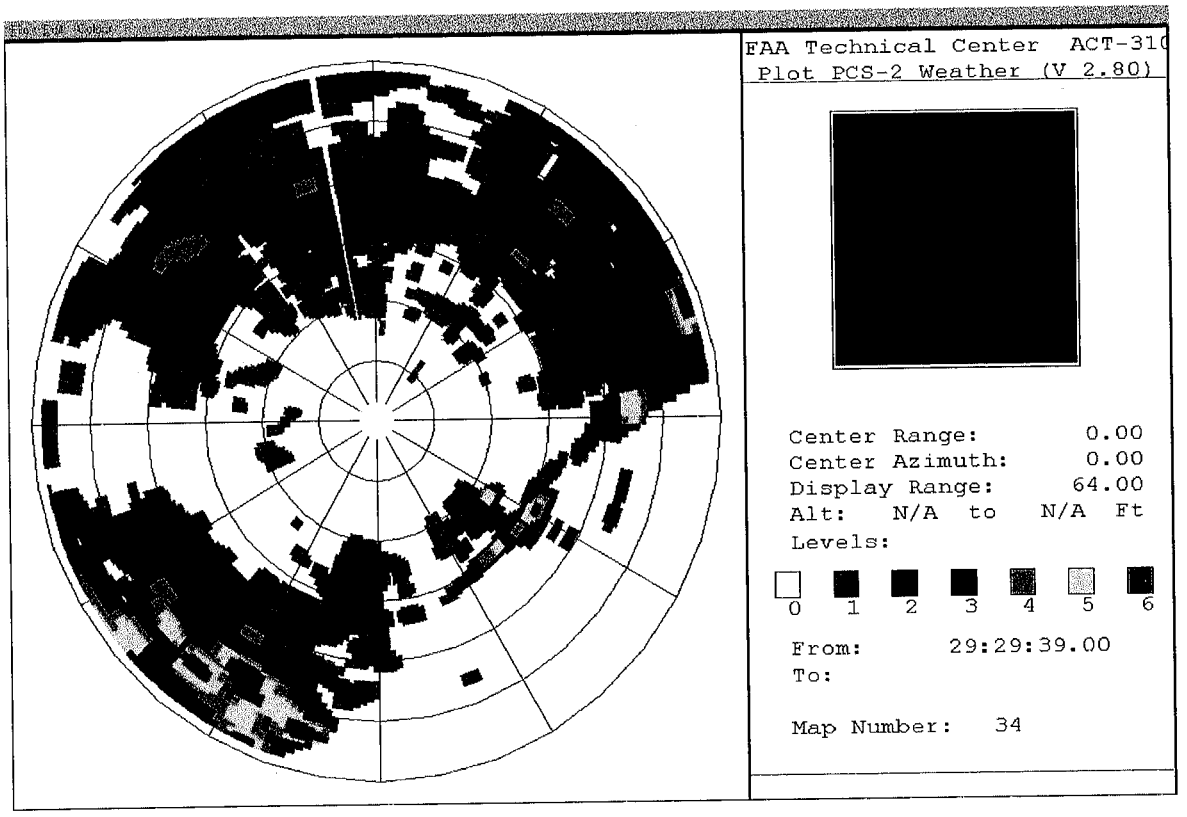


Figure 4.4-2 – Site 2a weather during maximum false track occurrence

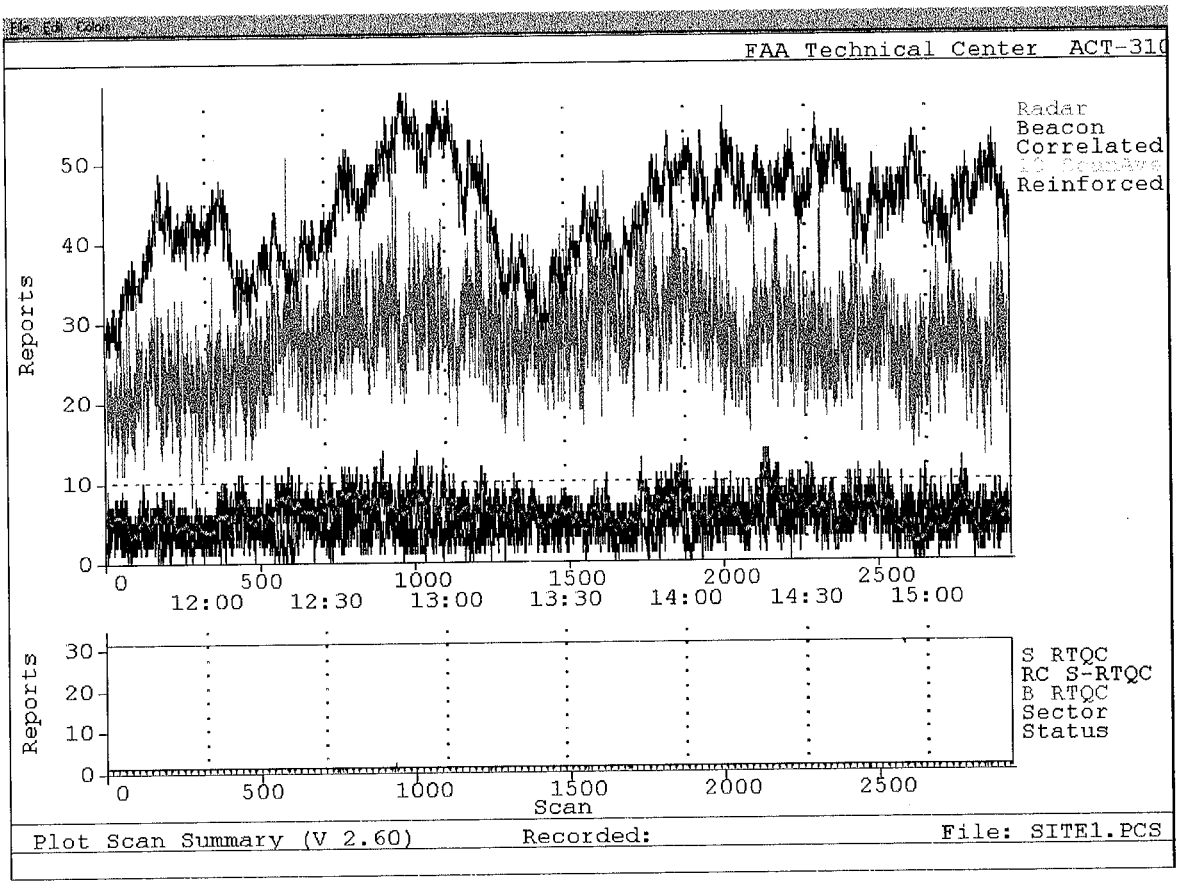


Figure 4.4-3a. Site 1 – Target counts with no quality filtering

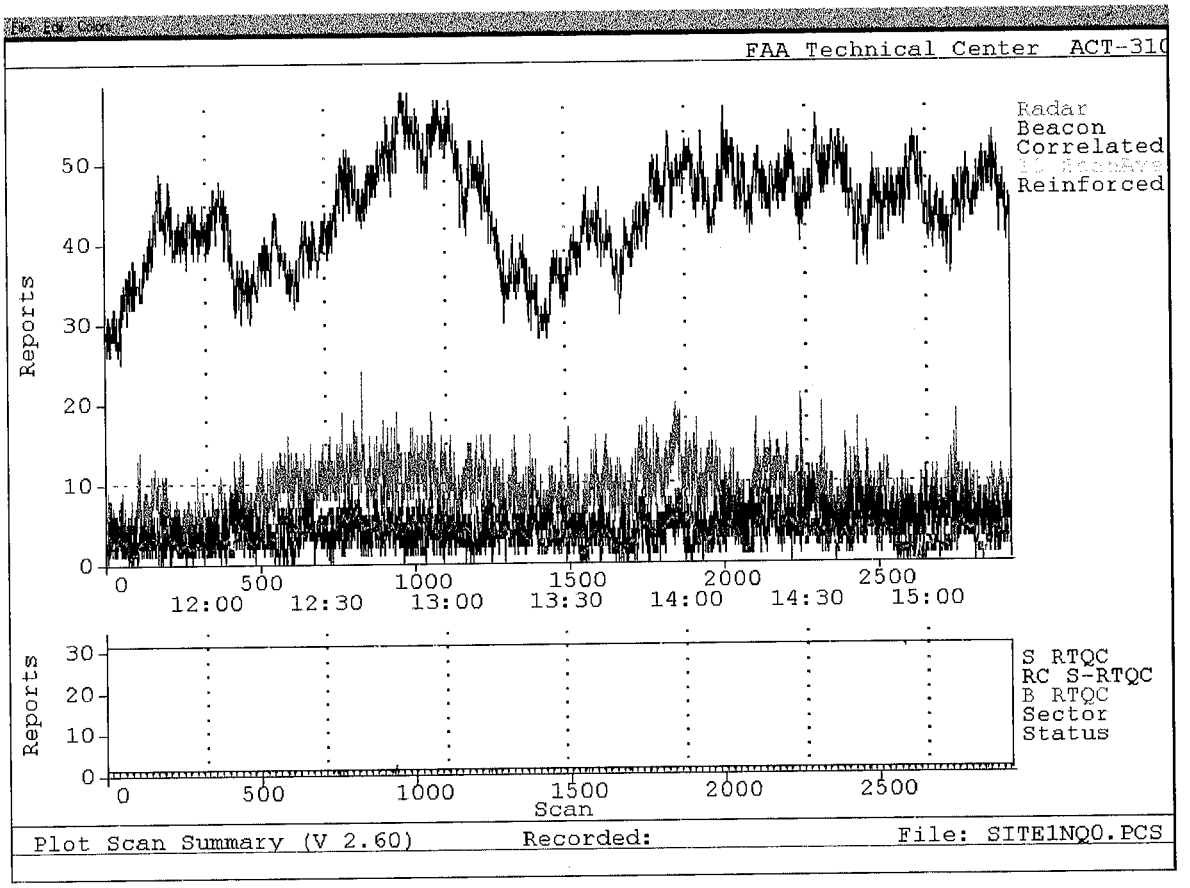


Figure 4.4-3b. Site 1 – Target counts with Quality 0 filtering

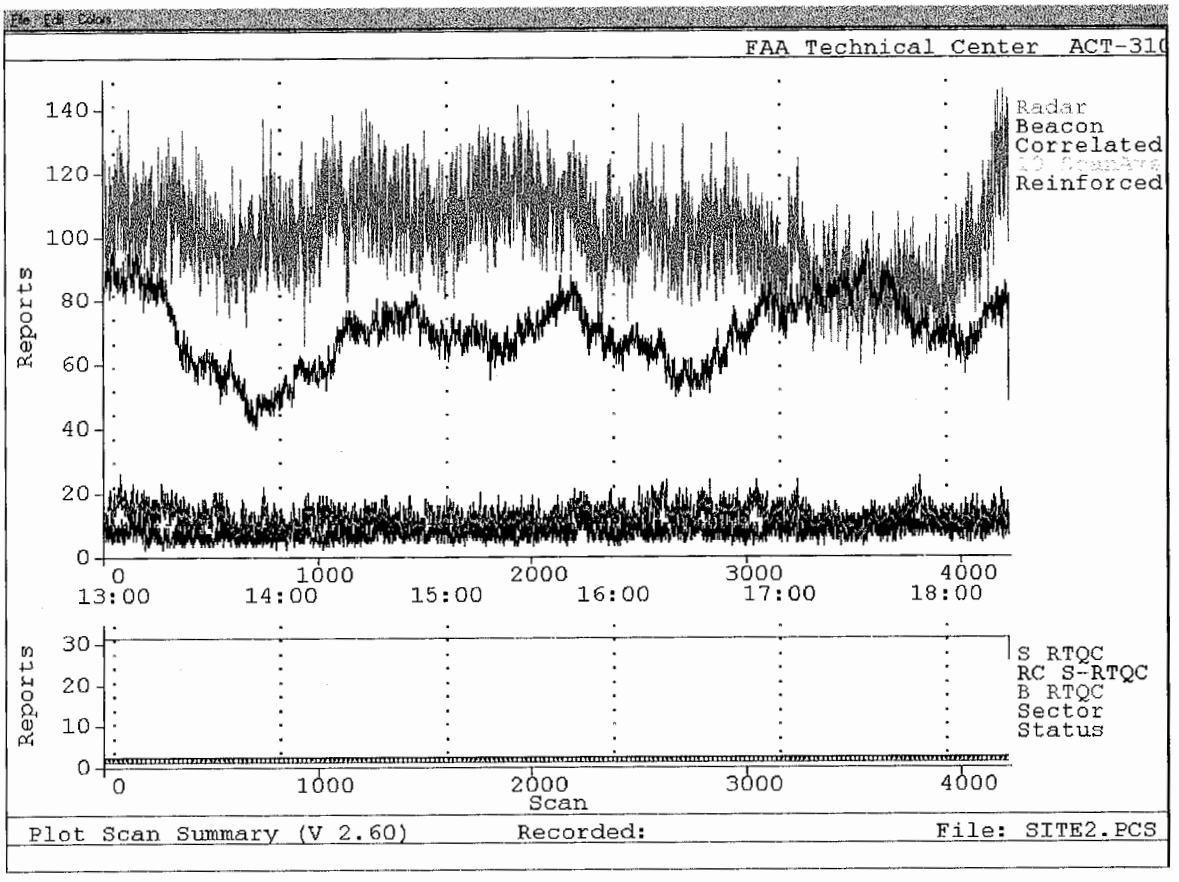


Figure 4.4-4a. Site 2 - clear conditions – Target counts with no quality filtering

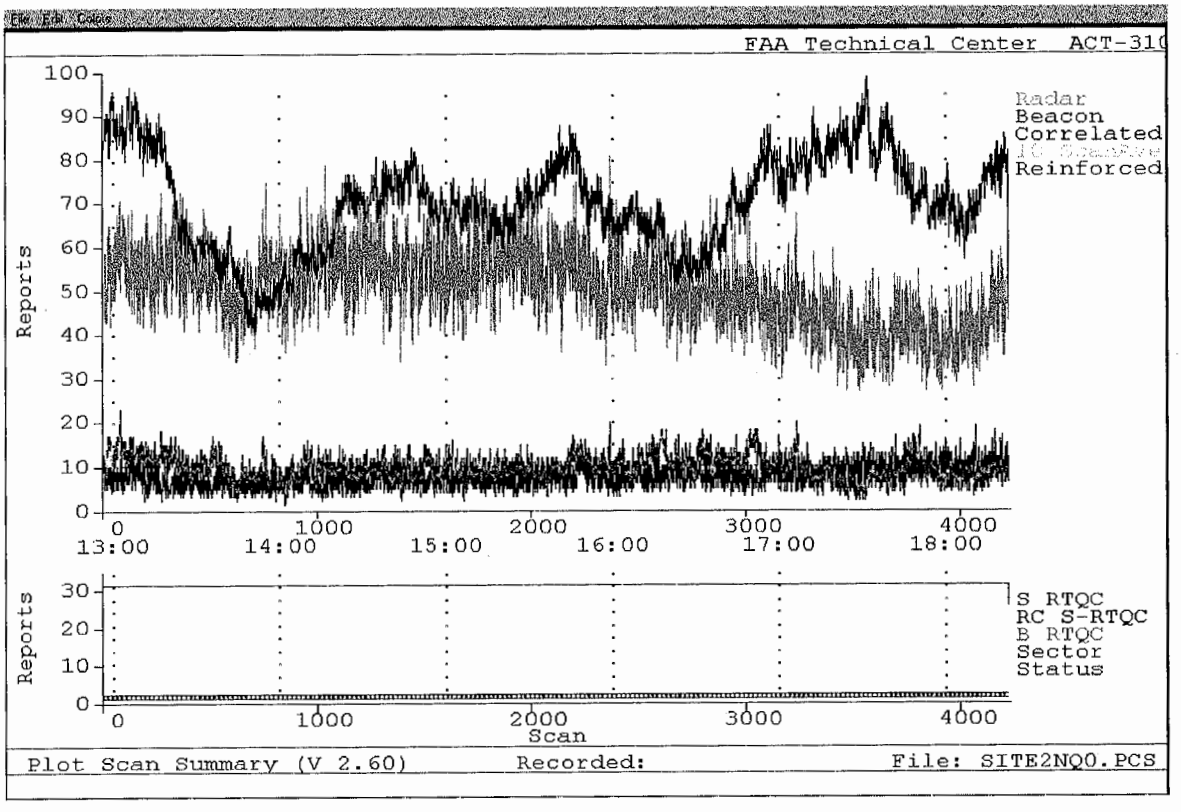


Figure 4.4-4b. Site 2 – clear conditions - Target Counts with quality 0 filtering

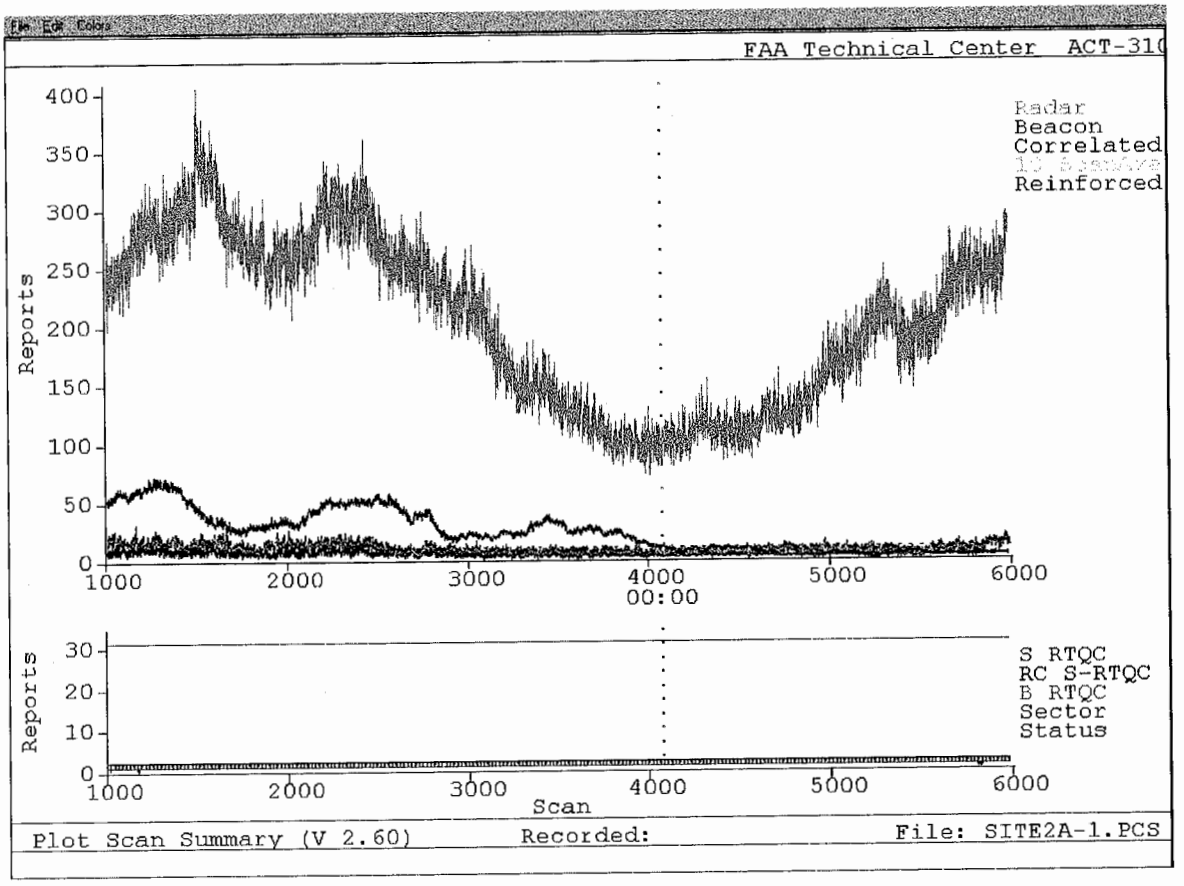


Figure 4.4-5a. Site 2 – Intense Weather and AP – Target Counts with no quality filtering

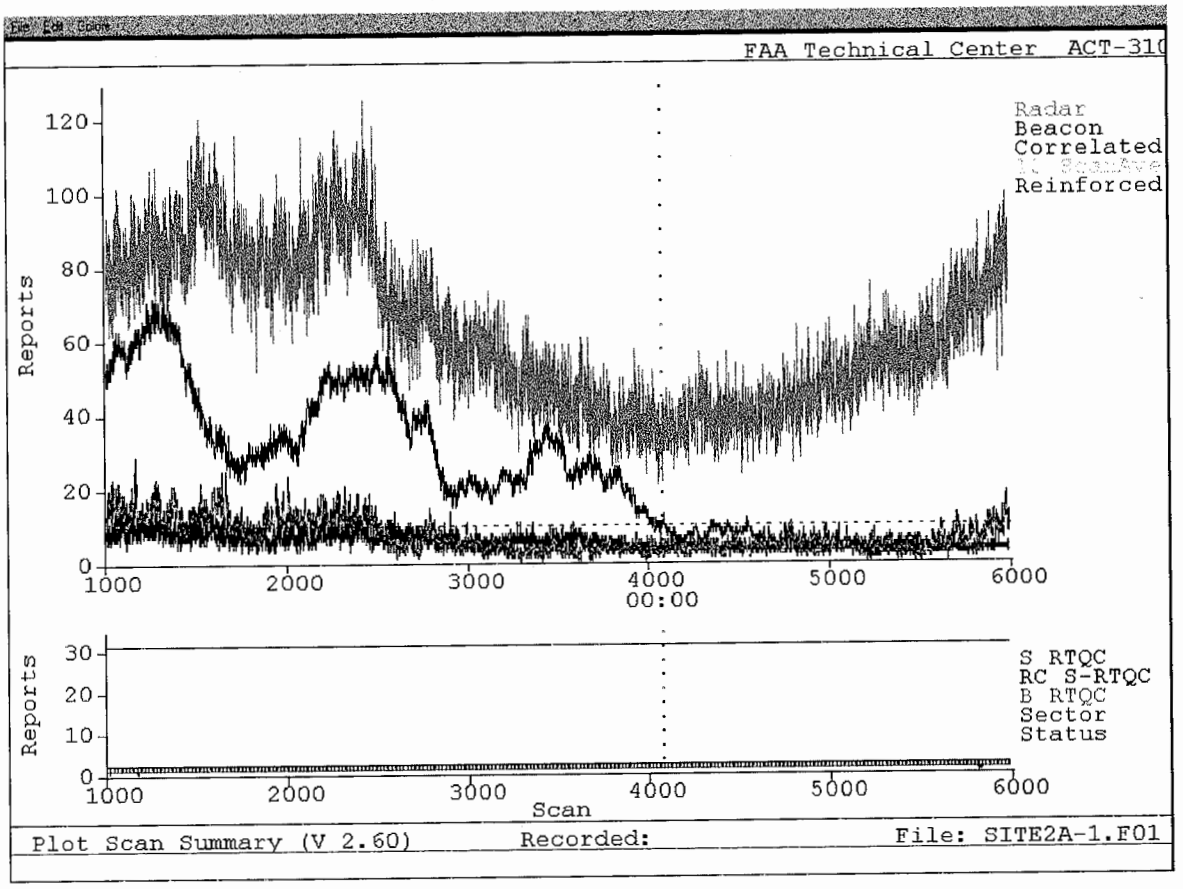


Figure 4.4-5b. Site 2 – Intense Weather and AP – Targets with quality 0 filtering

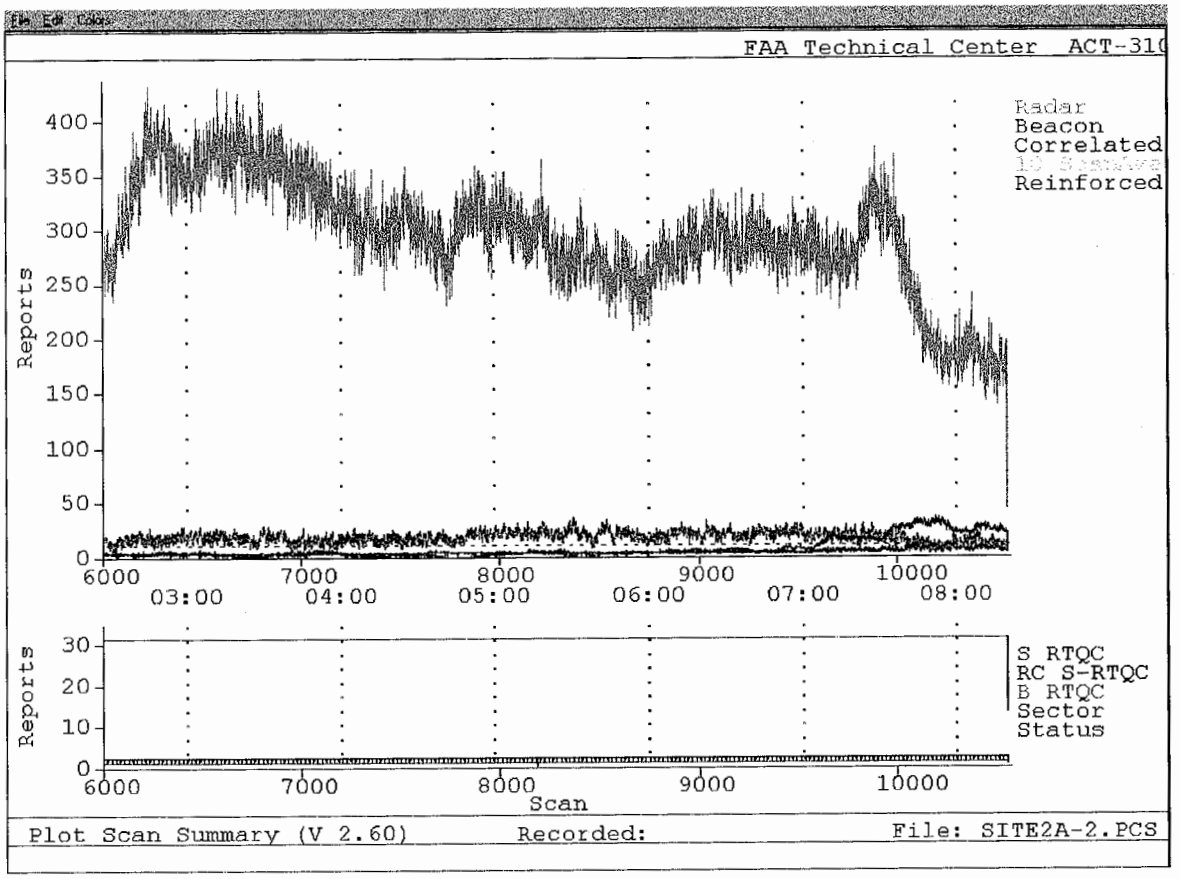


Figure 4.4-5c. Site 2 – Intense Weather and AP – Target Counts with no quality filtering

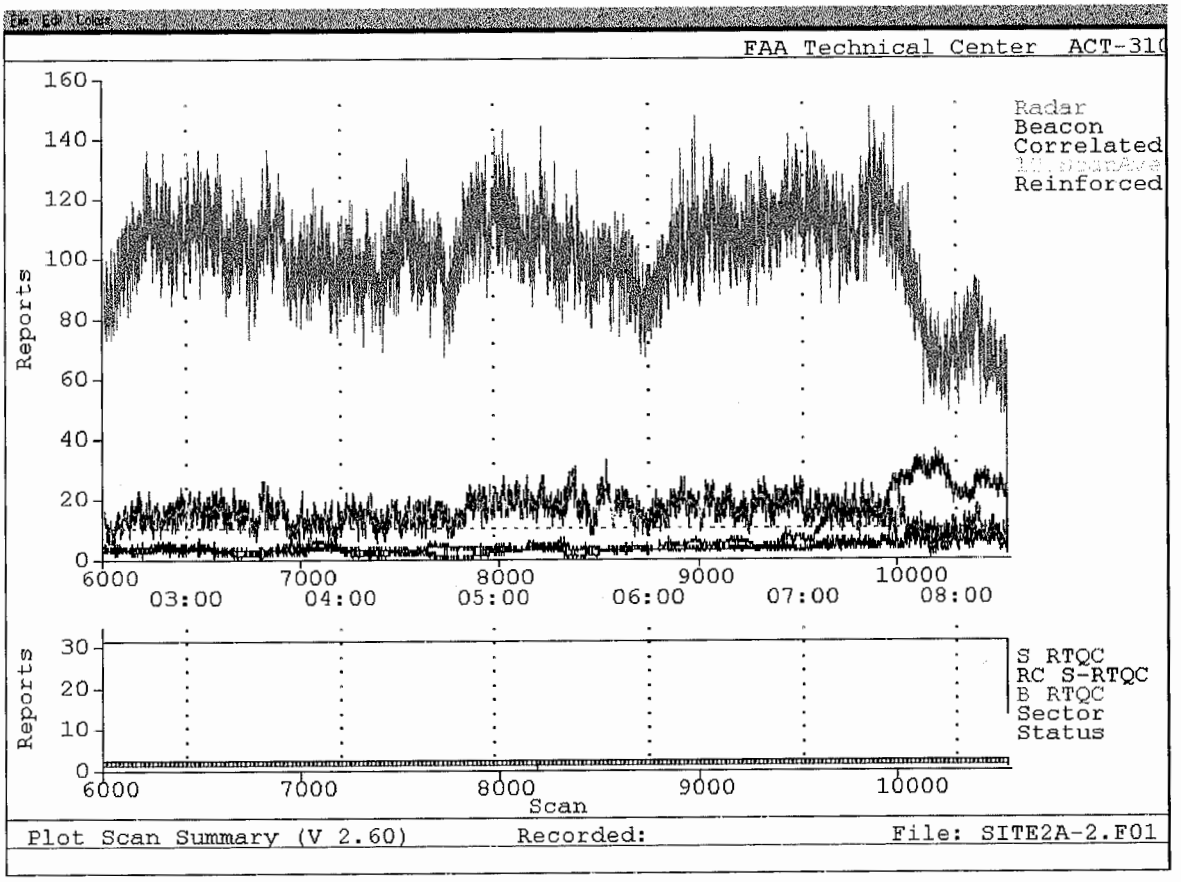


Figure 4.4-5d. Site 2 – Intense Weather and AP – Target Counts with quality 0 filtering

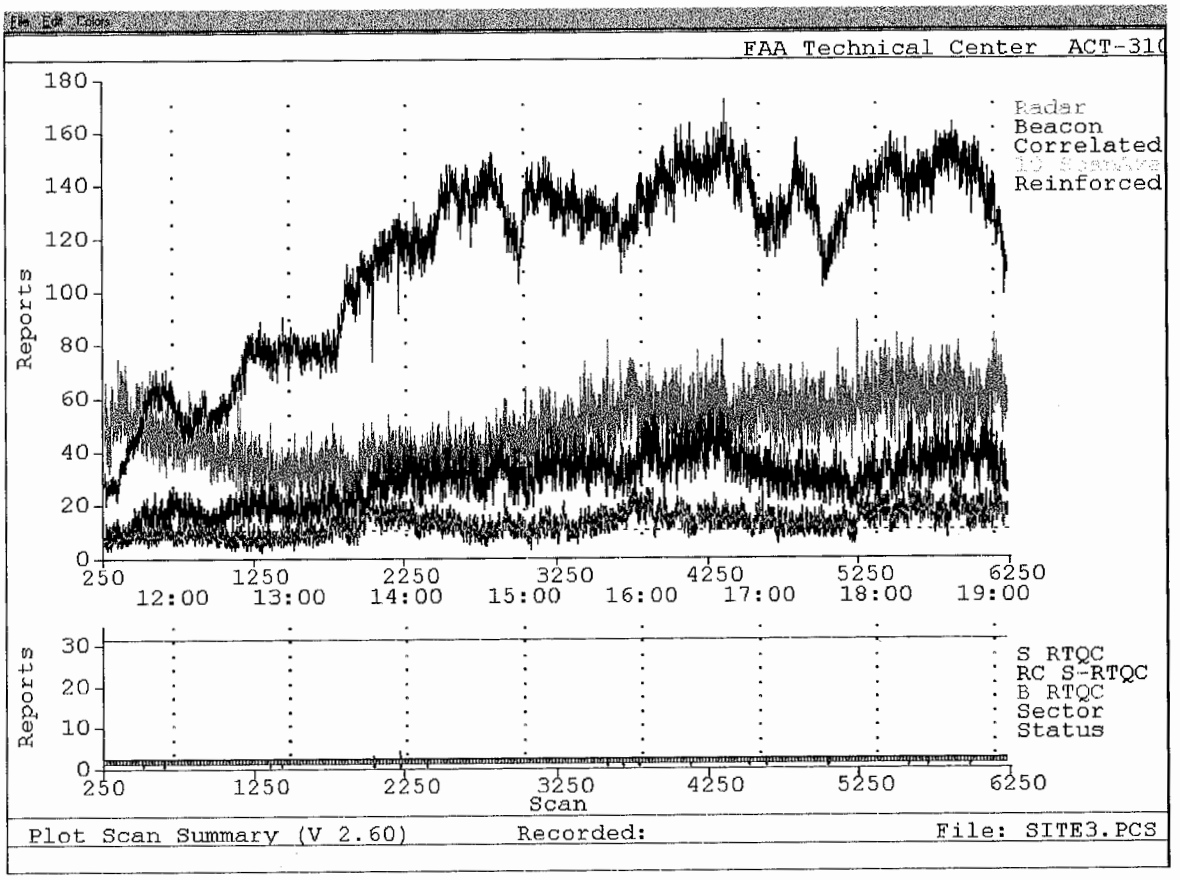


Figure 4.4-6a. Site 3 - Target counts with no quality filtering

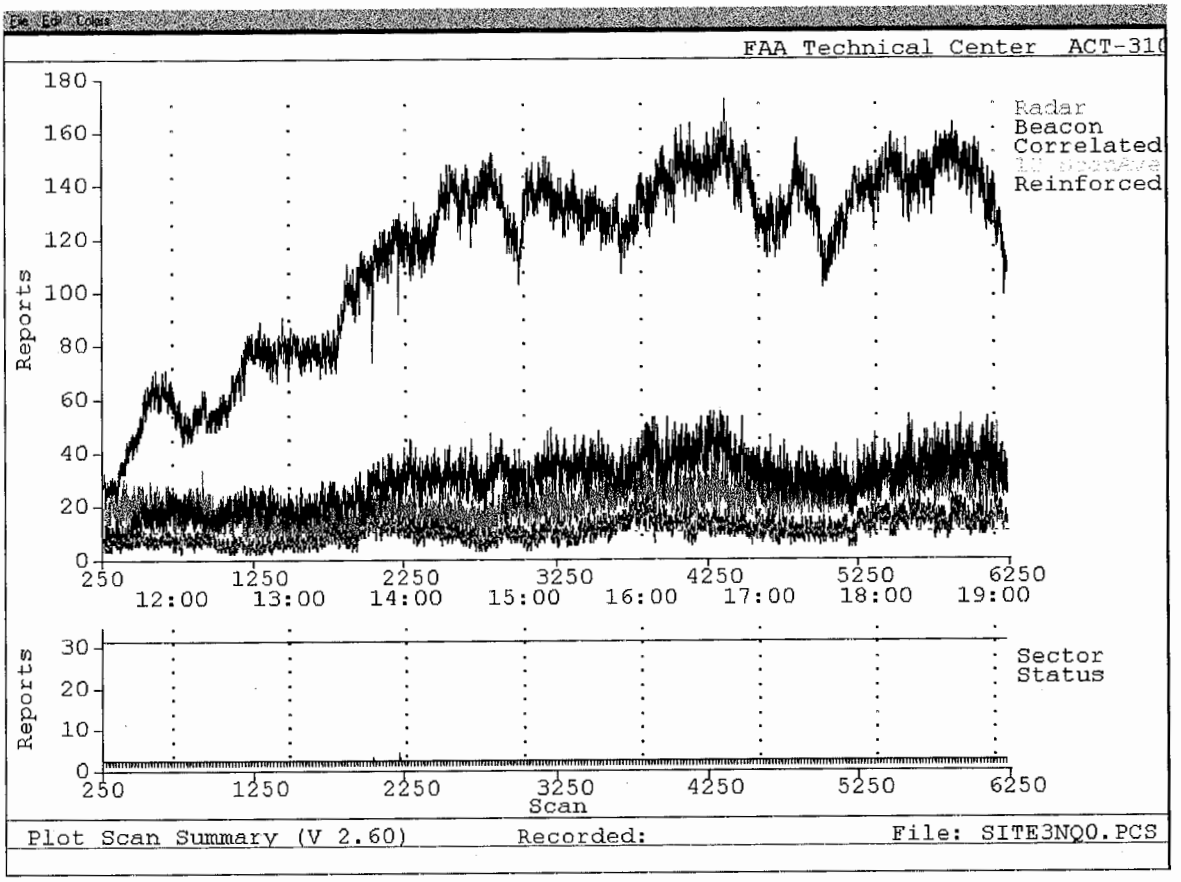


Figure 4.4-6b. Site 3 - Target counts with quality 0 filtering

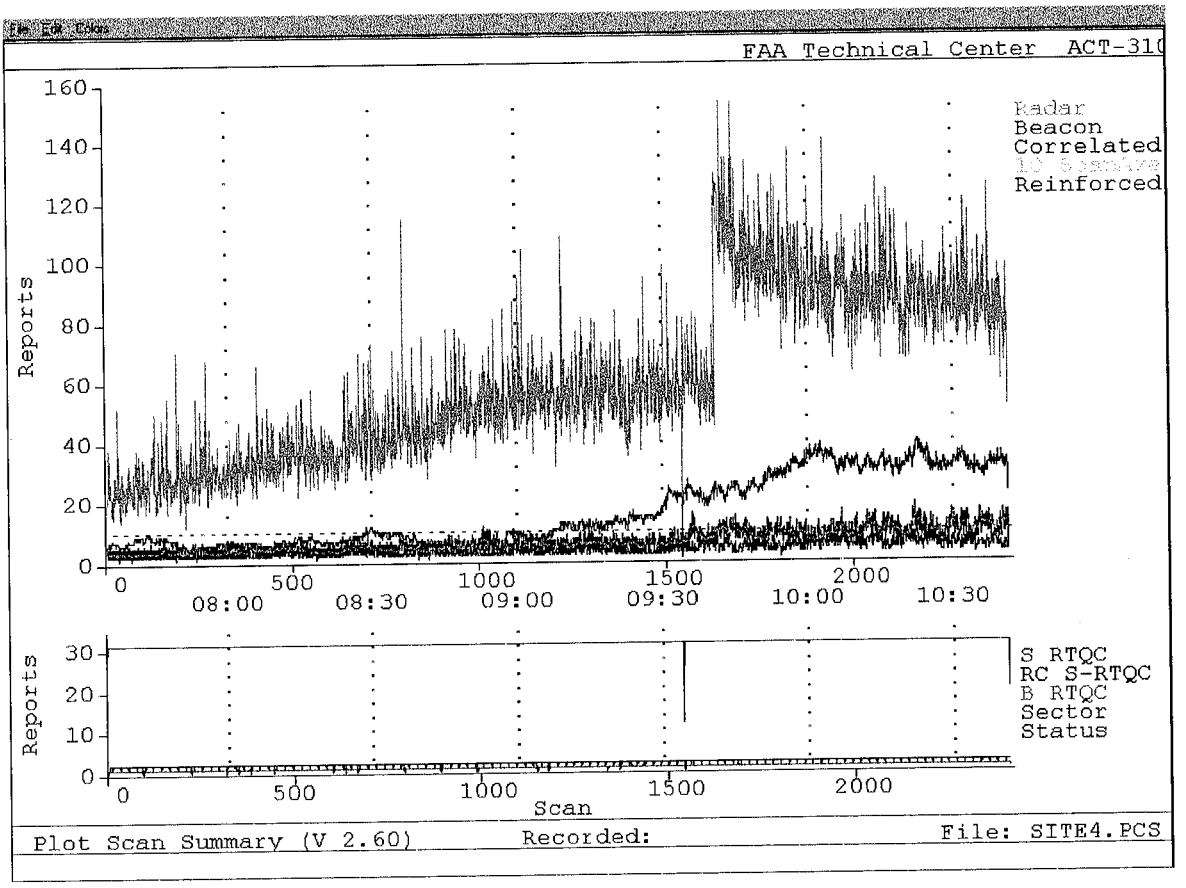


Figure 4.4-7a. Site 4 - Target counts with no quality filtering

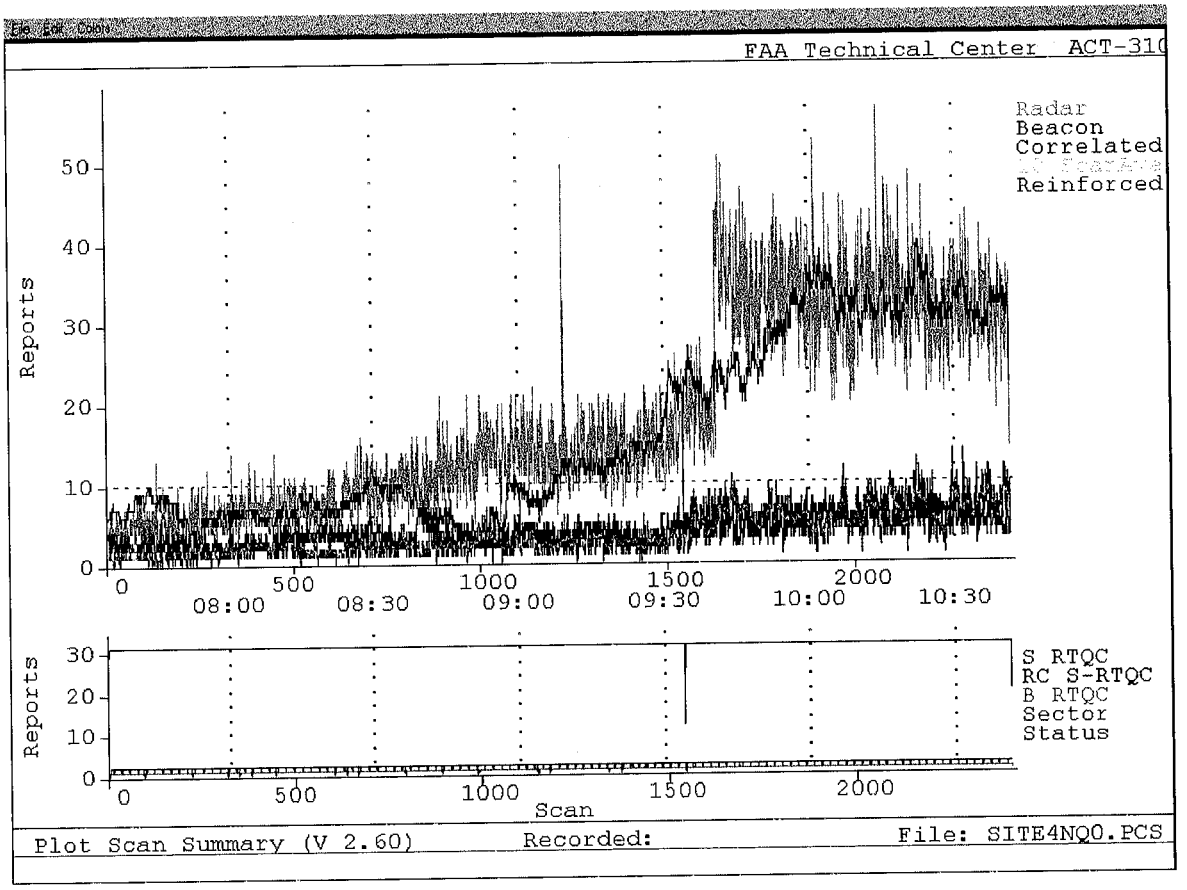


Figure 4.4-7b. Site 4 - Target Counts with quality 0 filtering

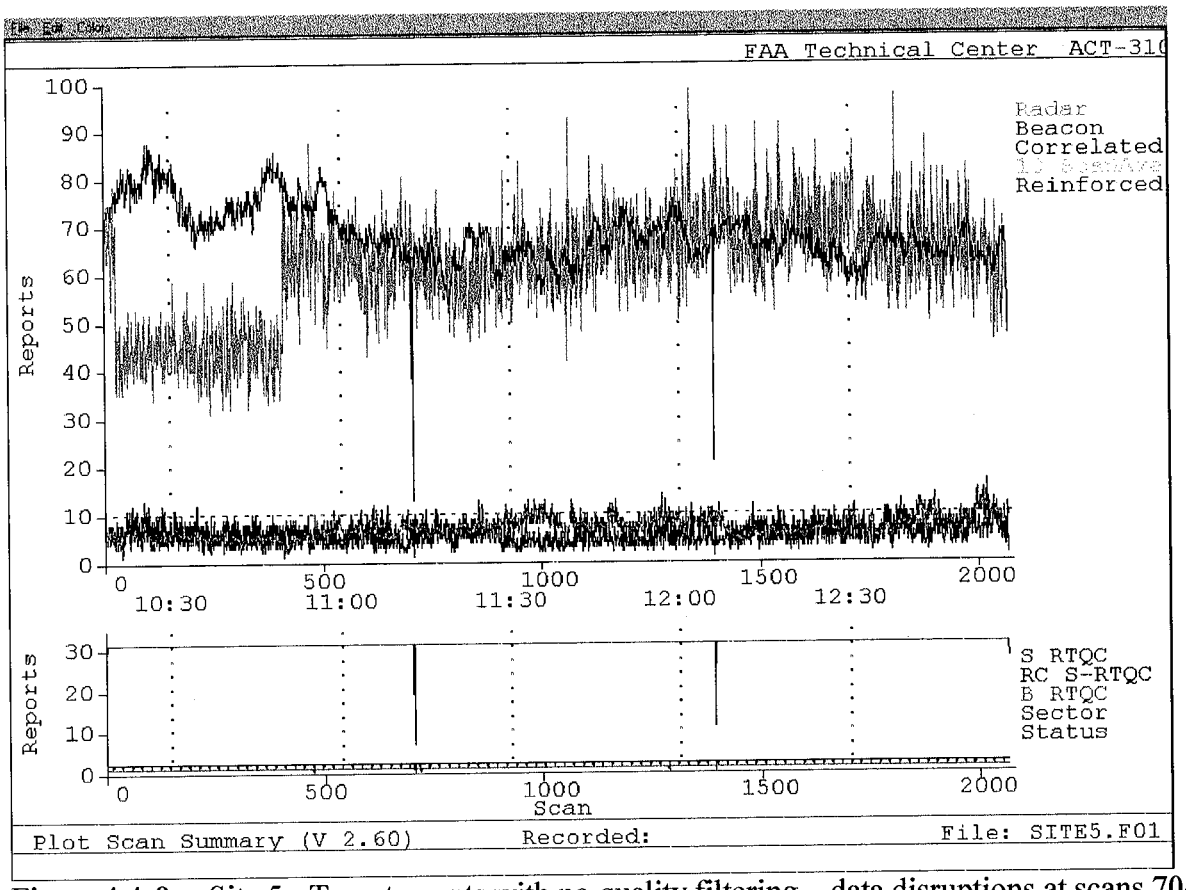


Figure 4.4-8a. Site 5 - Target counts with no quality filtering – data disruptions at scans 704 and 1397 are due to appending files.

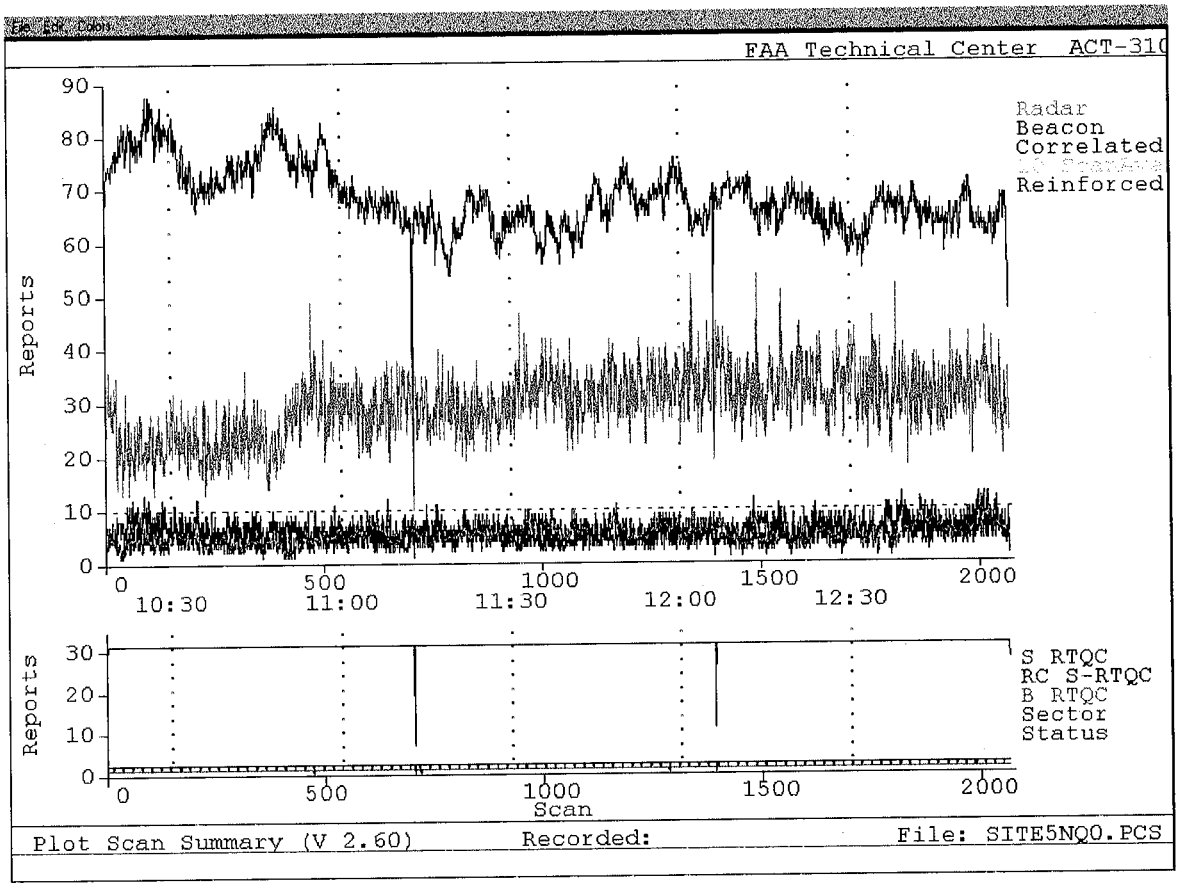


Figure 4.4-8b. Site 5 - Target Counts with quality 0 filtering

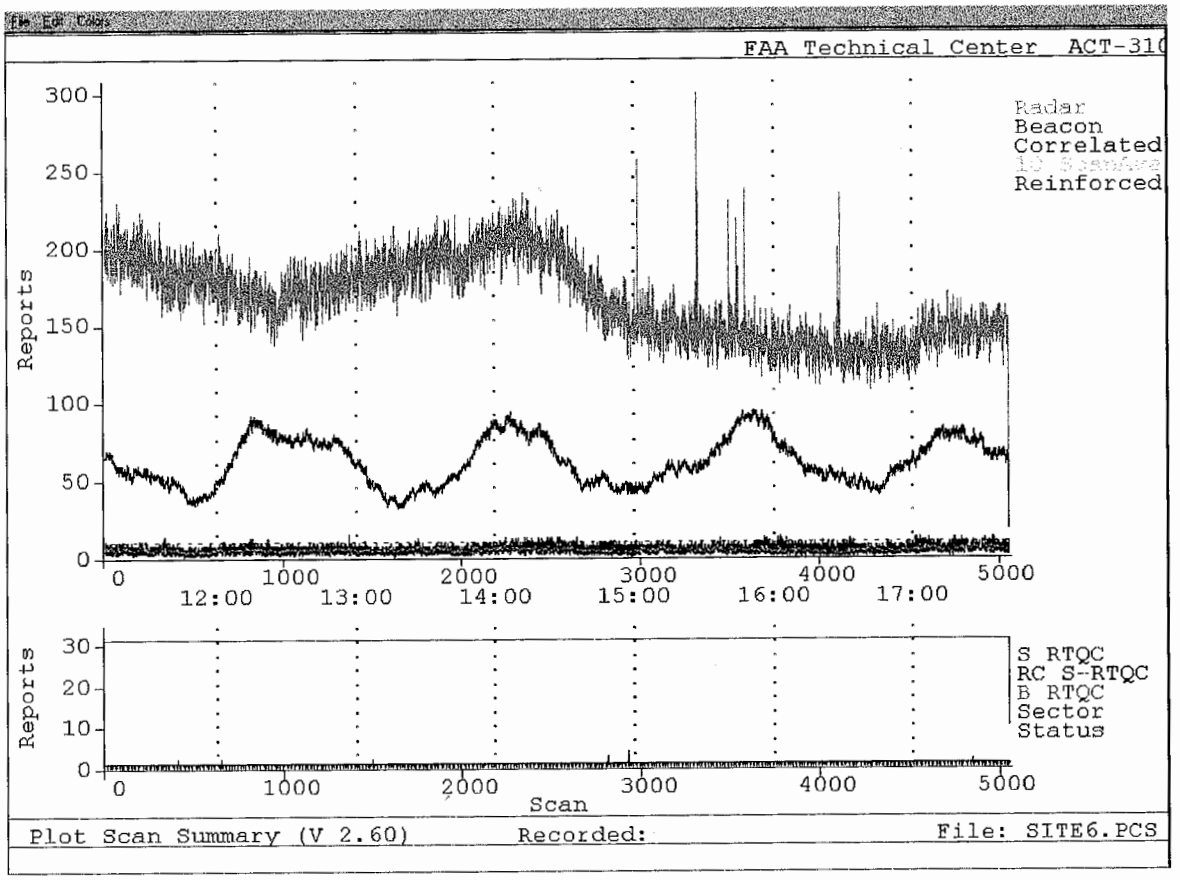


Figure 4.4-9a. Site 6 – Target counts with no quality filtering

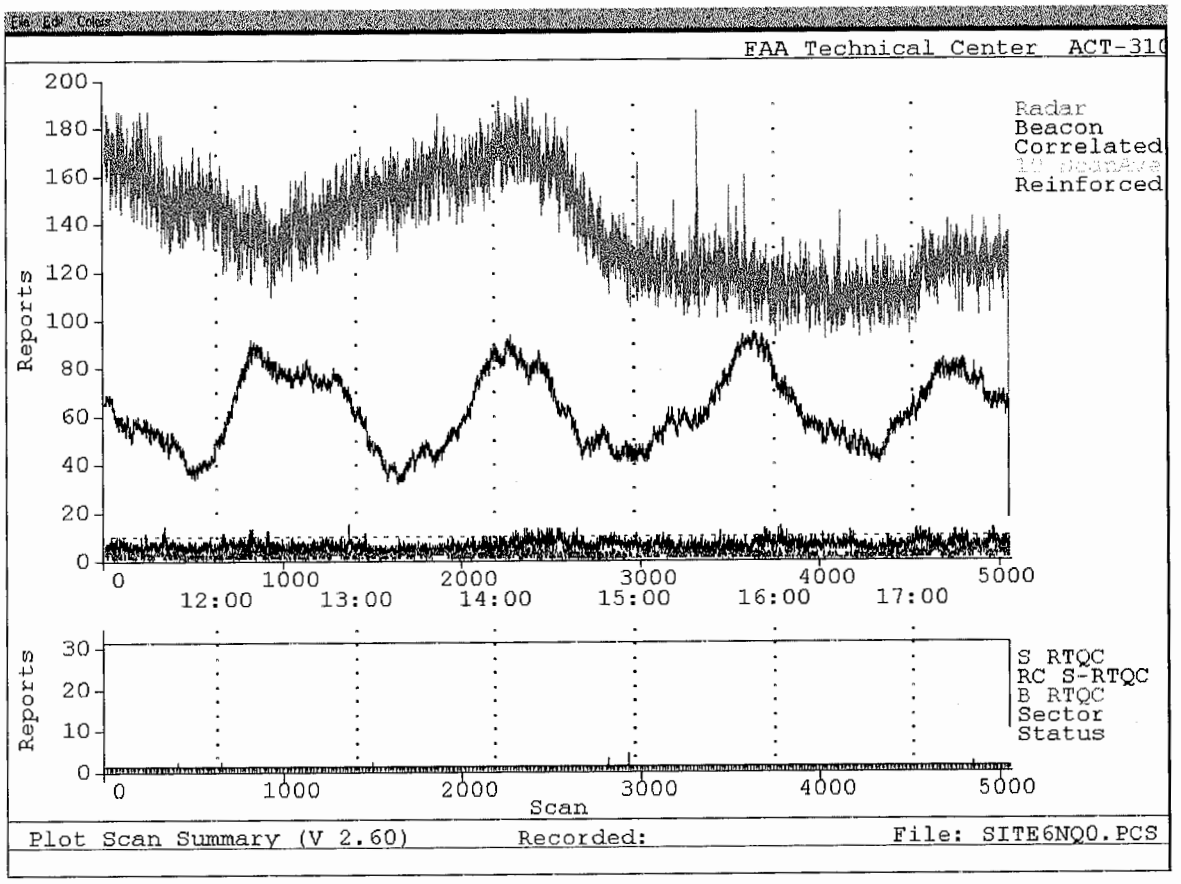


Figure 4.4-9b. Site 6 – Target counts with quality filtering zero filtering

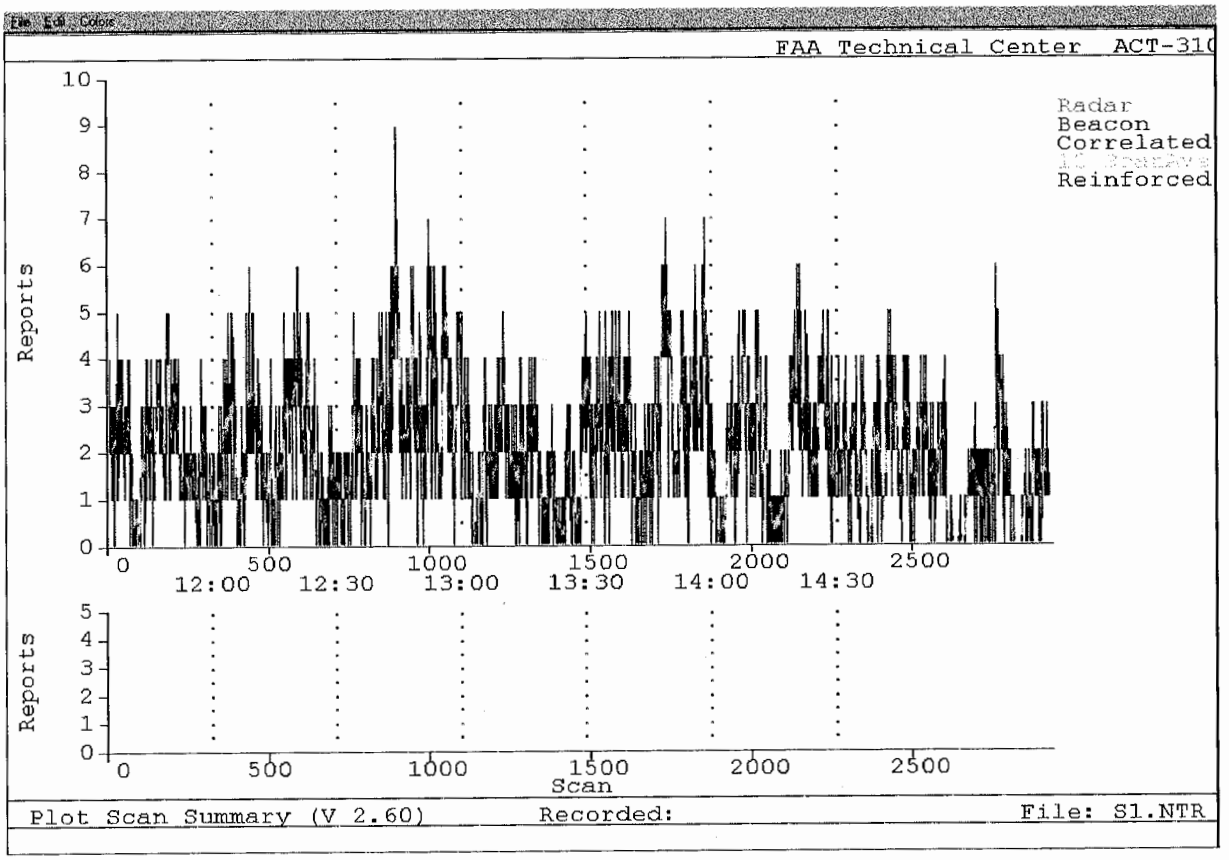


Figure 4.4-10a. Site 1 - False tracks – no quality filtering

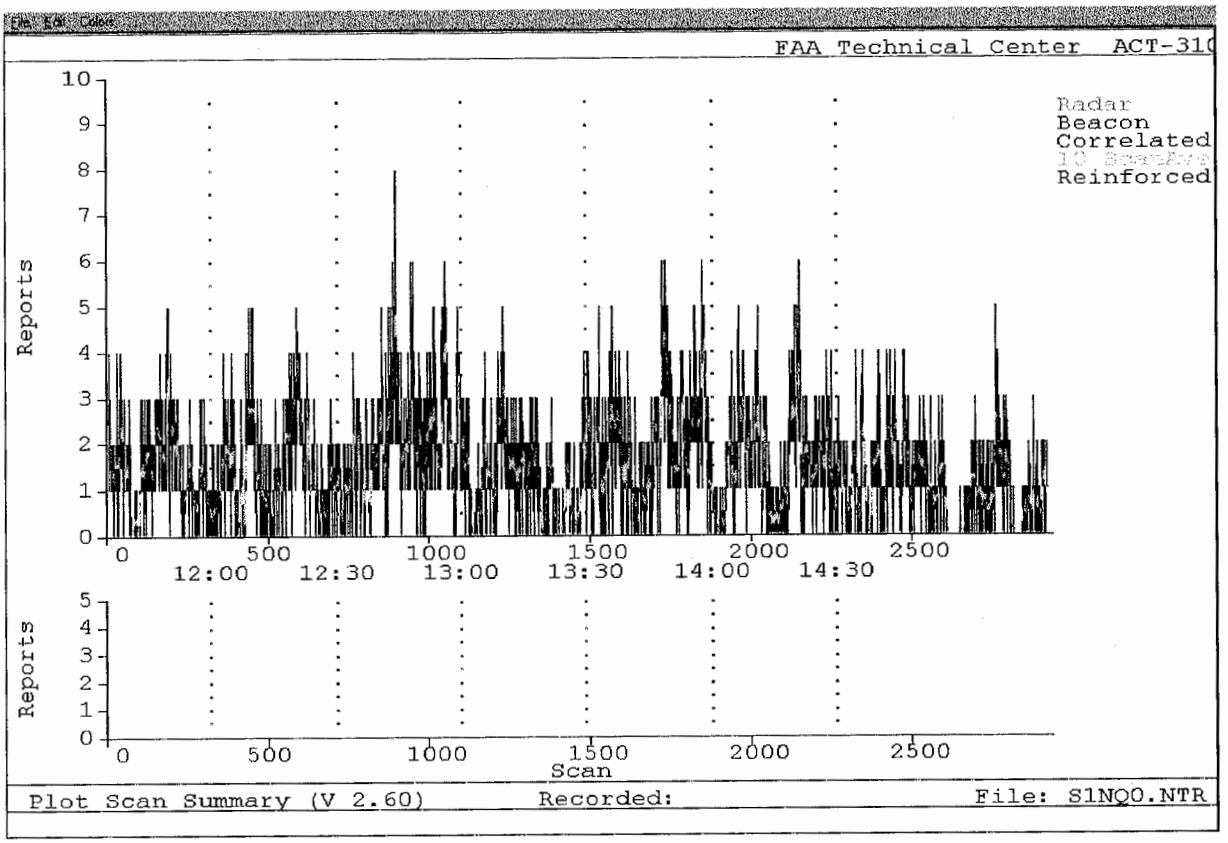


Figure 4.4-10b. Site 1 - False tracks – quality 0 filtering

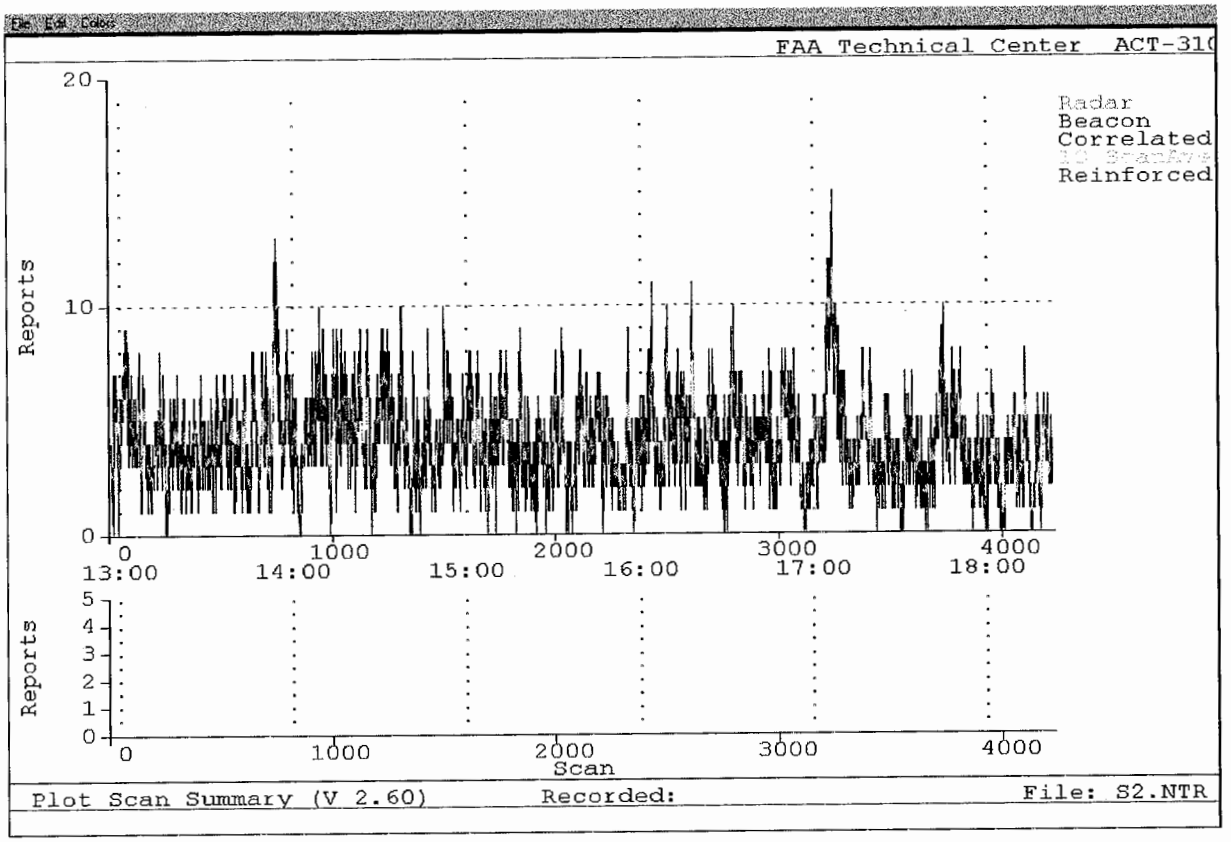


Figure 4.4-11a. Site 2 – clear conditions – False Tracks.

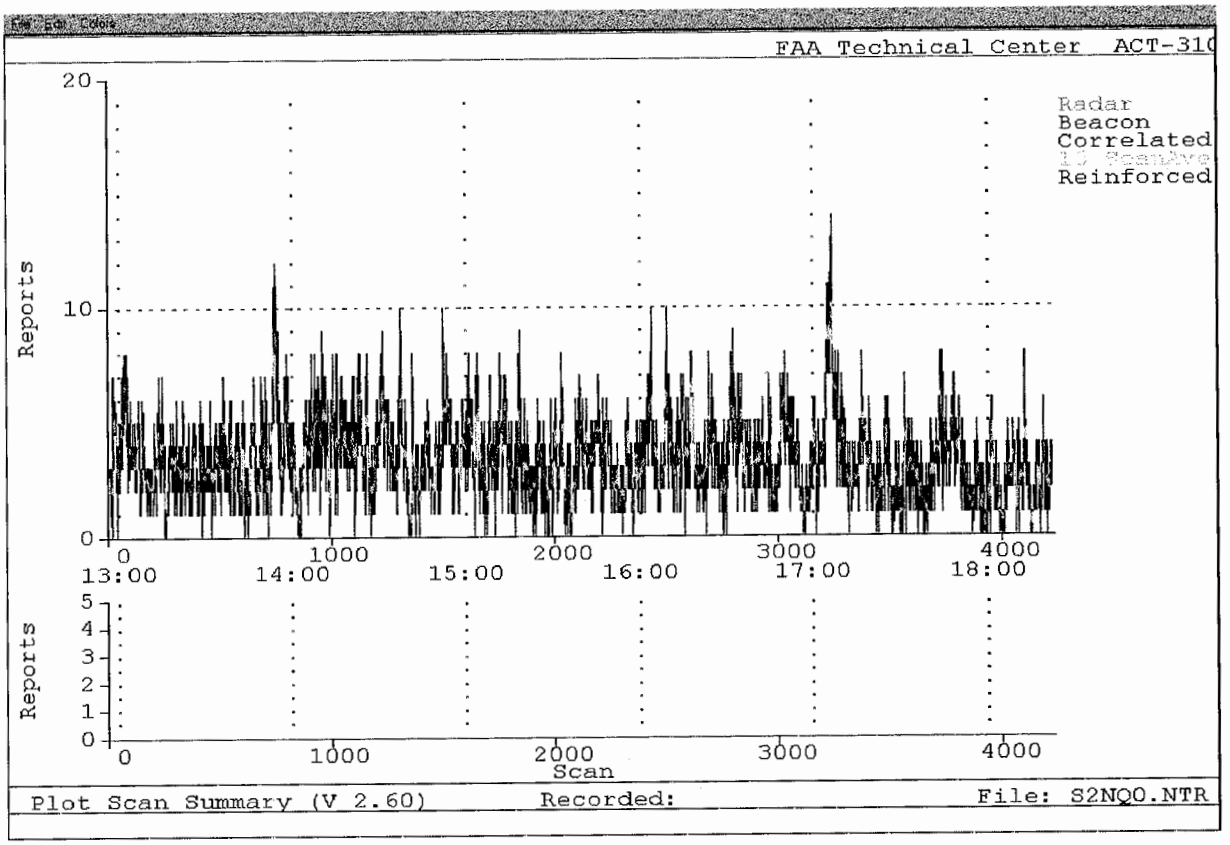


Figure 4.4-11b. Site2 – clear conditions – False Tracks with quality zero filtering

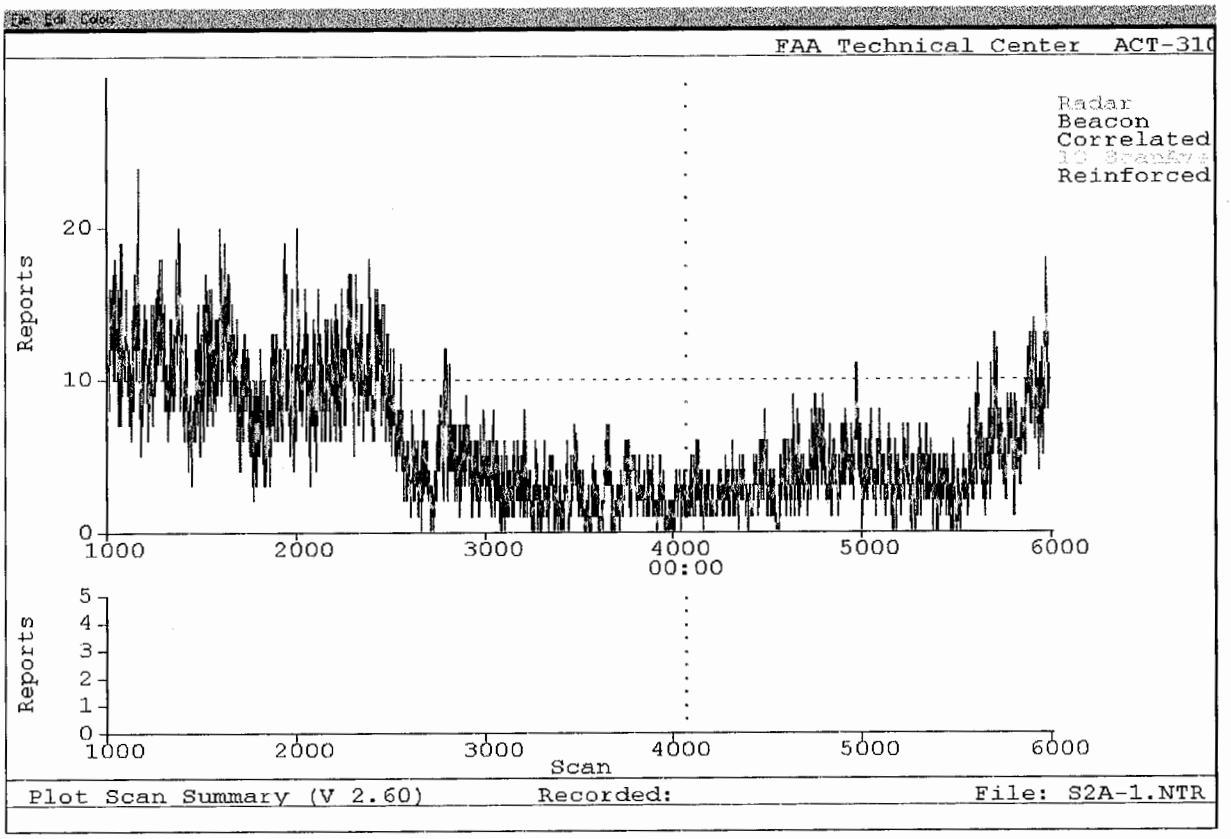


Figure 4.4-12a – Site 2 – Intense Weather and AP – False Tracks

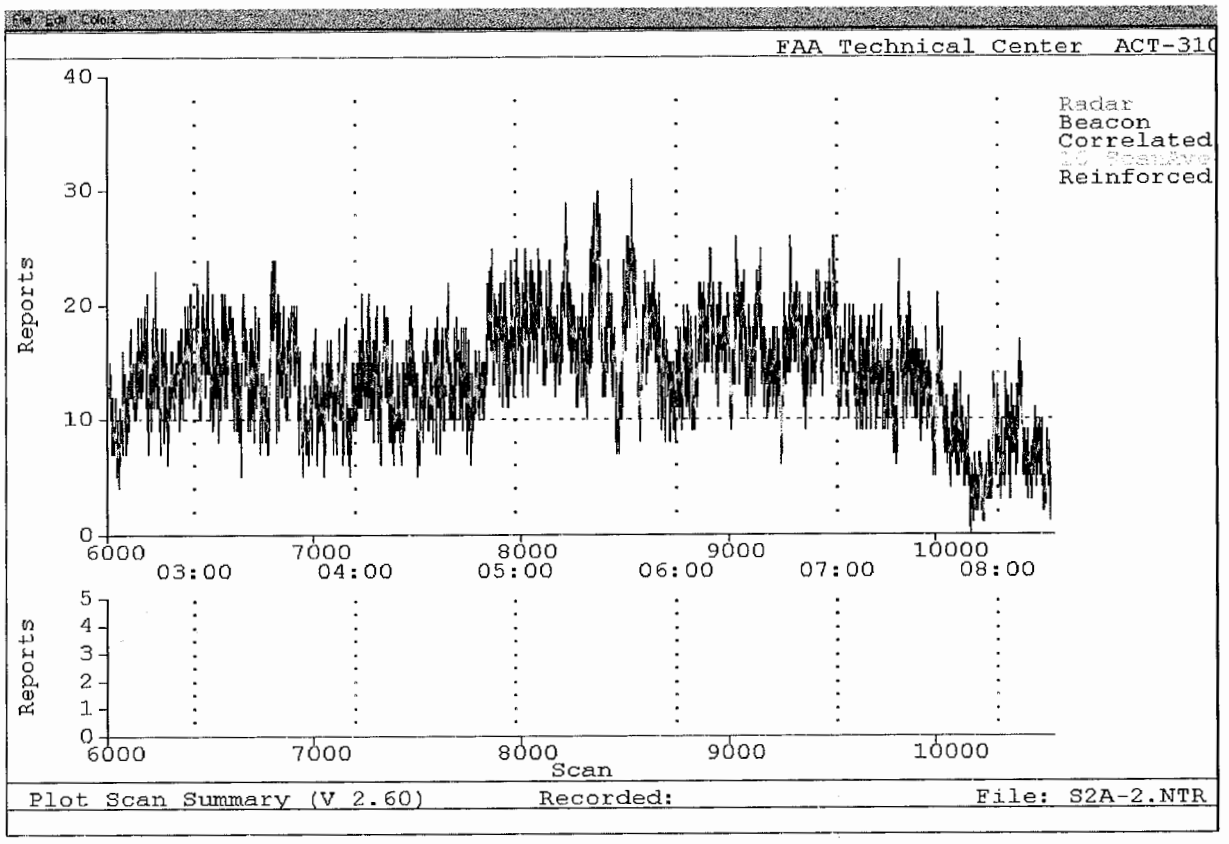


Figure 4.4-12b. Site 2 – Intense Weather and AP – False Tracks

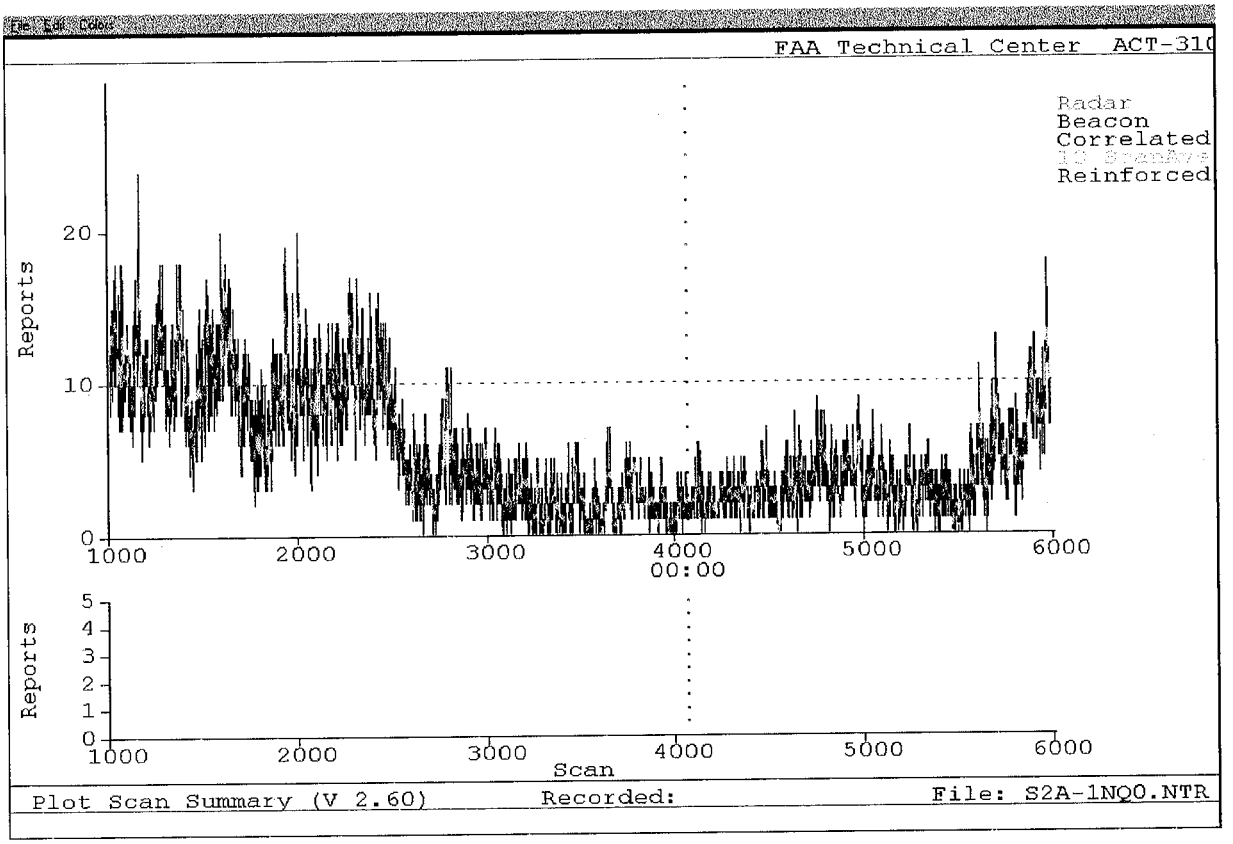


Figure 4.4-12c. Site 2 – Intense Weather and AP – False Tracks w/ Quality zero filtering

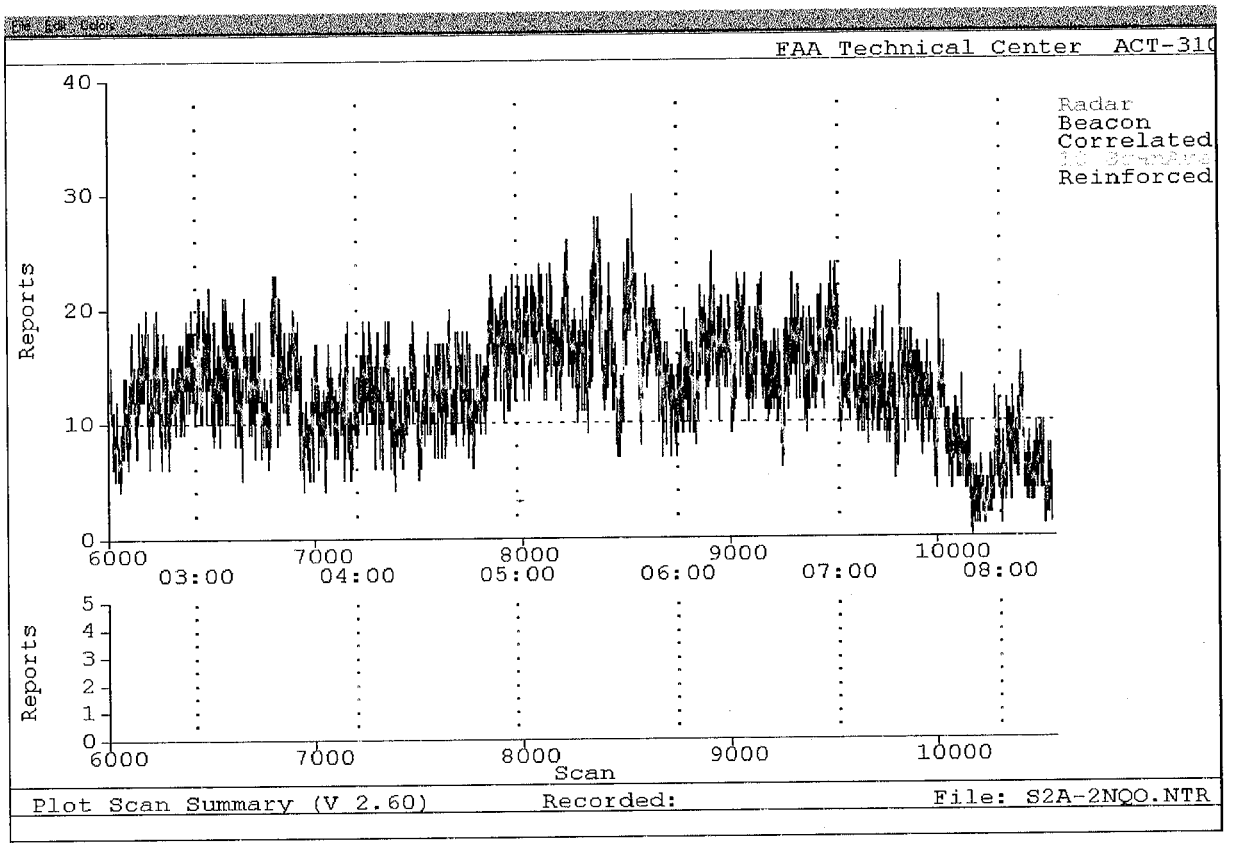


Figure 4.4-12d. Site 2 – Intense Weather and AP – False Tracks w/ Quality zero filtering

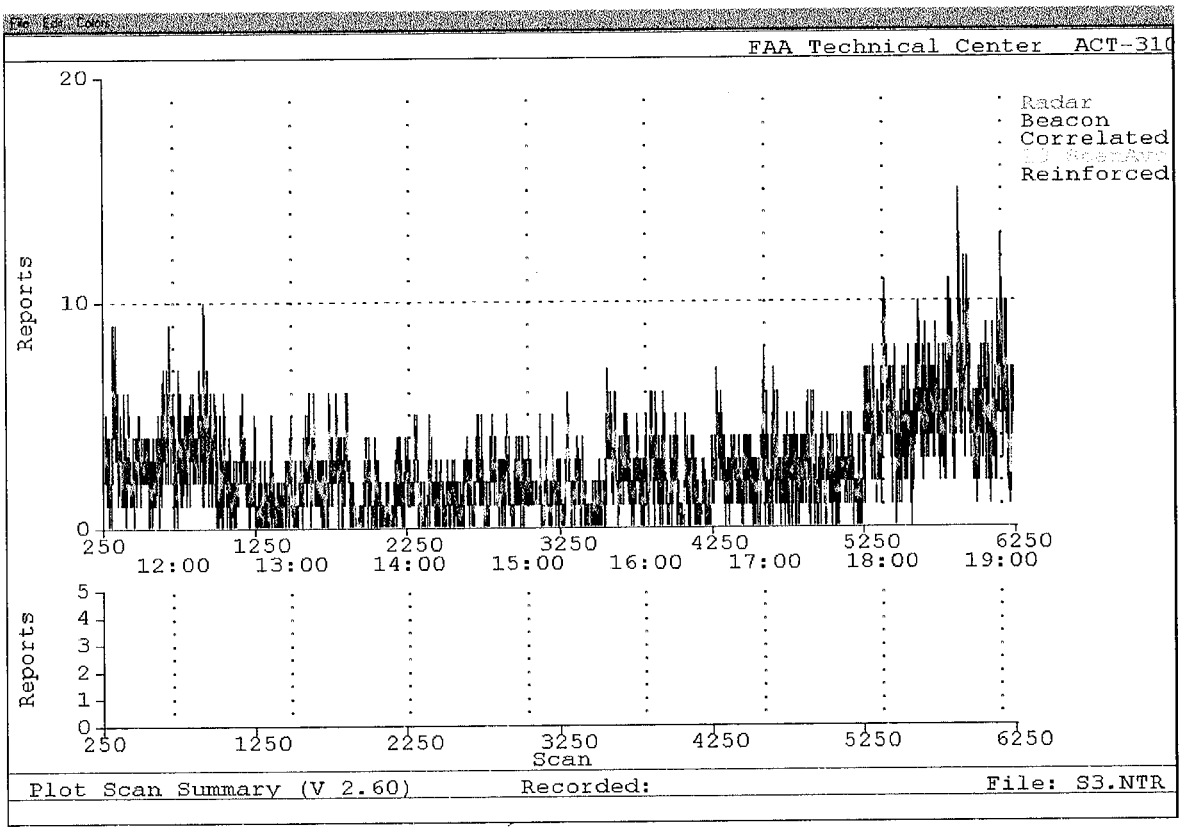


Figure 4.4-13a. Site 3 – False tracks no quality filtering

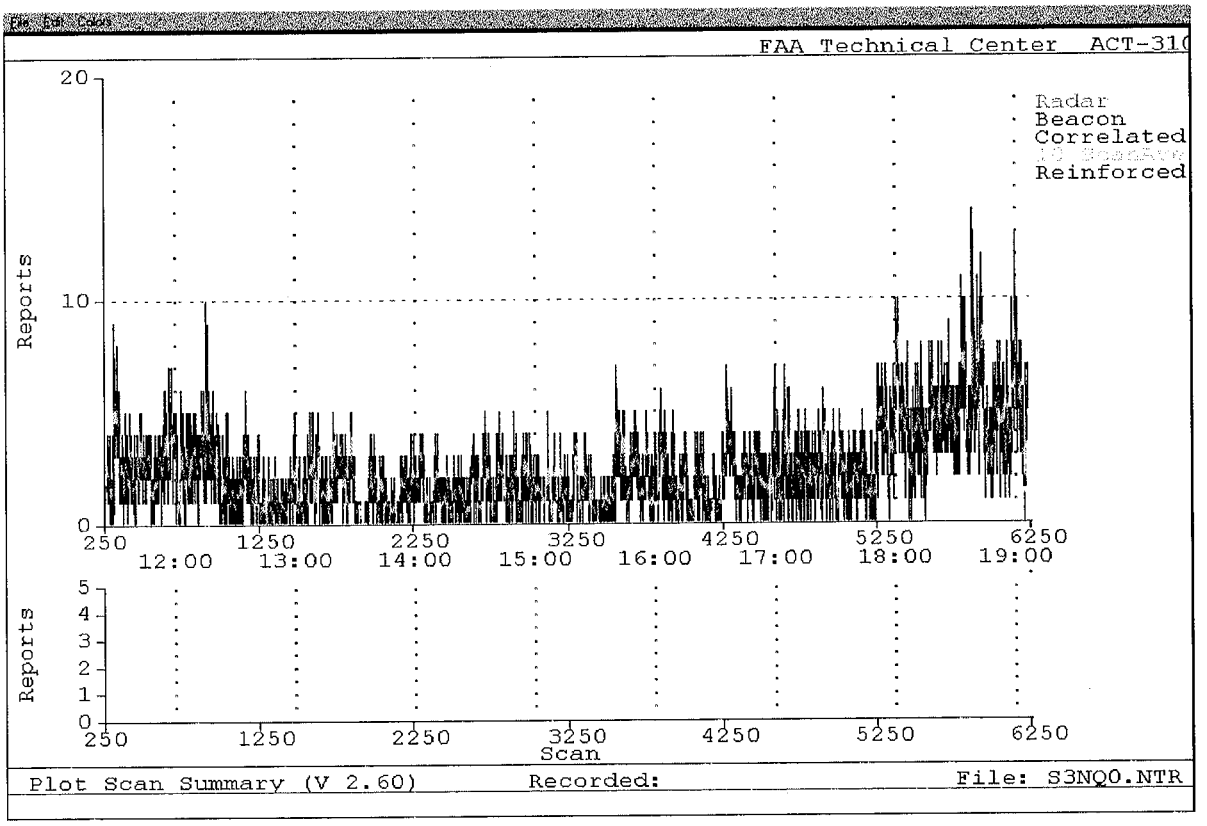


Figure 4.4-13b. Site 3 – False tracks with quality 0 filtering

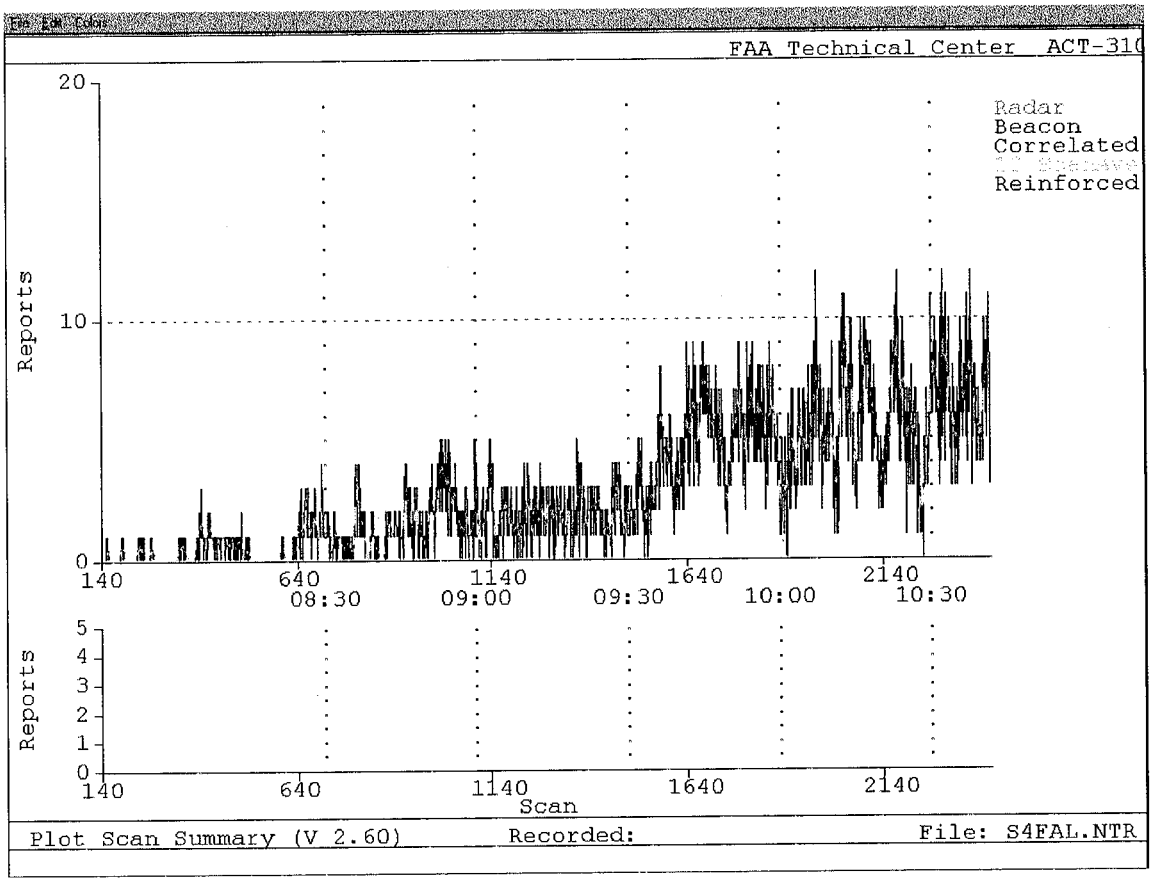


Figure 4.4-14a. Site 4 – False tracks no quality filtering

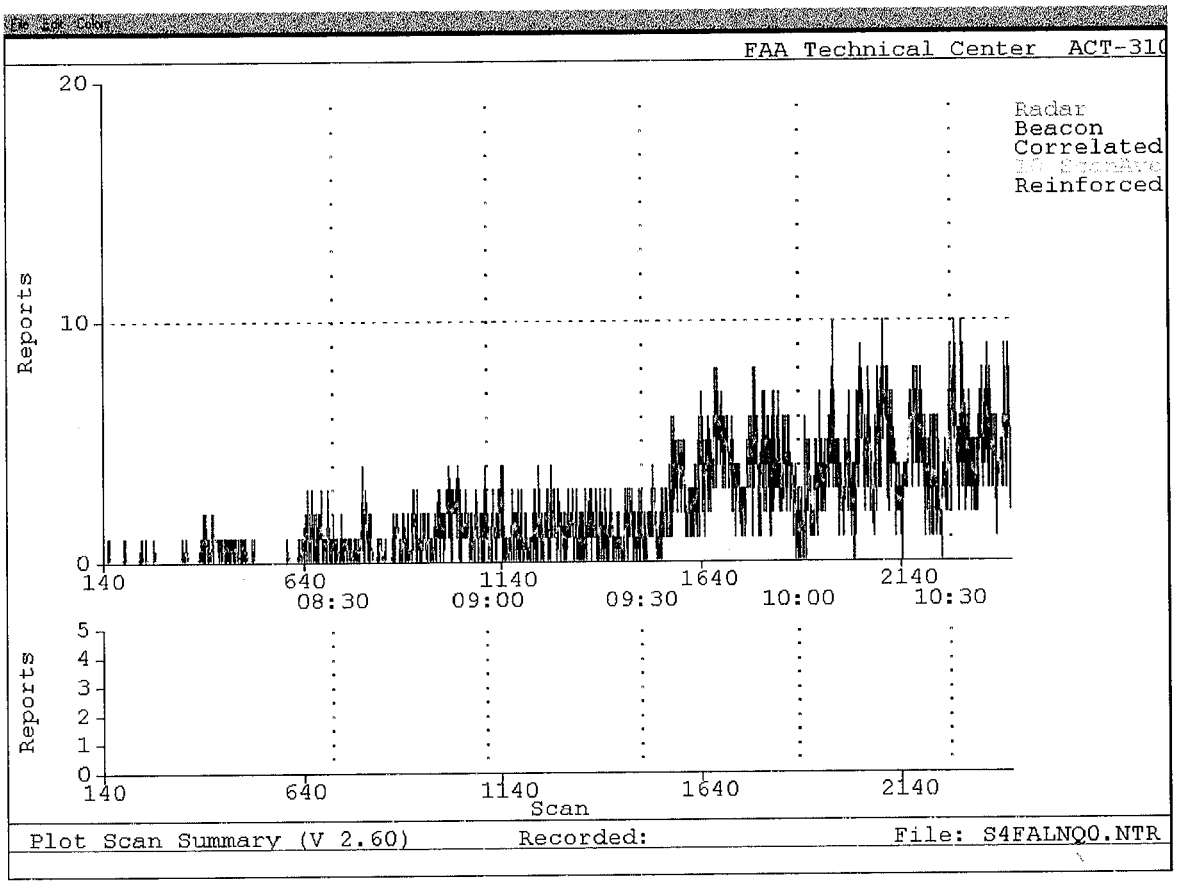


Figure 4.4-14b. Site 4 – False tracks – quality zero filtering

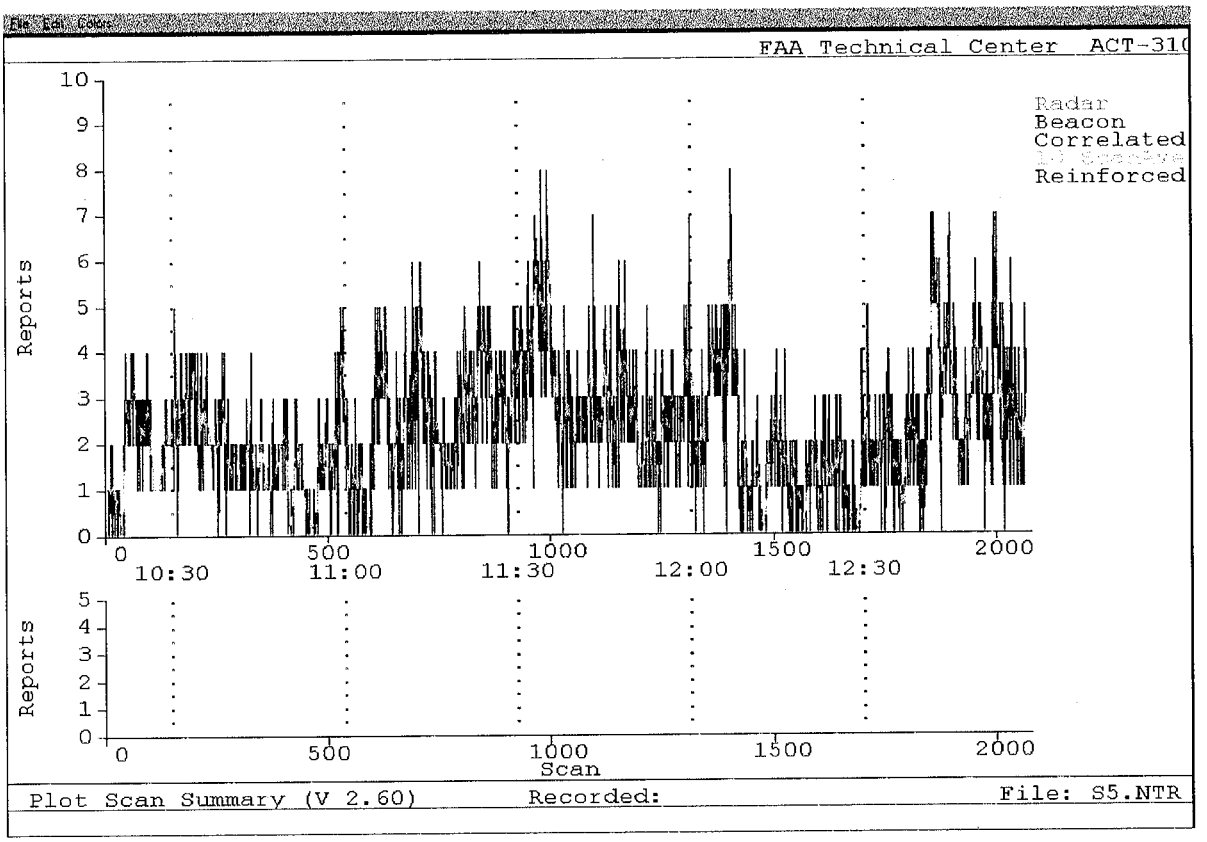


Figure 4.4-15a. – Site 5 – False tracks no quality filtering

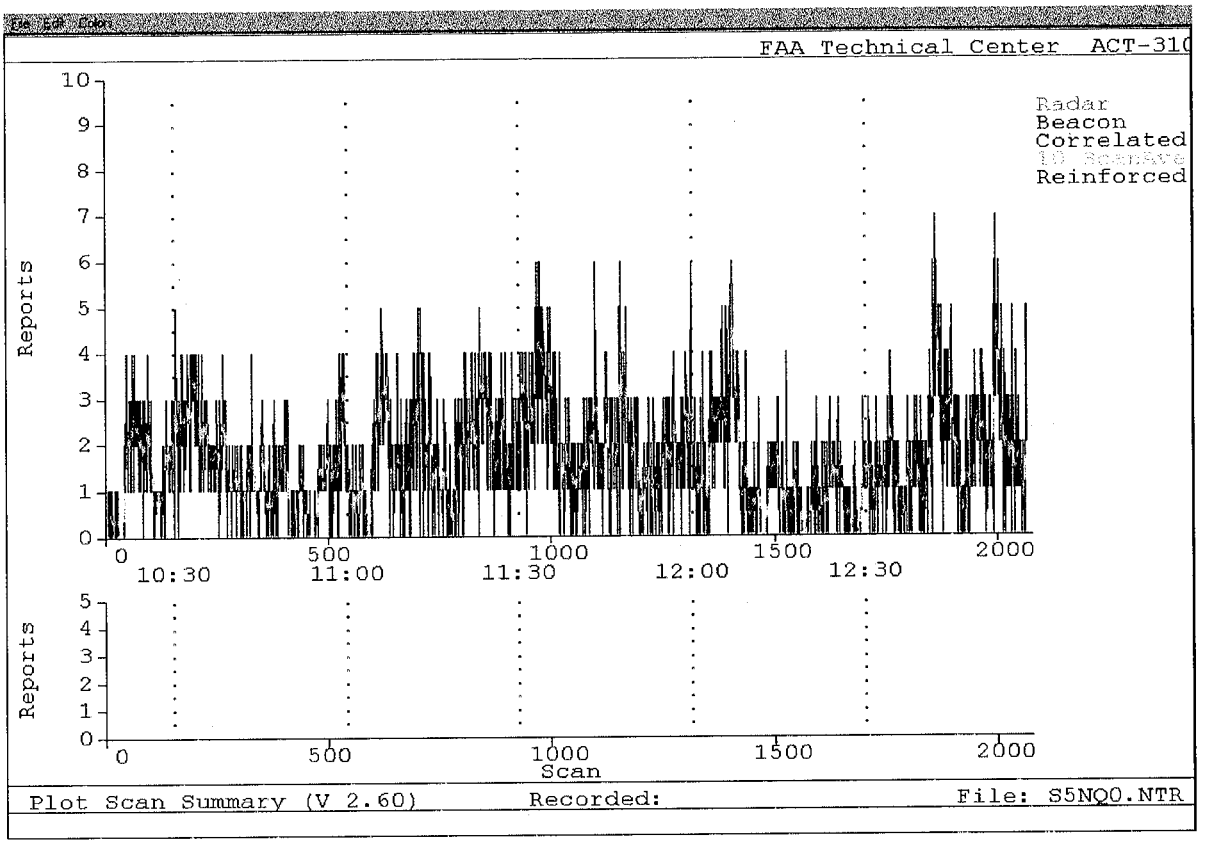


Figure 4.4-15b. Site 5 – False tracks – quality zero filtering

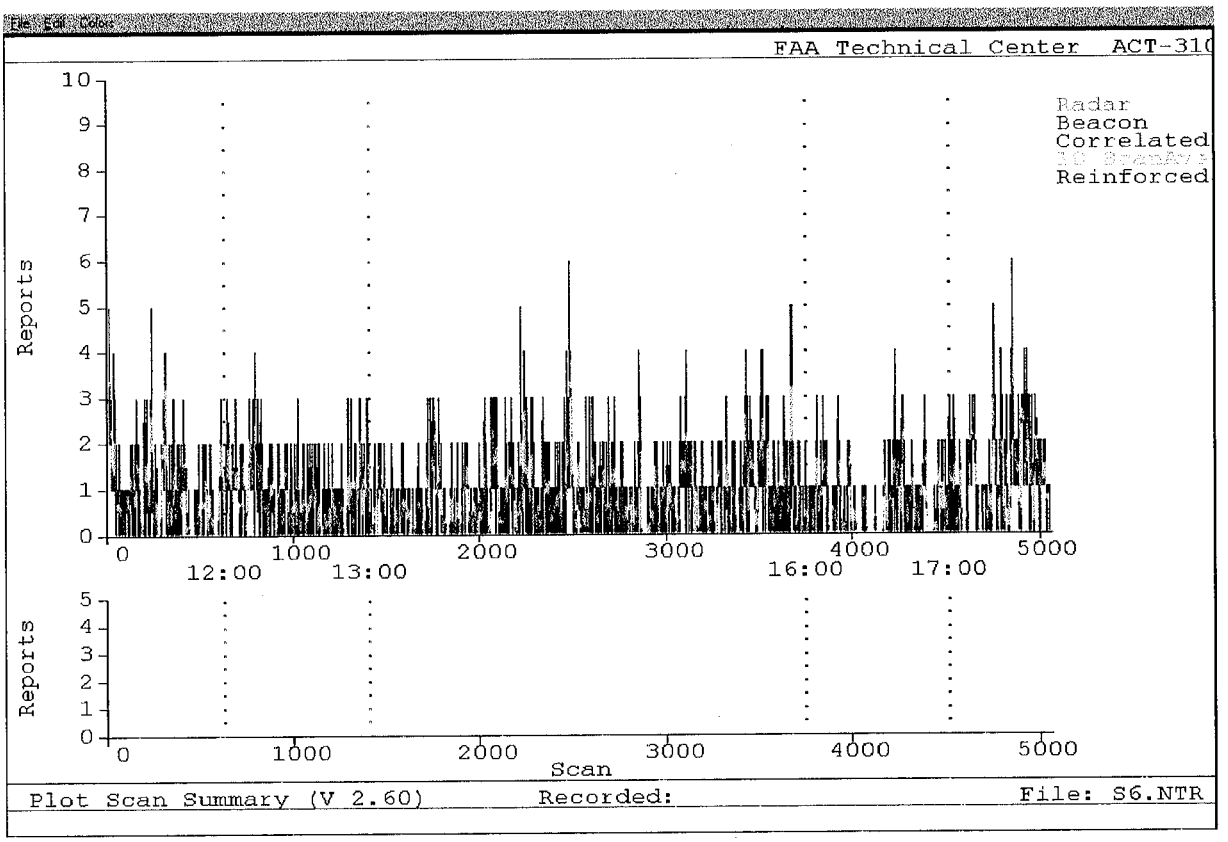


Figure 4.4-16a. Site 6 – False Tracks

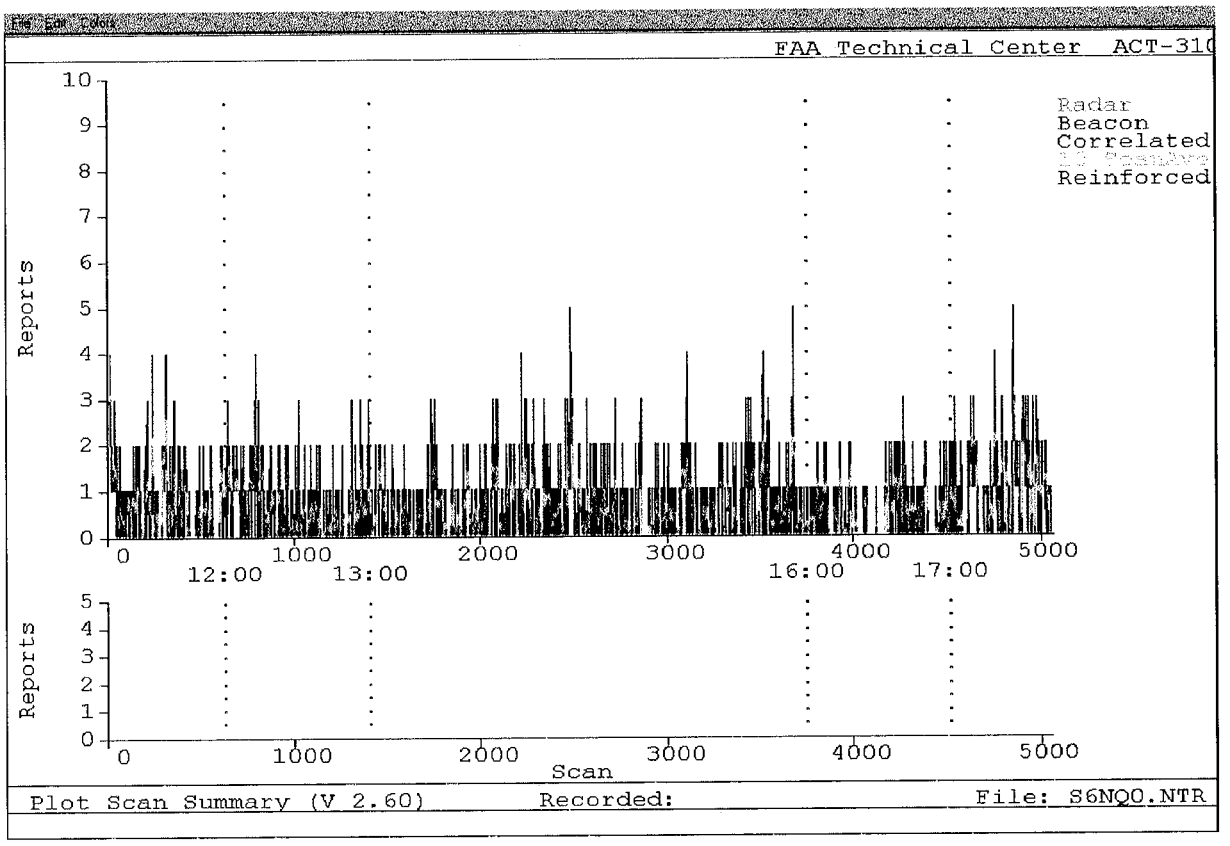


Figure 4.4.16b. Site 6 – False Tracks quality zero filtering

4.5 Quality Filtering Assessment

4.5.1 Test Objective: The objective of target report quality filtering is to remove false target reports while minimizing the loss of true aircraft reports. The objective of this test is to evaluate the effects of quality filtering on the loss of true targets and assess the effectiveness of quality filtering in decreasing radar target report volume.

4.2.2 Specification Performance Related Requirements: There are no specific requirements for the maximum acceptable loss of true targets due to quality filtering for the ASR-11 or the ASR-9. Target Quality filtering is a tool available within both the ASR-9 and ASR-11 to help limit the number of false targets. However, quality filtering also results in the removal of some true targets, effectively lowering the probability of detection.

4.5.3 Test Description: Testing is divided into the following two separate tests.

4.5.3.1 Test case a: ASR-9 Radar data is collected before the Surveillance and Communications Interface Processor (SCIP) so that the radar report quality filtering features of the SCIP can be evaluated.

Data from each site is separated into true and false track reports by analysis of scan-to-scan target progression using the IRES tool set (Radar only targets are not included in this analysis due to the complexity and time consuming nature of their analysis). The target quality distribution is calculated for the true track targets. The percentage of these targets that are quality zero represents that percentage of true targets that will be lost if quality zero filtering were enabled in the SCIP.

The quality distributions of the total radar target population is calculated (both true and false Radar only and Radar Correlated targets). The percentage of these targets that are quality zero represents the decrease in total target volume that would be observed if quality filtering were enabled in the SCIP.

The percentage of true quality zero track target reports is compared to the percentage decrease in total target volume that would be observed if quality zero filtering were implemented.

Since radar target report quality is lost when beacon and radar target reports are merged, this test does not include the reported radar target report quality for all radar targets detected by the radar. The overall ratio of radar correlated targets target reports to combined radar target reports is calculated to assess the percentage of radar reports not included due to radar/beacon target merge.

4.5.3.2 Test case b: A separate data recording was made at Site 5 to assess the impacts of quality filtering. Data was recorded with the merge window on the ASR-9 post processor set to zero, to inhibit the ability of the ASR-9 post processor to combine the radar and beacon targets and thus preserve the reported quality in the radar reports.

The recorded file was processed to remove radar targets unless they were close to a beacon target on the same scan (within 1.58 degrees and 10/64 nautical miles - keeping only targets that were

likely to have merged in the ASR-9). Since the rate of beacon false targets is low (.236 per scan based upon RBAT analysis of this site), these radar reports are considered to represent true targets. The target quality distribution is calculated for these targets. The percentage of these targets that are quality zero represents that percentage of true targets that will be lost if quality zero filtering were enabled in the SCIP.

The quality distributions of the total radar target population is calculated (both true and false Radar only and Radar Correlated targets). The percentage of these targets that are quality zero represents the decrease in total target volume that would be observed if quality filtering were enabled in the SCIP.

The percentage of true target reports lost is compared to the percentage decrease in total target population that would have been observed if quality zero filtering were implemented.

This data set is further analyzed to determine the relationship between the percentage of quality zero targets versus range and azimuth using the filtering utilities of the IRES tool set.

4.5.4 Test Limitations:

4.5.4.1 Test case a: There are no controls for aircraft radar cross section. Since radar target quality is lost when radar reports are merged with beacon reports, the true target distribution only includes radar targets that did not combine with beacon replies and radar returns from aircraft that are not transponder equipped. This represents a very small sample size for each data set.

4.5.4.2 Test case b: There are no controls for aircraft radar cross section. This target subset is considered highly representative of the true target population. It will, however, contain a small percentage of false reports and also does not consider aircraft that are not transponder equipped.

4.5.5 Discussion/Results:

4.5.5.1 Test Case a:

Site 2 and 2a represent the same site in clear weather and severe weather conditions respectively.

Tables 4.5-1 thru 4.5-7 show radar target quality distributions for Radar Only (RO) and Radar Correlated (RC) reports from the data collected from each of the six sites, as well as radar target quality distributions for Radar Correlated reports determined to represent true aircraft returns. Review of the data for sites one thru five shows a reduction in Radar Only target volume of 50-70% by the use of Quality zero filtering. Site six, the only 9-PAC phase 2 site, only show a reduction of 17.54%. Further review of the data from site six (not included in this test report) shows that filtering of low amplitude quality zero targets is being done internal to the radar and therefore comparison to the quality filtering of the 9-PAC phase one is not appropriate.

The negative effects of quality zero filtering are shown by reviewing the percentage of true Radar Correlated report lost by quality filtering. Between 6.25 and 24.47 percent of true aircraft returns were lost by implementing quality zero filtering on the Radar Correlated reports

This data does not consider radar returns which were merged with beacon reports. Table 4.5-8 shows the radar target report counts for all six sites. The unmerged Radar Correlated reports account for only 5% of true aircraft radar returns. They account for aircraft without transponders and radar reports which did not merge with beacon reports.

4.5.5.2 Test Case b:

This test case is based upon a separate data collection at Site 5 with the merge window set to zero to inhibit the combining of radar and beacon targets. Table 4.5-9 shows the quality distribution of the total target population. Table 4.5-10 shows the population of targets that would have combined with beacon target had the ASR-9 been configured in a normal operational configuration. These targets are considered to be true aircraft returns. Quality zero filtering is shown to remove 25.8% of the raw radar only target volume while also removing 4.89% of true radar only reports. Quality zero filtering of Radar Correlated reports (which has not been recommended for fielded systems) resulted in the removal of 8.01% of the raw radar correlated target volume while removing 3.89% of true radar correlated targets.

Table 4.5.11 shows the radar target statistics that would have been observed if the merge window had not been set to zero. It was generated by subtracting the number of radar targets that would have combined from the total number of radar targets and is equivalent to the total target count shown in the Case a. test above (Tables 4.5-1 thru 4.5-7). This table shows that quality zero filtering would have removed 35.6% the total radar only target reports.

Table 4.5.-12 shows the percentage of quality zero targets observed as a function of range and elevation angle. Only 0.44% of radar targets between 1 and 20 degrees in elevation and 0.5-20 nautical miles in range were quality zero targets. This is in contrast to 26.64% of radar targets between 0 and 0.25 degrees in azimuth and 40 to 60 nautical miles in range. This table demonstrates that the percentage of quality zero targets increases at longer ranges and lower elevation angles (below one degree). It is expected that the number of quality zero targets will also increase as the limits of high angle coverage are reached. However insufficient data samples were available for evaluation.

Reinforcement Rates :

Angle	Rate (%)
1-20 degrees	95.46
.5-1.0 degrees	92.67
.25-.5 degrees	87.95
0-.25 degrees	75.24
All angles	90.56

Quality Filtering Assessment. Data was collected over 9572 scans and does not include radar reports that were merged with beacon reports.

	Total Radar Only and Radar Correlated Reports				Real Aircraft	
	RO	%RO	RC	%RC	RC	%RC
Q0	1596742	67.35	20834	16.70	708	22.80
Q1	409224	17.26	29283	23.48	911	29.34
Q2	90520	3.82	5968	4.78	66	2.13
Q3	274501	11.58	68652	55.04	1420	45.73
Total	2370987	100	124737	100	3105	100

Site Assessment: Reinforcement rates are very high even down to low angles. AP and weather significantly impacted false plot and false track rates. Quality filtering has a significant effect on removing false plots and false tracks. However, road traffic and marine traffic picked up due to AP can clearly be identified on PPI plots after quality 0 filtering. This ASR-9 site has 6 active airports within its coverage volume. The high false target rates observed may be due to trade-offs made to achieve high Pd for the low angle targets in the surrounding airports.

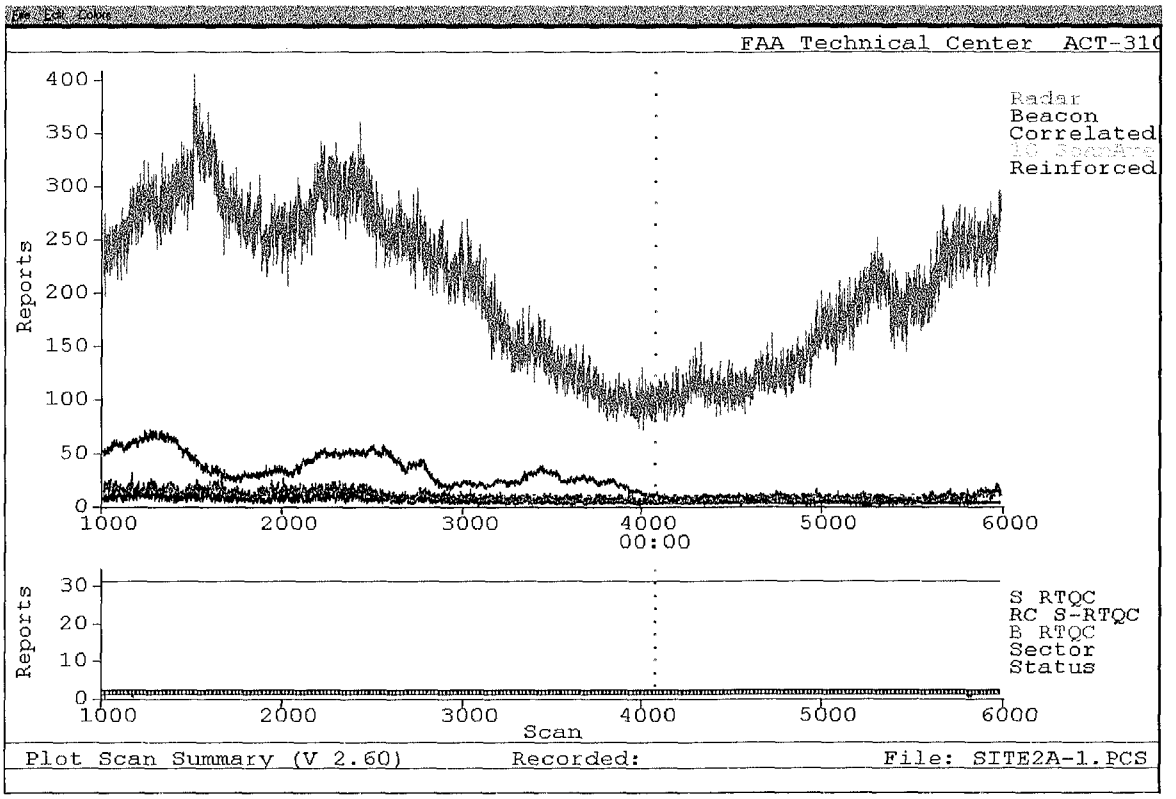


Figure C-1. Site 2 – Intense Weather and AP – Target Counts with no quality filtering

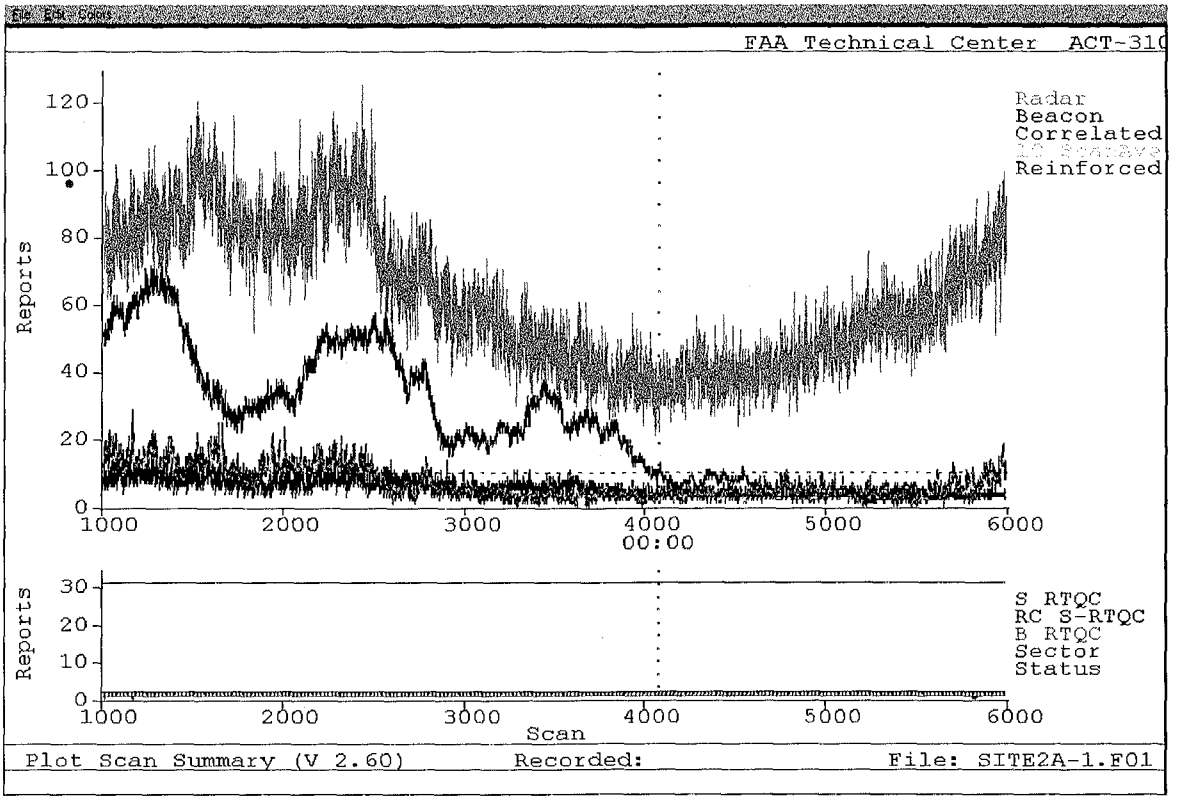


Figure C-2. Site2 – Intense Weather and AP – Targets with quality 0 filtering

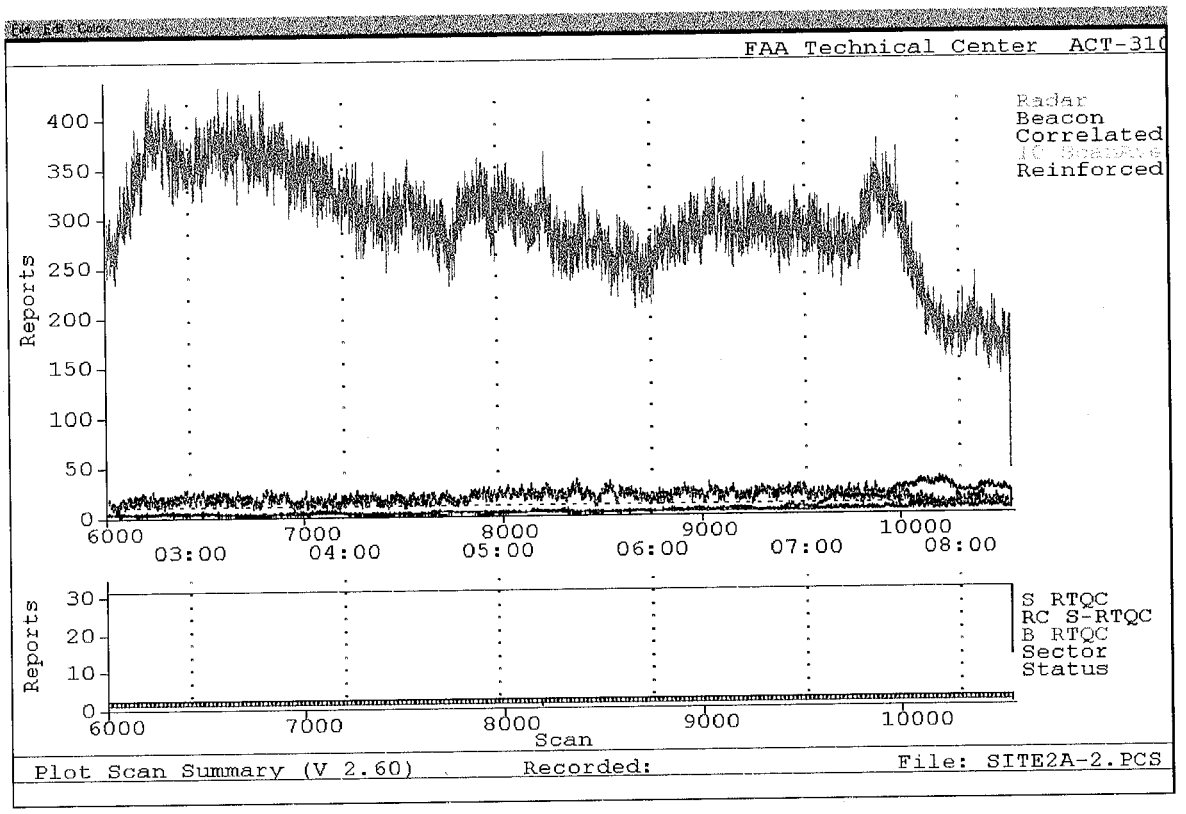


Figure C-3. Site 2 – Intense Weather and AP – Target Counts with no quality filtering

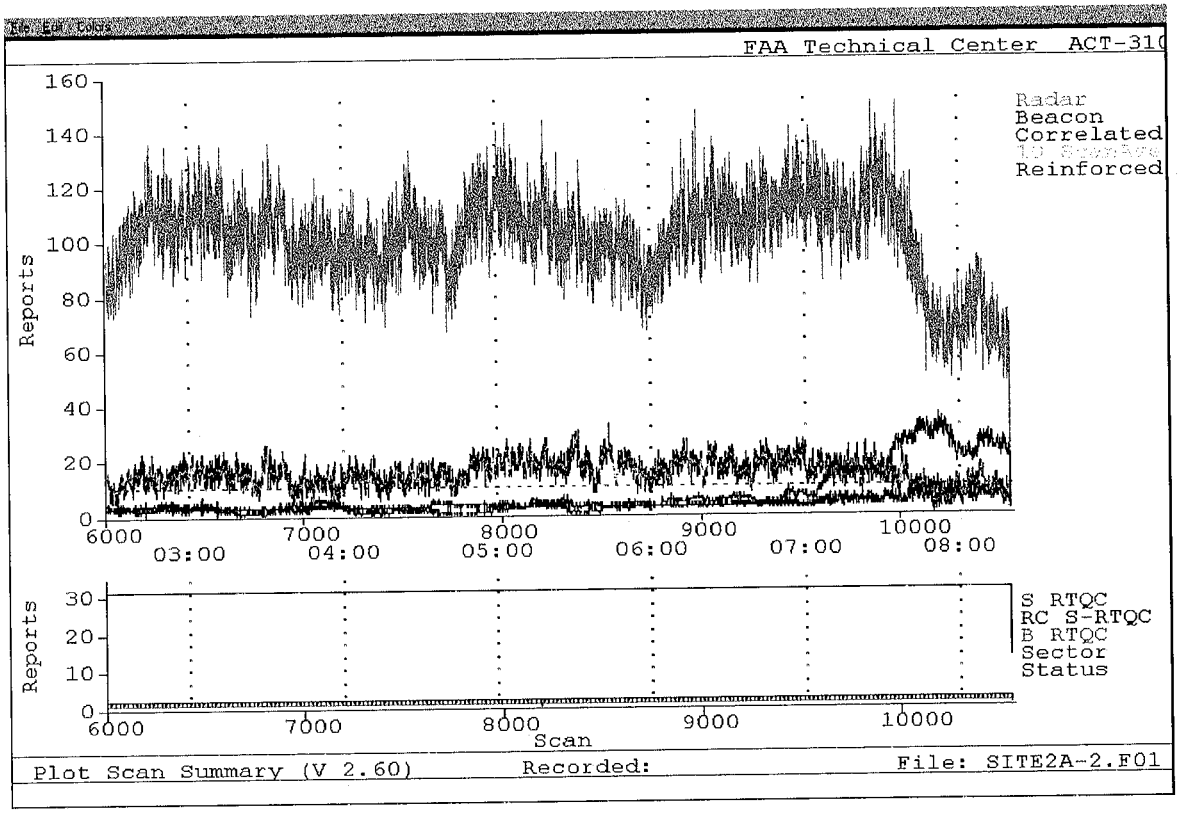


Figure C-4. Site 2 – Intense Weather and AP – Target Counts with quality 0 filtering

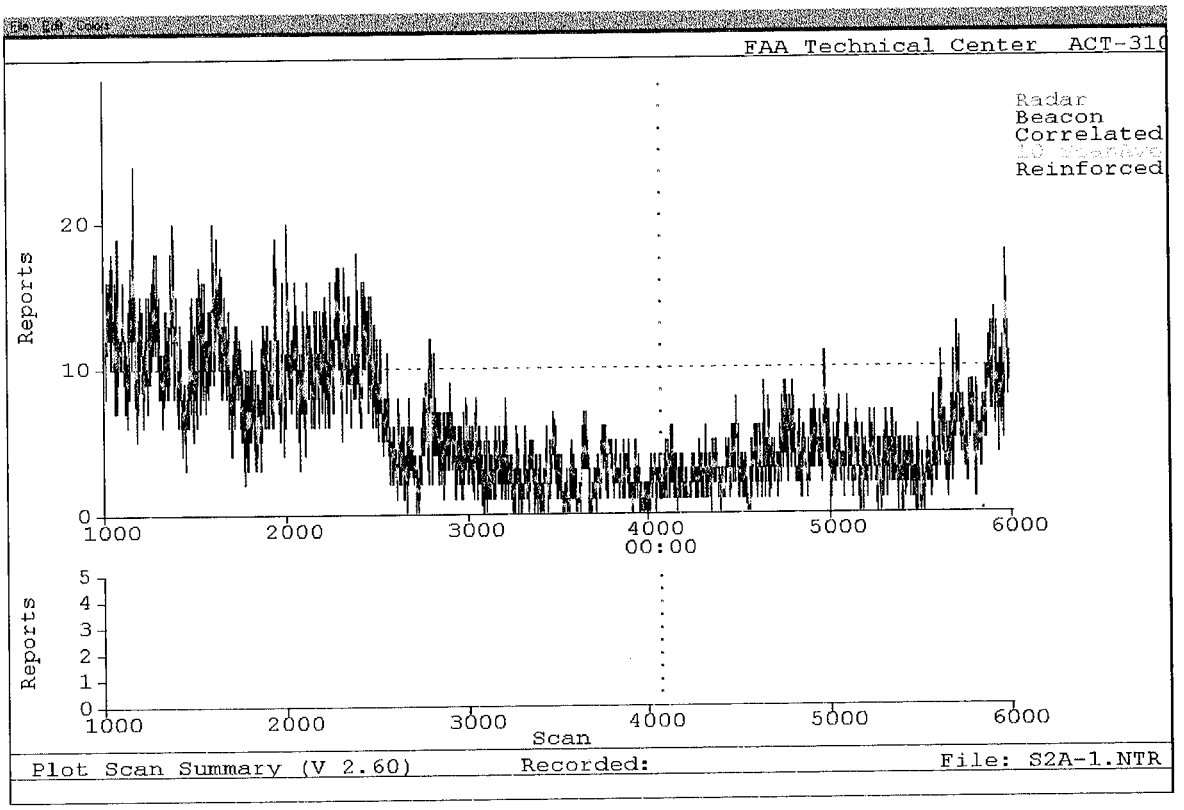


Figure C-5 – Site 2 – Intense Weather and AP – False Tracks

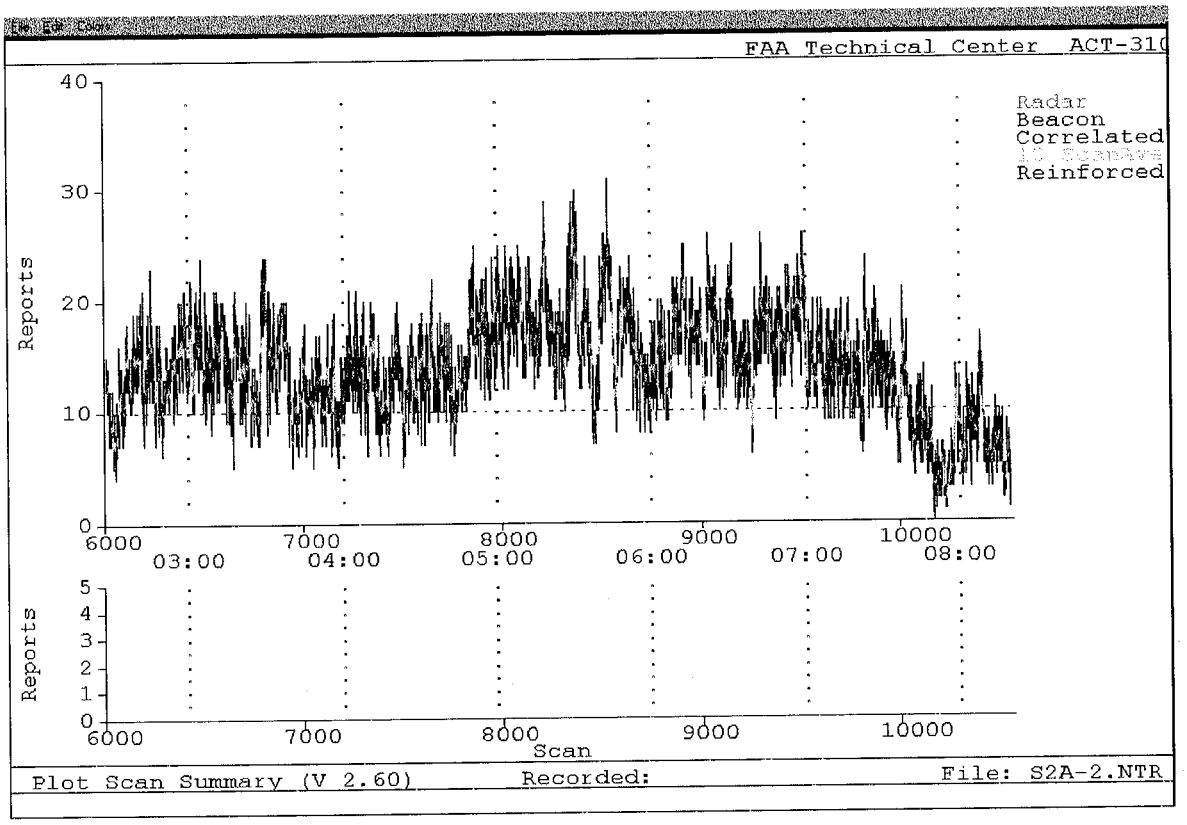


Figure C-6. Site 2 – Intense Weather and AP – False Tracks

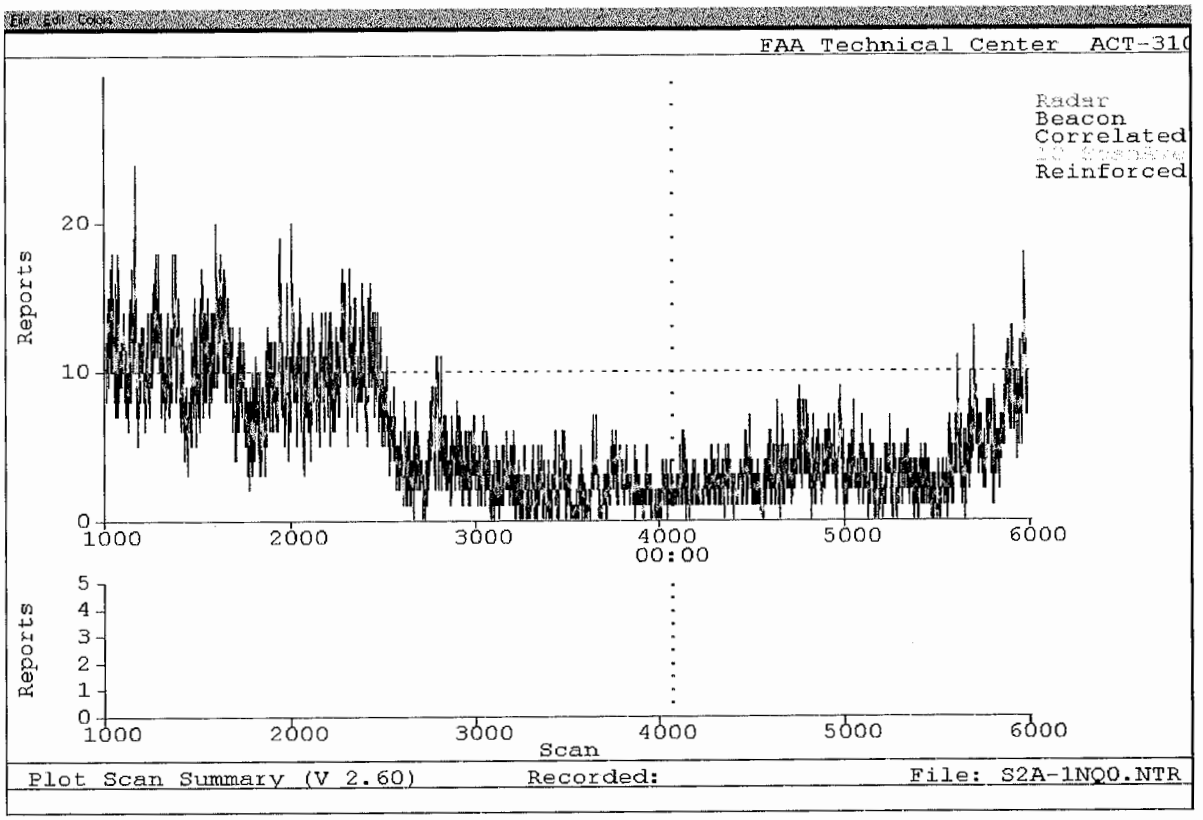


Figure C-7. Site 2 – Intense Weather and AP – False Tracks w/ Quality zero filtering

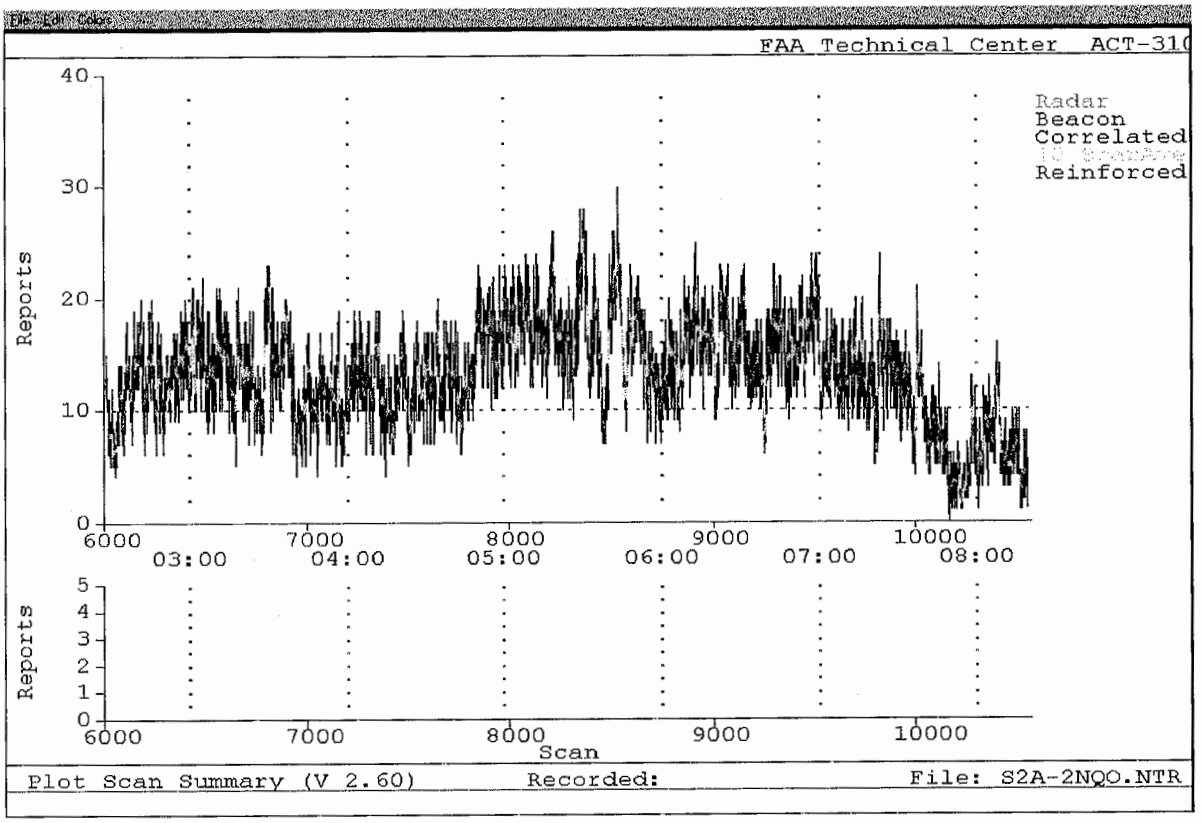


Figure C-8. Site 2 – Intense Weather and AP – False Tracks w/ Quality zero filtering

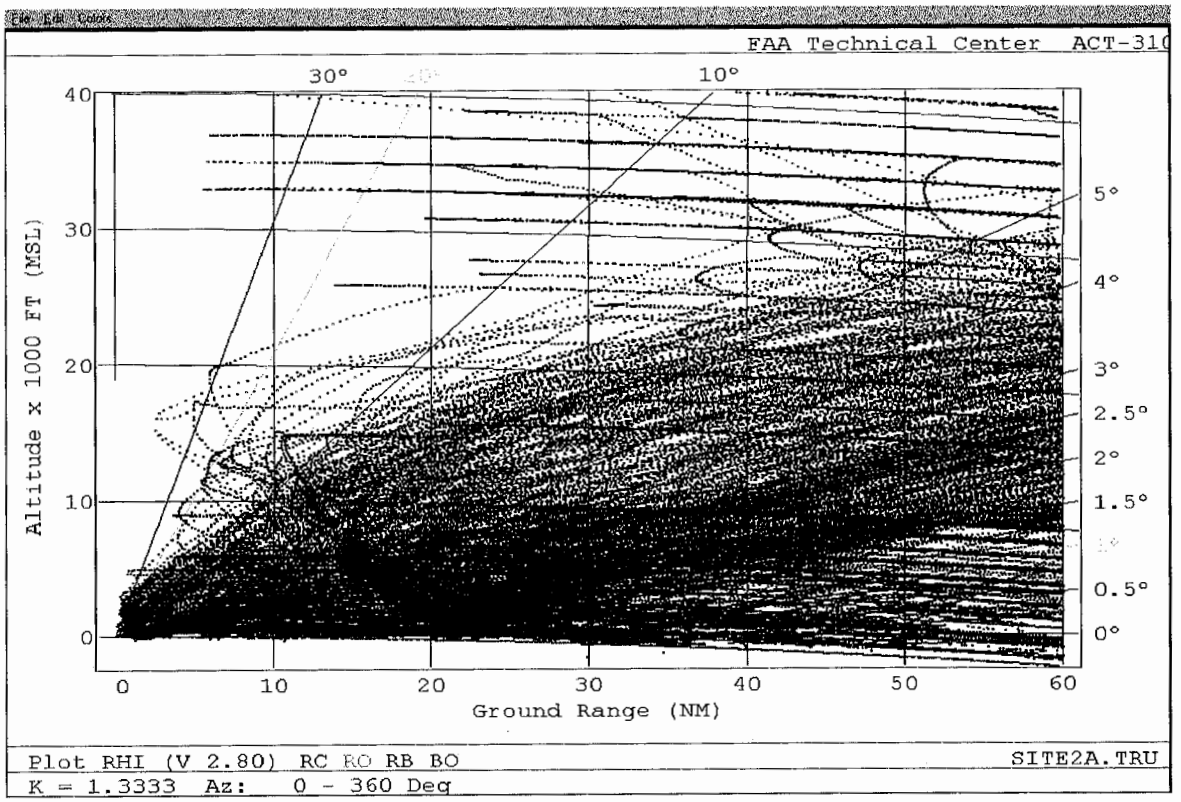


Figure C-9 . Site 2 – Intense weather and AP – Range Height Indicator

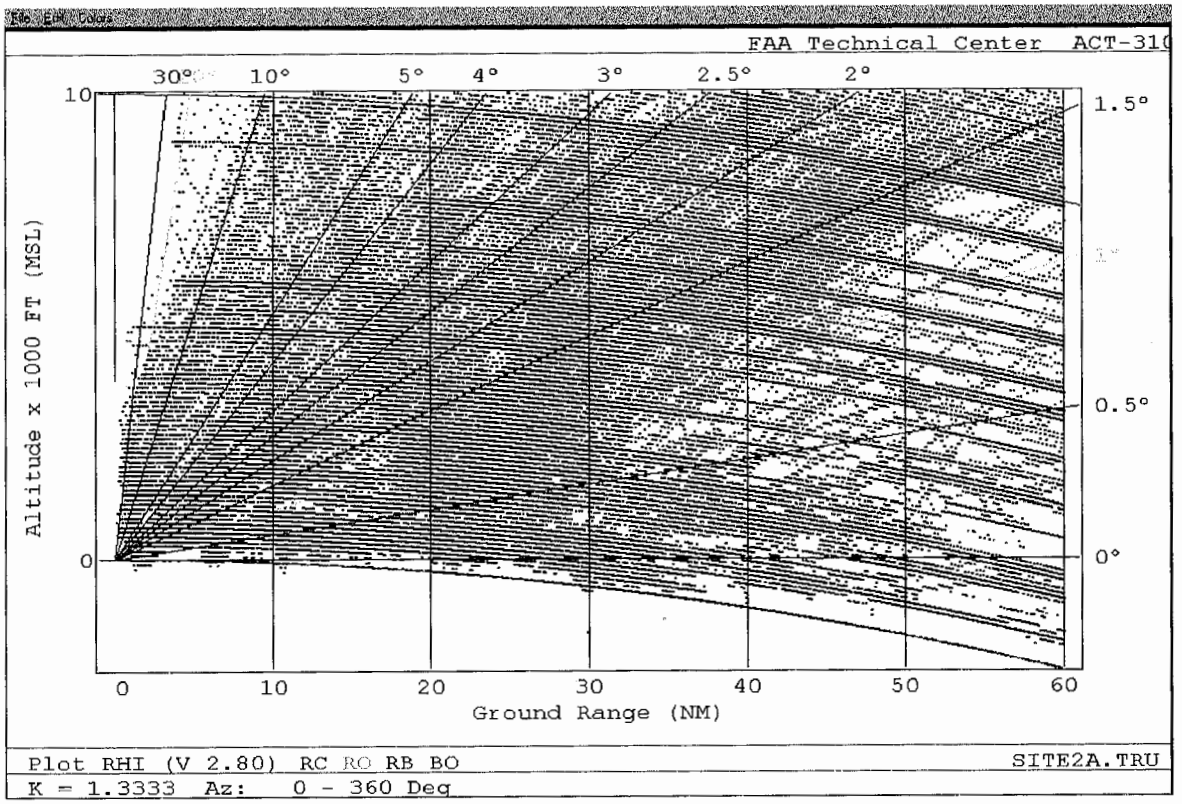


Figure C-10 . Site 2 – Intense weather and AP – Range Height Indicator – Low Angle Coverage

Appendix D

Site 3 Results:

Antenna Tilt: Antenna Polarization: Circular
Radar Antenna Tilt: Unknown
Beacon Antenna Tilt: Unknown
Beacon Interrogator Type: Mode-S
Weather Conditions: Level 1 and level 2 over most of the coverage volume with cells of levels 3 and 4
Clutter environment: Metropolitan area with some tall buildings, ground terrain is relatively flat
Road Traffic Environment: Less than two miles from a major interstate highway
Radar Interference Observed: Yes
AP Present (YES/NO): No

Maximum False Plot Rate Estimate: 64 in scan, averaged over 3 scans
Maximum False Plot Rate Estimate (Quality 0 filtering): 36
Maximum False Track Rate (10 scan average): 10
Maximum False Track Rate (10 scan average - Quality 0 filtering): 9

RBAT Surveillance Analysis Result Summary:

Target Category	Beacon Pd	Search Pd	Total Pd	Reinforcement
DISCRETE	99.1	87.46	99.61	87.06
NON DISCRETE	97.4	77.29	98.84	77.2
TOTAL	98.15	81.75	99.18	81.57

Beacon False Target Summary: (based upon 461817 discrete code target reports)

Category	Number	Percent
Split	264	.06
Ringaround	4	.00
Down reflection	15	.00
PRF	11	.00
Upreflection	99	.02
ATCRBS/Mode S	0	.00
Other	0	.00
Total	393	.09
Overall False Targets per Scan: .0655		

Reinforcement Rates :

Angle	Rate (%)
1-20 degrees	92.62
.5-1.0 degrees	82.63
.25-.5 degrees	77.78
0-.25 degrees	58.53
All angles	81.3

Quality Filtering Assessment: Data was collected over 6000 scans.

	Total Radar Only and Radar Correlated Reports				Real Aircraft	
	RO	%RO	RC	%RC	RC	%RC
Q0	16063	55.29	13853	18.18	11483	24.47
Q1	55812	19.17	17961	23.57	10039	21.39
Q2	4765	1.64	589	.77	233	.5
Q3	69601	23.91	43791	57.47	25175	53.64
Total	291141	100	76192	100	46930	100

Site Assessment: Very high traffic site. Relatively low number of false plot. Quality filtering significantly decreased the number of plots. However, it removed 25% of the true targets. Further evaluation shows that for tracks with a significant number of radar only reports there is only a 6% loss of true aircraft. A high percentage of the Quality zero targets were accompanied by Beacon only targets that failed to merge. More than 55% of traffic is below 1 degree in elevation. Analysis indicates that low angle targets have a higher percentage of quality zero targets.

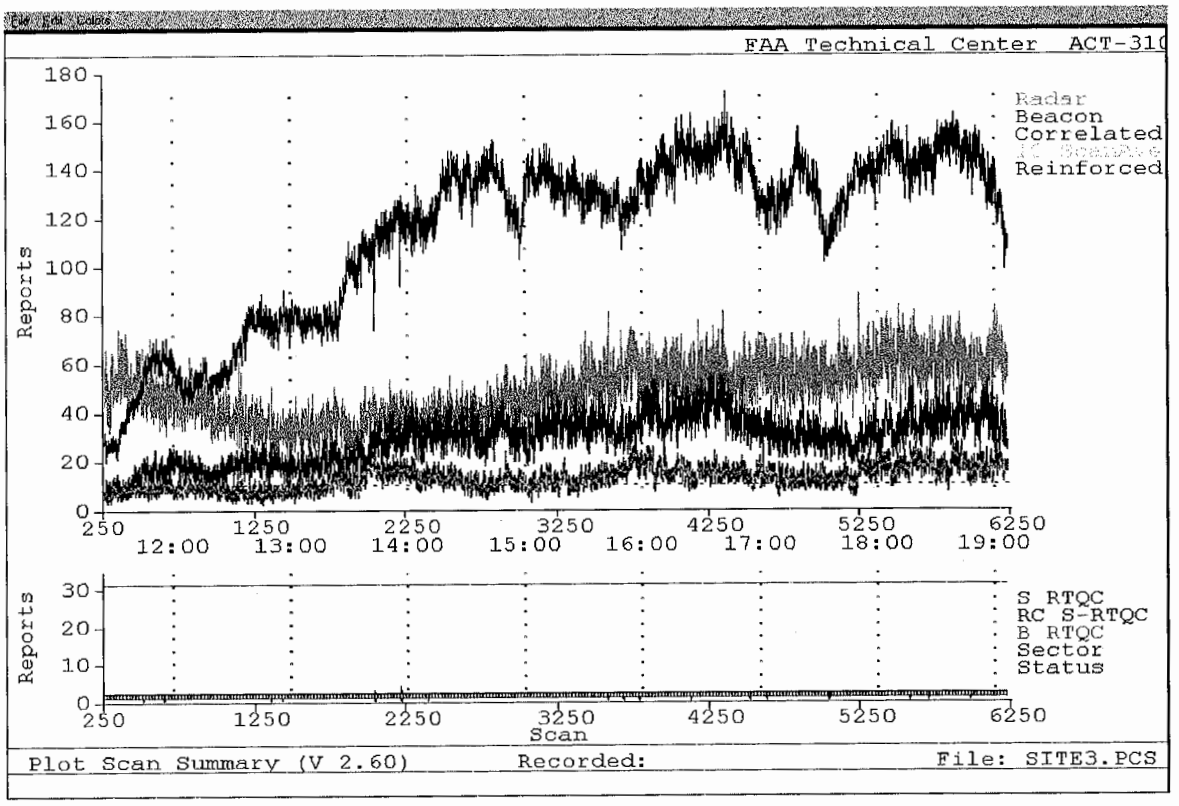


Figure D-1. Site 3 - Target counts with no quality filtering

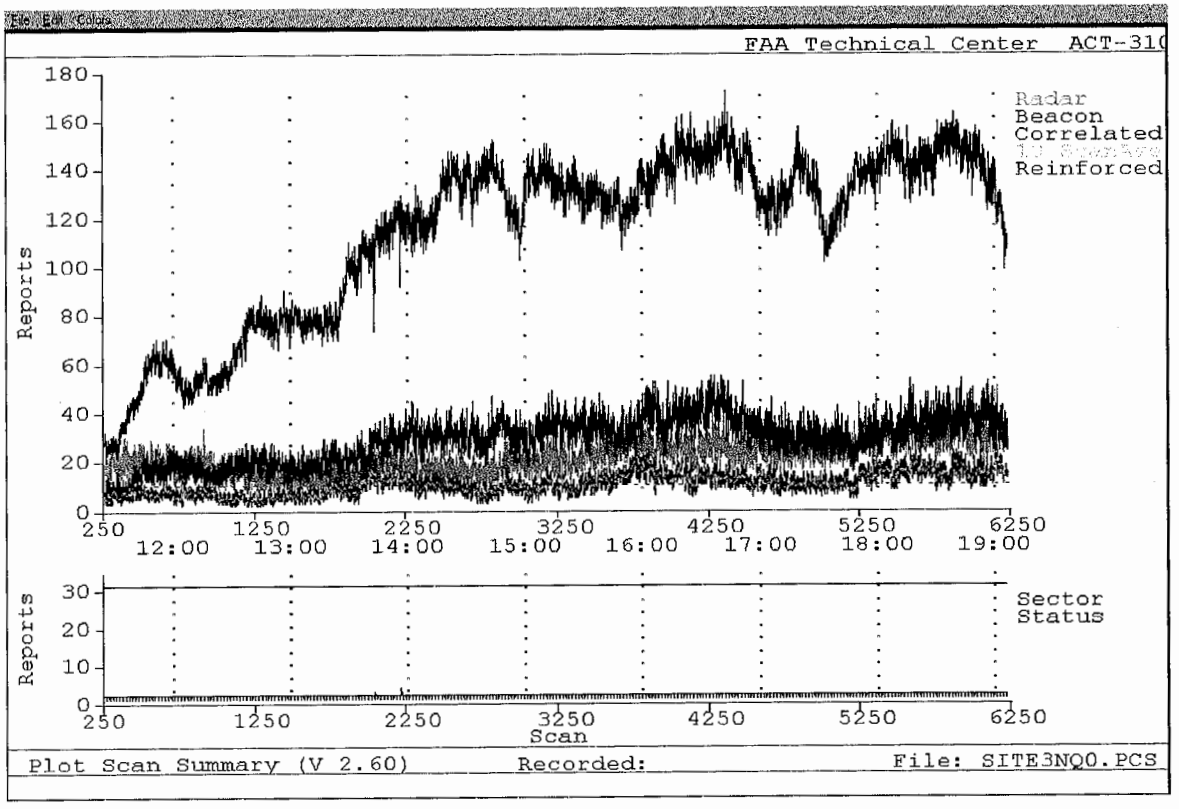


Figure D-2. Site 3 - Target counts with quality 0 filtering

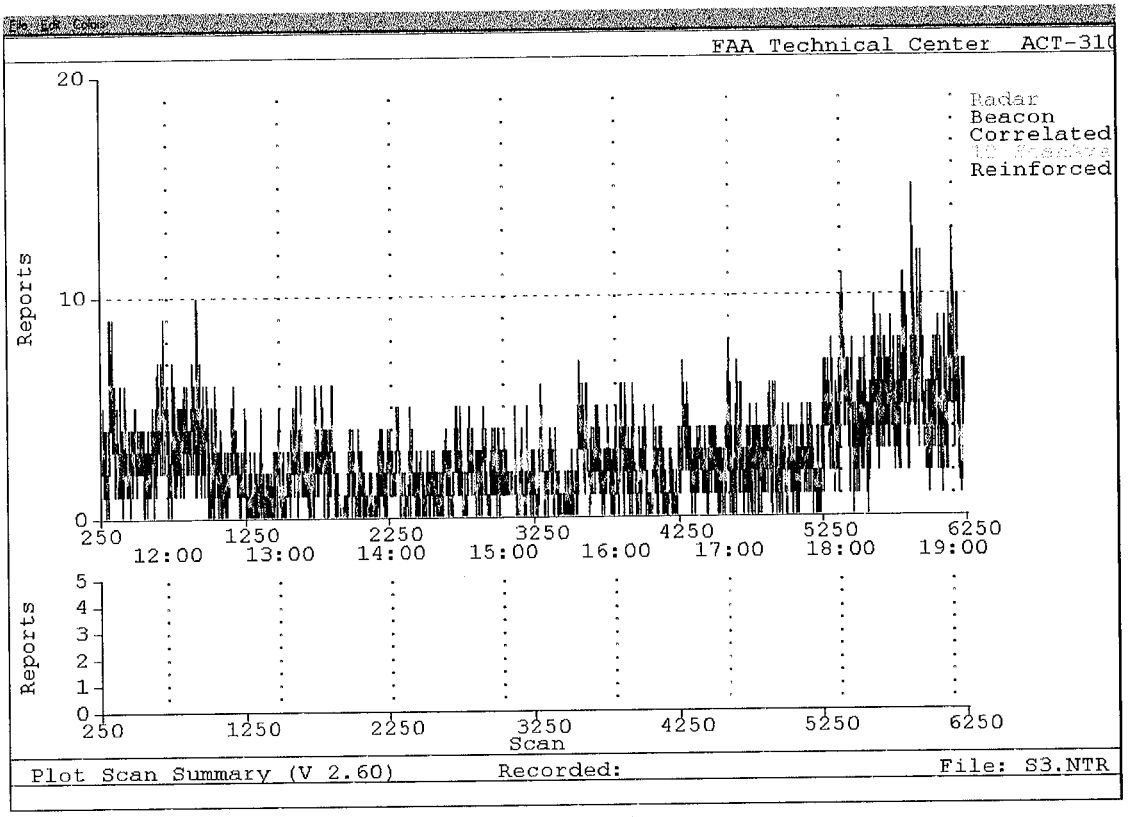


Figure D-3. Site 3 – False tracks no quality filtering

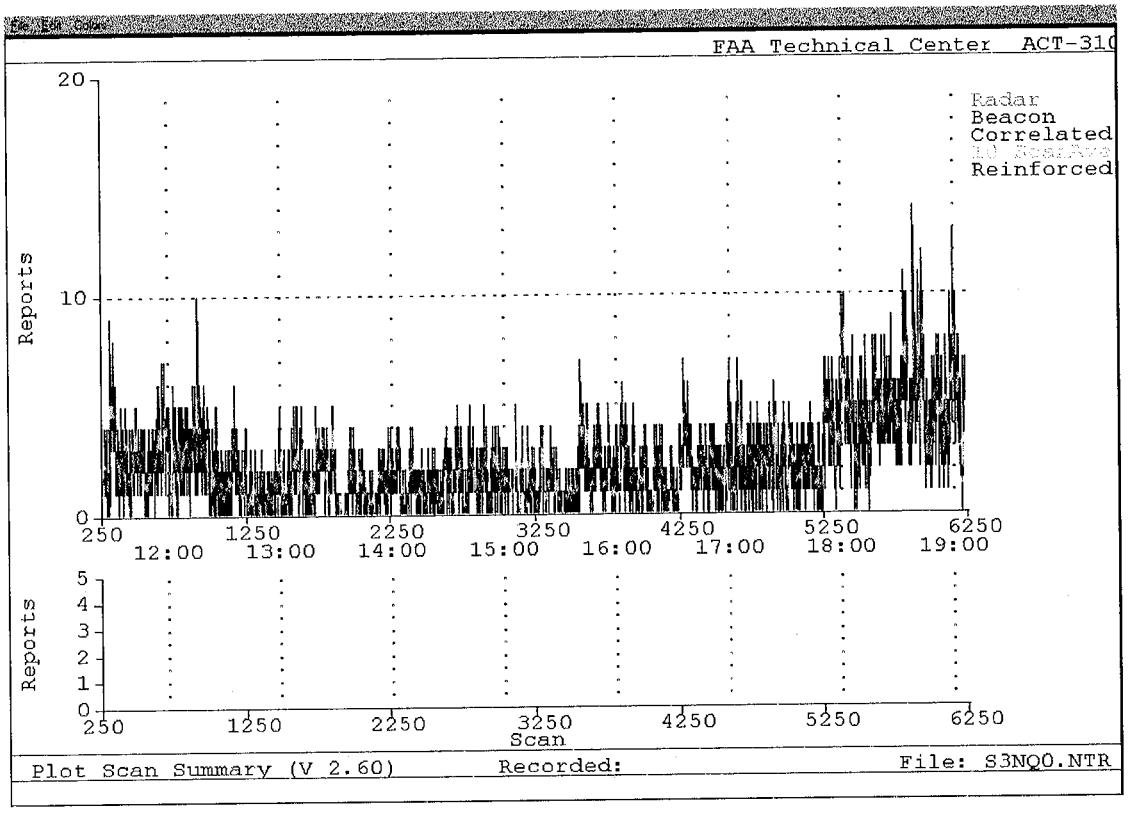


Figure D-4. Site 3 – False tracks with quality 0 filtering

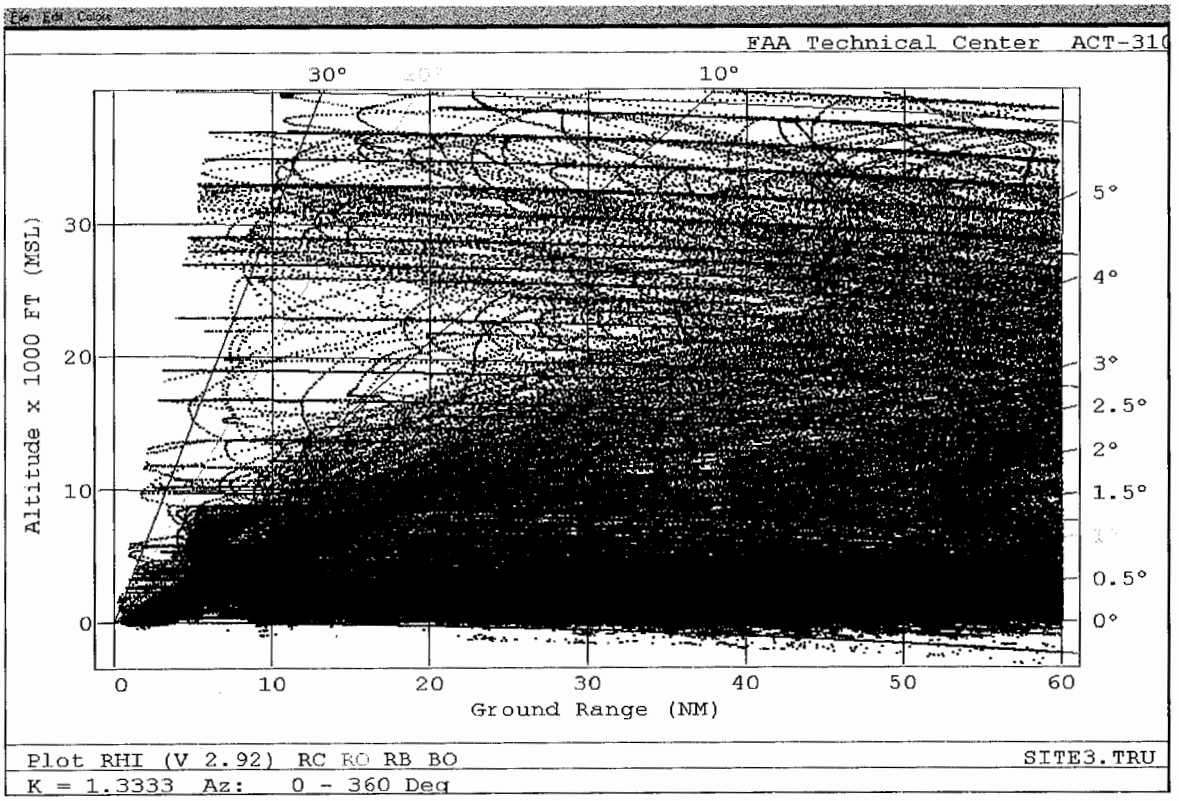


Figure D-5. Site 3 - Range Height Indicator display

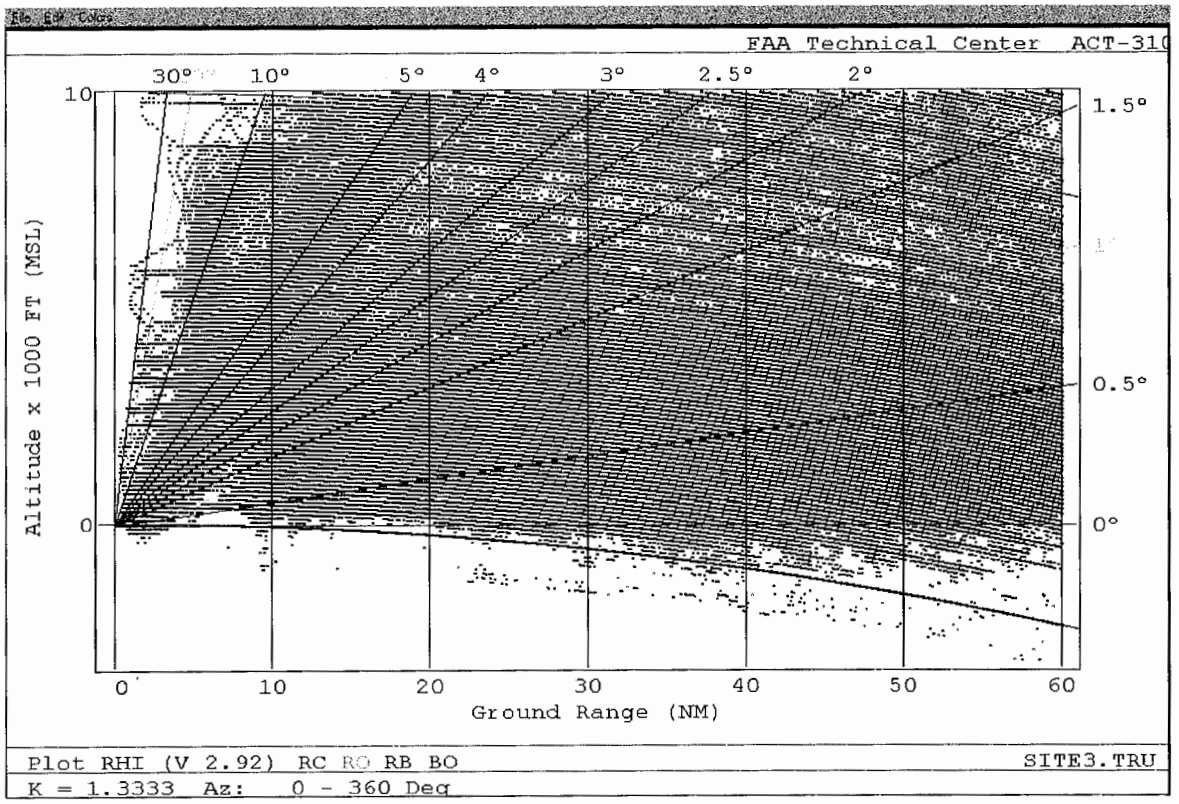


Figure D-6. Site 3 – Range Height Indicator display – Low angle coverage

Appendix E

Site 4 Results:

Antenna Polarization: Circular then linear at scan 1634
Radar Antenna Tilt: 0°
Beacon Antenna Tilt: 0°
Beacon Interrogator Type: Mode-S
Weather Conditions: Unknown
Clutter environment: Near major metropolitan area
Road Traffic Environment: Less than two miles from major city beltway and interstate
Radar Interference Observed: No
AP Present (YES/NO): No

Maximum False Plot Rate Estimate: 128 in scan, averaged over 3 scans
Maximum False Plot Rate Estimate (Quality 0 filtering): 42 in scan, averaged over 3 scans
Maximum False Track Rate (10 scan average): 9.5
Maximum False Track Rate (10 scan average - Quality 0 filtering): 7

RBAT Surveillance Analysis Result Summary:

Target Category	Beacon Pd	Search Pd	Total Pd	Reinforcement
DISCRETE	99.38	91.09	99.75	91.21
NON DISCRETE	100	93.52	100	93.52
TOTAL	99.39	91.10	99.75	91.22

Beacon False Target Summary: (based upon 43301 discrete code target reports)

Category	Number	Percent
Split	7	.02
Ringaround	13	.03
Down reflection	0	.00
PRF	0	.00
Upreflection	12	.03
ATCRBS/Mode S	0	.00
Other	0	.00
Total	32	.07
Overall False Targets per Scan: .0132		

Reinforcement Rates :

Angle	Rate (%)
1-20 degrees	95.6
.5-1.0 degrees	91.83
.25-.5 degrees	86.91
0-.25 degrees	77.97*
All angles	90.92

*small sample size

Quality Filtering Assessment: . Data was collected over 2422 scans.

	Total Radar Only and Radar Correlated Reports				Real Aircraft	
	RO	%RO	RC	%RC	RC	%RC
Q0	102294	70.33	7230	46	596	16.33
Q1	29777	20.47	4236	26.95	760	20.82
Q2	1229	.84	91	.58	35	.96
Q3	12158	8.36	4159	26.46	2259	61.89
Total	145458	100	15716	100	3650	100

Site Assessment: Data reflects low traffic site. All aircraft flying within radar coverage during the recording appeared to be transponder equipped. Review of figures A5-1 and A5-2 shows that quality zero filtering causes a significant drop in radar target volume.

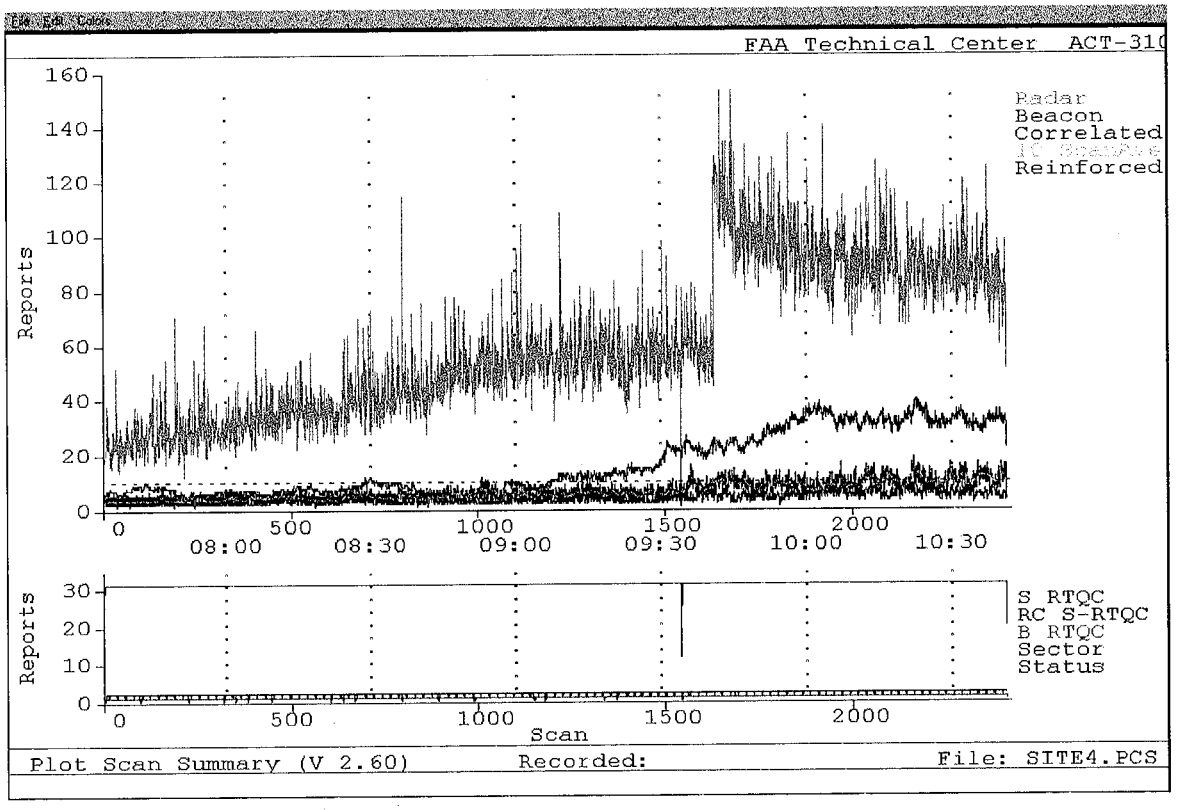


Figure E-1. Site 4 - Target counts with no quality filtering

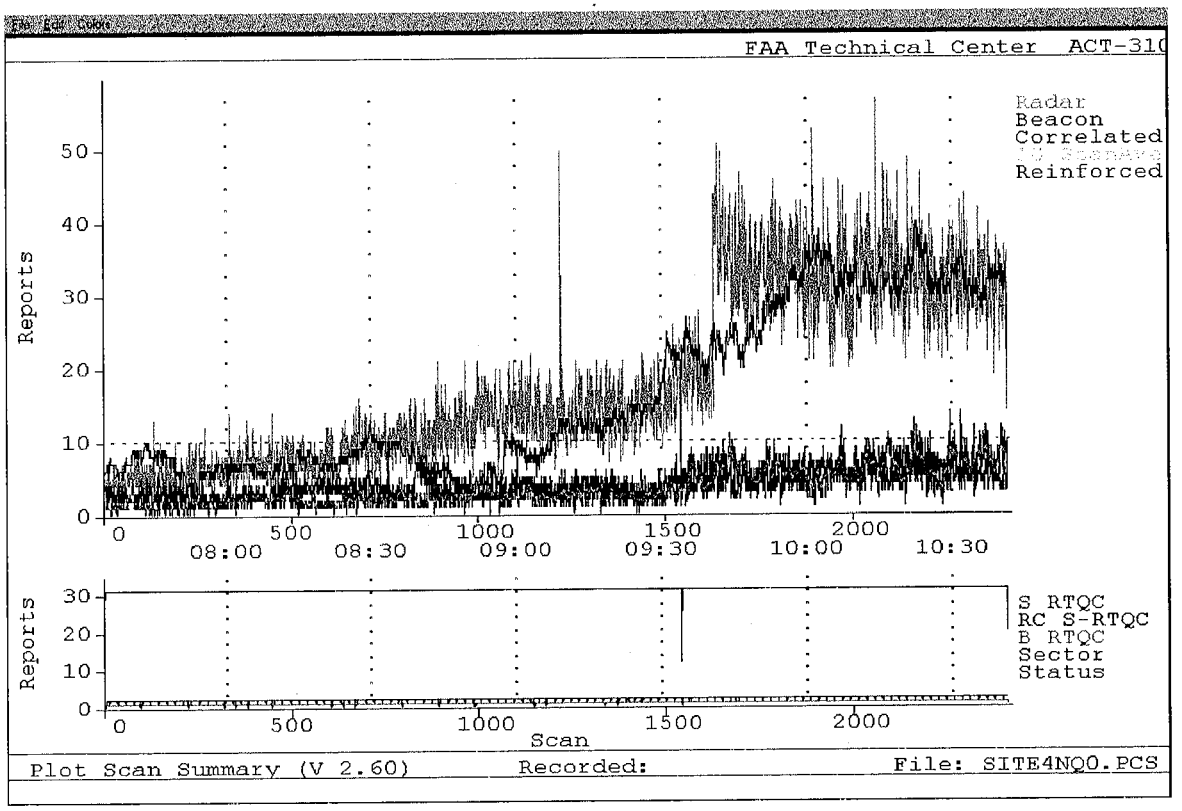


Figure E-2. Site 4 - Target Counts with quality 0 filtering

	Total Radar Only and Radar Correlated Reports				Real Aircraft	
	RO	%RO	RC	%RC	RC	%RC
Q0	55483	68.04	7291	40.11	423	6.25
Q1	13651	16.74	3335	18.35	871	12.87
Q2	337	.41	33	.18	18	.27
Q3	12070	14.80	7517	41.36	5455	80.61
Total	81541	100	18541	100	6767	100

Table 4.5-1 – Target quality distribution - Site 1

	Total Radar Only and Radar Correlated Reports				Real Aircraft	
	RO	%RO	RC	%RC	RC	%RC
Q0	214884	50.13	12067	22.97	3153	13.09
Q1	129525	30.21	13889	26.43	5723	23.77
Q2	12703	2.96	292	.56	111	.46
Q3	71579	16.7	26294	50.4	15092	62.68
Total	429691	100	52542	100	24079	100

Table 4.5-2 – Target quality distribution - Site 2

	Total Radar Only and Radar Correlated Reports				Real Aircraft	
	RO	%RO	RC	%RC	RC	%RC
Q0	1596742	67.35	20834	16.70	708	22.80
Q1	409224	17.26	29283	23.48	911	29.34
Q2	90520	3.82	5968	4.78	66	2.13
Q3	274501	11.58	68652	55.04	1420	45.73
Total	2370987	100	124737	100	3105	100

Table 4.5-3 – Target quality distribution - Site 2a

	Total Radar Only and Radar Correlated Reports				Real Aircraft	
	RO	%RO	RC	%RC	RC	%RC
Q0	16063	55.29	13853	18.18	11483	24.47
Q1	55812	19.17	17961	23.57	10039	21.39
Q2	4765	1.64	589	.77	233	.5
Q3	69601	23.91	43791	57.47	25175	53.64
Total	291141	100	76192	100	46930	100

Table 4.5-4 – Target quality distribution - Site 3

	Total Radar Only and Radar Correlated Reports				Real Aircraft	
	RO	%RO	RC	%RC	RC	%RC
Q0	102294	70.33	7230	46	596	16.33
Q1	29777	20.47	4236	26.95	760	20.82
Q2	1229	.84	91	.58	35	.96
Q3	12158	8.36	4159	26.46	2259	61.89
Total	145458	100	15716	100	3650	100

Table 4.5-5 – Target quality distribution - Site 4

	Total Radar Only and Radar Correlated Reports				Real Aircraft	
	RO	%RO	RC	%RC	RC	%RC
Q0	65847	51.74	6394	37.15	833	22.30
Q1	26737	21.01	3637	21.13	753	20.16
Q2	5150	4.05	1549	9.00	193	5.17
Q3	29527	23.20	5629	32.71	1956	52.37
Total	127267	100	17209	100	3735	100

Table 4.5-6 – Target quality distribution - Site 5

	Total Radar Only and Radar Correlated Reports				Real Aircraft	
	RO	%RO	RC	%RC	RC	%RC
Q0	148317	17.54	13356	54.70	902	19.02
Q1	340813	40.30	6558	26.86	1530	32.26
Q2	84063	9.94	193	.79	102	2.15
Q3	272600	32.23	4309	17.65	2209	46.57
Total	845793	100	24416	100	4743	100

Table 4.5-7 – Target quality distribution - Site 6

Target Report Type	Site							Total	% of Total Radar Reports
	1	2	2a	3	4	5	6		
Radar Correlated	6767	24079	3105	46930	3650	3735	4743	93009	5.02
Radar Beacon Merge	128214	296785	150477	686347	39346	141524	314083	1756776	94.98

Table 4.5-8 – Distribution of Radar Correlated and Radar/Beacon Merge Targets for all sites

	Radar Only		Radar Correlated	
Quality Level	Reports	Percent	Reports	Percent
Q0	88138	25.80	15048	8.01
Q1	60006	17.57	20499	10.91
Q2	6034	1.77	879	.47
Q3	187407	54.86	151537	80.62
Total	341580	100	187402	100

Table 4.5-9 – Quality distribution of total target population – Site 5 with merge window set to zero

	Radar Only		Radar Correlated	
Quality Level	Reports	Percent	Reports	Percent
Q0	5323	4.89	2176	3.89
Q1	10350	9.50	4766	8.51
Q2	530	.49	220	.39
Q3	92763	85.13	48816	87.21
Total	108966	100	55978	100

Table 4.5-10 – Quality distribution of real targets – Site 5 with merge window set to zero

	Radar Only		Radar Correlated	
Quality Level	Reports	Percent	Reports	Percent
Q0	82815	35.6	12872	9.8
Q1	49656	21.3	15733	12.0
Q2	5504	2.4	659	0.5
Q3	94644	40.7	102721	77.8
Total	232614	100	131424	100

Table 4.5-11 – Quality distribution had radar targets been able to merge with beacon targets – data collection from Site 5 with merge window set to zero

Range Band (nmi)	%Quality zero versus elevation angle			
	1°-20°	.5°-1°	.25°-.5°	0°-.25°
0-20	.44	2.35	4.65	16.51
20-40	1.84	4.37	8.02	13.48
40-60	6.2	15.78	17.15	26.64

Table 4.5-12 – Percentage of Quality zero targets as a function of range and azimuth – Site 5 with merge window set to zero

5.0 Summary of Results

Beacon Pd - ASR-9 Beacon Pd ranged from 98.15% to 99.55% using RBAT analysis.

Radar Pd - The ASR-9 radar Pd ranged from 81.75 to 95.56% using RBAT analysis. Five of the six sites had a radar Pd over 90%. Site 3 whose radar Pd was 81.75% had over 55% of its air traffic at elevation angles less than 1 degree.

Overall Reinforcement Rates - Overall reinforcement rates (all angles) ranged from 81.57 to 95.7%. Reinforcement rates at all sites were in excess of 90% with the exception of site 3, whose reinforcement rate was 81.57%. As stated above, over 55% of the air traffic at this site was at elevation angles less than one degree.

Reinforcement Rates vs. Elevation Angle - Reinforcement rates in the peak of the antenna beam (between 1 and 20 degrees elevation) ranged between 92.62 and 98.24%. Low angle coverage at all sites was good. Reinforcement rates between .25 and .5 degrees ranged from 77.78 to 91.31 %.

Beacon False Targets - Observed beacon false target rates ranged from .004 to .236 false beacon targets per scan (averaged over the data recording duration).

False Track Report Rates - Maximum false track report rates ranged from 4 to 28 false track reports per scan averaged over 10 scans. The highest maximum false plot rate of 28 false tracks per scan (averaged over 10 scans) was observed at site 2 under severe weather conditions. The lowest maximum false track report rate of 4 tracks per scan was observed at site 6, the only 9-PAC phase 2 site analyzed. It was observed under conditions of level three weather with weather peaks up to level 5.

False Plot Report rates - Maximum false plot report rages ranges from 40 to 410 false plots per scan averaged over three scans without quality zero filtering. The maximum average of 410 false plots per scan (averaged over 3 scans) was observed at Site 2 under severe weather conditions. With the recommended ASR-9 target report quality zero filtering (simulated), the maximum average false plot rate of 136 false plots per scans was observed at this site. Note: there is no false plot requirement in the ASR-9 specification.

Quality Filtering - Enabling of quality zero filtering was found to result in the removal of 3.8-24.47% of true radar targets while removing an estimated 35-70% of false plots at 9-PAC phase 1 sites. Quality zero filtering could not be evaluated at the 9-PAC phase 2 site due to limits in the data collection. In general, quality zero targets report rates increase at lower angles and greater distances from the radar.

6.0 Recommendations

It is recommended that total system performance requirements be considered when comparing these results to ASR-11 performance. All sites analyzed were operational radar sites optimized to meet operational user needs. All of the ASR-9 sites were optimized to achieve high reinforcement rates at low coverage angles. Low angle coverage achieved by a radar is a function of radar optimization. Trade-offs can be made between low angle coverage and primary radar false alarm rates. In general, achieving good low angle coverage requires a lower antenna tilt to increase the signal returned from low angle targets. In doing so, clutter returns are also increased in signal strength. This is likely to cause significant increases in false alarm rates and in some cases decreases overall sensitivity since all radar returns must compete with the increased clutter signal strength.

Meaningful comparison with the baseline performance documented within this test report requires radar optimization to similar overall user needs.

Appendix A

Site 1 Performance:

Antenna Polarization: Linear
Radar Antenna Tilt: 0°
Beacon Antenna Tilt: 0°
Beacon Interrogator type: ATCBI 4
Weather Conditions: Clear, very sporadic level 1 weather, visually observed as cloudy with some sun
Clutter environment: 15 miles from metropolitan area. Ground is relatively flat over half of coverage area. Other half of coverage area is rolling hills starting at 10 miles rising up to 600 ft at the outer edge of the coverage area
Road Traffic Environment: 15 miles from interstate highway. Minor roads locally
Radar Interference Observed: No
AP Present (YES/NO): No

Maximum False Plot Rate Estimate: 40 in scan, averaged over 3 scans
Maximum False Plot Rate Estimate (Quality 0 filtering): 20 in scan averaged over 3 scans
Maximum False Track Rate (10 scan average): 6
Maximum False Track Rate (10 scan average - Quality 0 filtering): 5

RBAT Surveillance Analysis Result Summary:

Target Category	Beacon Pd	Search Pd	Total Pd	Reinforcement
DISCRETE	99.39	91.53	99.71	91.76
NON DISCRETE	98.13	86.91	99.22	87.44
TOTAL	99.27	91.08	99.66	91.35

Beacon False Target Summary: (based upon 133604 discrete code target reports)

Category	Number	Percent
Split	10	.01
Ringaround	0	.00
Down reflection	2	.00
PRF	0	.00
Upreflection	0	.00
ATCRBS/Mode S	0	.00
Other	0	.00
Total	12	.01
Overall False Targets per Scan: .004		

Reinforcement Rates vs Angle:

Angle	Rate (%)
1-20 degrees	94.82
.5-1.0 degrees	89.45
.25-.5 degrees	86.87
0-.25 degrees	67.55
All angles	91.32

Quality Filtering Assessment: Data was collected over 2934 scans and does not include radar reports that were merged with beacon reports.

	Total Radar Only and Radar Correlated Reports				Real Aircraft	
	RO	%RO	RC	%RC	RC	%RC
Q0	55483	68.04	7291	40.11	423	6.25
Q1	13651	16.74	3335	18.35	871	12.87
Q2	337	.41	33	.18	18	.27
Q3	12070	14.80	7517	41.36	5455	80.61
Total	81541	100	18541	100	6767	100

Site Assessment: Low angle reinforcement rates are good down to .25 to .5 degree elevation range. Low Pd impacts observed from implementing quality filtering of Quality zero targets. Several transponderless aircraft were observed in this data set.

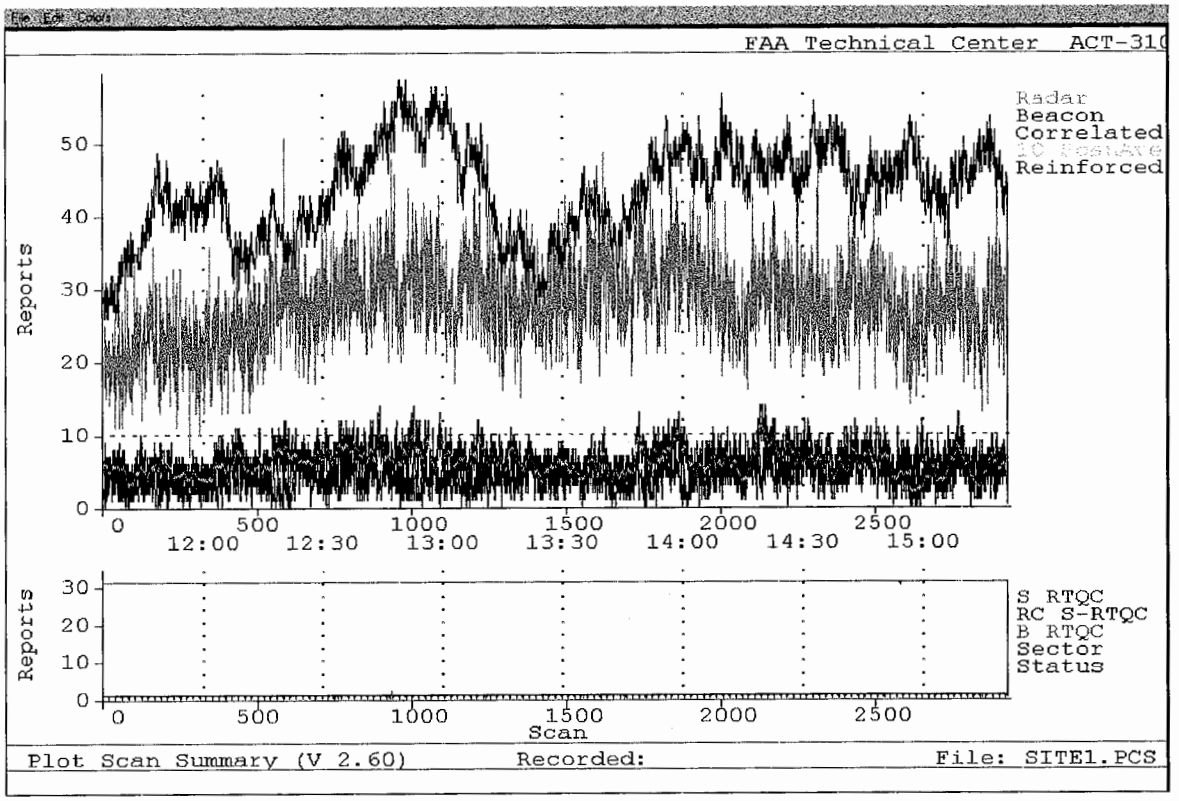


Figure A-1. Site 1 – Target counts with no quality filtering

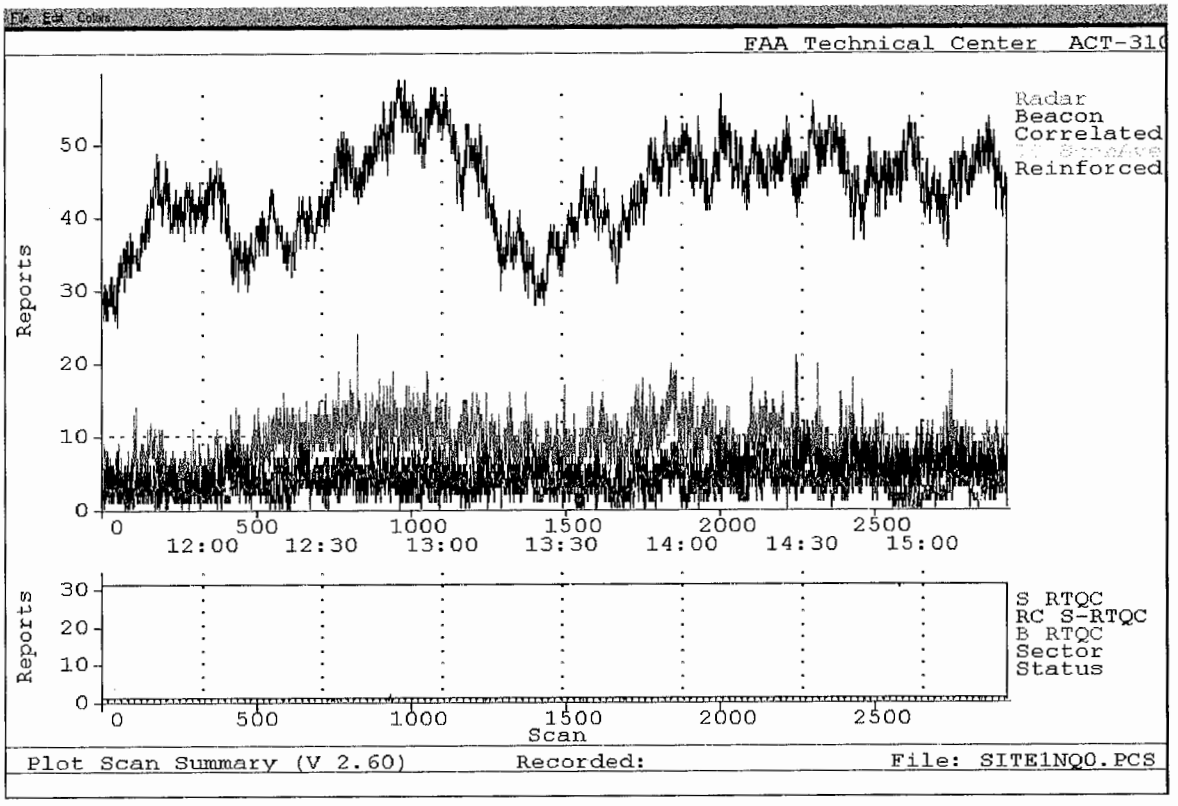


Figure A-2. Site 1 – Target counts with Quality 0 filtering

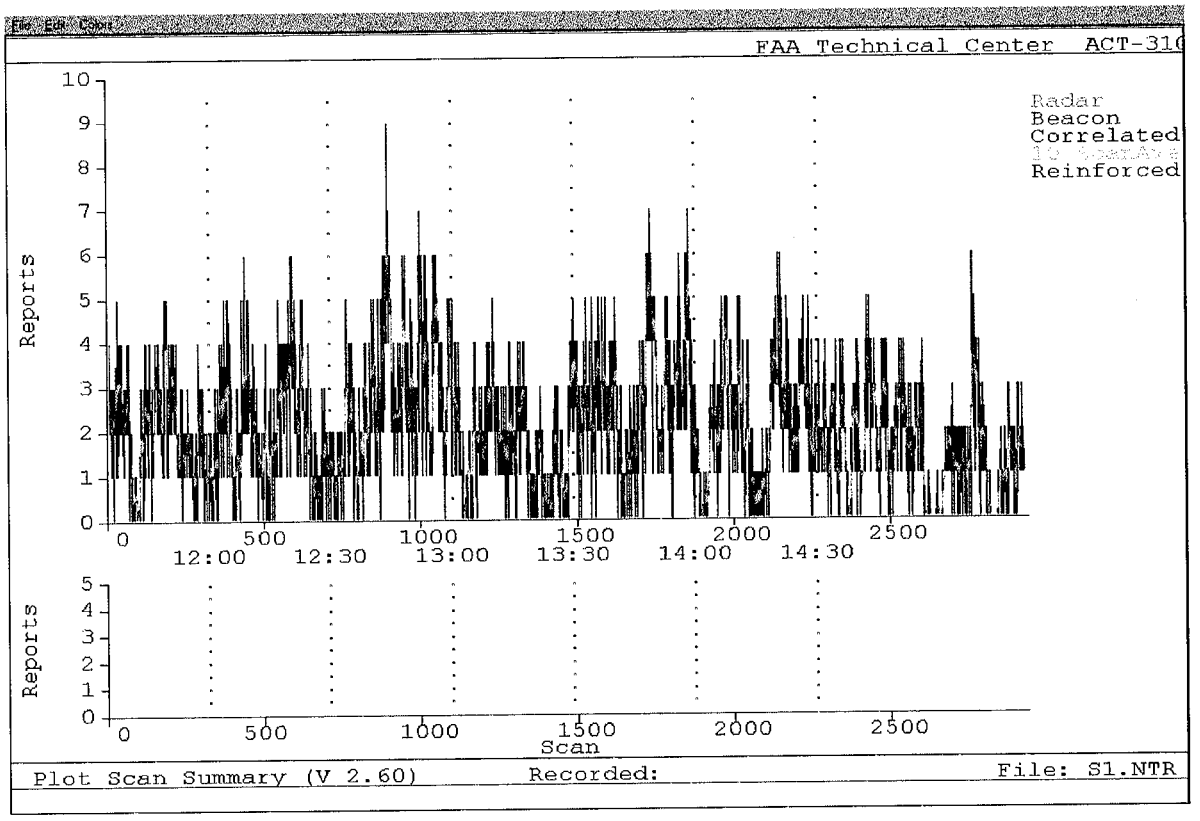
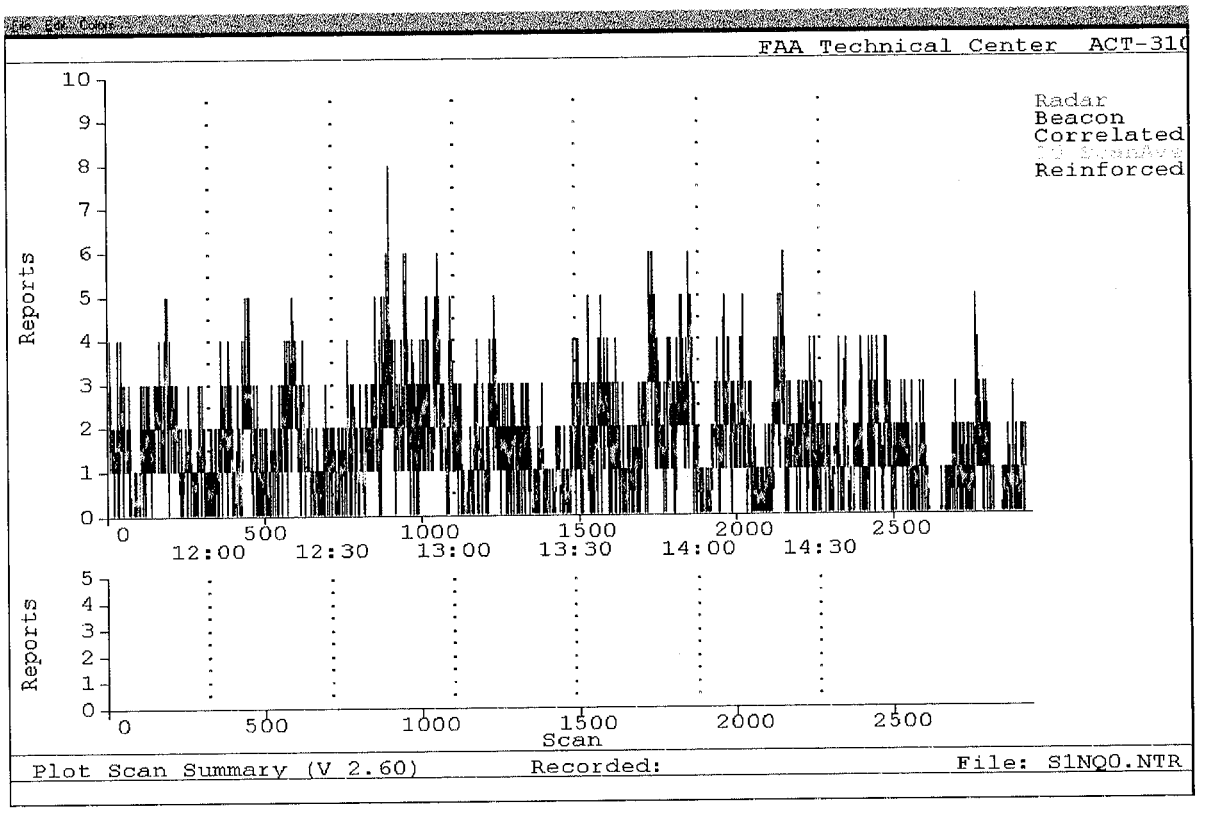


Figure A-3. False tracks



Site Figure A-4. False tracks – quality 0 filtering

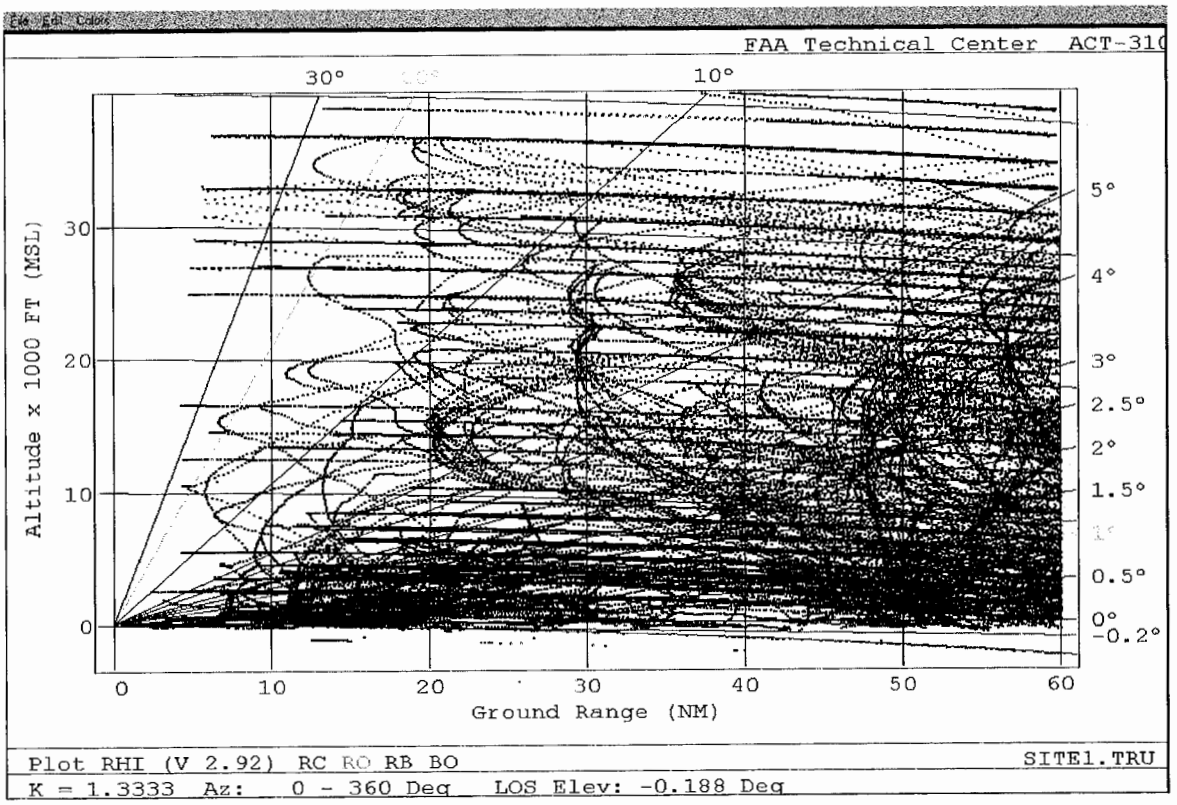


Figure A-5. Site 1 – Range Height Indicator display

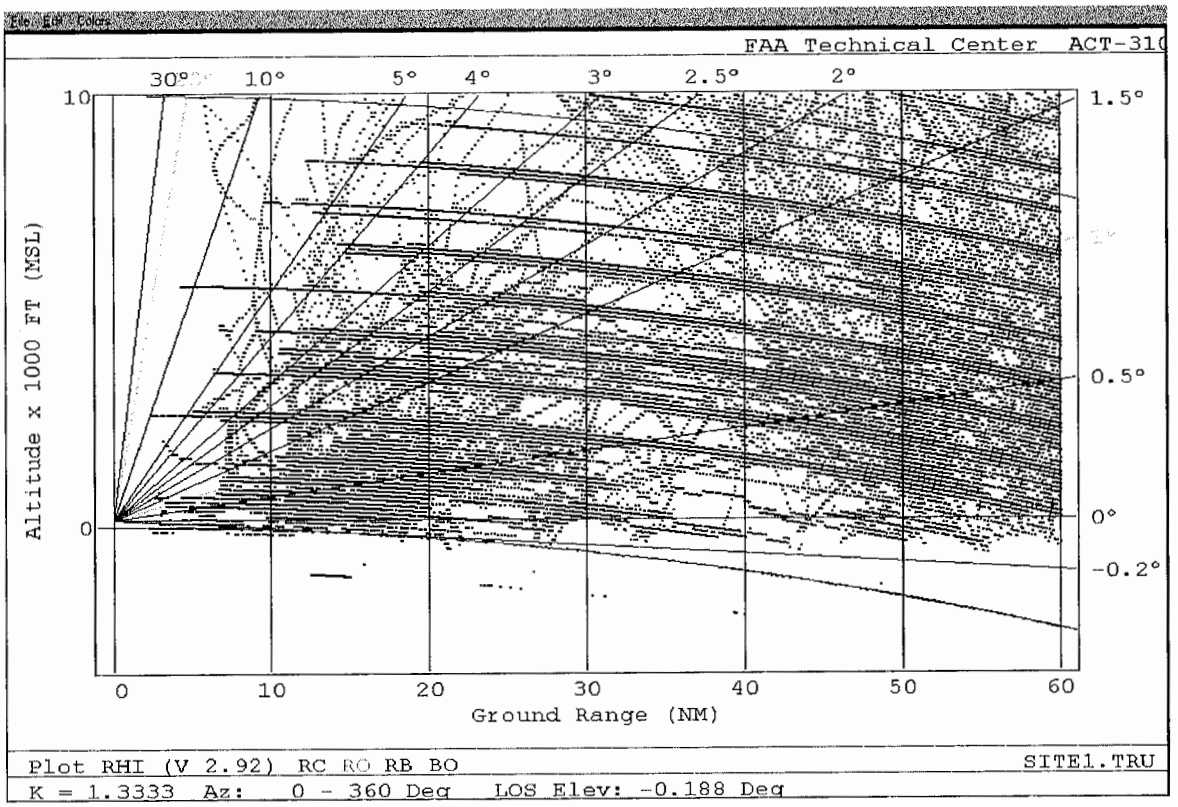


Figure A-6. Site 1 – Range Height Indicator display – Low angle coverage

Appendix B

Site 2 – clear conditions:

Antenna Polarization: Linear
Radar Antenna Tilt: Unknown
Beacon Antenna Tilt: Unknown
Beacon Interrogator Type: Mode-S
Weather Conditions: Clear and sunny
Clutter environment: Major metropolitan area, sea clutter over portion of the coverage area. Ground terrain is relatively flat
Road Traffic Environment: Between inner and outer beltways of major city (less than three miles from each), less than two miles from major interstate
Radar Interference Observed: No
AP Present (YES/NO): No

Maximum False Plot Rate Estimate (no Quality filtering): 135 in scan, averaged over 3 scans
Maximum False Plot Rate Estimate (Quality 0 filtering): 65 in scan, averaged over 3 scans
Maximum False Track Rate (10 scan average): 12
Maximum False Track Rate (10 scan average - Quality 0 filtering): 12

RBAT Surveillance Analysis Result Summary:

Target Category	Beacon Pd	Search Pd	Total Pd	Reinforcement
DISCRETE	99.44	95.77	99.77	95.97
NON DISCRETE	96.49	90.82	98.78	91.74
TOTAL	98.15	93.6	99.34	94.15

Beacon False Target Summary: (based upon 222514 discrete code target reports)

Category	Number	Percent
Split	159	.07
Ringaround	6	.00
Down reflection	10	.00
PRF	99	.04
Upreflection	161	.07
ATCRBS/Mode S	0	.00
Other	0	.00
Total	435	.18
Overall False Targets per Scan: .102		

Reinforcement Rates :

Angle	Rate (%)
1-20 degrees	98.17
.5-1.0 degrees	96.77
.25-.5 degrees	91.31
0-.25 degrees	81.92
All angles	94.00

Quality Filtering Assessment: Data was collected over 4238 scans and does not include radar reports that were merged with beacon reports.

	Total Radar Only and Radar Correlated Reports				Real Aircraft	
	RO	%RO	RC	%RC	RC	%RC
Q0	214884	50.13	12067	22.97	3153	13.09
Q1	129525	30.21	13889	26.43	5723	23.77
Q2	12703	2.96	292	.56	111	.46
Q3	71579	16.7	26294	50.4	15092	62.68
Total	429691	100	52542	100	24079	100

Site Assessment: Relatively high plot and false track rates. Reinforcement rates are very high even down to low angles. This ASR-9 site has 6 active airports within its coverage volume. The high false target rates observed may be due to trade-offs made to achieve high Pd for the low angle targets in the surrounding airports.

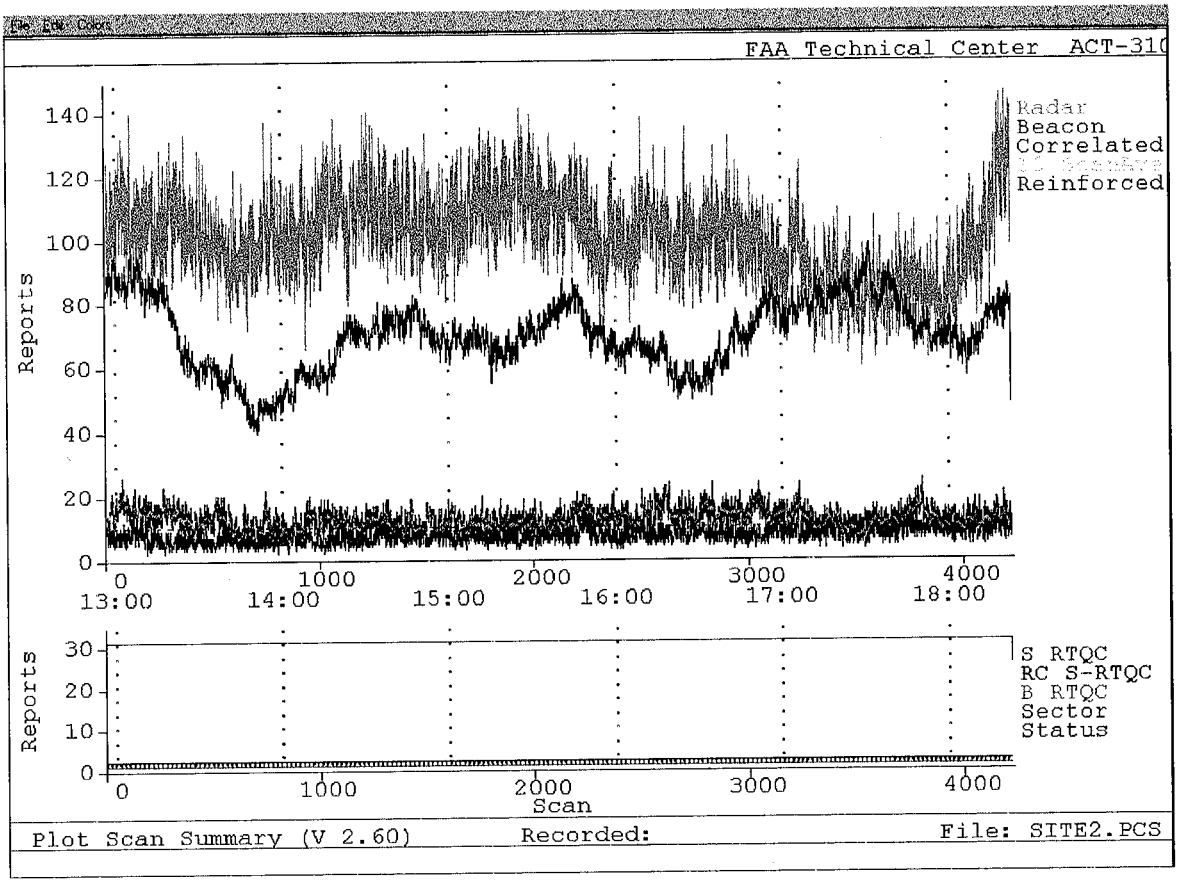


Figure B-1. Site 2 - clear conditions – Target counts with no quality filtering

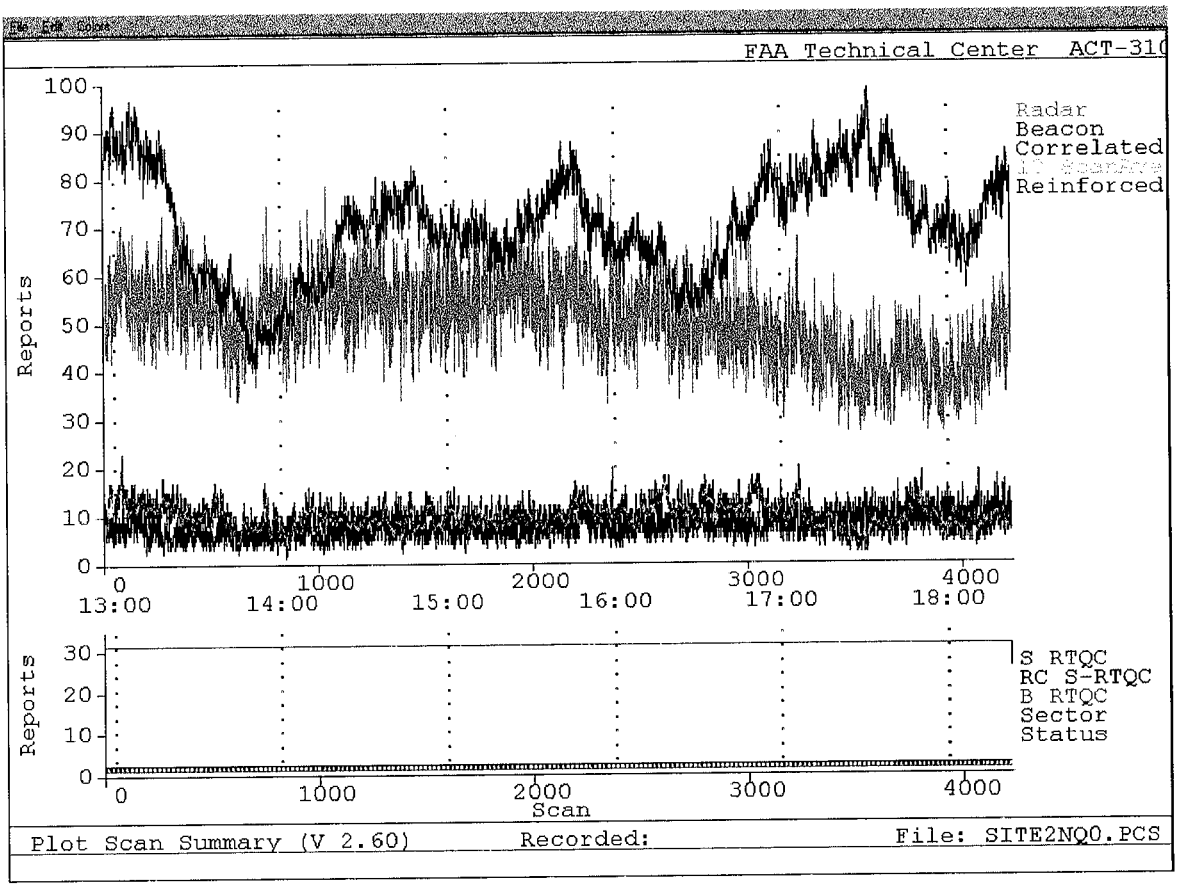


Figure B-2. Site2 – clear conditions - Target Counts with quality 0 filtering

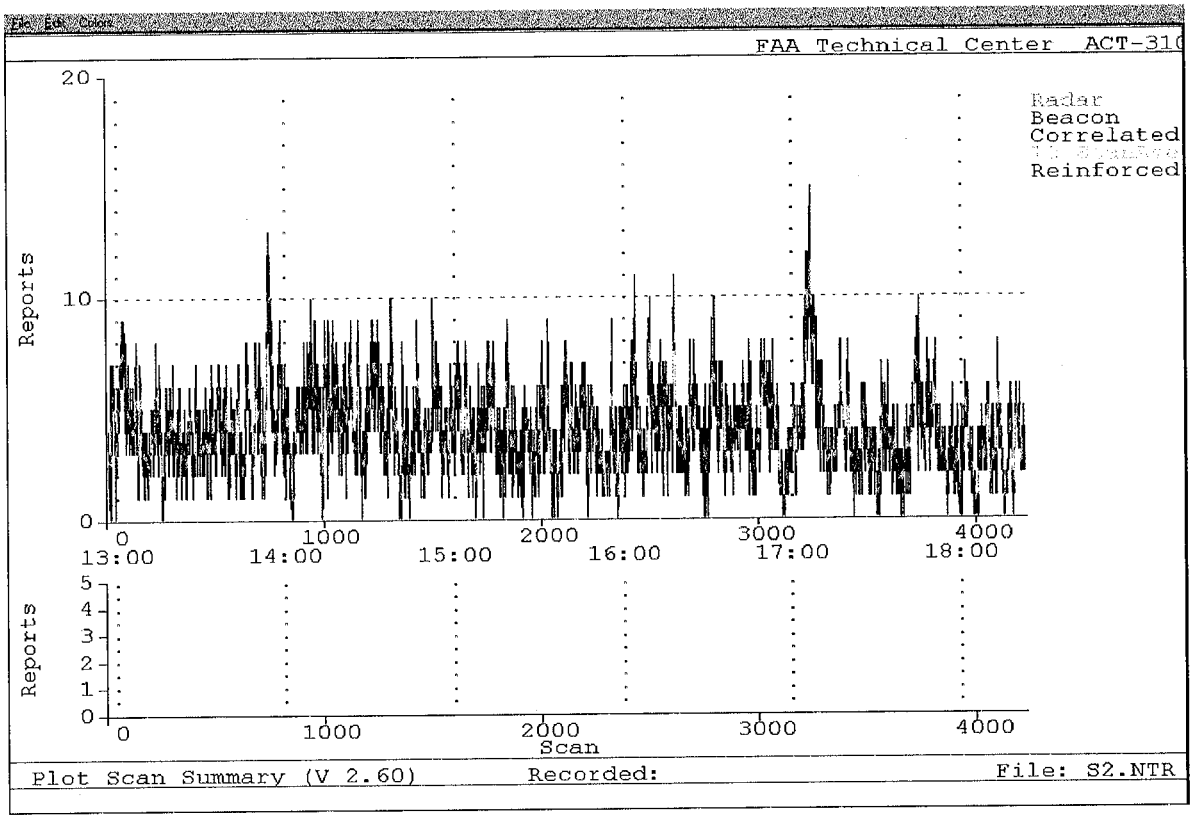


Figure B-3. Site 2 – clear conditions – False Tracks.

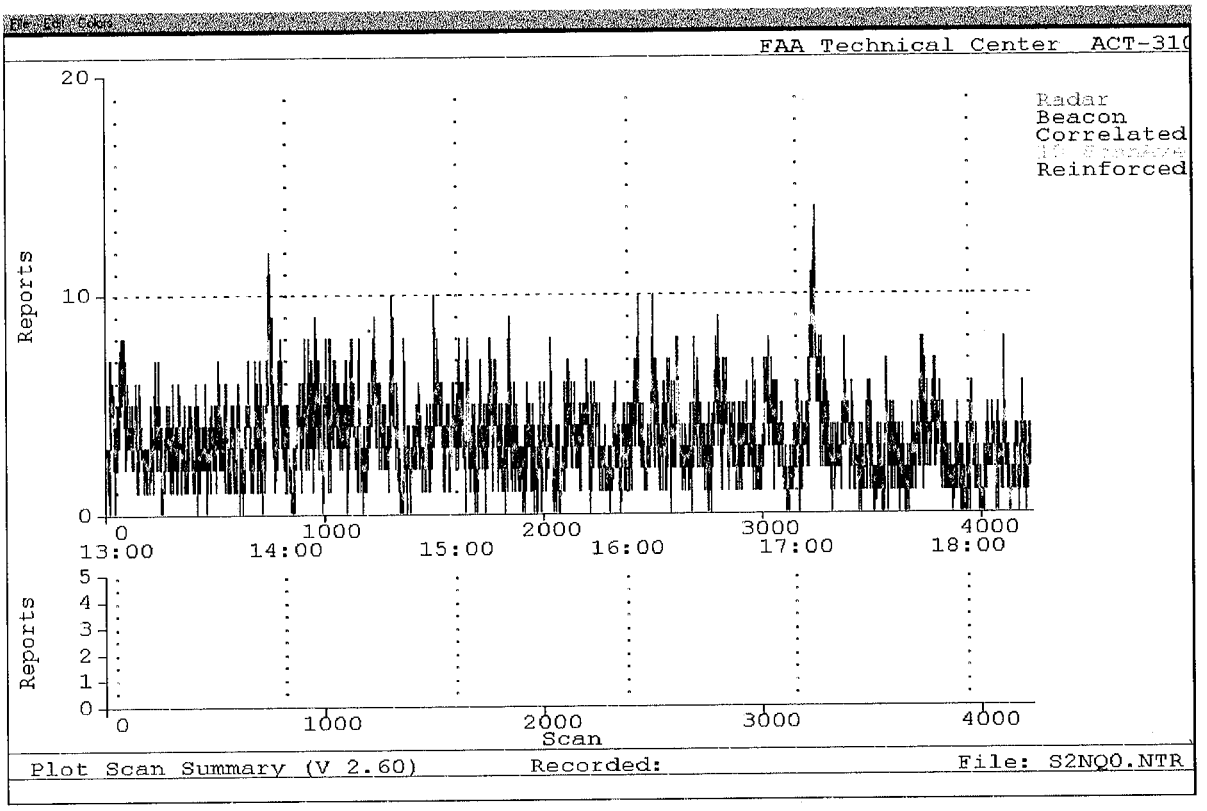


Figure B-4. Site2 – clear conditions – False Tracks with quality zero filtering

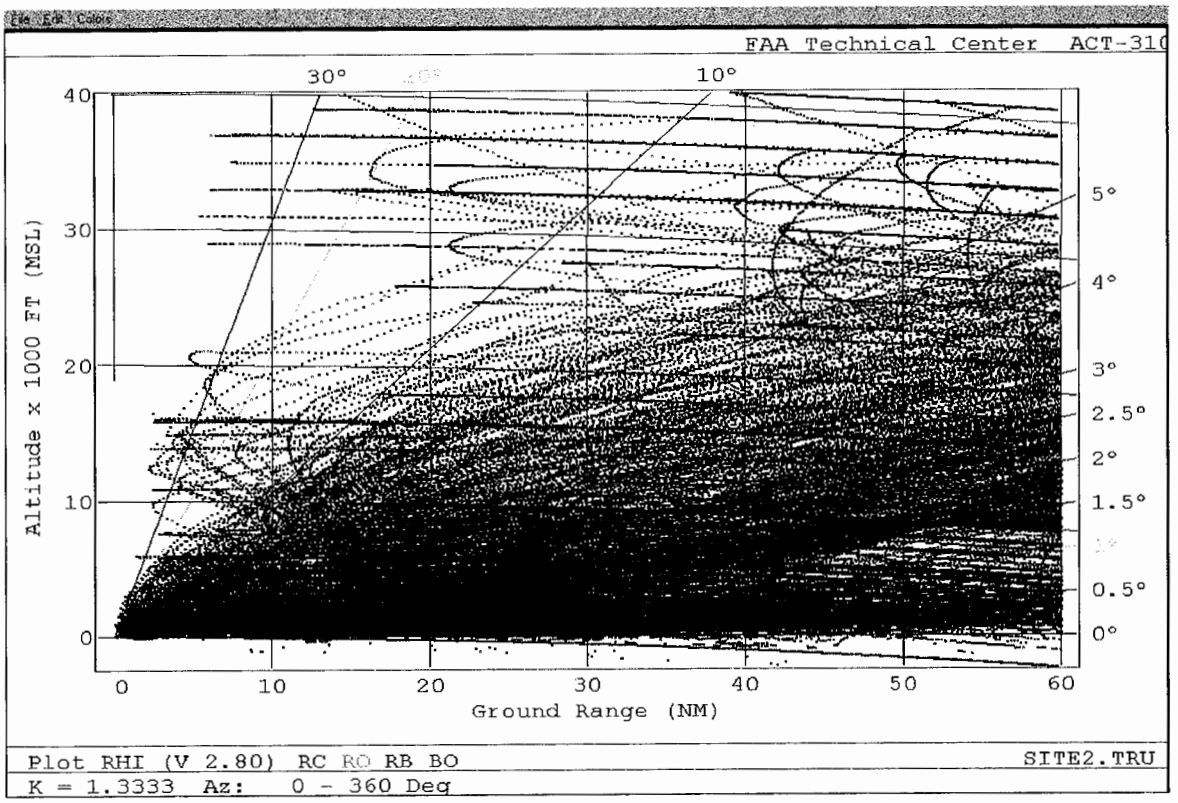


Figure B-5. Site 2 – clear conditions – Range Height Indicator display

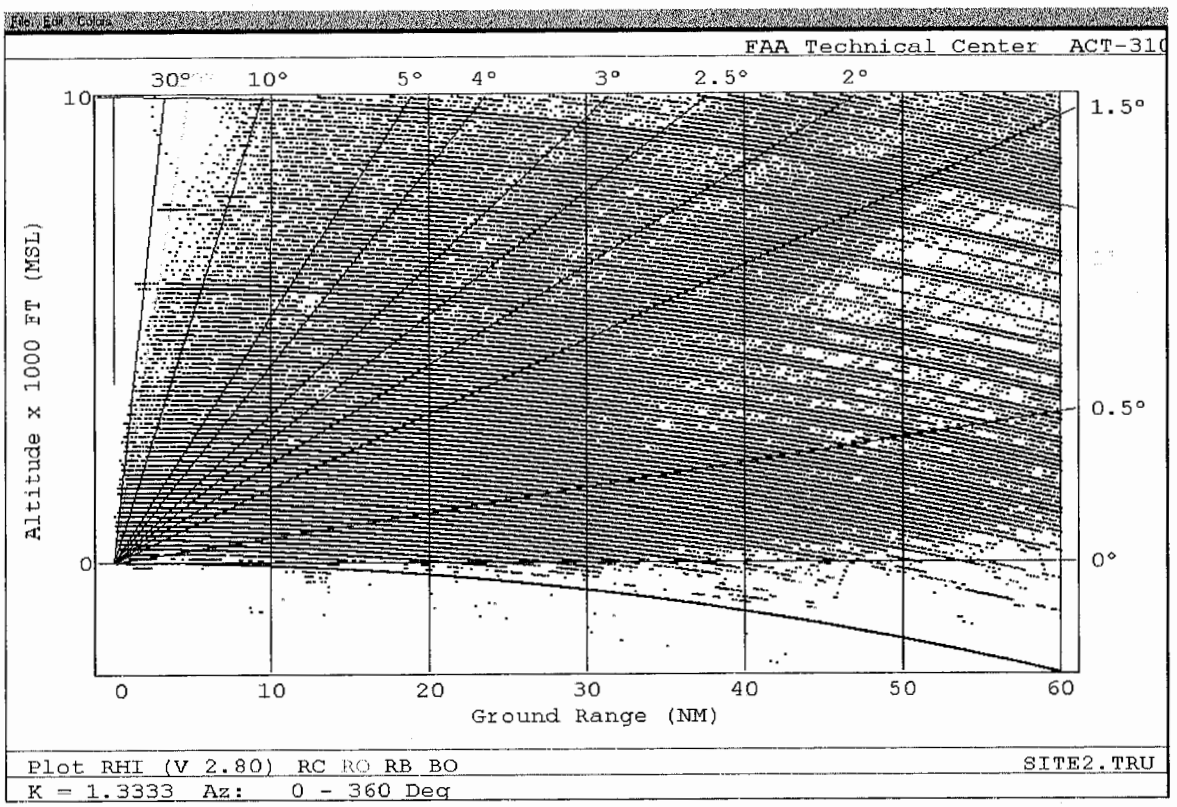


Figure B-6. Site 2 – clear conditions – Range Height Indicator display low angle coverage

Appendix C

Site 2 - intense weather:

Antenna Polarization: Linear then Circular
Radar Antenna Tilt: Unknown
Beacon Antenna Tilt: Unknown
Beacon Interrogator Type: Mode-S
Weather Conditions: Rain with levels 2-6, Level 6 weather at end of recording
Clutter environment: Major metropolitan area, sea clutter over portion of the coverage area. Ground terrain is relatively flat
Road Traffic Environment: Between inner and outer beltways of major city (less than three miles from each), less than two miles from major interstate
Radar Interference Observed: No
AP Present (YES/NO): Yes

Maximum False Plot Rate Estimate: 410 in scan, averaged over 3 scans
Maximum False Plot Rate Estimate (Quality 0 filtering): 136 in scan, averaged over 3 scans
Maximum False Track Rate (10 scan average): 28
Maximum False Track Rate (10 scan average - Quality 0 filtering): 27

RBAT Surveillance Analysis Result Summary:

Target Category	Beacon Pd	Search Pd	Total Pd	Reinforcement
DISCRETE	99.58	92.77	99.79	92.91
NON DISCRETE	96.88	83.33	98.46	84.28
TOTAL	98.94	90.55	99.48	90.92

Beacon False Target Summary: (based upon 223543 discrete code target reports)

Category	Number	Percent
Split	134	.06
Ringaround	17	.01
Down reflection	12	.01
PRF	271	.12
Upreflection	480	.21
ATCRBS/Mode S	0	.00
Other	0	.00
Total	914	.41
Overall False Targets per Scan: .0954		

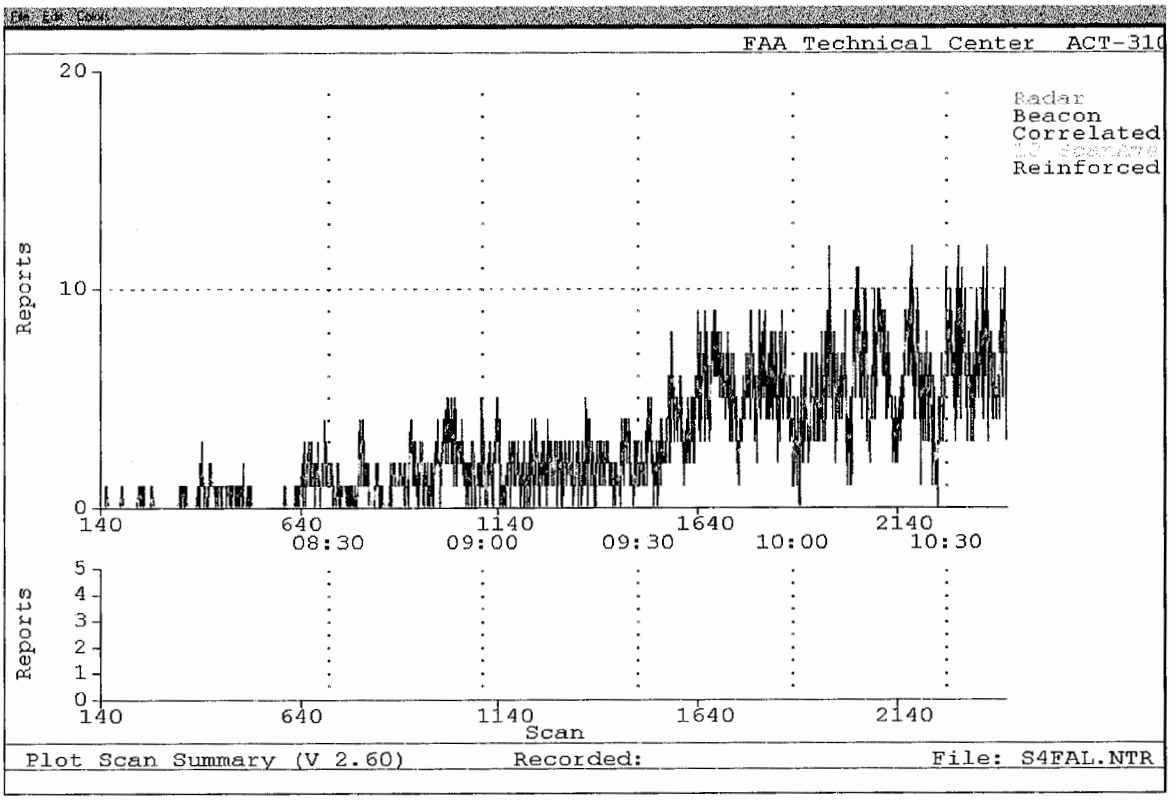


Figure E-3. Site 4 – False tracks no quality filtering

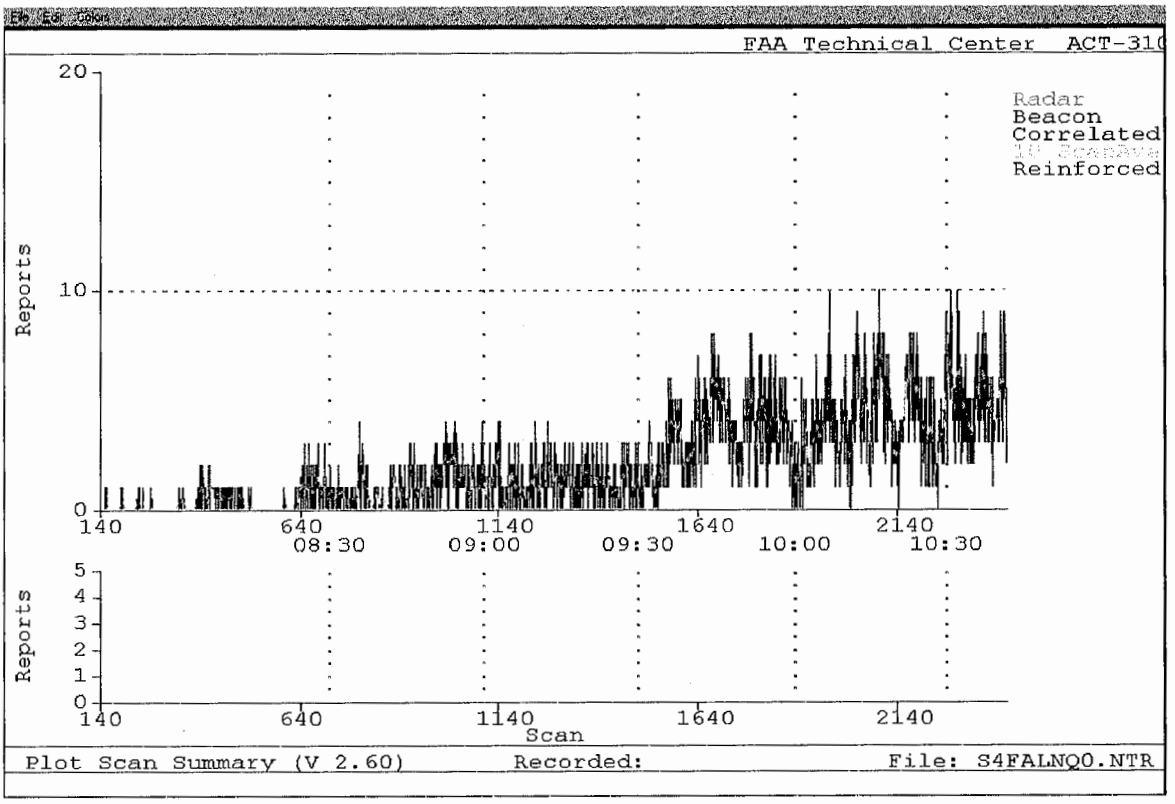


Figure E-4. Site 4 – False tracks – quality zero filtering

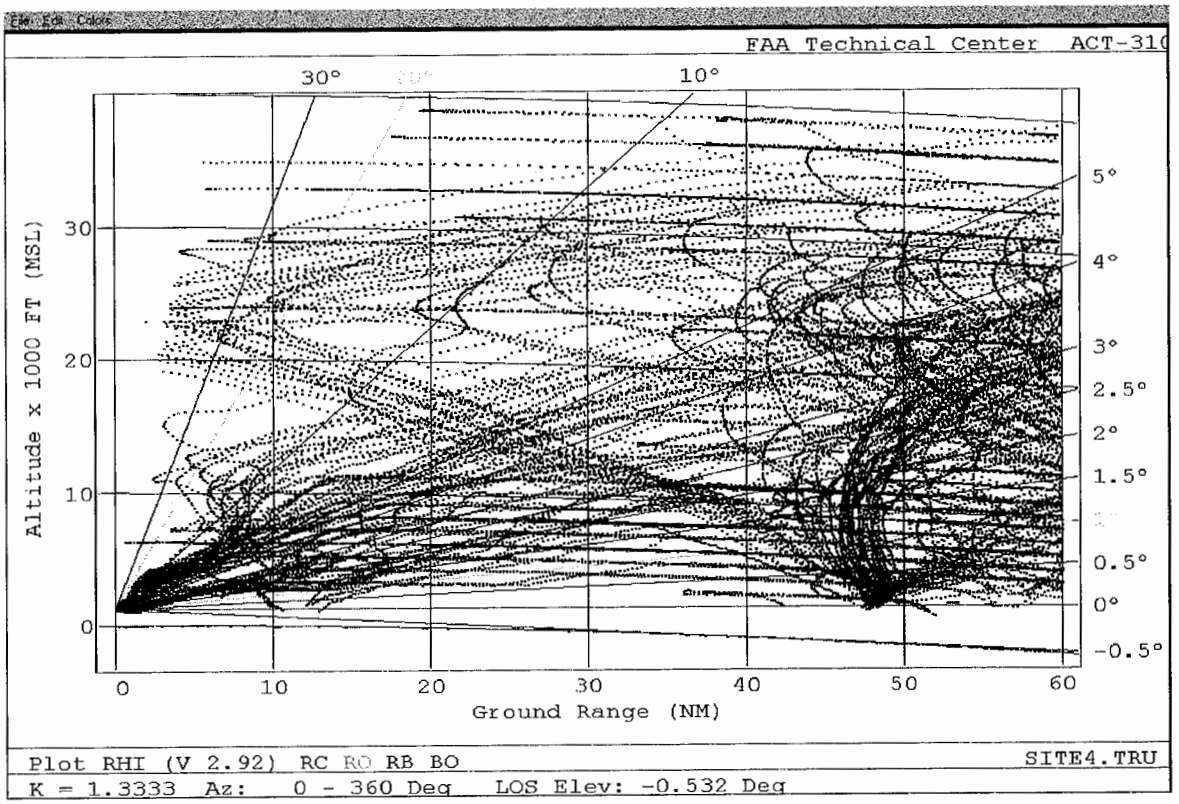


Figure E-5. Site 4 - Range Height Indicator display

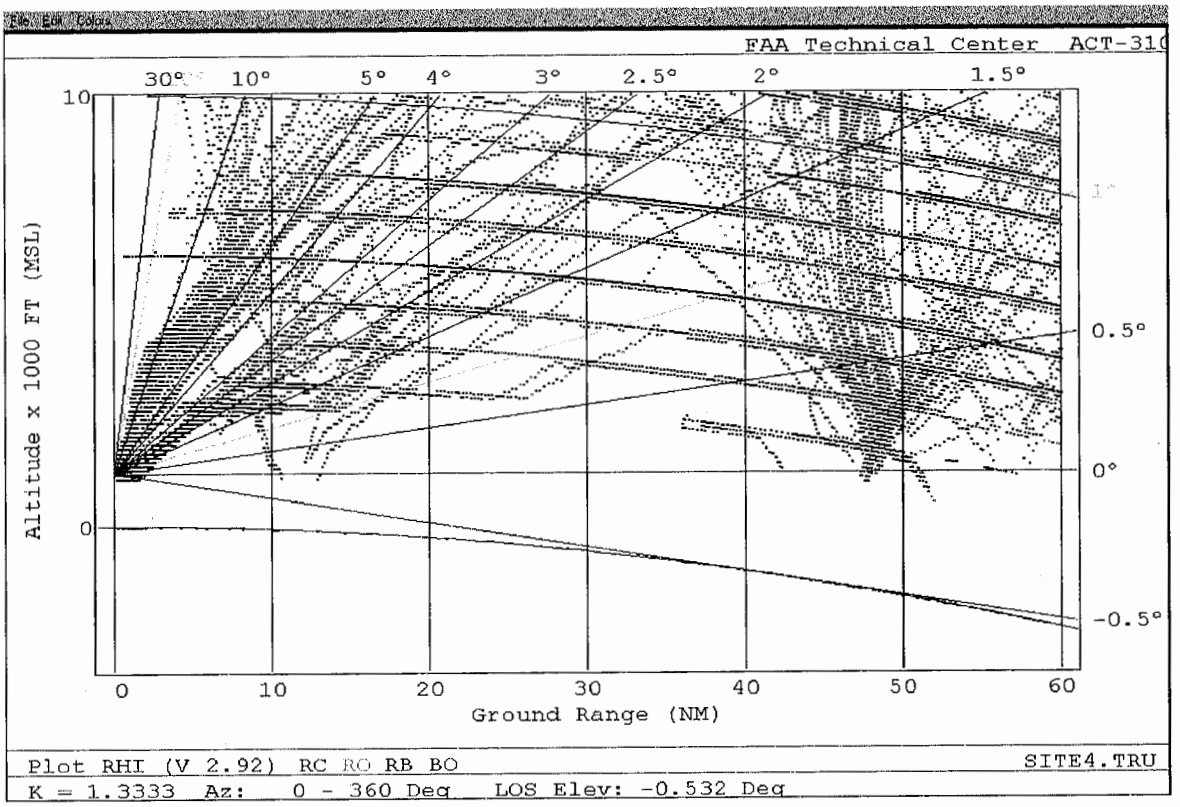


Figure E-6. Site 4 - Range Height Indicator display – Low angle coverage

Appendix F

Site 5 Results:

Antenna Polarization: Linear to scan 24, circular scans 25-407, linear scans 408 to end
Radar Antenna Tilt: 1°
Beacon Antenna Tilt: Unknown
Beacon Interrogator Type: Mode-S
Weather Conditions: Unknown
Clutter environment: Urban area on edge of major metropolitan area, ground terrain is rolling hills of 200-300 ft.
Road Traffic Environment: Less than two miles from beltway of a city and feeding interstate highway
Radar Interference Observed: No
AP Present (YES/NO): No

Maximum False Plot Rate Estimate: 86 in scan, averaged over 3 scans
Maximum False Plot Rate Estimate (Quality 0 filtering): 47 in scan, averaged over 3 scans
Maximum False Track Rate (10 scan average): 6
Maximum False Track Rate (10 scan average - Quality 0 filtering): 5

RBAT Surveillance Analysis Result Summary:

Target Category	Beacon Pd	Search Pd	Total Pd	Reinforcement
DISCRETE	99.56	95.53	99.84	95.5
NON DISCRETE	97.39	93.16	99.35	93.65
TOTAL	99.55	95.53	99.84	95.5

Beacon False Target Summary: (based upon 149402 discrete code target reports)

Category	Number	Percent
Split	75	.05
Ringaround	76	.05
Down reflection	23	.02
PRF	3	.00
Upreflection	313	.21
ATCRBS/Mode S	0	0
Other	0	0
Total	490	.32
Overall False Targets per Scan: .236		

Reinforcement Rates :

Angle	Rate (%)
1-20 degrees	97.47
.5-1.0 degrees	92.29
.25-.5 degrees	82.05
0-.25 degrees	63.27*
All angles	95.6

*small sample size

Quality Filtering Assessment: . Data was collected over 2073 scans and does not include radar reports that were merged with beacon reports.

	Total Radar Only and Radar Correlated Reports				Real Aircraft	
	RO	%RO	RC	%RC	RC	%RC
Q0	65847	51.74	6394	37.15	833	22.30
Q1	26737	21.01	3637	21.13	753	20.16
Q2	5150	4.05	1549	9.00	193	5.17
Q3	29527	23.20	5629	32.71	1956	52.37
Total	127267	100	17209	100	3735	100

Site Assessment: Review of file on PPI display indicated that all aircraft observed within the data collection used in this analysis were beacon equipped. False plot and false track rates are relatively low. Reinforcement rates are very high.

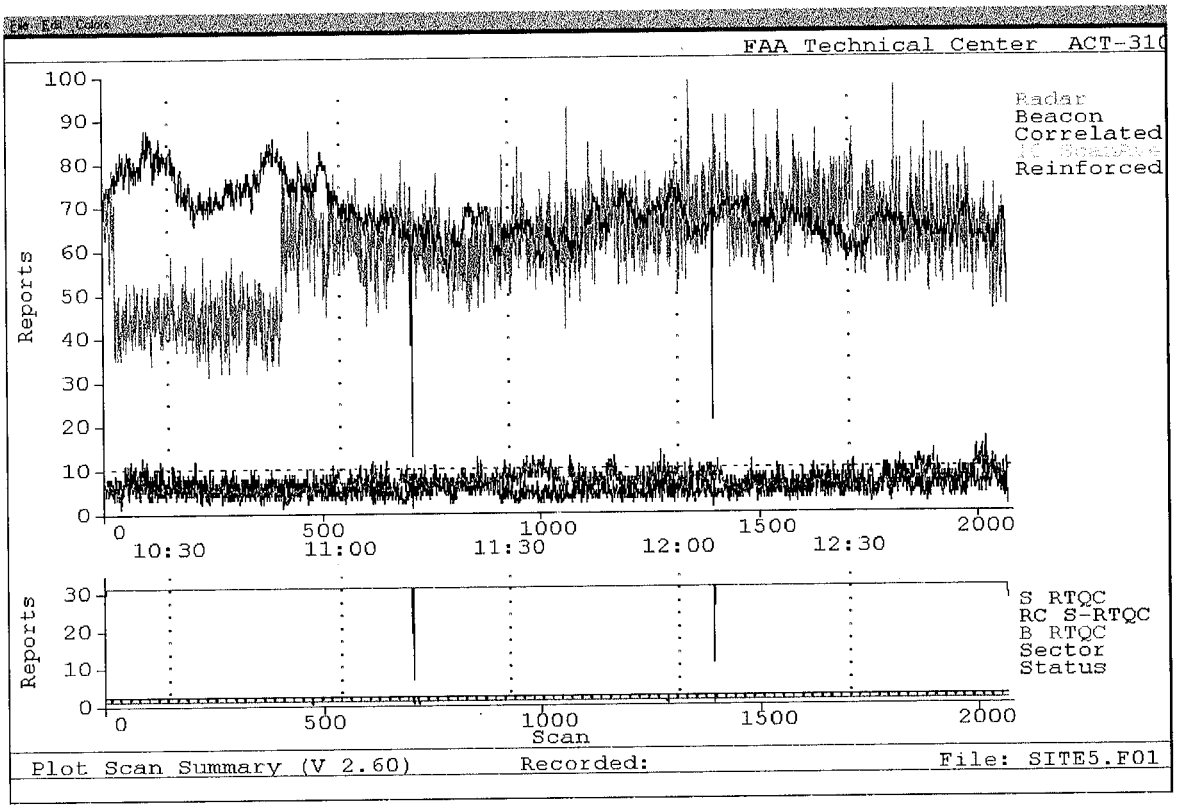


Figure F-1. Site 5 - Target counts with no quality filtering – data disruptions at scans 704 and 1397 are due to appending files.

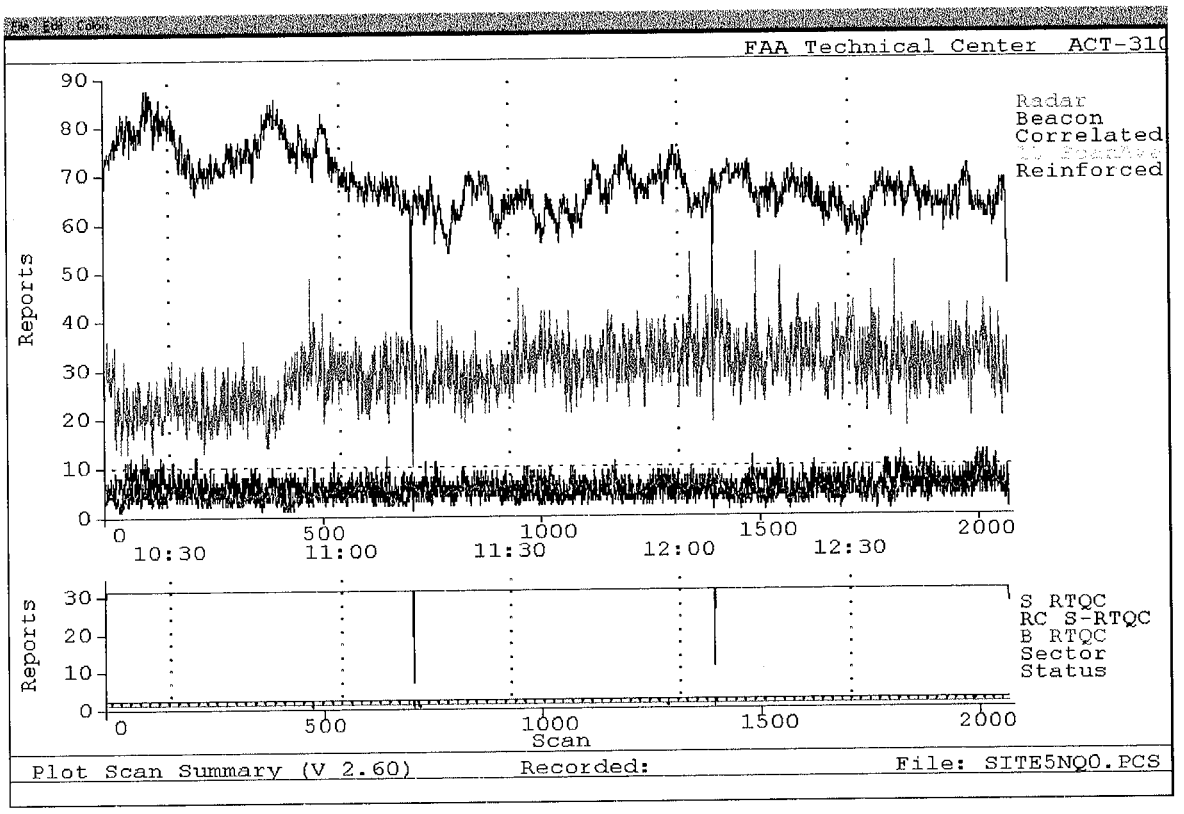


Figure F-2. Site 5 - Target Counts with quality 0 filtering

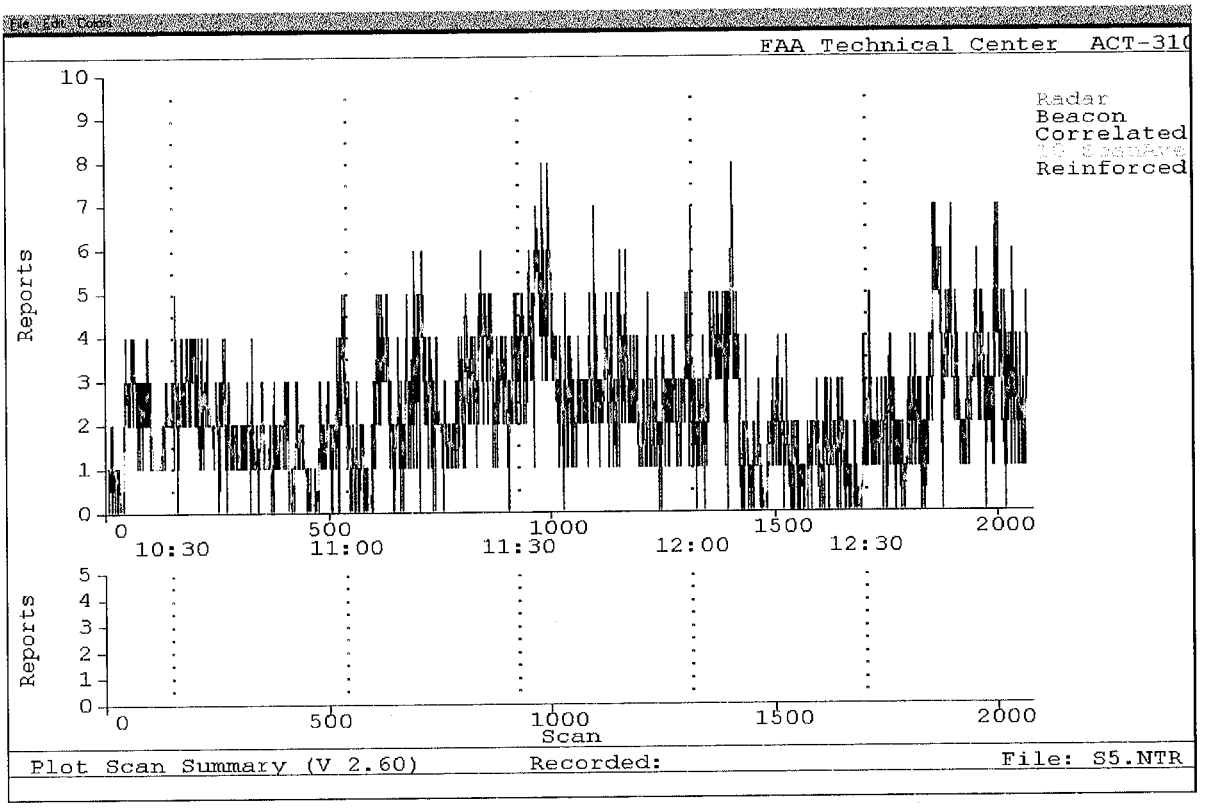


Figure F-3. Site 5 – False tracks no quality filtering

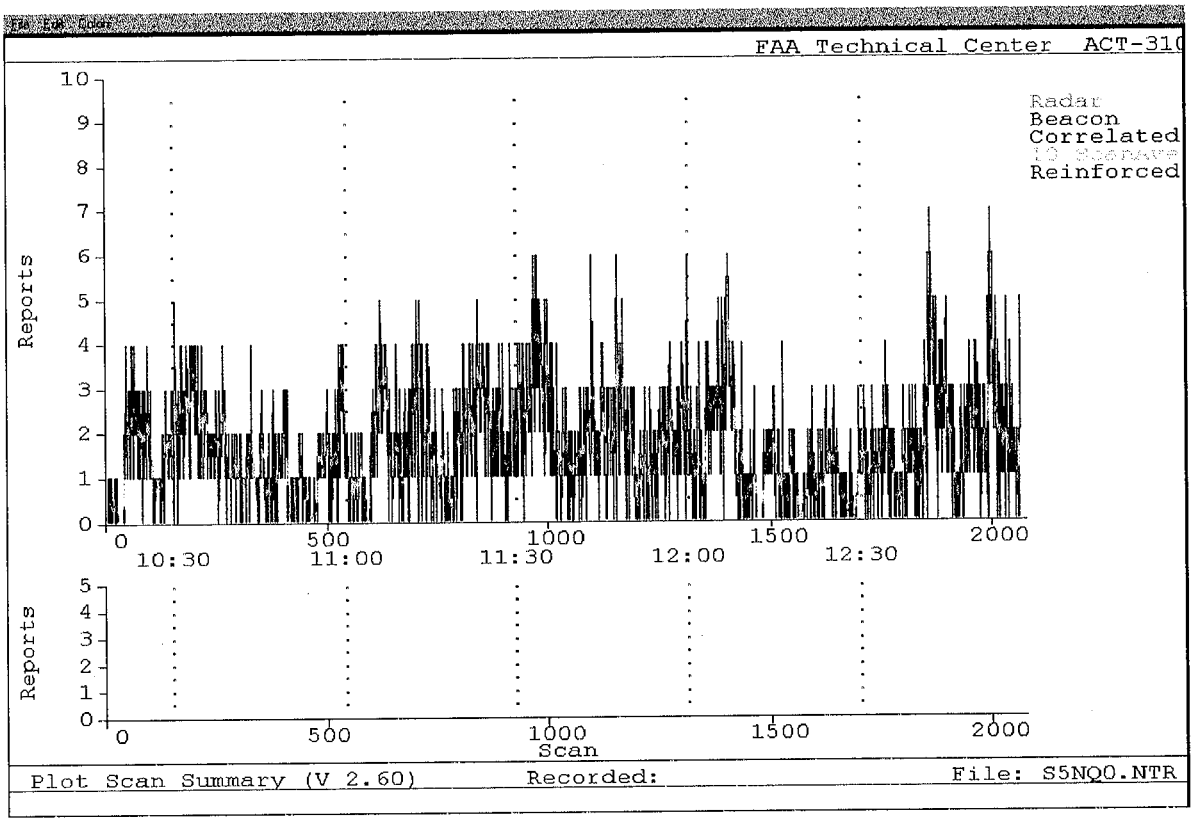


Figure F-4. Site 5 – False tracks – quality zero filtering

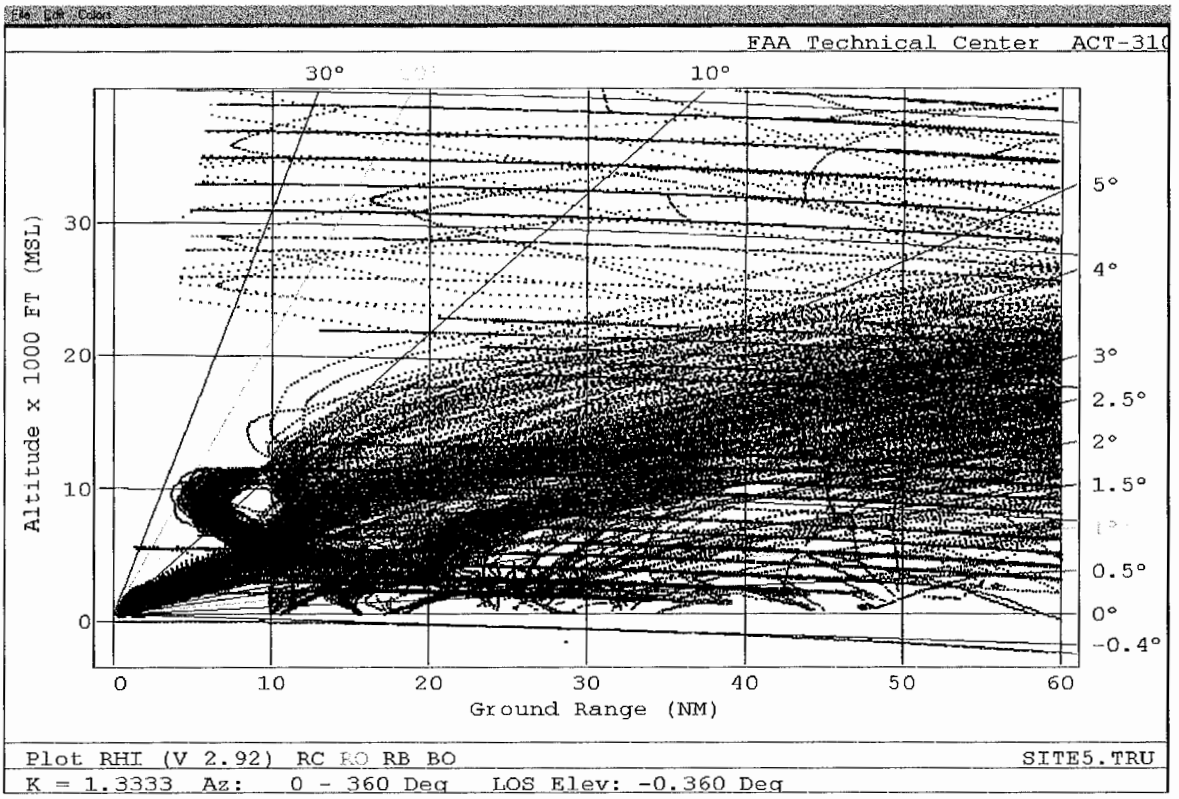


Figure F-5. Site 5 - Range Height Indicator display

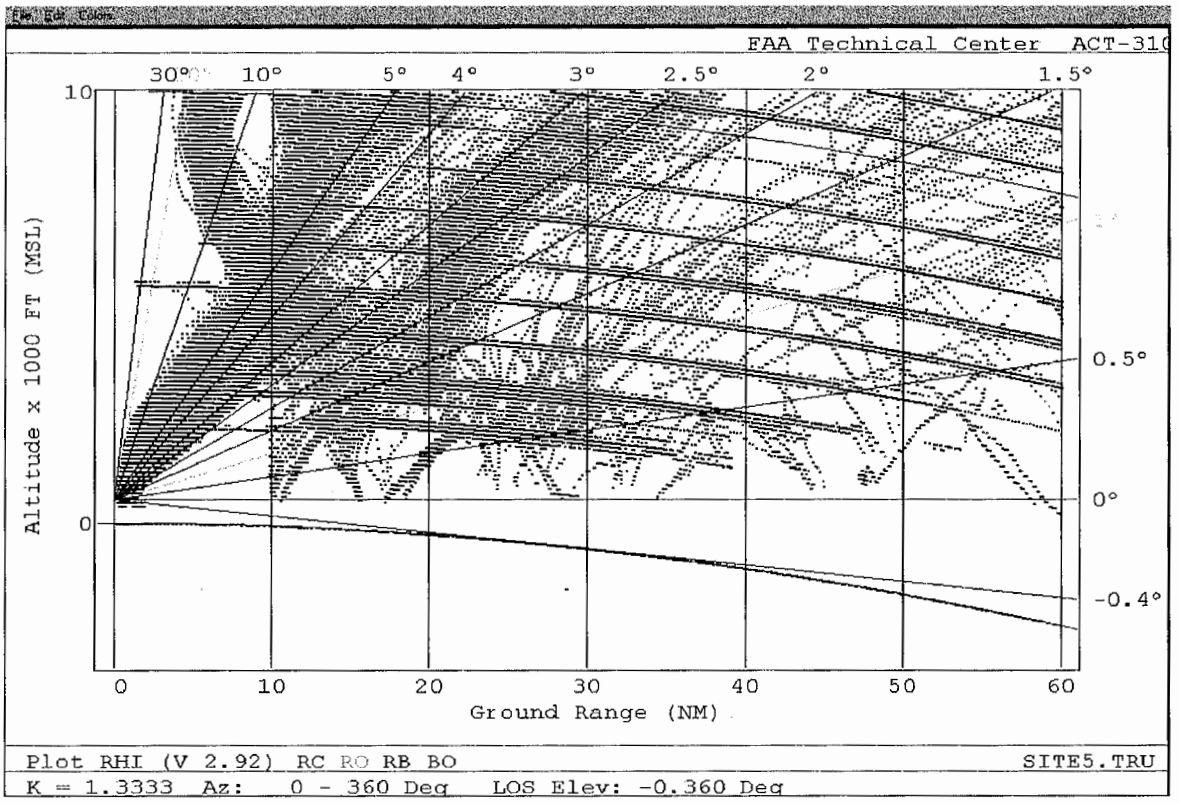


Figure F-6. Site 5 - Range Height Indicator display – Low angle coverage

Appendix G

Site 6 Results: (9-PAC phase 2 site)

Antenna Polarization: linear changing to circular at scan 2933 of 5068 scans
Radar Antenna Tilt: 0°
Beacon Antenna Tilt: 0°
Beacon Interrogator Type: ATCBI-4
Weather Conditions: Level 2 at beginning of recording increasing to large areas of level three with small areas of intense weather up to level 5
Clutter environment: Major metropolitan area, ground terrain is rolling hills to 300 ft
Road Traffic Environment: Less than two miles from interstate, several interstate highways within ten miles
Radar Interference Observed: No
AP Present (YES/NO): No

Maximum False Plot Rate Estimate: 220 in scan, averaged over 3 scans
Maximum False Plot Rate Estimate (Quality 0 filtering): in scan, averaged over 3 scans
Maximum False Track Rate (10 scan average): 4
Maximum False Track Rate (10 scan average - Quality 0 filtering): 3

RBAT Surveillance Analysis Result Summary:

Target Category	Beacon Pd	Search Pd	Total Pd	Reinforcement
DISCRETE	99.53	95.86	99.74	95.98
NON DISCRETE	96.51	79.63	98.14	80.80
TOTAL	99.48	95.56	99.71	95.70

Beacon False Target Summary: (based upon 324540 discrete code target reports)

Category	Number	Percent
Split	93	.03
Ringaround	49	.02
Down reflection	65	.02
PRF	1	0
Upreflection	69	.02
ATCRBS/Mode S	0	0
Other	0	0
Total	277	.09
Overall False Targets per Scan: .054		

Reinforcement Rates :

Angle	Rate (%)
1-20 degrees	98.24
.5-1.0 degrees	94.26
.25-.5 degrees	82.57
0-.25 degrees	79.10*
All angles	96.06

*small sample size

Quality Filtering Assessment: . Data was collected over 5068 scans and does not include radar reports that were merged with beacon reports.

	Total Radar Only and Radar Correlated Reports				Real Aircraft	
	RO	%RO	RC	%RC	RC	%RC
Q0	148317	17.54	13356	54.70	902	19.02
Q1	340813	40.30	6558	26.86	1530	32.26
Q2	84063	9.94	193	.79	102	2.15
Q3	272600	32.23	4309	17.65	2209	46.57
Total	845793	100	24416	100	4743	100

Site Assessment: Site has very good low angle coverage. Figures A7-1 and A7-2 indicate a high number of false plots. Figures A7-3 and A7-4 indicate very good false track rates

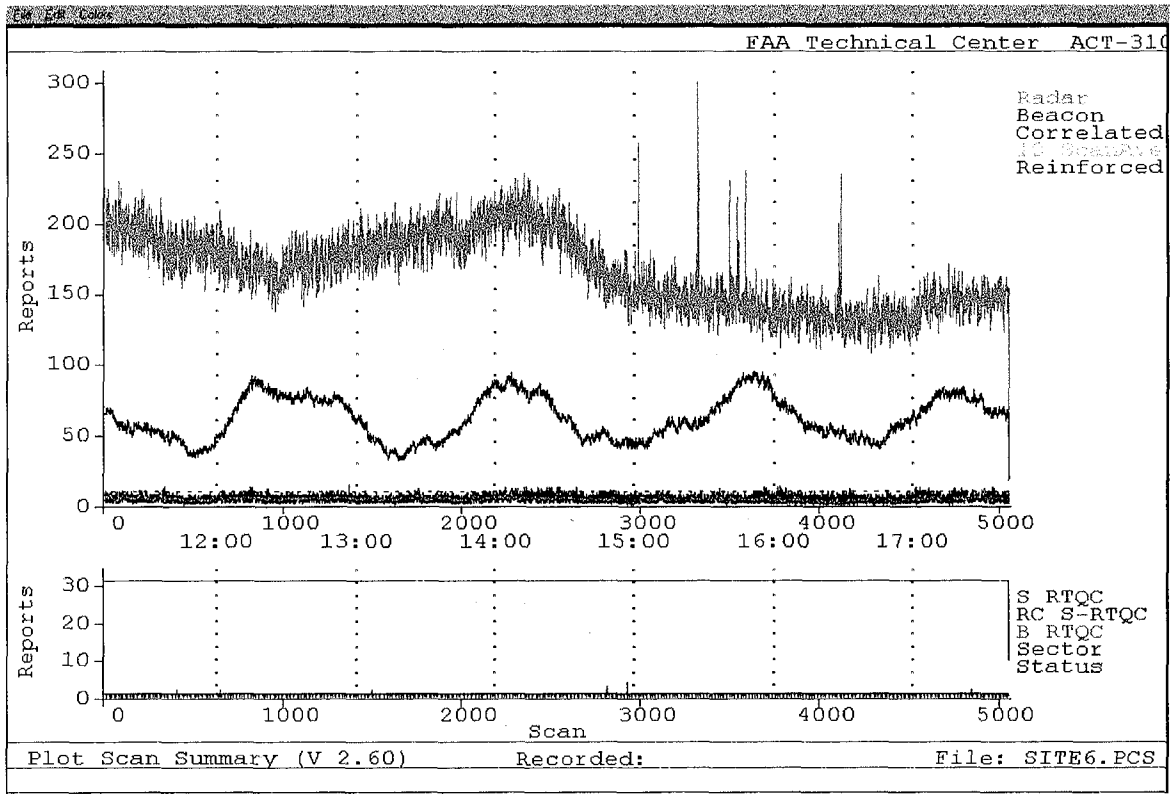


Figure G-1. Site 6 – Target counts with no quality filtering

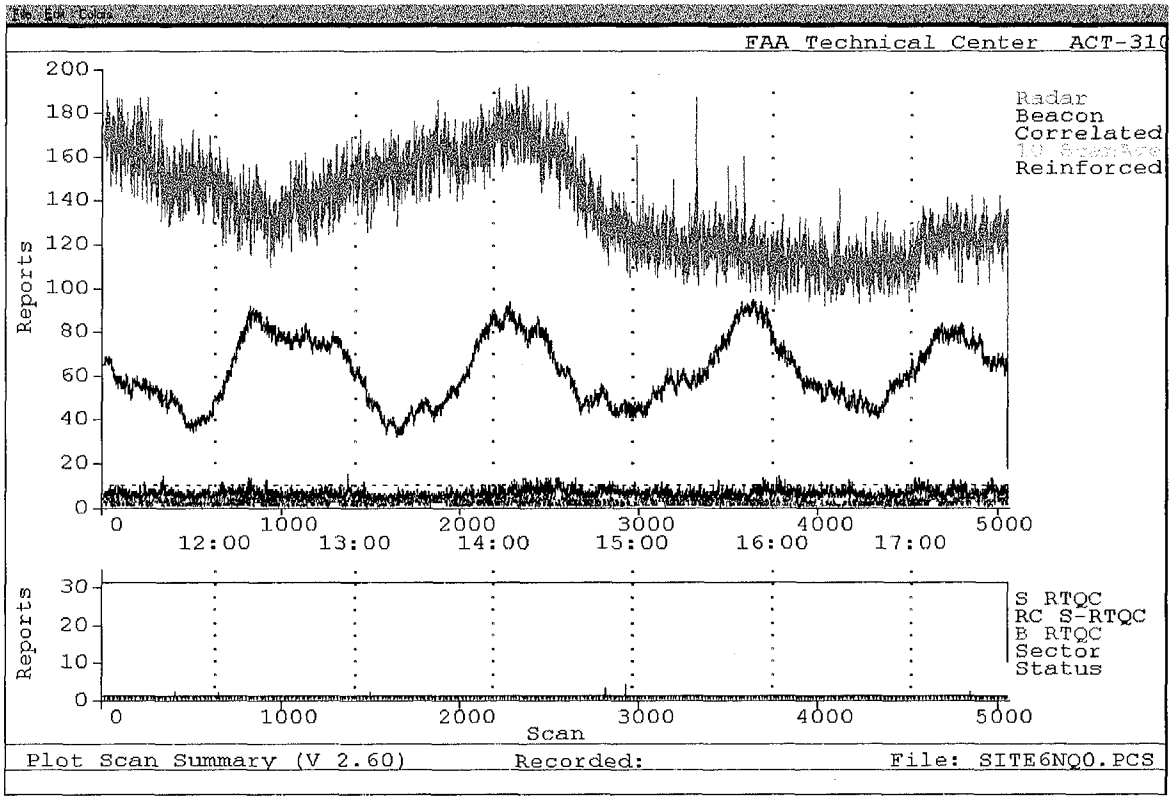


Figure G-2. Site 1 – Target counts with quality filtering zero filtering

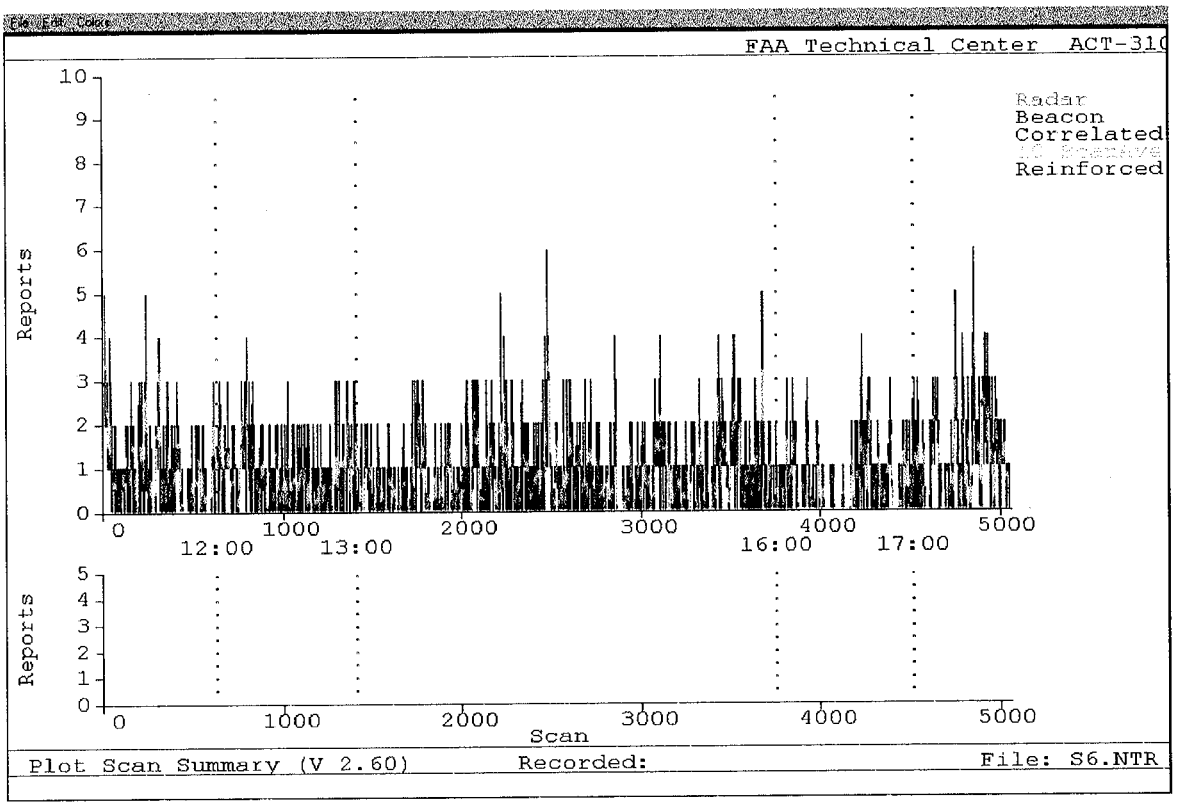


Figure G-3. Site 6 – False Tracks, Beacon and Reinforced target counts

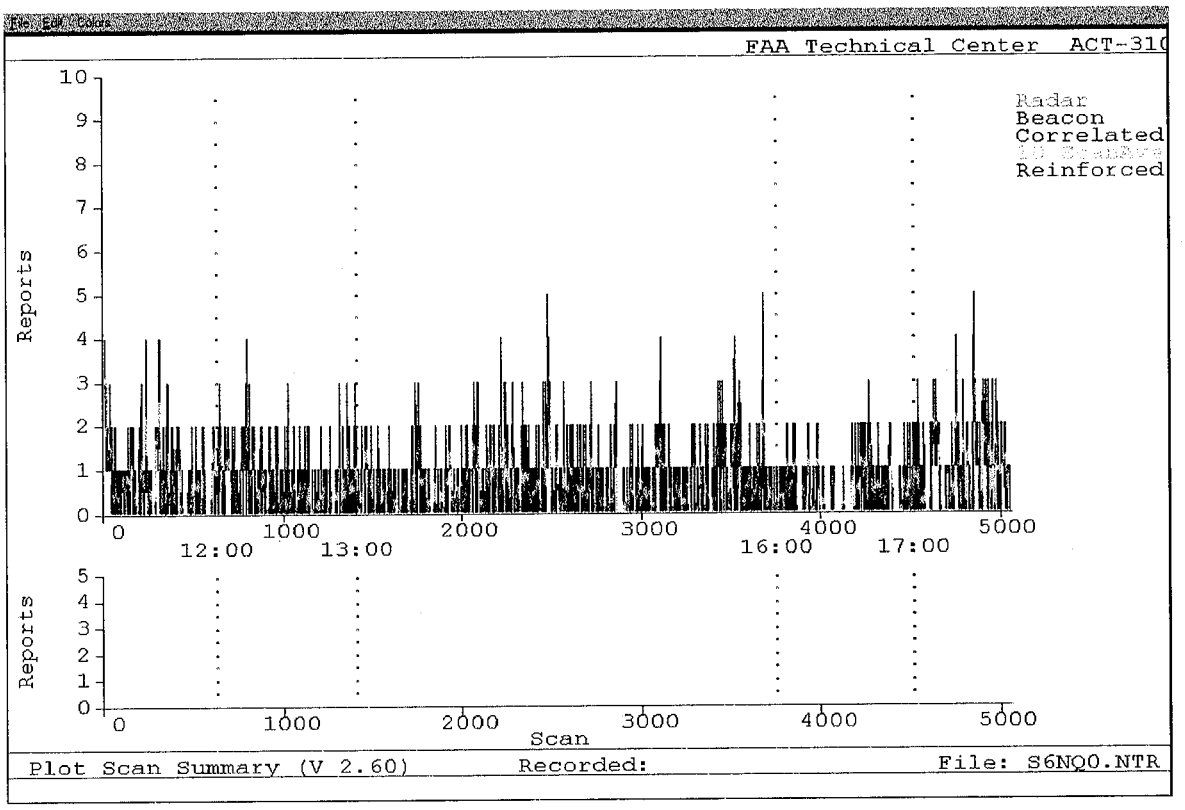


Figure G-4. Site 6 – False Tracks, Beacon and Reinforced target counts with quality zero filtering

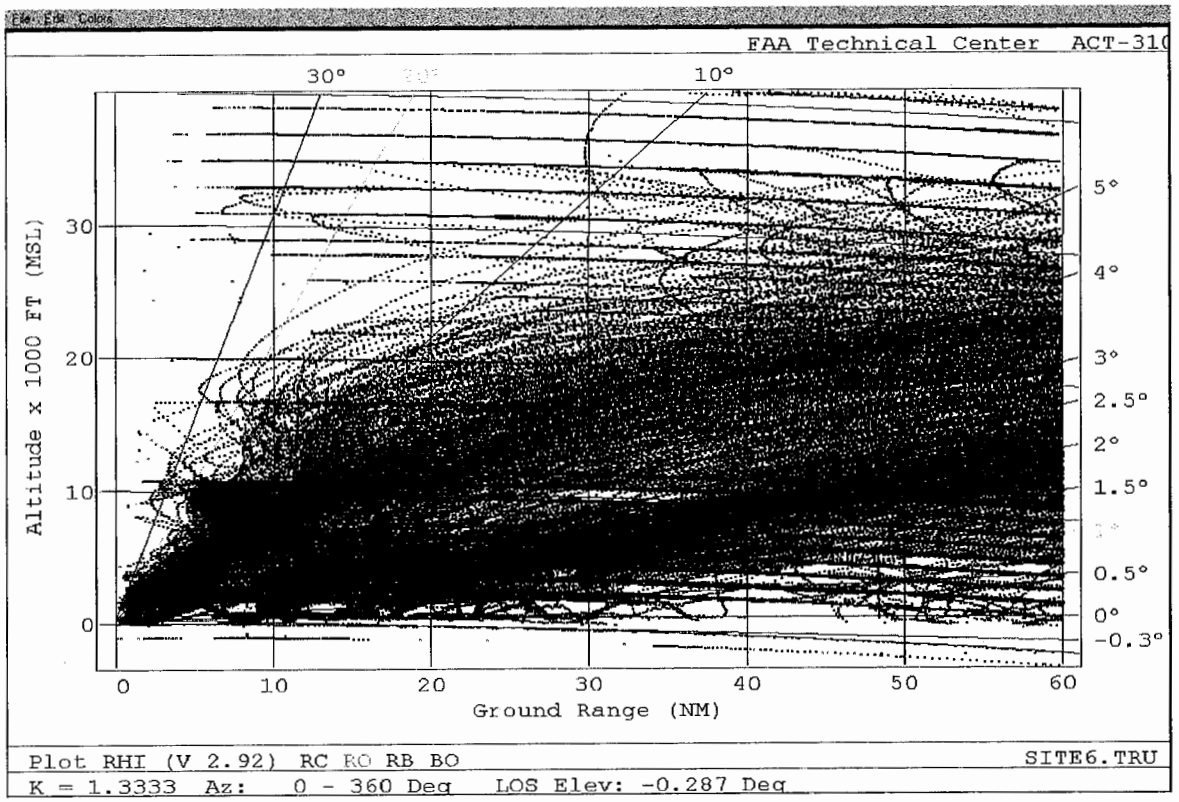


Figure G-5. Site 6 – Range Height Indicator display

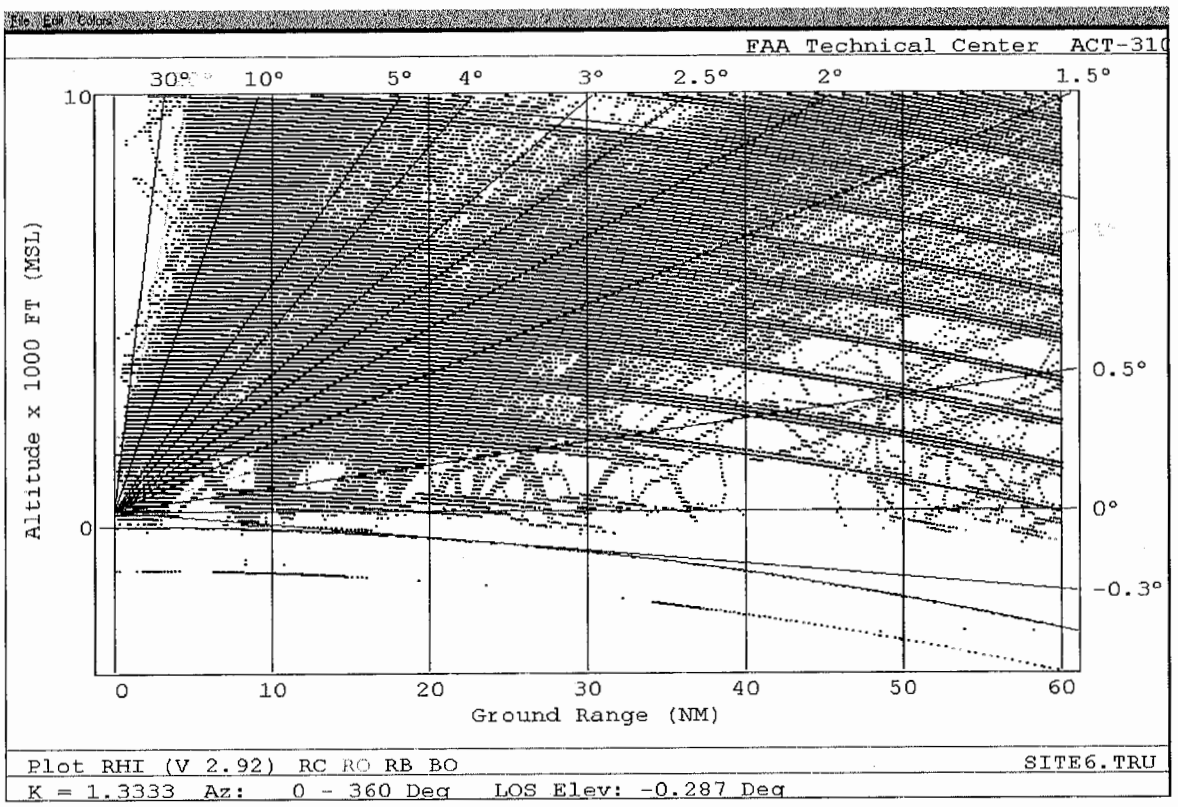


Figure G-6. Site 6 – Range Height Indicator display – Low Angle Coverage