FAA TECHNICAL CENTER LETTER REPORT

MATH MODEL STUDY FOR RUNWAY 21R

INSTRUMENT LANDING SYSTEM LOCALIZER

AT FELTS FIELD, SPOKANE, WASHINGTON

by

JOHN WALLS

JANUARY 1982

U. S. DEPARTMENT OF TRANSPORTATION
FEDERAL AVIATION ADMINISTRATION
TECHNICAL CENTER
Atlantic City Airport, N.J. 08405

PURPOSE

This study was performed to provide computer modeled performance data for the proposed installation of a Wilcox Log Periodic Localizer System to serve Runway 21R at Felts Field, Spokane, Washington.

BACKGROUND

The Northwest Region (ANW-450) plans to install an Instrument Landing System (ILS) Localizer to service Runway 21R at Felts Field, Spokane, Washington. The Wilcox 8-element and the Wilcox 14-element self clearing log periodic antenna arrays are being considered for this installation to provide ILS performance for category 1 service. ILS math modeling of this site was requested by ANW-450 to assist them in antenna system selection.

This request for ILS modeling was forwarded to the FAA Technical Center through the Airway Facilities Service, Terminal Aids Branch, AAF-420. This math modeling study was performed under Technical Program Document 07-115, Subprogram Number 071-313, Project 071-313-840, ILS Math Models. The author of this technical letter report is John E. Walls, ACT-100E. The Program Manager for this study is Edmund A. Zyzys, ACT-100E. Messrs. Jesse Jones or John Walls may be contacted for additional information at FTS 346-3807 or (Area Code 609) 641-8200, extension 3807.

DISCUSSION:

The FAA Technical Center conducted mathematical computer model studies through application of a localizer model which was developed by the Transportation System Center (TSC) and converted to the Technical Center's Honeywell 66/60 computer. For a description of this modeling technique, see references 1 through 3. Reference 4 provides validation data for the localizer model. The site data inputs to the model were as follows:

1. Runway length: 4,500 feet

2. Localizer frequency: 111.9 megahertz (MHz)

3. Localizer course width: 6.00 degrees

4. Origin of coordinate system: runway 21R threshold and centerline

5. Localizer ground elevation: 1943 feet above mean sea level (MSL)

The coordinate system used in the computer model is a right-handed system with the origin located at the threshold of runway 21R (figure 1) with the positive X-axis directed along runway centerline towards the northeast, the positive Y-axis directed towards the northwest, and the positive Z-axis directed up. Alpha, the angle between the base of a reflector and the X-axis, is measured in the counterclockwise direction. Therefore, an alpha of 90 degrees faces the reflector in the positive X-direction. Delta, the angle between the surface of the reflector and the vertical direction is equal to -90 degrees for a horizontal reflector facing down.

Figures 1 and 2 show the surfaces entered into the model as sources of ILS signal reflections and scattering. The surfaces of figure 1 represent the buildings of concern in the area about the localizer site. Figure 2 depicts the adjacent hills as entered into the model. Relevant orientation data for these reflecting surfaces are given in table 1. The surfaces are considered to be of infinite conductivity over the total surface and to have zero thickness. This assumption will result in a worst-case performance prediction. Only those surfaces which may result in derogatory reflections are entered into the model.

Wilcox theoretical log periodic antenna array current and phase distributions were provided for the 8 and 14 element antenna array by the Northwest Region, and are listed in table 2.

DATA PRESENTATION AND ANALYSIS

Reflecting surfaces used in this modeling study are shown in figure 1 (buildings) and figure 2 (hills). Additional reflecting surface data (coordinates and dimensions) are provided in table 1.

Distances shown on the horizontal axis of the course structure plots (figures 3 and 4) are referenced to the threshold of runway 21R. Negative values are between threshold and the localizer. Positive distance values are between the threshold and the outer marker. Angles shown on the horizontal axis of the clearance orbit plots (figures 5 and 6) and antenna pattern plots (figures 7 and 8) are based on a 35,000 foot arc and 1,000 feet altitude referenced to the runway 21R threshold. The vertical axis of the course structure and clearance orbit plots shows the model output value of the course deviation indicator (CDI) deflection in microamps. The vertical axis of the antenna pattern plots is a relative scale with each pattern being normalized to its peak.

Model output course structure plots (using a 0.4 second time constant for smoothing) for the 8-element and 14-element log periodic antenna arrays are shown in figures 3 and 4, respectively. These plots show that either antenna should provide an ILS performance category 1 course structure. As anticipated, superior course structure is indicated when the 14-element antenna array is utilized. The 8-element and 14-element clearance orbit plots are shown in figures 5 and 6. These plots show that both antennas provide the minimum clearance requirements within $\pm$ 30 degrees of centerline. Figures 7 and 8 show the normalized CSB and SBO patterns for the two antennas. The 90-Hz and 150-Hz sides of the patterns plots should be identical; however, the building reflections result in the irregularities on the 150-Hz side of both plots.

CONCLUSIONS:

Based on math modeled results, both the Wilcox 8-element and the 14-element self clearing log periodic antenna arrays, should provide Category 1 ILS performance to runway 21R at Felts Field, Spokane, Washington.

REFERENCES

1. Instrument Landing System Scattering, DOT/FAA Report FAA-RD-72-137, 1972.

2. User's Manual for ILSLOC: Simulation for Derogation Effects on the Localizer Portion of the Instrument Landing System, DOT/FAA Report FAA-RD-73-76, 1973.

3. Instrument Landing System Performance Prediction, DOT/FAA Report FAA-RD-73-200, 1974.

4. ILS Localizer Performance Study, Part 1, Dallas/Fort Worth Regional Airport and Model Validation, Syracuse Hancock Airport, DOT/FAA Report FAA-RD-72-96, 1972.

TABLE 1 SPOKANE (FELTS FIELD), WASHINGTON REFLECTING SURFACE DATA

Surface ID.	Coordinates (ft)* X	Y	Z	Alpha (deg.)	Delta (deg.)	Width (ft)	Length (ft)
B 1	-4485	-615	0	162.4	0.0	158	46
B 2	-4137	-633	0	163.9	0.0	205	37
B 3	-3159	-947	0	164.7	0.0	216	45
B 4	-1670	-1325	0	167.0	0.0	27	80
B 5	77	-1645	0	232.7	0.0	299	25
B 6	260	-1405	0	231.3	0.0	102	34
B 7	387	-1234	0	233.2	0.0	129	25
H 1	-440	2550	60	15.5	75.0	2096	776
H 2	2260	2615	80	-16.7	74.5	1148	674
H 3	3205	1895	60	-34.2	81.0	907	506
H 4	3495	2305	137	-36.7	76.5	886	514
H 5	4840	2595	257	9.0	82.4	1215	908

*Midpoint of base of surface referenced to threshold of runway 21R

TABLE 2 SPOKANE (FELTS FIELD) LOG PERIODIC ANTENNA ARRAY DATA - 111.9 MHz

Ant.	Spacing	14-element array				8-element array			
		Carrier Sideband		Sideband Only		Carrier Sideband		Sideband Only	
#	λ	Amplitude	Phase (deg.)	Amplitude	Phase (deg.)	Amplitude	Phase (deg.)	Amplitude	Phase (deg.)
7R	-4.88	0.060	0.00	0.138	0.00				
6R	-4.12	0.060	0.00	0.379	0.00				
5R	-3.36	0.212	0.00	0.276	0.00				
4R	-2.59	0.212	0.00	0.586	0.00	0.055	-180.00	0.415	0.00
3R	-1.83	0.394	0.00	0.414	0.00	0.143	0.00	0.700	0.00
2R	-1.07	0.394	0.00	0.759	0.00	0.363	0.00	0.890	0.00
1R	-0.31	1.000	0.00	1.000	0.00	1.000	0.00	1.000	0.00
1L	0.31	1.000	0.00	1.000	-180.00	1.000	0.00	1.000	-180.00
2L	1.07	0.394	0.00	0.759	-180.00	0.363	0.00	0.890	-180.00
3L	1.83	0.394	0.00	0.414	-180.00	0.143	0.00	0.700	-180.00
4L	2.59	0.212	0.00	0.586	-180.00	0.055	-180.00	0.415	-180.00
5L	3.36	0.212	0.00	0.276	-180.00				
6L	4.12	0.060	0.00	0.379	-180.00				
7L	4.88	0.060	0.00	0.138	-180.00				

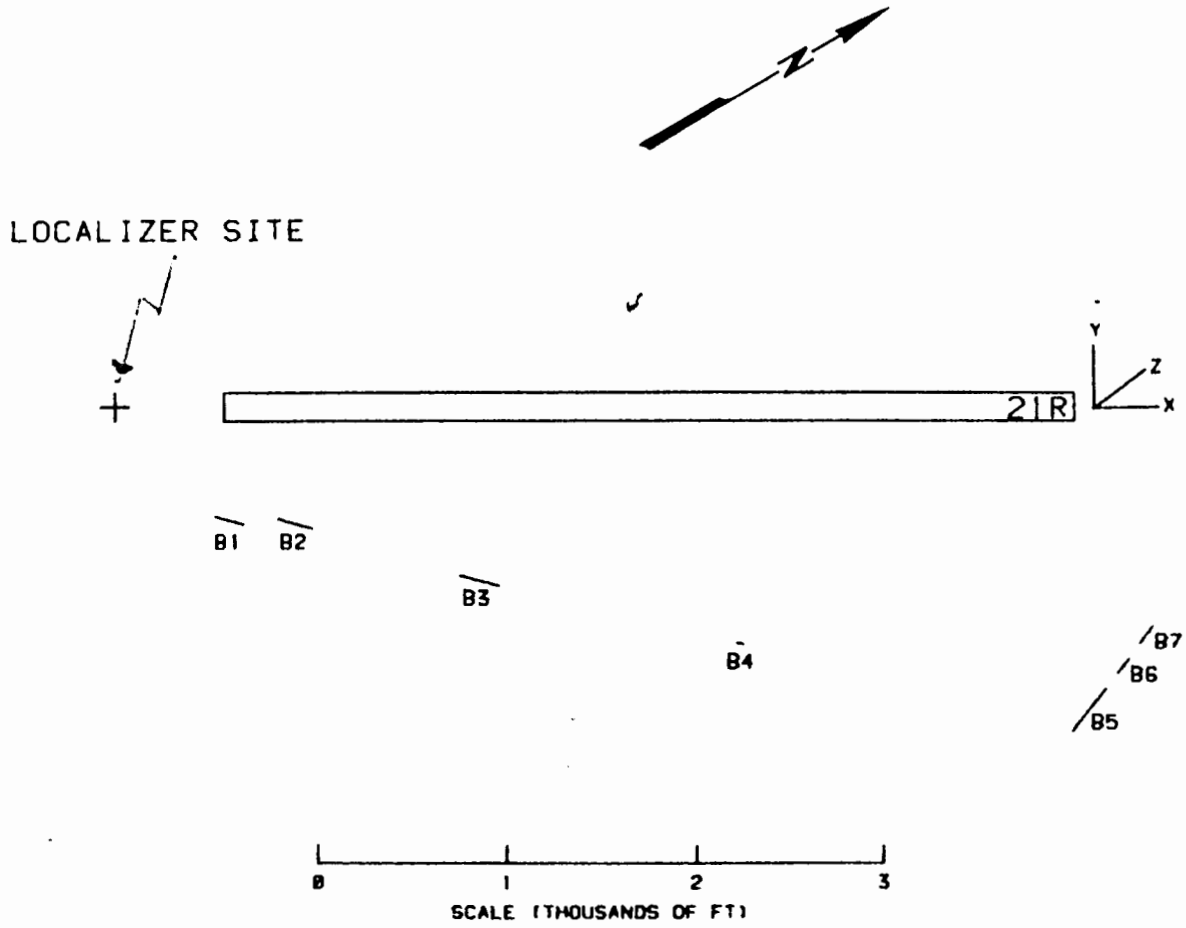

FIGURE 1 - SPOKANE (FELTS FIELD), WASHINGTON, REFLECTING BUILDING SURFACES

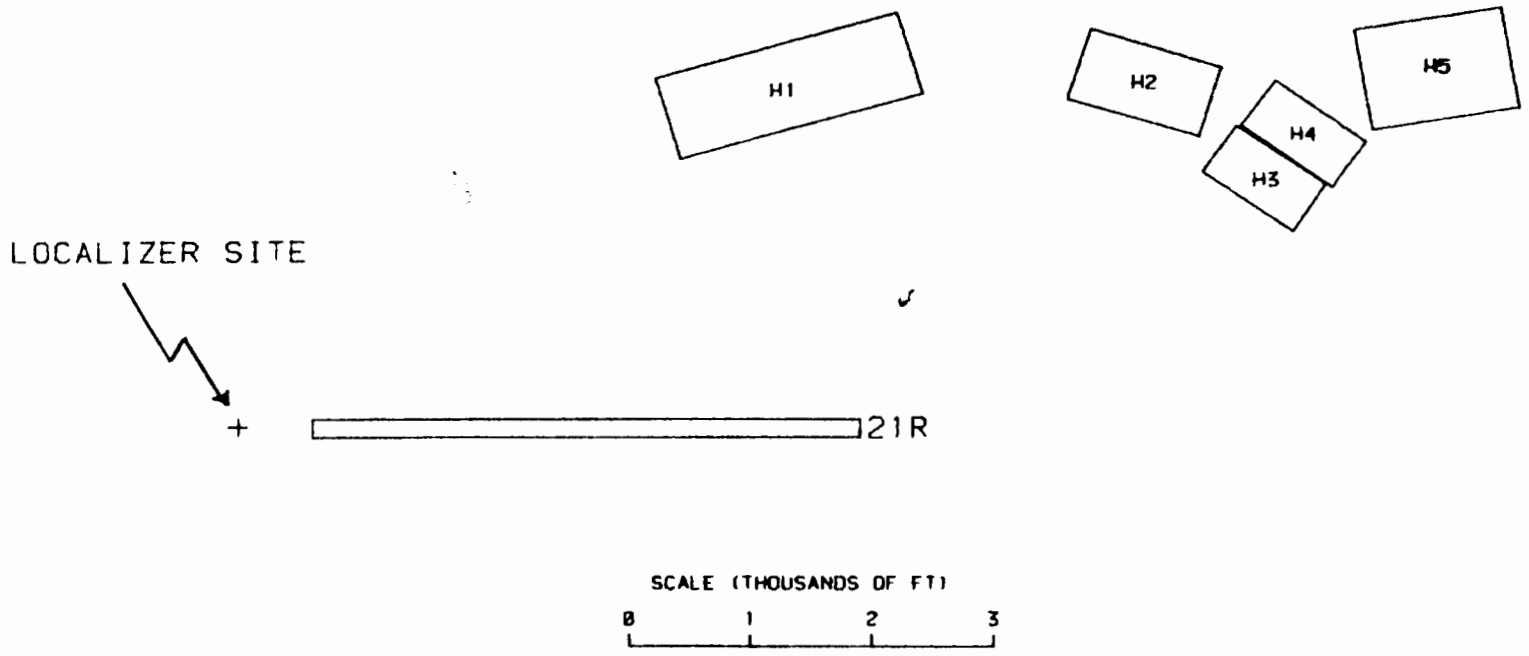

FIGURE 2 - SPOKANE (FELTS FIELD), WASHINGTON - MODELED HILL REFLECTORS

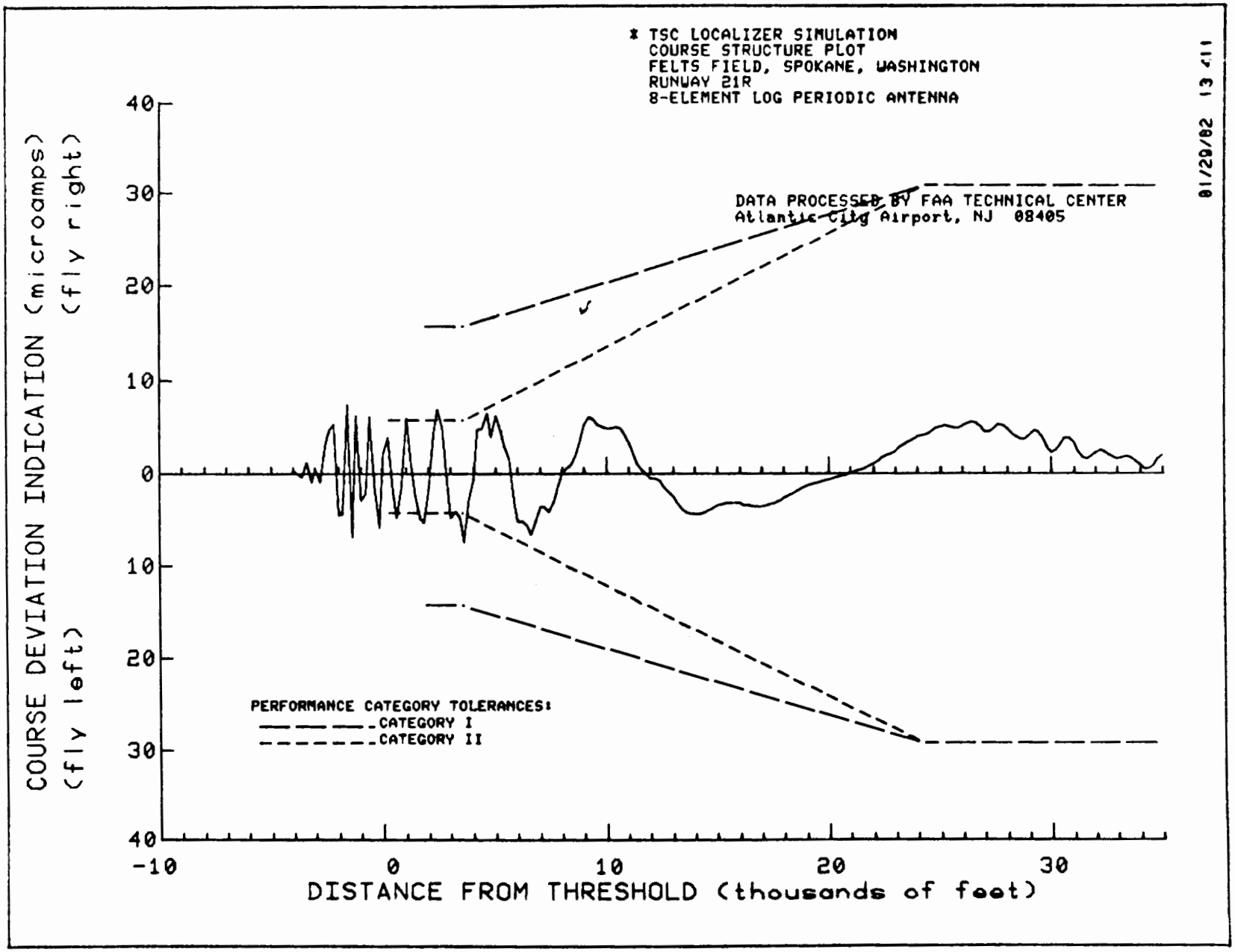

FIGURE 3 - COURSE STRUCTURE PLOT SPOKANE (FELTS FIELD), WASHINGTON 8-ELEMENT ANTENNA

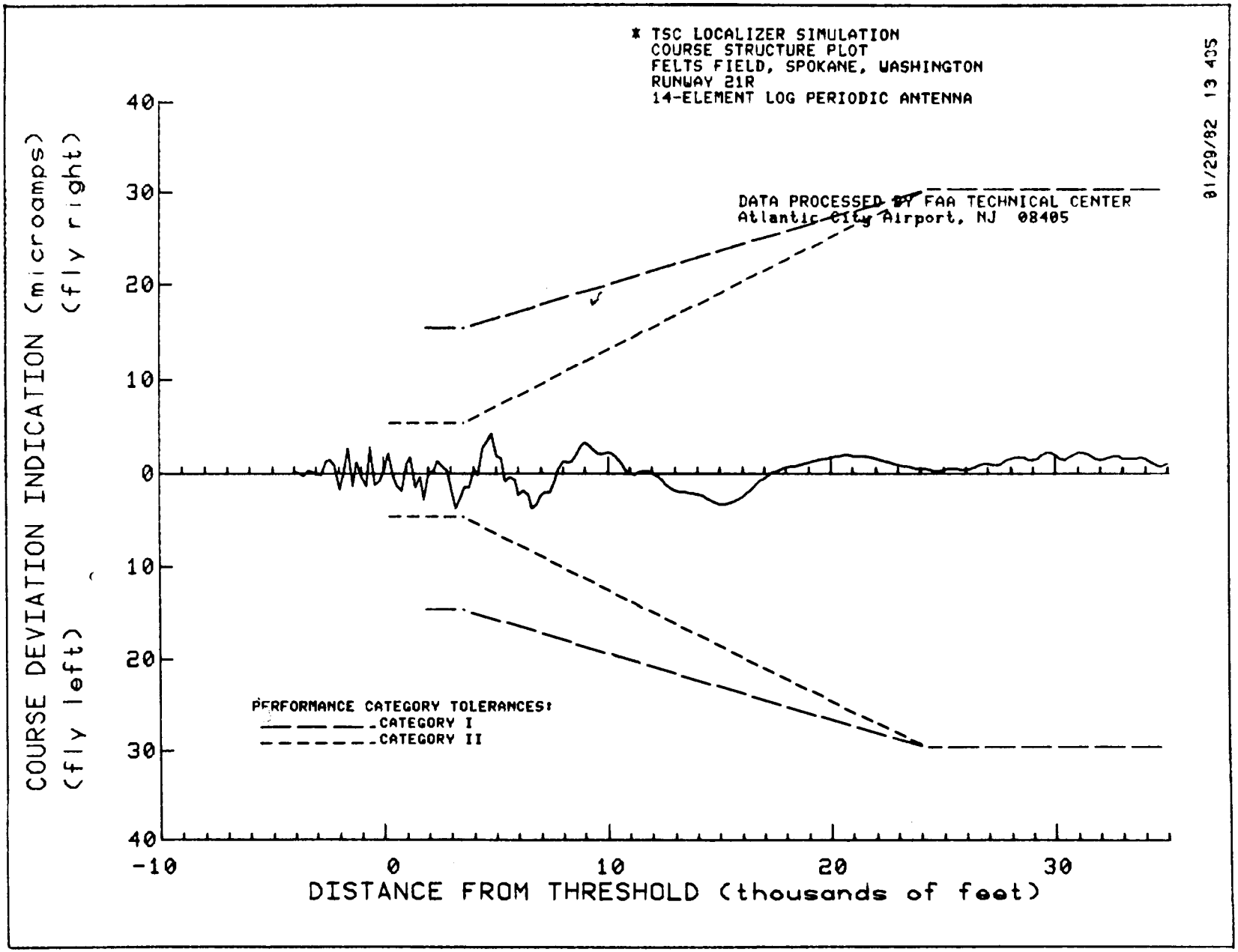

FIGURE 4 - COURSE STRUCTURE PLOT - SPOKANE (FELTS FIELD), WASHINGTON 14-ELEMENT ANTENNA

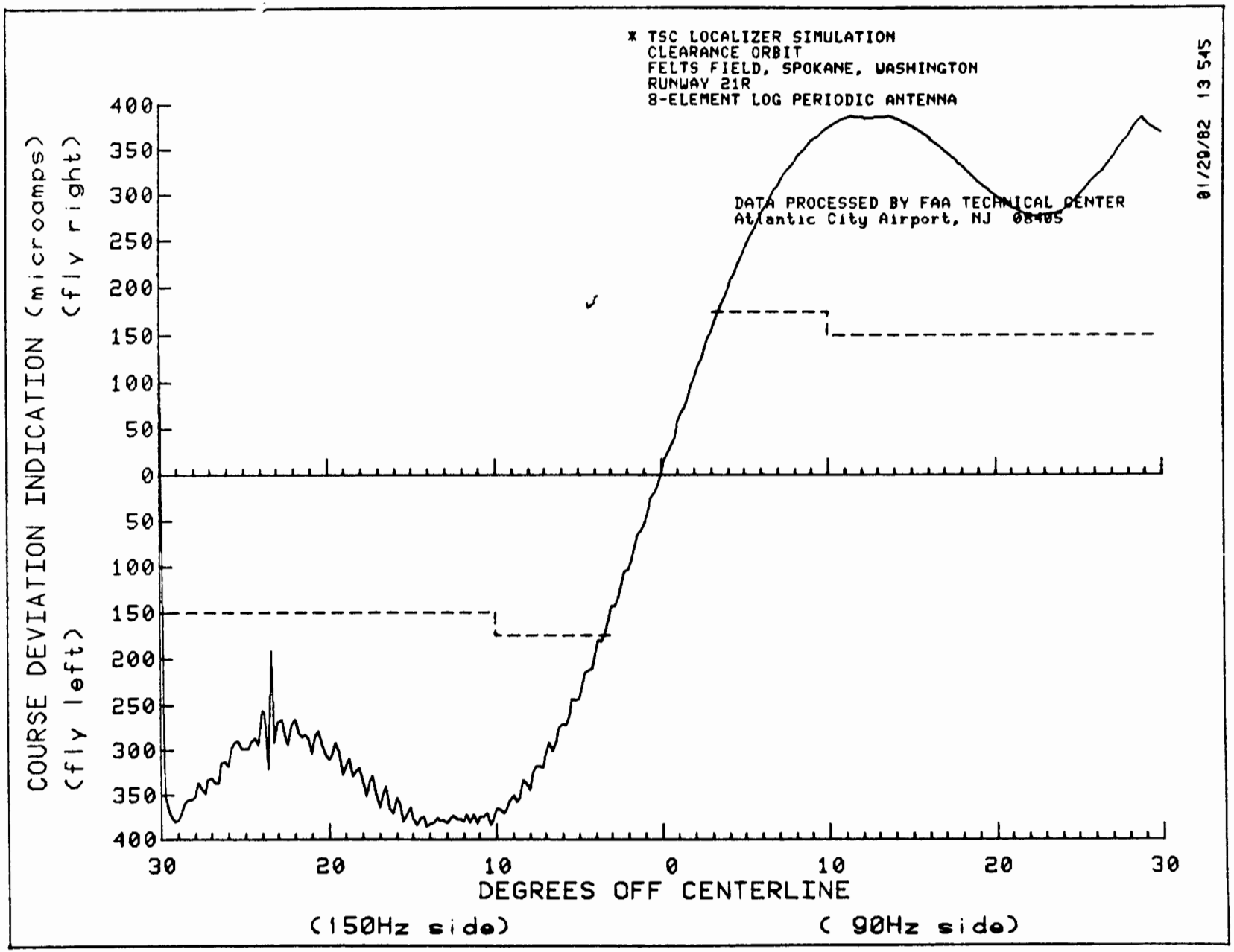

FIGURE 5 - CLEARANCE ORBIT - SPOKANE(FELTS FIELD), WASHINGTON 8-ELEMENT ANTENNA

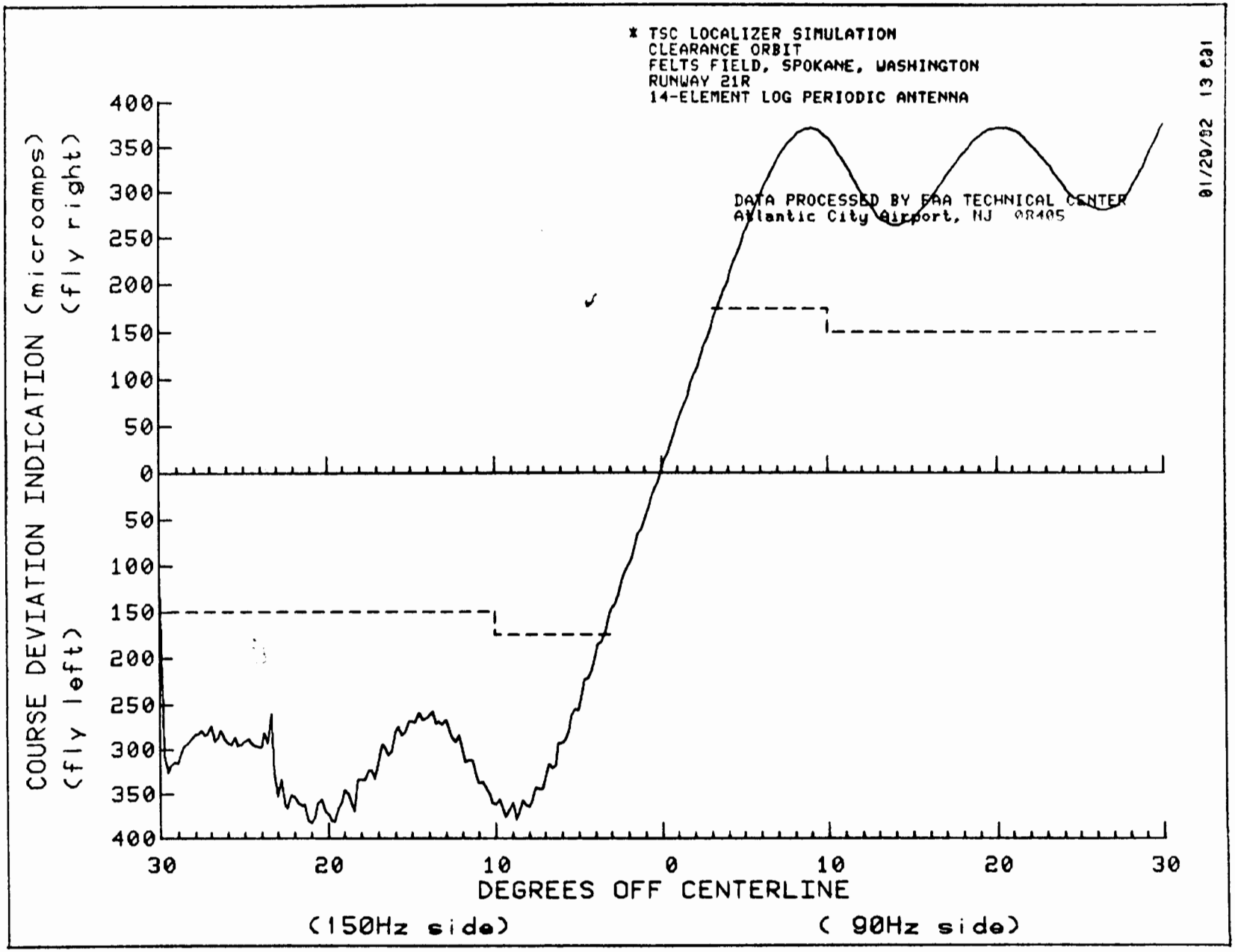

FIGURE 6 - CLEARANCE ORBIT - SPOKANE (FELTS FIELD), WASHINGTON 14-ELEMENT ANTENNA

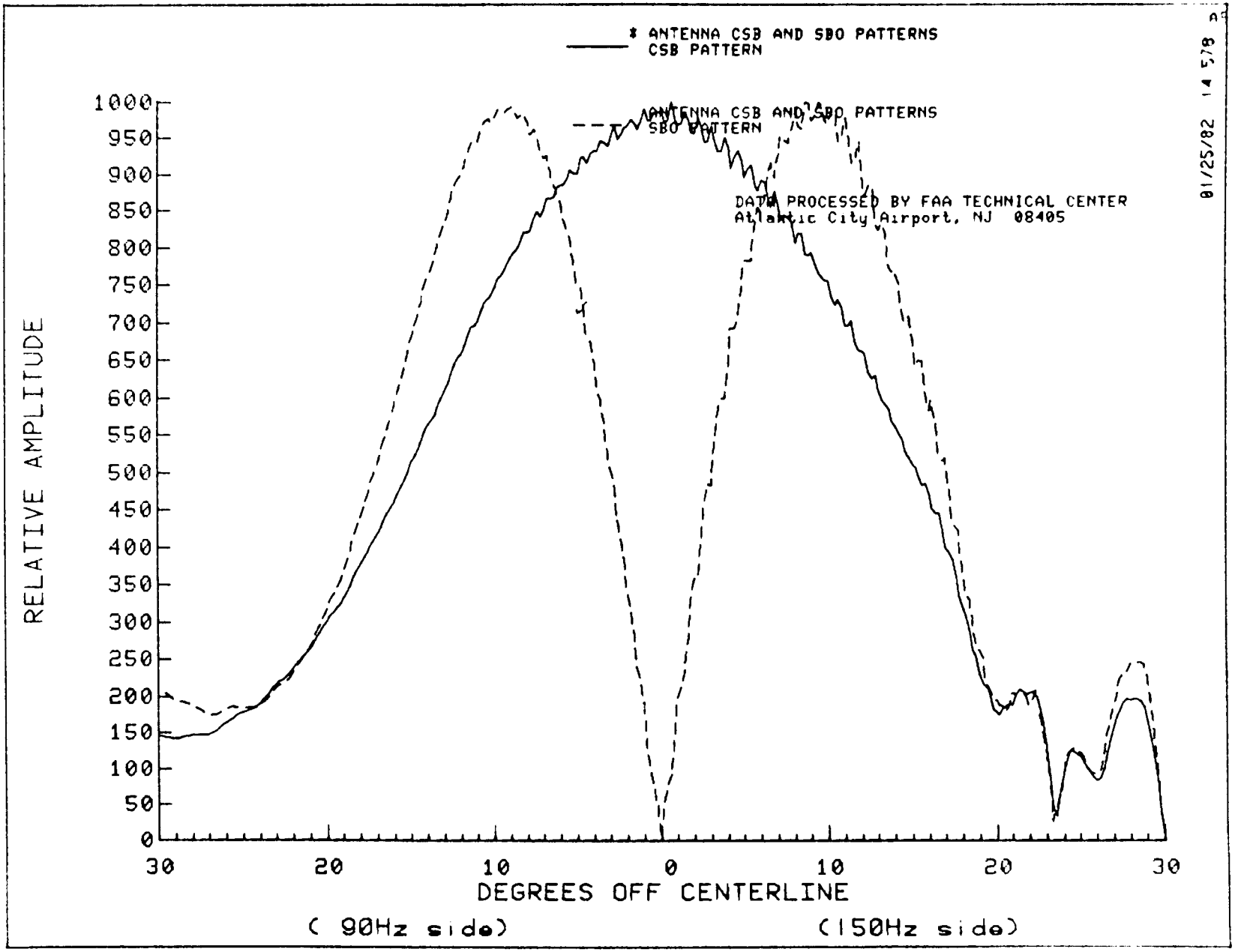

FIGURE 7 - CSB and SBO PATTERNS - SPOKANE (FELTS FIELD), WASHINGTON
8-ELEMENT LOG PERIODIC ANTENNA ARRAY

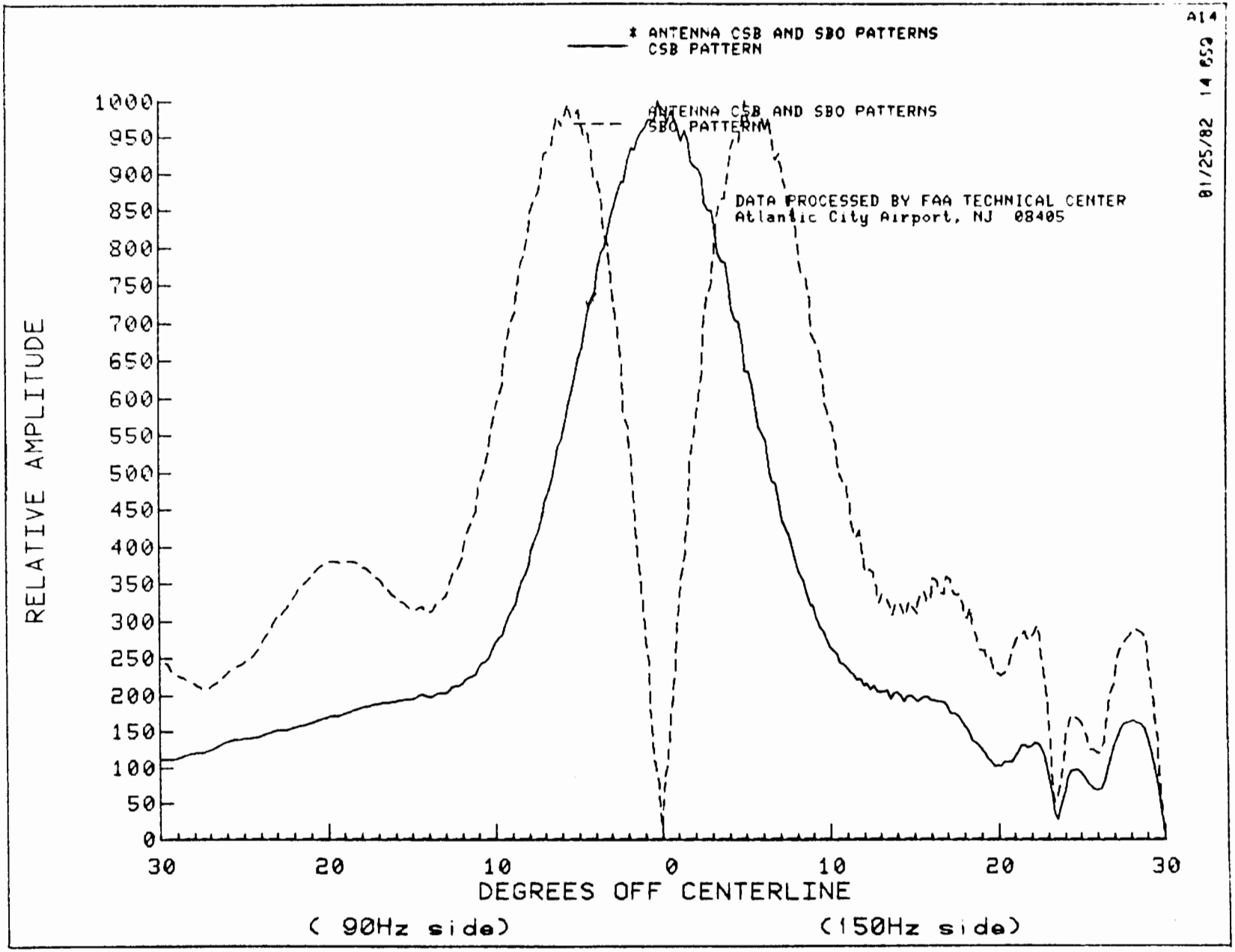

FIGURE 8 - CSB and SBO PATTERNS - SPOKANE (FELTS FIELD), WASHINGTON
14-ELEMENT LOG PERIODIC ANTENNA ARRAY