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ILS Localizer Math Modeling of a Planned Satellite Passenger Terminal for Runway 17R at Dallas-Fort Worth Regional Airport

John Walls

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Technical Report Documentation Page

1. Report No.	2. Government Accession No.	3. Recipient's Catalog No.
DOT/FAA/CT-TN86/48		

4. Title and Subtitle	5. Report Date
ILS LOCALIZER MATH MODELING OF A PLANNED SATELLITE PASSENGER TERMINAL FOR RUNWAY 17R AT DALLAS-FORT WORTH REGIONAL AIRPORT	October 1986
	6. Performing Organization Code: ACT-140
7. Author(s): John E. Walls	8. Performing Organization Report No.: DOT/FAA/CT-TN86/48
9. Performing Organization Name and Address: U.S. Department of Transportation, Federal Aviation Administration, Technical Center, Atlantic City Airport, N.J. 08405	10. Work Unit No. (TRAIS)
	11. Contract or Grant No.: T0603N
12. Sponsoring Agency Name and Address: U.S. Department of Transportation, Federal Aviation Administration, Program Engineering and Maintenance Service, Washington, D.C. 20590	13. Type of Report and Period Covered: Technical Note, August 1986
	14. Sponsoring Agency Code

15. Supplementary Notes

16. Abstract

This Technical Note describes the instrument landing system (ILS) mathematical modeling performed at the request of the Southwest Region. Computed data are presented showing the effects of a proposed satellite passenger terminal on the performance of the ILS localizer for runway 17R at the Dallas-Fort Worth Regional Airport. Reflections from other structures on the airport are not considered. Modeled course structure results indicate that the proposed terminal should not seriously affect localizer category I performance. Computed clearance orbit results indicate satisfactory linearity, course crossover, and signal clearance levels.

17. Key Words	18. Distribution Statement
Instrument Landing System ILS Math Modeling	Document is on file at the Technical Center Library, Atlantic City Airport, New Jersey 08405

19. Security Classif. (of this report)	20. Security Classif. (of this page)	21. No. of Pages	22. Price
Unclassified	Unclassified	15	

Form DOT F 1700.7 (8-72) Reproduction of completed page authorized

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EXECUTIVE SUMMARY

This instrument landing system (ILS) math model study was performed at the request of the Southwest Region to compute the effects of a proposed satellite passenger terminal on the performance of the ILS localizer for runway 17R at the Dallas-Fort Worth Regional airport. Reflections from other structures on the airport are not considered. Modeled course structure results indicate that the proposed terminal should not seriously affect localizer category I performance. Computed clearance orbit results indicate satisfactory linearity, course crossover, and signal clearance levels.

INTRODUCTION

PURPOSE.

This report provides computer modeled performance data showing the effects from proposed construction of a satellite passenger terminal on the course structure of the instrument landing system (ILS) localizer for runway 17R at the Dallas-Fort Worth Regional Airport.

BACKGROUND.

The Southwest Region, ASW-464, is concerned that signal reflections from a satellite passenger terminal (figure 1) planned for construction in the vicinity of runway 17R at the Dallas-Fort Worth Regional Airport may degrade the ILS localizer performance. The term "satellite" is used to indicate that this terminal will be located in an area detached from the main terminal complex. ILS math modeling assistance was sought prior to construction to determine and to minimize potential course degradation. ASW-464 submitted the request for a math model study to the Navigation and Landing Division, APM-400, which, in turn, was forwarded to the Federal Aviation Administration (FAA) Technical Center for accomplishment. Runway 17R is serviced by a 14-element traveling wave antenna located on the runway's south end to provide category I performance. This modeling effort was performed under project T0603N. The Program Manager is Mr. Edmund A. Zyzys. Additional information regarding this study may be obtained by contacting Messrs. Jesse Jones or John Walls at FTS-482-4572 or (609) 484-4000, extension 4572.

DISCUSSION

ILS MATH MODEL.

The FAA Technical Center conducts ILS mathematical computer model studies through application of a localizer model developed by the Transportation Systems Center and converted to the Technical Center's Honeywell 66/60 computer. References 1 through 3 describe the modeling technique and implementation. Reference 4 provides validation data for the localizer model.

The coordinate system used in the computer model is a right-handed system with the origin located at the threshold of the runway. The positive x-axis is directed out from the threshold along runway centerline extended; the positive y-axis is directed to the left; the positive z-axis is directed up. Alpha, the angle between the base of a reflector and the x-axis, is measured in the counterclockwise direction. A reflector facing in the negative y-direction has an alpha of 0°; a reflector facing in the positive x-direction has an alpha of 90°. Delta is the angle between the surface of the reflector and the vertical direction. A reflector with a delta of zero is perpendicular to the ground. Delta is equal to -90° for a horizontal reflector facing down. A surface illuminated by radio frequency (RF) energy from the antenna is modeled by a rectangular flat surface. This surface is 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. The model does not compute multiple reflections or diffractions. Course deviation indicator (CDI) deflections are computed as follows: (1) the magnitude and phase of the RF signals arriving at the aircraft location are determined for each surface independently; (2) a resultant RF signal is computed by vectorially combining the independent signals; and (3) CDI deflection is then computed from the resultant RF signal.

ILS MODELING PERFORMED.

Figure 1 shows the general orientation of the proposed satellite terminal and the runway. Table 1 summarizes the rectangular plate data and other model input parameters. Note, as discussed under model description, the combined effect of the plates is a vectorial addition of the independent effects of each reflecting surface and does not consider shadowing nor any interactions between surfaces. Antenna currents and phases used throughout this study for the 14-element traveling wave antenna are also given in table 1.

DATA PRESENTATION.

Modeled output results are provided on three types of plots: (1) localizer course structure plots, (2) localizer clearance orbit plots, and (3) carrier plus sideband (CSB) and sideband only (SBO) antenna pattern plots. The simulated flightpaths for the course structure runs are centerline approaches starting 60,000 feet from runway threshold. The aircraft crosses the runway threshold at an altitude of 55 feet and continues at this altitude to a point 2,000 feet from stop end of runway. Distances shown on the horizontal axis of the course structure plots are referenced to the approach threshold. Negative values are shown for distances between the threshold and the localizer. Positive values apply to distances on the approach path toward the outer marker. Angular values on the horizontal axes of the CSB and SBO antenna pattern plots and on the clearance orbit plot was run with a flight arc of 35,000 feet at an altitude of 1,000 feet, with respect to runway threshold.

The vertical axis of the course structure and clearance orbit plots are the model output values of CDI deflection in microamps (0.4-second time constant applied for smoothing). The vertical axis of the antenna pattern plot uses a relative scale with the pattern normalized to its peak value. Note that all data presented do not include the effects from any other structures on the airport. The usual range for the vertical scale of modeled course structure data plots is 40 microamps. This range has been reduced to 10 microamps for the course structure plot provided in this study in order to better display small values of CDI deflection. This choice of scale eliminates the display of category I limits from the plot and shows only the final segment of the category II tolerance limits. Category IIIA tolerance limits (not shown) extend the 5-microamp tolerance shown for category II performance to a point on the runway 3,000 feet from threshold. The limits then increase linearly to 10 microamps at a point which is 2,000 feet from the stop end of the runway.

Modeled output data are provided in figures 2 through 4. Figure 2 is the modeled course structure plot showing the computed effect of the satellite terminal on localizer course structure. Figure 3 is the computed clearance orbit plot for the satellite terminal. Figure 4 is the computed CSB and SBO antenna pattern plot.

TABLE 1. MODEL INPUT DATA SUMMARY

Dallas-Fort Worth - Runway 17R

Localizer Antenna	14-element TWA
Site Elevation (ft m.s.l.)	556.3
Antenna Height (ft AGL)	7.7
Course Width (deg)	3.24
Course Ant. to Threshold	1000 ft to 35L
Runway Length (ft)	11387.5
Frequency (MHz)	111.5
Grnd. Height at Proposed Bldgs (ft m.s.l.)	568.0

Reflecting Surfaces

Reflector	Coordinates X*	Y*	Z**	Alpha (deg)	Delta (deg)	Width (ft)	Length (ft)
Satellite Terminal	-8275	1366	12	-39.9	0	236	23
	-8084	1228	12	-32.1	0	236	23
	-8337	1474	12	47.9	0	87	23

*Midpoint of base of surface references to threshold of respective runway.
**Referenced to base of antenna.
***Equivalent of building height.

14 Element Traveling Wave Antenna Data

Ant #	Spacing (wave length)	Carrier+Sideband Amplitude	Carrier+Sideband Phase (deg)	Sideband Only Amplitude	Sideband Only Phase (deg)
7L	-4.85	0.060	0	0.138	0
6L	-4.09	0.060	0	0.379	0
5L	-3.33	0.212	0	0.279	0
4L	-2.58	0.212	0	0.586	0
3L	-1.82	0.394	0	0.414	0
2L	-1.06	0.394	0	0.759	0
1L	-0.30	1.000	0	1.000	0
1R	0.30	1.000	0	1.000	180
2R	1.06	0.394	0	0.759	180
3R	1.82	0.394	0	0.414	180
4R	2.58	0.212	0	0.586	180
5R	3.33	0.212	0	0.279	180
6R	4.09	0.060	0	0.379	180
7R	4.85	0.060	0	0.138	180

DATA ANALYSIS.

Modeled course structure results (figure 2) indicate that the proposed satellite terminal should have little derogative effect on the localizer course structure performance. Maximum CDI deflections of approximately 1.3 microamps (peak to peak) occur in the approach segment at the runway threshold. These values are well within category I tolerance limits. The computed clearance orbit plot (figure 3) indicates satisfactory linearity, crossover, and clearance levels. In figure 4, the CSB and SBO antenna patterns indicate only very minor oscillations on the 150 hertz side beyond 15° off centerline.

CONCLUSIONS

Math modeling results indicate that construction of the proposed satellite terminal should have little effect on localizer course structure on runway 17R. Computed clearance orbit results indicate satisfactory linearity, course crossover, and signal clearance levels. These results do not include any other structures on the airport.

REFERENCES

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

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

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

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

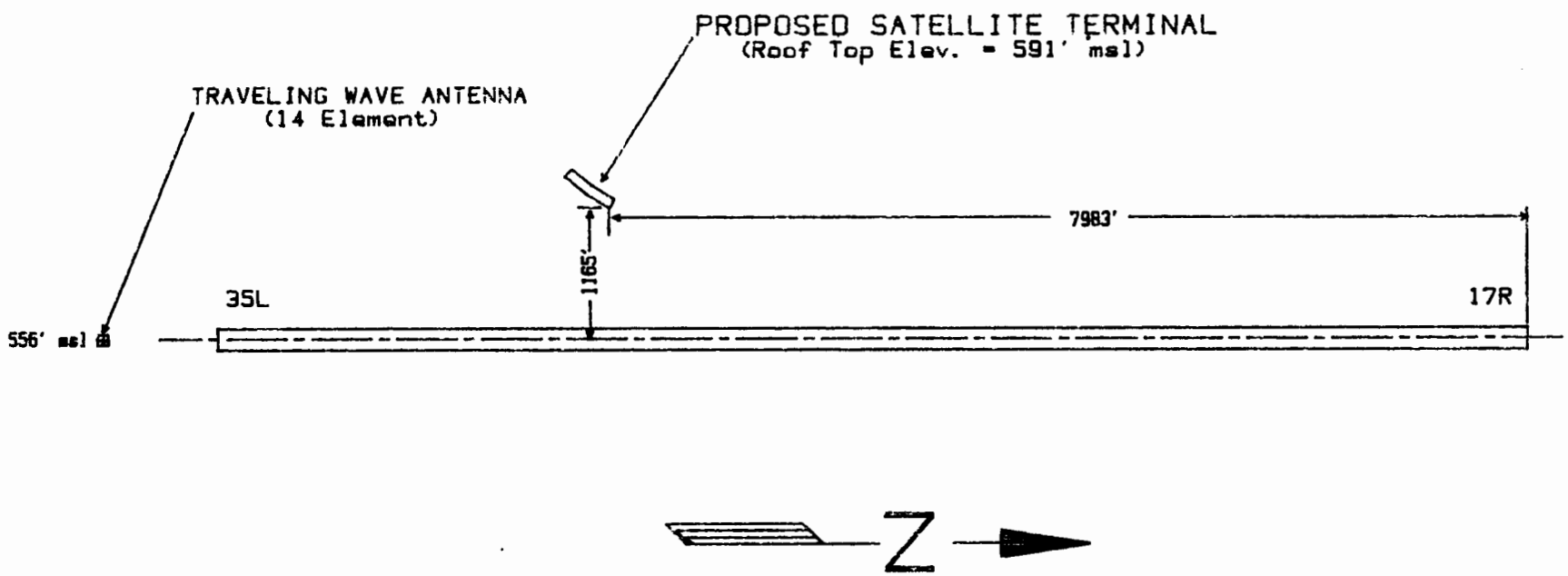

FIGURE 1. ILS MODELING LAYOUT, DFW RUNWAY 17R

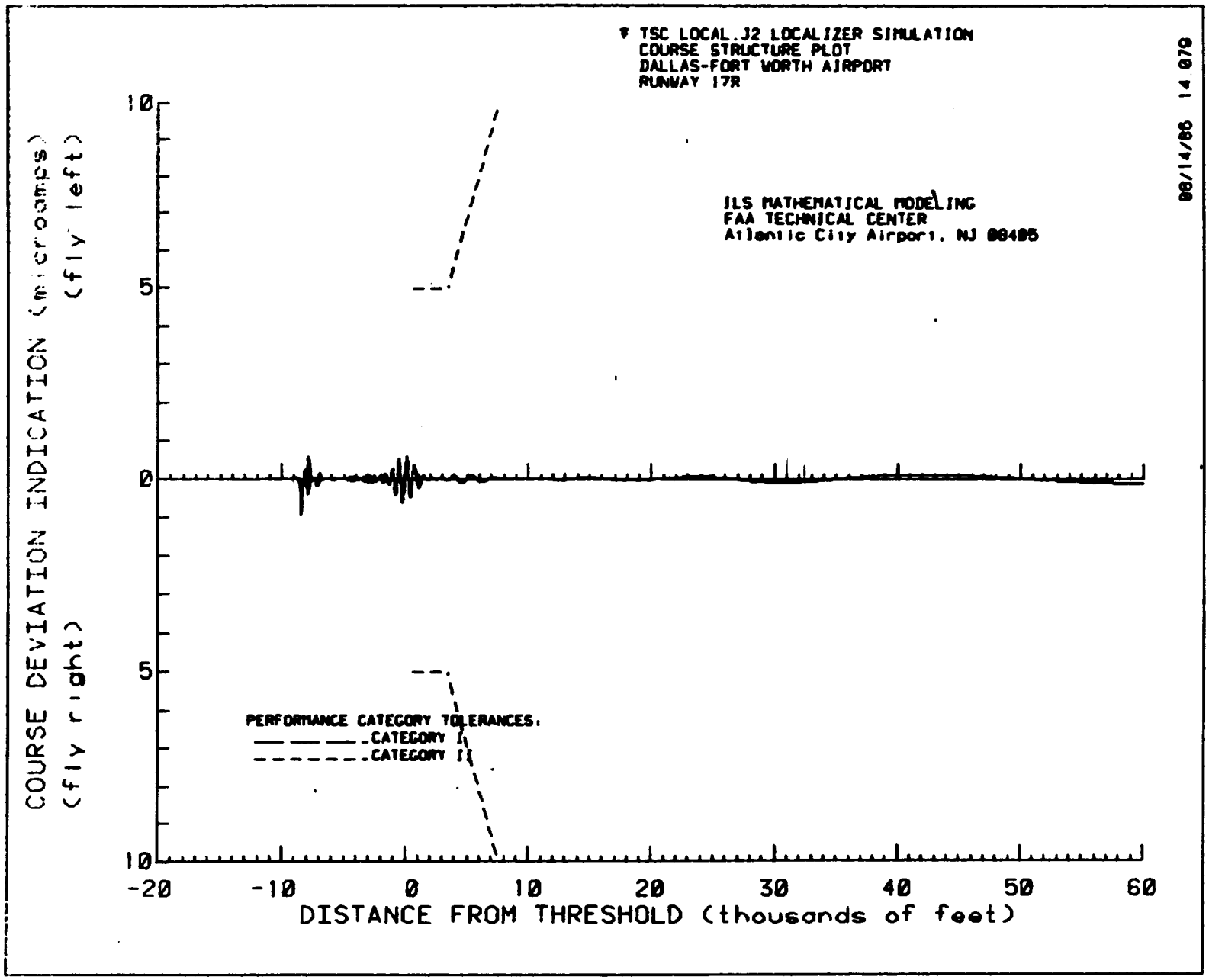

FIGURE 2. COURSE STRUCTURE PLOT, DFW RUNWAY 17R, PROPOSED SATELLITE TERMINAL EFFECTS

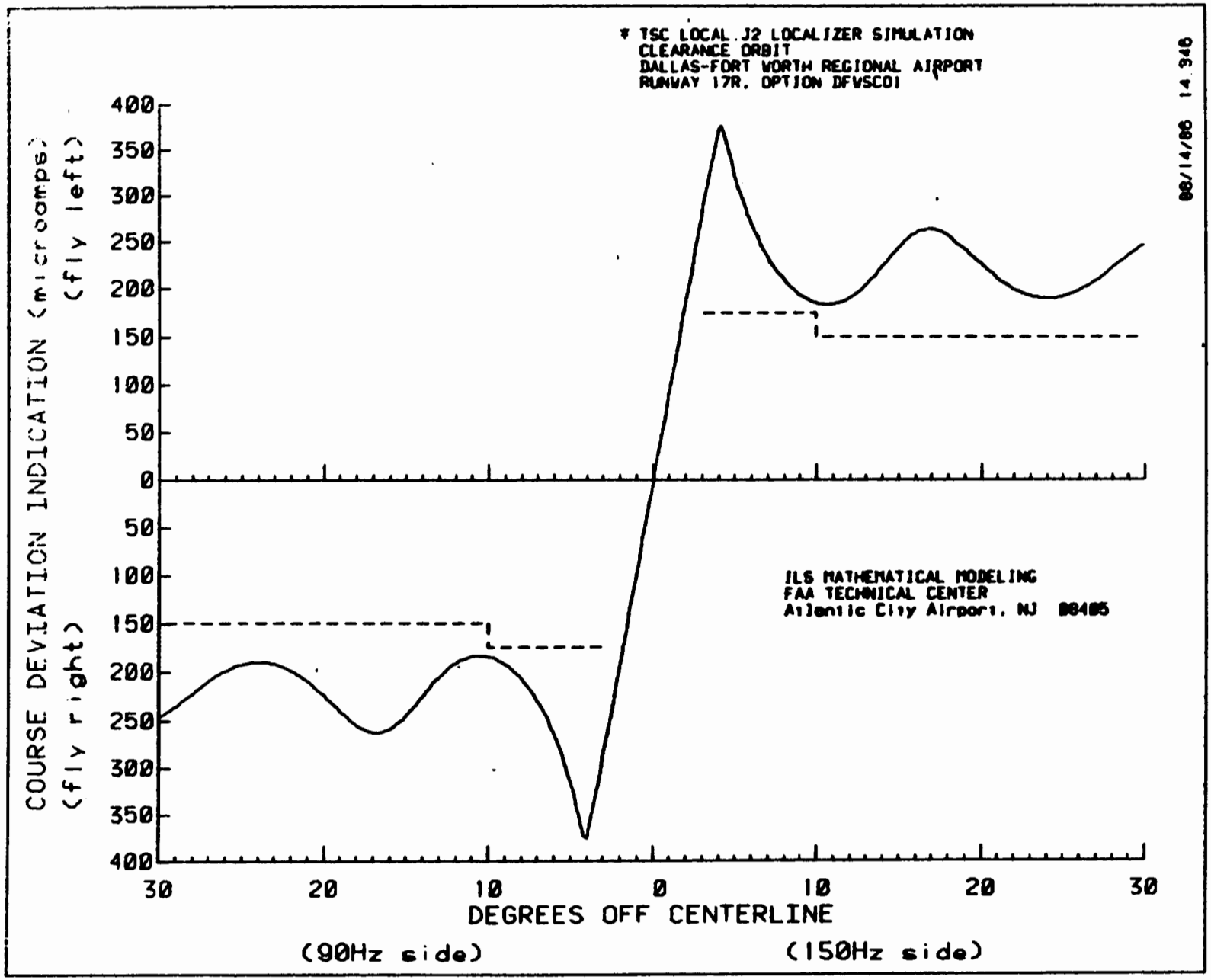

FIGURE 3. CLEARANCE ORBIT PLOT, DFW RUNWAY 17R, PROPOSED SATELLITE TERMINAL EFFECTS

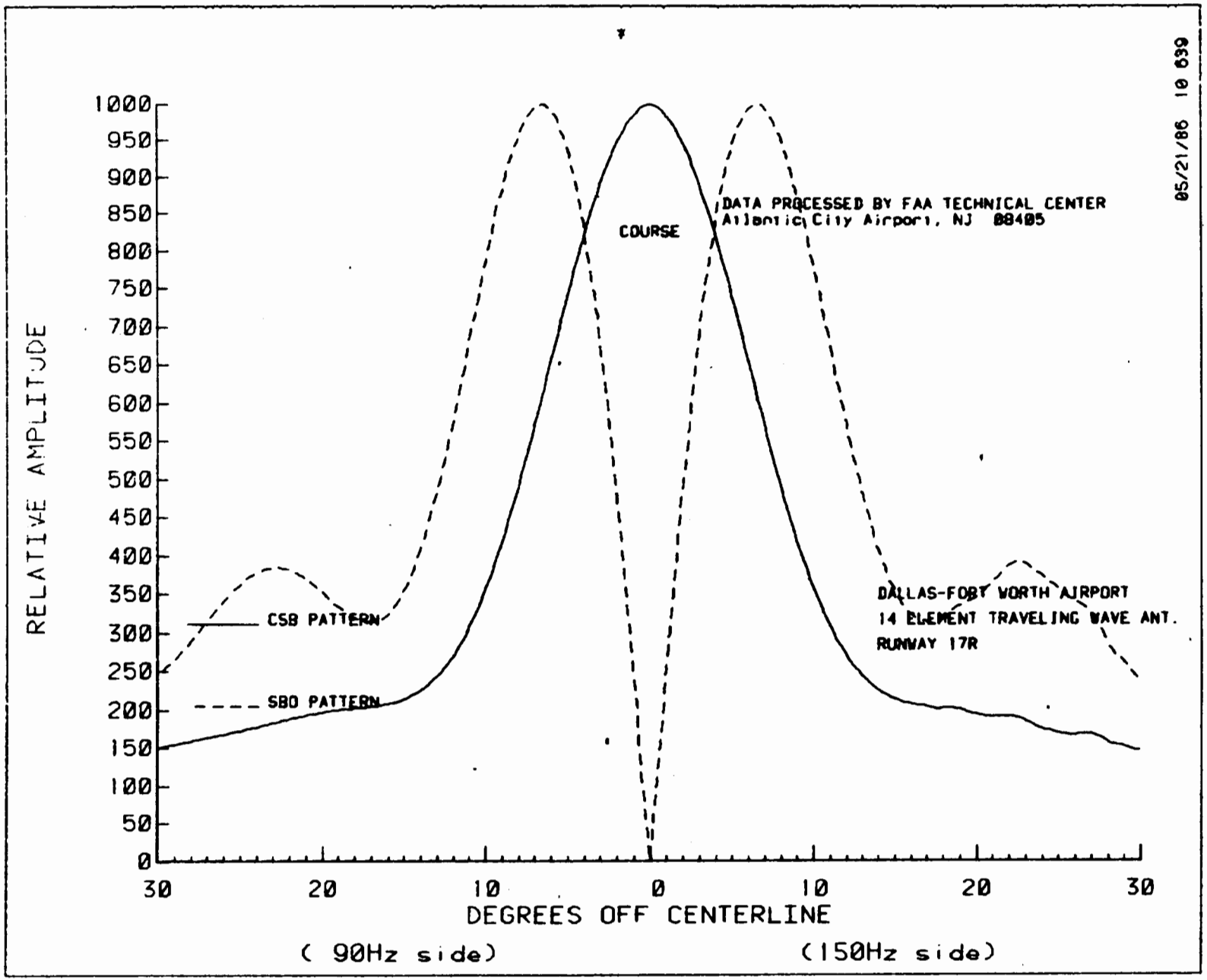

FIGURE 4. CSB and SBO ANTENNA PATTERNS, DFW RUNWAY 17R, 14-ELEMENT TRAVELING WAVE ANTENNA, PROPOSED SATELLITE TERMINAL EFFECTS