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ILS Localizer Math Modeling of Potential Satellite Passenger Terminals for Runway 17R at Dallas-Fort Worth Regional Airport

John Walls

October 1986

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16. Abstract

This Technical Note describes the instrument landing system (ILS) math modeling performed at the request of the Southwest Region. Computed data are presented showing the effects of a proposed Delta and two hypothetical satellite passenger terminals 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 terminals modeled should not seriously affect localizer category I performance. Computed clearance orbit results indicate satisfactory linearity, course crossover, and signal clearance levels.

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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 Delta and two hypothetical satellite passenger terminals 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 terminals modeled 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 of a proposed Delta satellite passenger terminal and two hypothetical satellite terminals 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 proposed satellite passenger terminals in the vicinity of runway 17R at the Dallas-Fort Worth Regional Airport may degrade the ILS localizer performance. Currently, one terminal is planned for construction. Math modeling of the effects of this proposed Delta terminal are described in Technical Note DOT/FAA/CT-TN86/48. Construction of additional terminals is anticipated. In order to gain some insight into possible effects from future construction, ASW-464 has requested that the effects of the proposed Delta terminal plus two additional hypothetical terminals be computed (figure 1). The term "satellite" is used to indicate that the terminal will be located in an area detached from the main terminal complex. 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. James D. Rambone 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

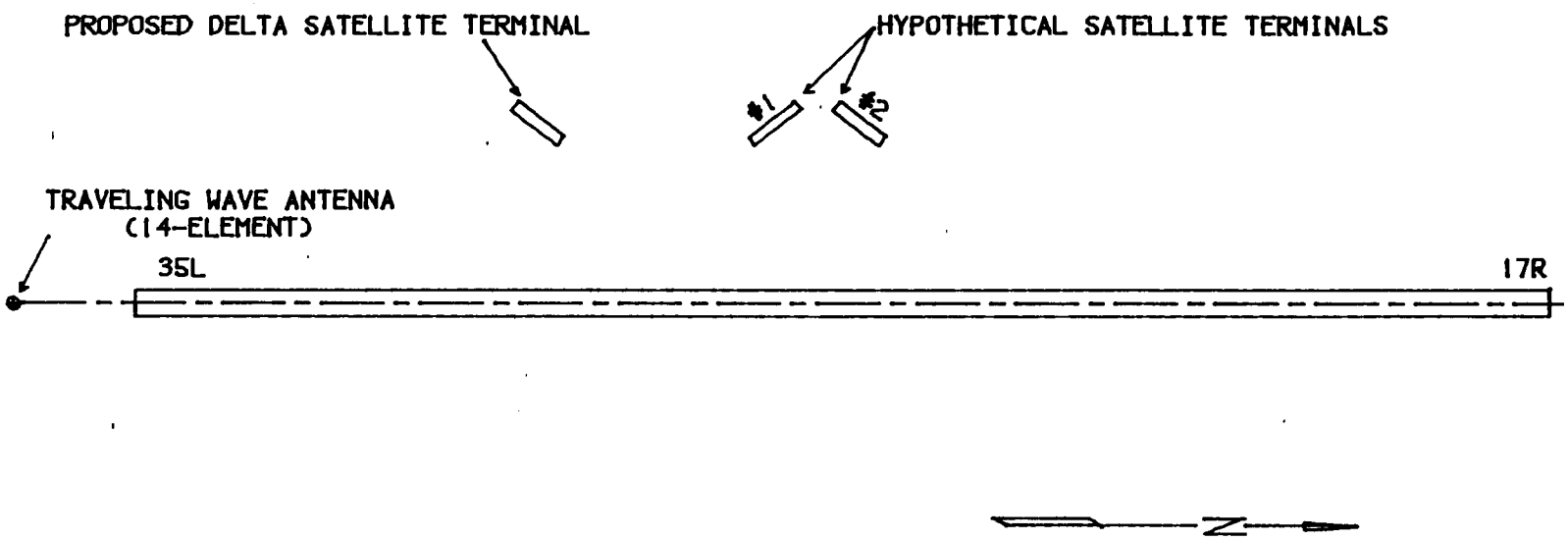

FIGURE 1. ILS MODELING LAYOUT, DFW RUNWAY 17R

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. The 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 Delta and hypothetical satellite terminals 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 the 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 plots and on the clearance orbit plots were run with flight arcs of 35,000 feet at altitudes 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 plots 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.

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	-8170	1305	12	-36.1	0	469	23
	-8331	1474	12	228.3	0	84	23
Hypothetical #1	-6251	1372	12	215.9	0	452	23
	-6413	1204	12	-60.3	0	84	23
Hypothetical #2	-5572	1306	12	-36.3	0	469	23
	-5732	1475	12	226.8	0	84	23

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*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

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 7. Figures 2 through 5 are modeled course structure plots showing the computed effects of the proposed satellite terminal (figure 2), the hypothetical terminals (figures 3 and 4), and the combined effect of all three terminals (figure 5). Figure 6 shows the computed clearance orbit plot and figure 7 shows the computed CSB and SBO antenna pattern plot for the three satellite terminals combined.

DATA ANALYSIS.

Modeled course structure results (figures 2 through 5) indicate that neither the proposed Delta nor the hypothetical satellite terminals should have serious 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 for all terminals modeled-(figure 6) indicates satisfactory linearity, course crossover, and clearance levels. Figure 7, CSB and SBO antenna patterns, indicates no obvious degradation in the antenna pattern formation.

CONCLUSIONS

Math modeling results indicate that neither the proposed Delta nor the hypothetical satellite terminals should seriously affect localizer course structure on runway 17R. Computed clearance orbit results indicate satisfactory linearity, course crossover, and clearance levels. These results do not include any other structures on the airport.

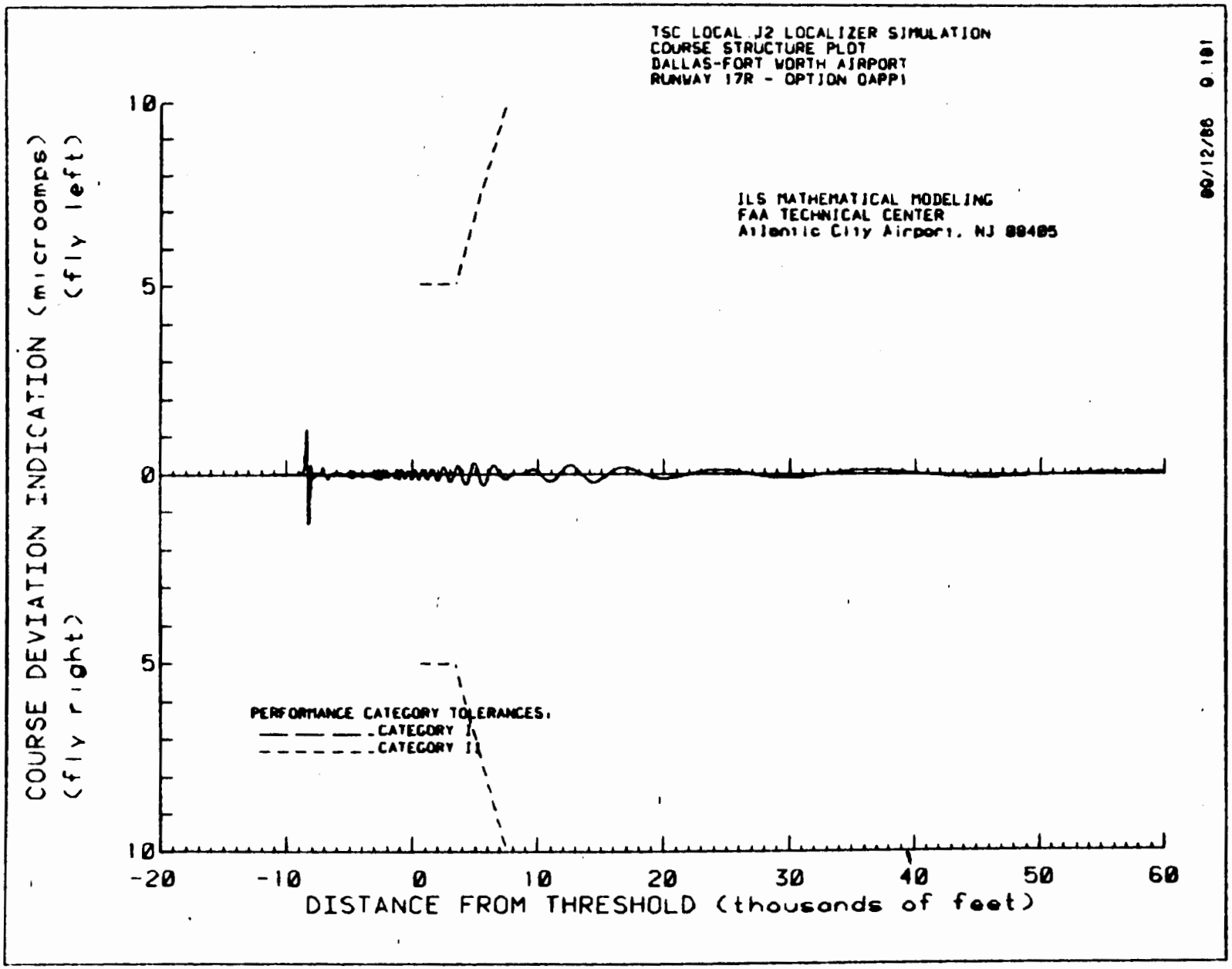

FIGURE 2. COURSE STRUCTURE PLOT, DFW RUNWAY 17R, PROPOSED DELTA SATELLITE TERMINAL EFFECTS

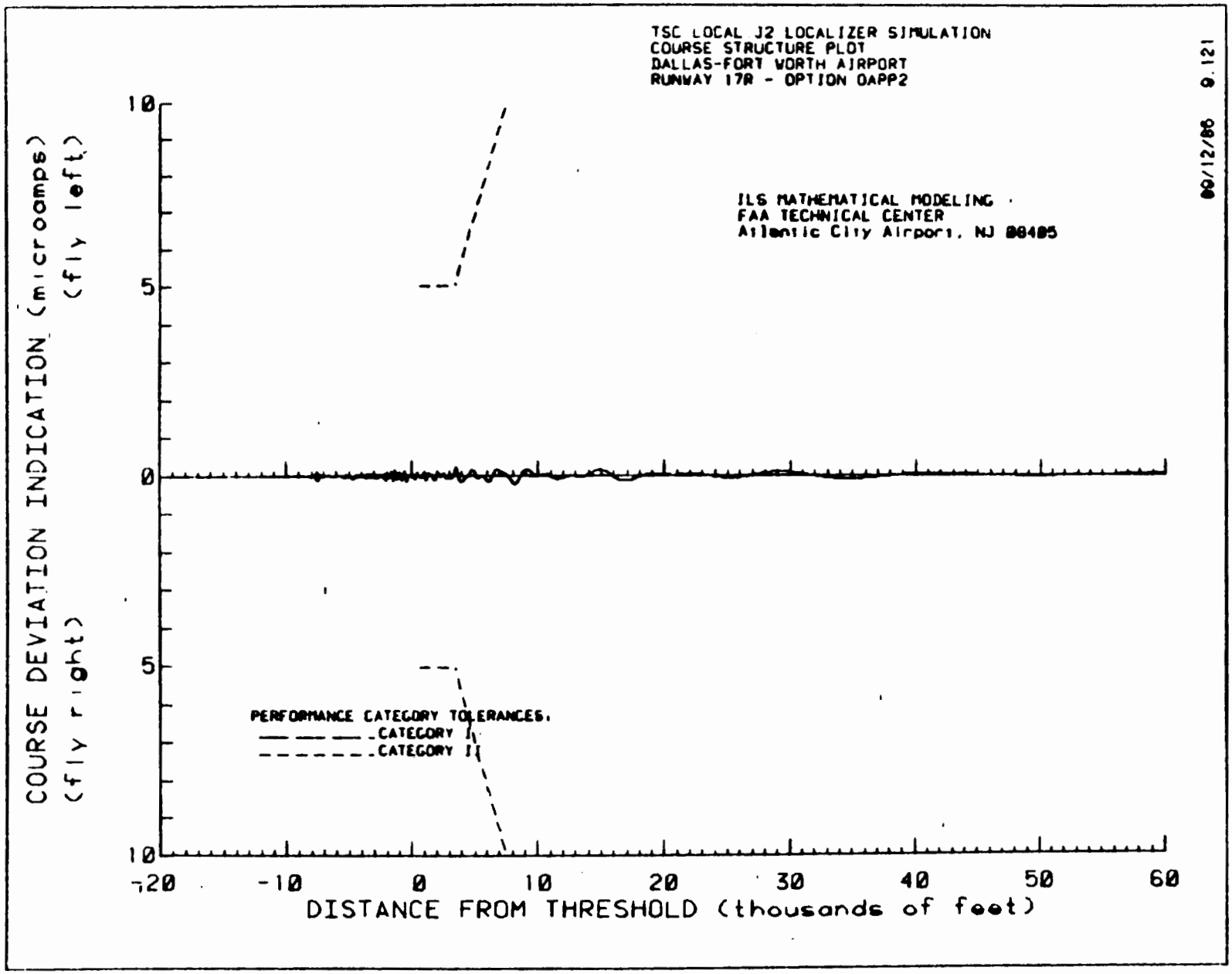

FIGURE 3. COURSE STRUCTURE PLOT, DFW RUNWAY 17R, HYPOTHETICAL SATELLITE TERMINAL #1 EFFECTS

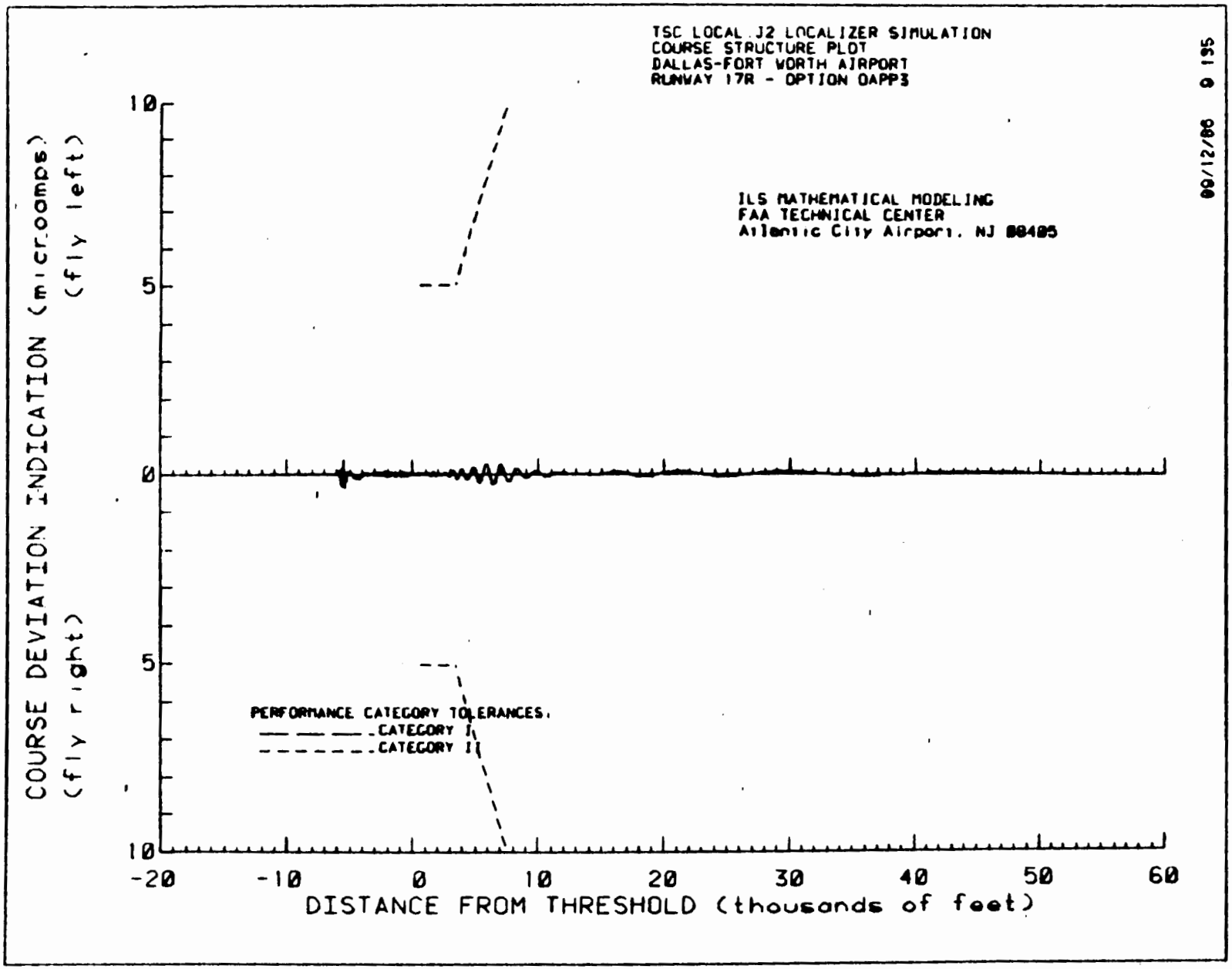

FIGURE 4. COURSE STRUCTURE PLOT, DFW RUNWAY 17R, HYPOTHETICAL SATELLITE TERMINAL #2 EFFECTS

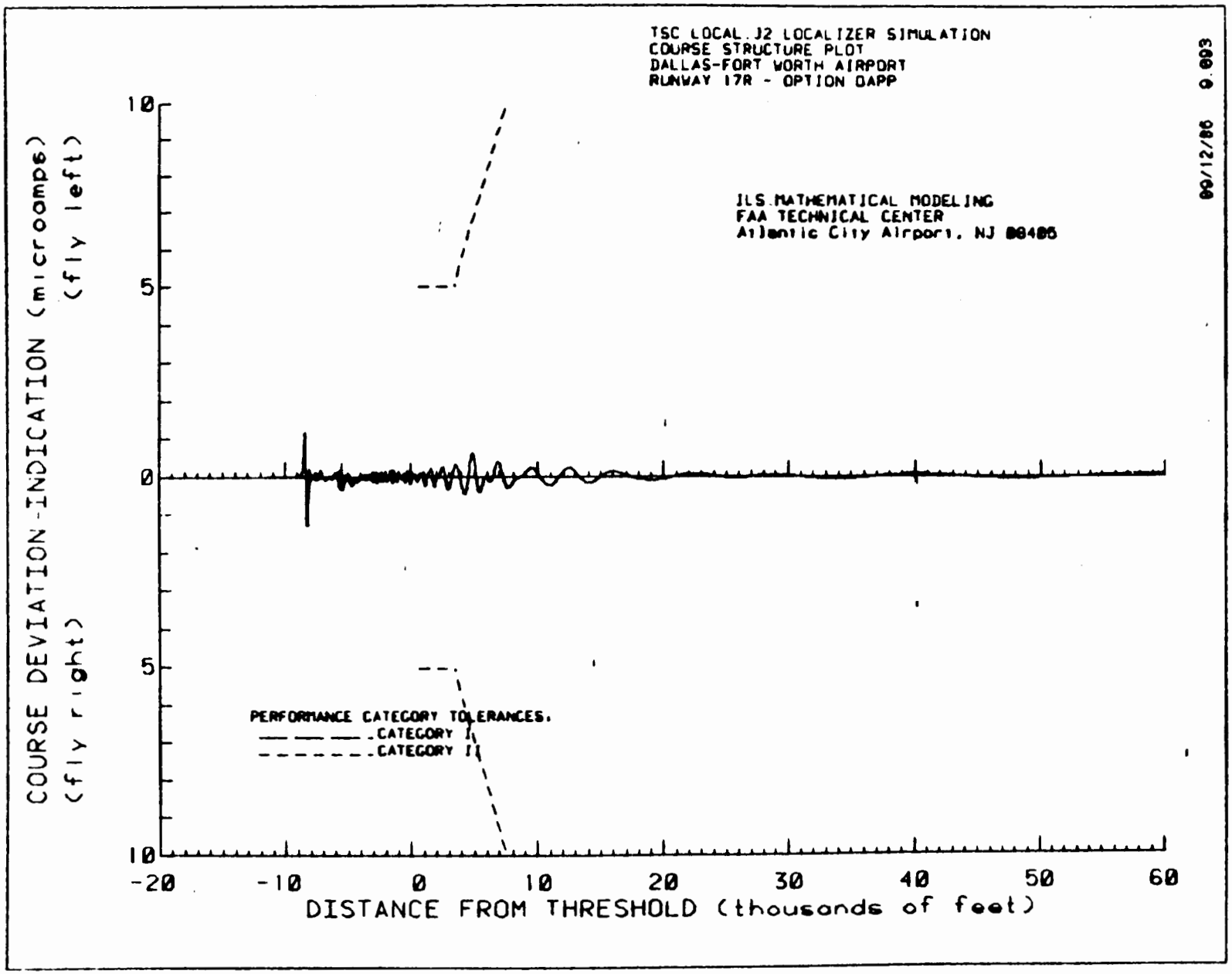

FIGURE 5. COURSE STRUCTURE PLOT, DFW RUNWAY 17R, PROPOSED DELTA PLUS HYPOTHETICAL SATELLITE TERMINAL EFFECTS

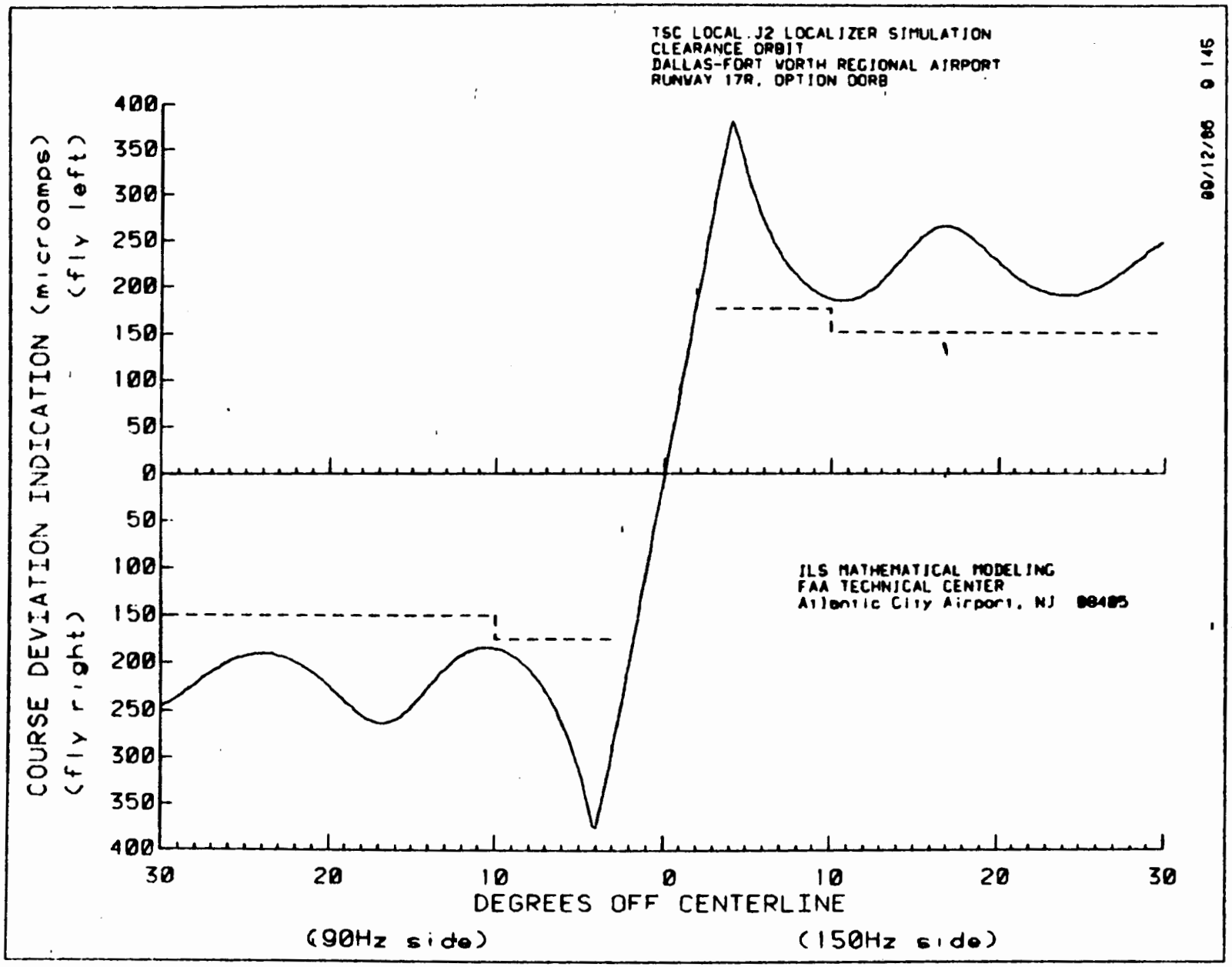

FIGURE 6. CLEARANCE ORBIT PLOT, DFW RUNWAY 17R, PROPOSED DELTA PLUS HYPOTHETICAL SATELLITE TERMINAL EFFECTS

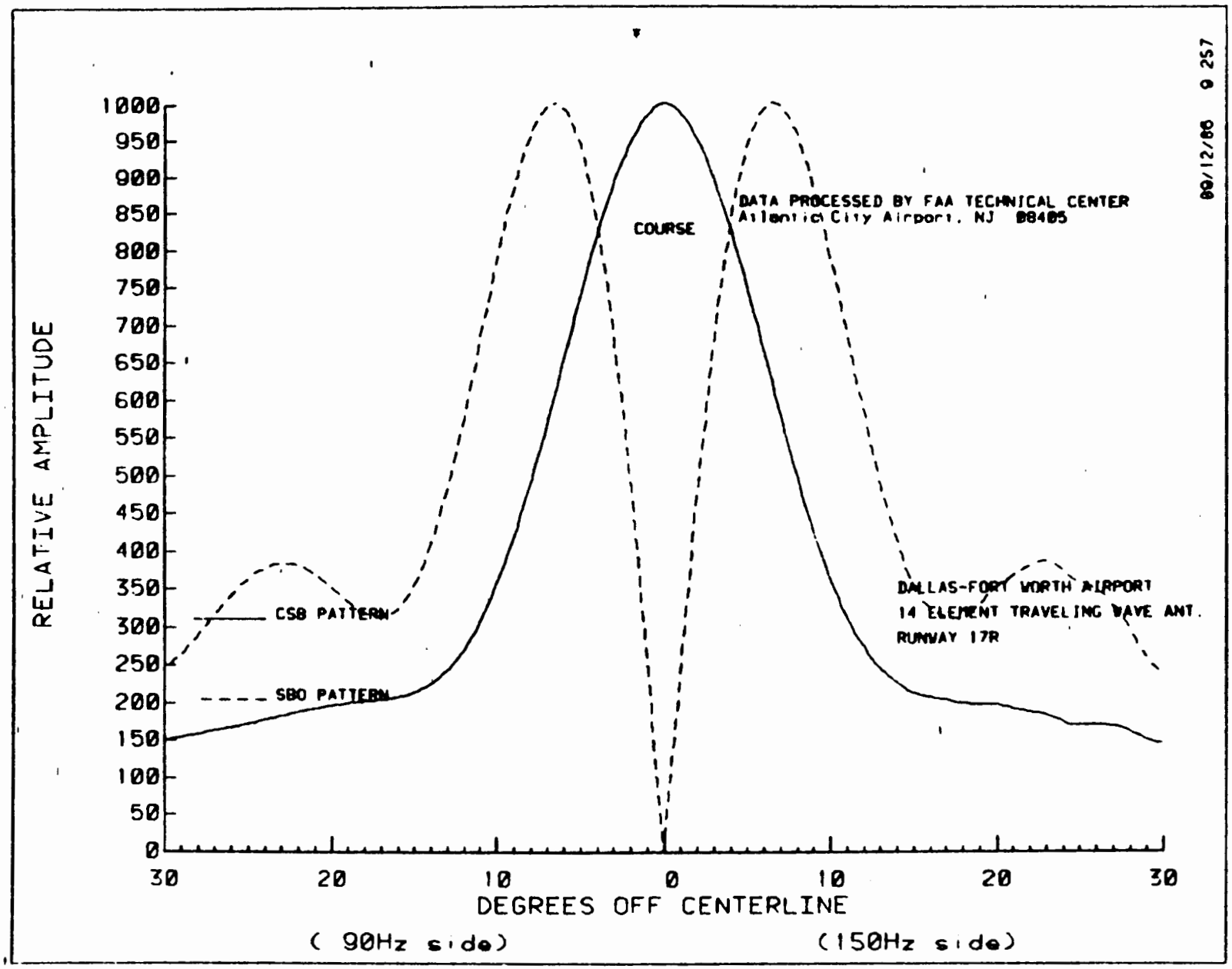

FIGURE 7. CSB AND SBO ANTENNA PATTERNS, DFW RUNWAY 17R, 14-ELEMENT TRAVELING WAVE ANTENNA, PROPOSED PLUS HYPOTHETICAL SATELLITE TERMINAL EFFECTS

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