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ILS Localizer Math Modeling of a Proposed American Airlines Hangar for Runway 18R at the Dallas-Fort Worth Regional Airport

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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 American Airlines hangar on the performance of the ILS localizer for runway 18R 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 hangar should not seriously affect localizer category III 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 modeling study was performed at the request of the Southwest Region to compute the effects of a proposed American Airlines hangar on the performance of the ILS localizer for runway 18R 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 hangar should not seriously affect localizer category III 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 American Airlines hangar on the course structure of the instrument landing system (ILS) localizer for runway 18R at the Dallas-Fort Worth Regional Airport.

BACKGROUND.

The Southwest Region, ASW-464, is concerned that signal reflections from an American Airlines hangar proposed for construction in the vicinity of runway 18R at the Dallas-Fort Worth Regional Airport may degrade the ILS localizer performance. Several candidate designs for this hangar were previously modeled. These results are detailed in Technical Note DOT/FAA/CT-TN85/2. The currently proposed design differs from the previously modeled configurations and, therefore, additional mathematical modeling was requested.

ASW-464 submitted the request for a math modeling 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 18R is serviced by a 14/6 type 1B antenna located on the runway's south end to provide category III 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 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. First, the magnitude and phase of the RF signals arriving at the aircraft location are determined for each surface independently. Next, a resultant RF signal is computed by vectorially combining the independent signals. CDI deflection is then computed from the resultant RF signal.

ILS MODELING PERFORMED.

Figure 1 shows the general orientation of the proposed American Airlines hangar 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 14/6 type 1B 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 axis of the CSB and SBO antenna pattern plot and on the clearance orbit plot 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 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 plot 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

TABLE 1. MODEL INPUT DATA SUMMARY

Localizer Antenna	14/6 type 1B
Runway Length (ft)	11388.0
Frequency (MHz)	111.9
Site Elevation (ft m.s.l.)	580.0
Course Width (deg)	3.25
Course Ant. to Threshold	960 ft to 36L
Clearance Ant. to Threshold	1160 ft to 36L

Reflecting Surfaces

Reflector	Coordinates (ft) X*	Y*	Z**	Alpha (deg)	Delta (deg)	Width (ft)	Length*** (ft)
Proposed Hangar	-1173	1930	35.4	270.0	0	460	98
	-1050	1726	35.4	11.6	0	252	98

* Midpoint of base of surface referenced to threshold of runway 18R
** Referenced to base of antenna
*** Equivalent of building height

14 Element Course Array

Ant. #	Spacing	Carrier+Sideband Amplitude	Carrier+Sideband Phase (deg)	Sideband Only Amplitude	Sideband Only Phase (deg)
7L	-4.88	0.160	0	0.367	180
6L	-4.12	0.160	0	0.555	180
5L	-3.36	0.263	0	0.889	180
4L	-2.59	0.491	0	1.000	180
3L	-1.83	0.714	0	1.000	180
2L	-1.07	1.000	0	0.667	180
1L	-0.31	0.893	0	0.222	180
1R	0.31	0.893	0	0.222	0
2R	1.07	1.000	0	0.667	0
3R	1.83	0.714	0	1.000	0
4R	2.59	0.491	0	1.000	0
5R	3.36	0.263	0	0.889	0
6R	4.12	0.160	0	0.555	0
7R	4.88	0.160	0	0.367	0

6-Element Clearance Array

3L	-1.83	0.200	0	0.013	180
2L	-1.07	0.000	0	0.300	180
1L	-0.31	1.000	0	0.900	180
1R	0.31	1.000	0	0.900	0
2R	1.07	0.000	0	0.300	0
3R	1.83	0.200	0	0.013	0

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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 effects of the proposed hangar. Figure 3 shows the computed clearance orbit plot and figure 4 shows the computed CSB and SBO antenna pattern plot.

DATA ANALYSIS.

Modeled course structure results (figure 2) indicate that the proposed hangar should have negligible derogative effect on the localizer course structure performance. Maximum CDI deflections of less than 0.1 microamps (peak to peak) were computed . These values are well within category III tolerance limits. The computed clearance orbit plot (figure 3) indicates satisfactory linearity, course crossover, and clearance levels. Figure 4, CSB and SBO antenna patterns, indicates obvious degradation on the 150 hertz side of the clearance signal pattern.

CONCLUSIONS

Math modeling results indicate that the proposed American Airlines hangar should not seriously affect localizer course structure on runway 18R. Computed clearance orbit results indicate satisfactory linearity, course crossover, and clearance levels. These results do not include any other structures on the airport.

REFERENCES

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

2. Chin, G., et al., User's Manual for ILSLOC, Simulation for Derogation Effects on the Localizer Portion of the Instrument Landing System, Report DOT/FAA-RD-73-13, 1973.

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

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

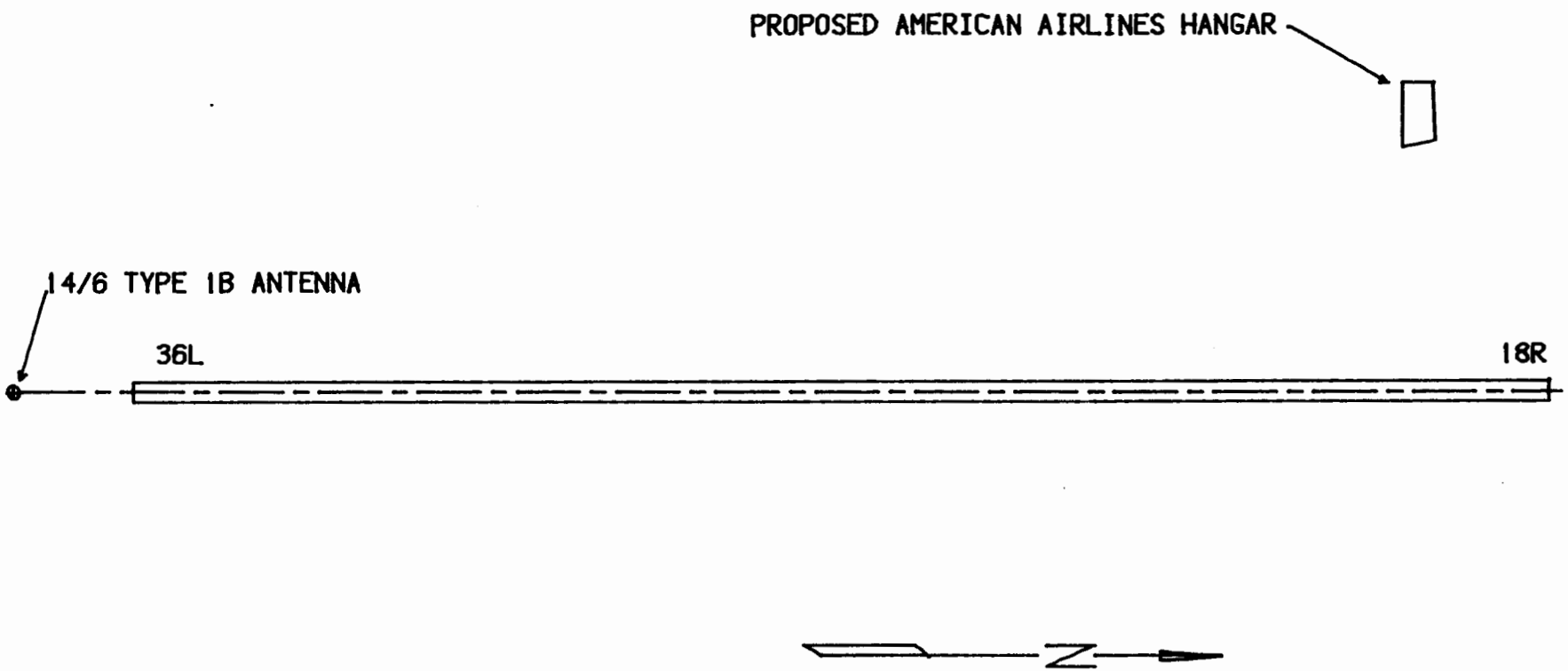

FIGURE 1. ILS MODELING LAYOUT, DFW RUNWAY 18R/36L

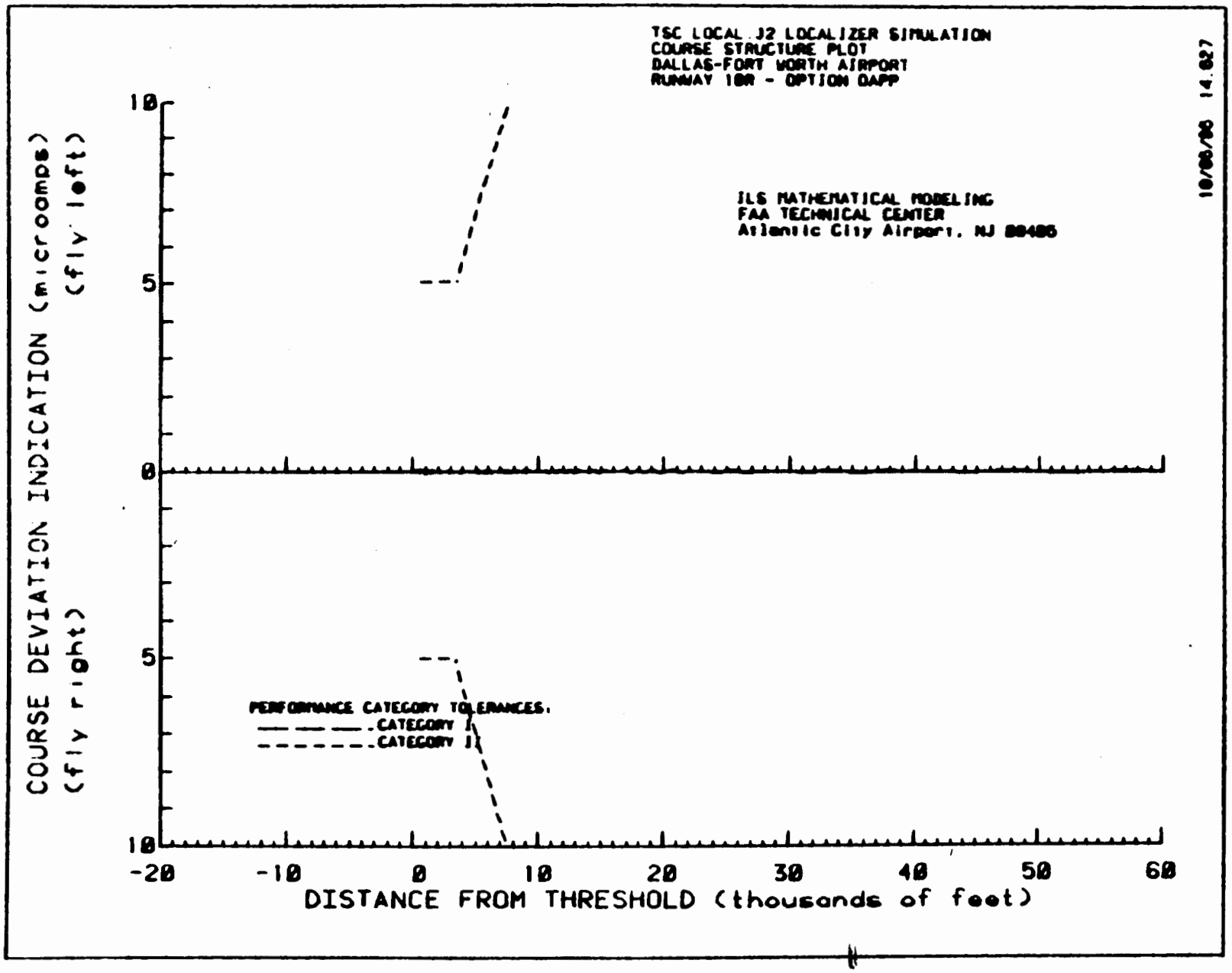

FIGURE 2. COURSE STRUCTURE, DFW RUNWAY 18R, PROPOSED AMERICAN AIRLINES HANGAR EFFECTS

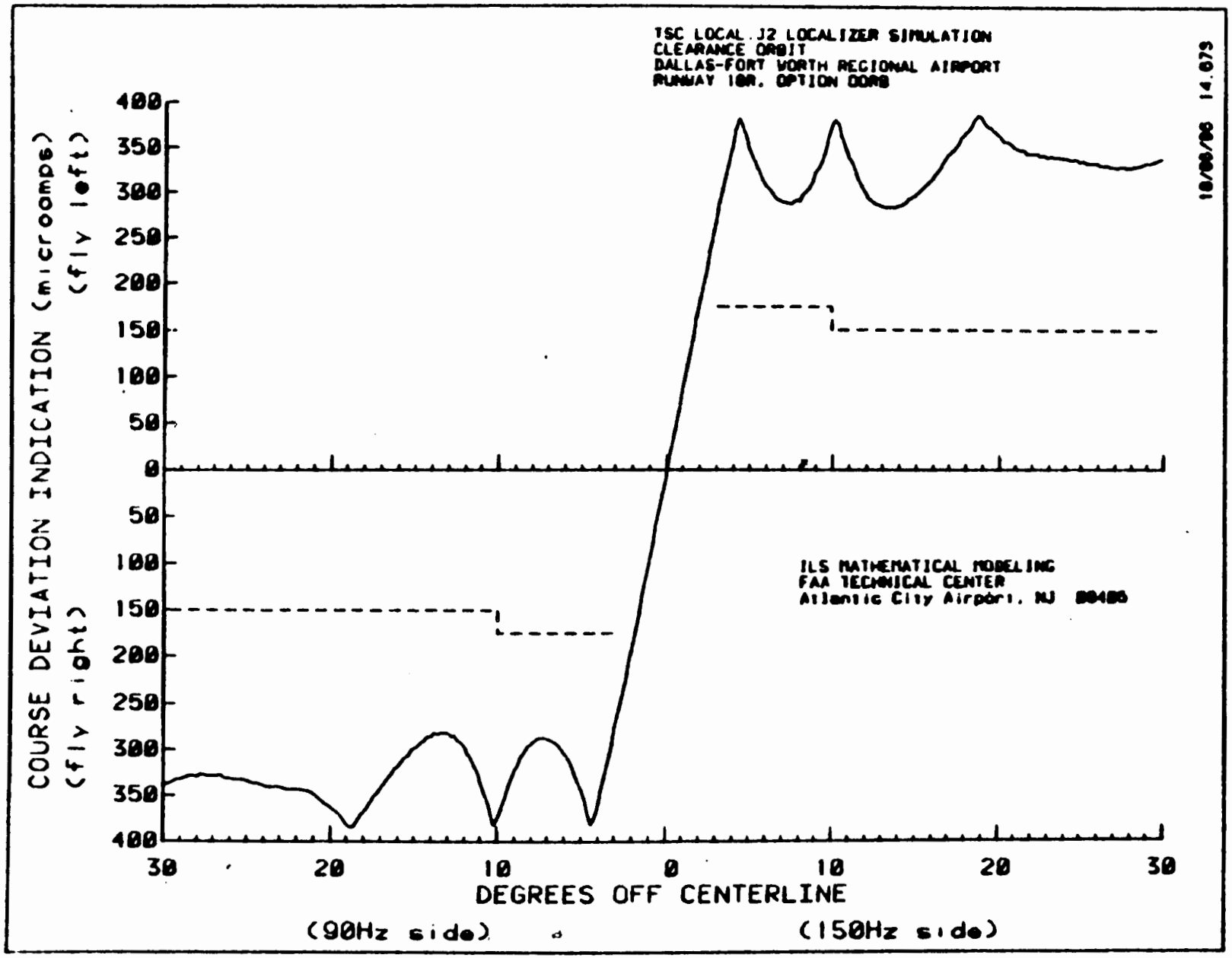

FIGURE 3. CLEARANCE ORBIT, DFW RUNWAY 18R, PROPOSED AMERICAN AIRLINES HANGAR EFFECTS

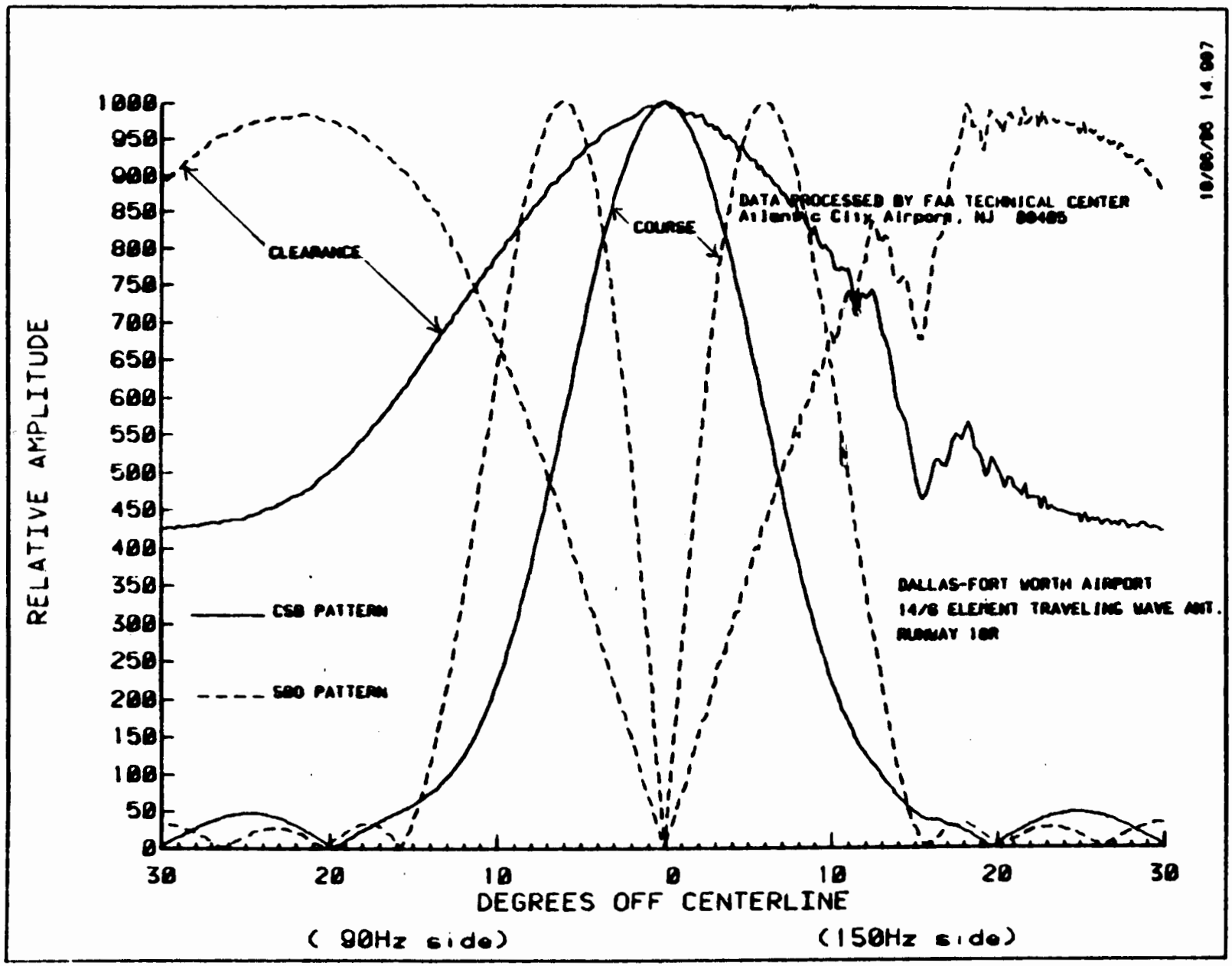

FIGURE 4. CSB AND SBO ANTENNA PATTERNS, DFW RUNWAY 18R, 14/6 TYPE 1B ANTENNA, PROPOSED AMERICAN AIRLINES HANGAR EFFECTS