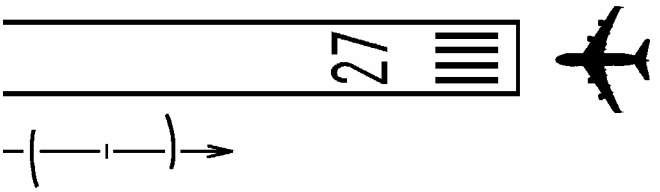

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TECHNICAL SUMMARY: WA-TS 97.002

SUBJECT: *COMPUTER MODELING AND ANALYSIS OF THE COURSE ARRAY PATH BROADENING EFFECT ON THE WATTS MODEL 201 LOCALIZER*

November 9, 1997

The Model 201 Localizer course antenna is a 270 ft. aperture line source excited by 64 probe-fed slots. The large aperture is necessary to form carrier plus sidebands (CSB) and sideband only (SBO) patterns narrow enough to reduce course array reflections at airports with considerable reflecting surfaces along the runway. One such example is the movement of large wide body jetliners that are taxing into position to hold, or holding, for take-off clearance.

Due to the large aperture, employed to achieve the narrow patterns, the ray paths from each slot to the observation point in ILS Zone 5 are not parallel and course broadening occurs. Using an accepted formula for calculating the far-field distance [1] of 2D^2/wavelength, where (D) is equal to the aperture, the far-field point is calculated to be 2.7 NM from the antenna for a facility operating at mid-band. The far-field boundary is defined as the distance where the ray path lengths from each slot differ by no more than 22.5 electrical degrees.

As an aircraft approaches the runway the outer most slots begin to de-phase and the radiation patterns are affected. Two significant results occur: 1) the course begins to broaden, and 2) the side-lobe levels as compared to the far-field begin to increase. If a scatterer, such as a large hanger, exists at the azimuth angle of a significantly increased side-lobe, multi-path could produce an out-of-tolerance condition. Some believe that these characteristics, inherent in any large aperture, define the limit of any useful aperture in Instrument Landing System (ILS) applications to be on the order of 150 to 180 ft.

One benefit of the slotted-line source is ability to curve the antenna to compensate for the afore mentioned near-field effects. If the antenna does not provide Category III service with co-linear elements, the design allows for curvature of the course antenna to produce the far-field condition at the range of the scatterer producing the perturbation. A near-field condition now exists between the focal point and the antenna, and again at long ranges from the facility. Now the width is sharper in the region of the focal point and broadens at long ranges from the facility. Side-lobes are increased at long ranges but no scatters exist to reflect the signal. This technical summary quantifies the affect of the course broadening with regard to Category III tolerances

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[2].

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Two scenarios were modeled using LOCXPTR4.EXE written by Watts Antenna. The first is a collinear antenna and the second is the antenna curved in a concave arc to focus at a range of 7000 ft.

An antenna setback of 1000 ft. and a 12,366 ft. runway length is used in both scenarios. Although increasing the antenna setback will reduce the broadening effect in Zone 5, 1000 ft. was chosen to model the worse case condition. The runway length was calculated for a tailored width of 3.00 degrees. Lateral arcs were modeled through the proportional guidance area at ranges corresponding to the boundaries of each ILS zone. Additional cuts were modeled within ILS Zone 5 where the affect is most predominant. The results are shown in the table on Page 3. A positive percentage indicates a broadening of the course and negative percentages indicate course sharpening.

The majority of the affect, in both scenarios, occurs at the extremity of Zone 5 at pt. E. The collinear antenna shows a 27 percent increase in the width. Applying Category III tolerance of 10 uA and converting this to feet of displacement indicates the aircraft can be displaced by an additional +/- 1.4 feet. If it is desirable to confine the aircraft to the conventional area, a deviation tolerance of +/- 7.9 uA could be established for pt. E. The focused antenna shows only a 9 percent broadening at pt. E. This allows an additional 0.5 feet of displacement. A new tolerance to confine the aircraft within the conventional bounds would be +/- 9.2 uA. Although a 7000 ft. focal distance was selected for comparison, focusing the antenna at any distance along the runway will reduce the effect of broadening at pt. E.

Changes in the width at all other points of interest are considered minor and are believed to be of no concern.

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Distance from Antenna (ft.)	Nominal Width (ft.) 3.0 Degrees	Width (deg.) Collinear Antenna	Percent Change from 3.0 Degrees	Width (deg.) Curved Antenna	Percent Change From 3.0 Degrees
3000 (ILS pt. E)	157.1	3.81	27	3.26	9
4000	209.5	3.46	15	3.09	3
5000	261.9	3.28	9	3.02	1
6000	314.2	3.19	6	2.98	-1
7000	366.6	3.16	5	2.96	-1
8000	419.0	3.11	4	2.96	-1
9000	471.3	3.09	3	2.96	-1
10366 (ILS pt. D)	542.9	3.07	2	2.96	-1
13366 (Threshold)	700.0	3.04	1	2.96	-1
16866 (ILS pt. B)	883.3	3.02	1	2.98	-1
37670 (ILS pt. A)	1972.9	3.00	0	3.00	0

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CONCLUSIONS:

Course broadening of 27 percent occurs for the collinear antenna and 9 percent with an antenna focused at 7000 ft. in ILS Zone 5 at ILS pt. E.

Focusing of the antenna at any range along the runways reduces the broadening effect.

Although the percentages appear large, the aircraft is approaching the vertex of the proportional guidance area, and the displacement in feet is small. The 27 percent allows and additional +/- 1.4 feet of displacement and the 9 percent allows and additional 0.5 feet.

Small changes in the course width in all other zones are considered minor and are of no concern.

If concern still exists, the displacement tolerance in microamperes could be tightened for application to wide aperture arrays.

RECOMMENDATIONS:

It is believed that the additional broadening of the course is small and still contains the aircraft well within a safe region on the runway surface. Therefore the standard FAA Flight Inspection Category II/III tolerances should be applied.

REFERENCES:

1. Balanis Antenna Theory, Analysis and Design, Constantine A. Balanis from West Virginia University, Harper & Row, New York, Copyright 1982.

2. United States Standard Flight Inspection Manual, Federal Aviation Administration Order 8200.1A, January 1996.

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