Characterizing Interference Effects of Opposite End Localizer Systems

Simbo A. Odunaiya, Ph.D.
Senior Research Engineer
Ohio University
Athens, Ohio 45701
Fax: (740) 593-1604
Email: odunaiya@ohio.edu

David Quinet
Senior Research Program Engineer
Ohio University
Athens, Ohio 45701
Fax: (740) 593-1604
Email: quinet@ohio.edu

ABSTRACT

Localizer systems that are located at opposite ends of a runway have the potential to interfere with each other if they are operating at the same time. When this happens the flyability of the localizer systems can be impaired. In fact when two systems are located at the opposite end of the same runway, interference through mere brute force does occur.

FAA Order 6750.16d, Siting Criteria for Instrument Landing Systems, requires that localizer systems whose signals may overlap one or more approaches be interlocked such that only one Localizer radiates at a time. The interlock is required to prevent destructive interference or aircraft receiver cross-modulation effects during over flights on the opposite runway localizer. This interlock is operated from the on airport air traffic control tower.

In some Airports where there is no air traffic control tower the issue becomes a little more complicated. The intent of this paper is to analyze this interference using a model that was developed for this purpose at Ohio University.

Using this model to predict the effect of one system over the other the behavior or characteristic of system performance due to this type of interference will be presented. In fact preliminary parametric model results do indicate that receiver systems do perform very well in these circumstances. However, a slight deviation of the aircraft from the centerline will result in excessive perturbations on course information for approaching aircraft during over flight of the opposite end localizer antenna array. Model results also indicate that Frequency assignments of the localizer arrays provide limited immunity and maximum degradation occurs if the frequencies are on the same or adjacent channels. All other frequencies provide similar immunity.

The opposite end localizer distance from the approach threshold affects the location, magnitude, and duration of system performance degradation. The further the array is from the threshold, the more the degradation is reduced. Array distances can also be found where the amount of degradation is acceptable. The course guidance quality of the on-course localizer will also determine how close the aircraft flies on centerline.

INTRODUCTION AND BACKGROUND

FAA Order 6750.16d [1], Siting Criteria for Instrument Landing Systems, requires localizers whose signals may overlap one or more approaches, see Figure 1B and Figure 1C, to be interlocked such that only one Localizer radiates at a time. The interlock is required to prevent destructive interference or aircraft receiver cross-modulation effects during over flights, and shall be installed and used to deactivate the localizer that is serving the inactive runway. Typically the on-airport Air Traffic Control (ATC) Facility controls which facility will be radiating based on the approach direction. If an on-airport ATC facility is not available, then a designated control point is assigned and the interlock control is remotely controlled from this facility. In special cases where local or remote control is not available, it may be possible to leave both localizers radiating at the same time. In this case analysis must be performed

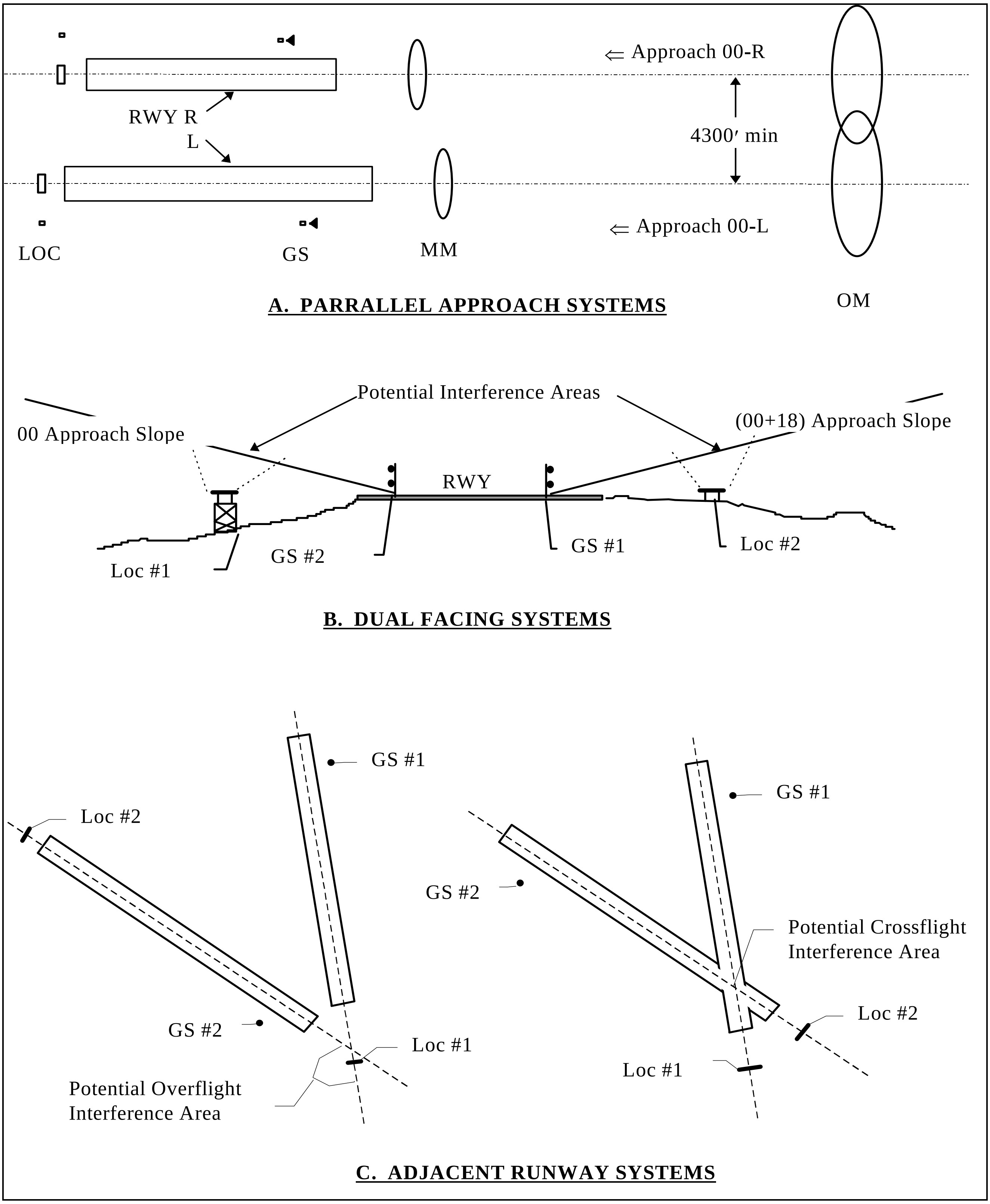

Figure 1. Multiple ILS Configurations

to quantify the amount, location, and duration of this degraded guidance signal to determine if adjustment to the Standard Instrument Approach Procedure (SIAP) is required.

In order to characterize the effect of these runway configurations on localizer performance the effect of the following localizer parameters needs to be investigated:

1. Localizer setback distance
2. Course roughness at opposing localizer location
3. Localizer frequency separation

The Ohio University Navigation Performance Prediction Model (OUNPPM) was modified [2] to predict the effect of these parameters when two localizers are located on opposite ends of the same runway.

MODELING RESULTS

Recent flight Inspection recordings from the FAA office of Flight Inspection which showed interference due to another localizer being left on was used to validate the modeling results of the model developed in [2]. The Airport was the Memphis International Airport. The facility data sheet was obtained for both ILS systems and the information used in the OUNPPM simulation as contained in Table 1.

Table 1 Simulation Results for flight inspection data for MEM Runway 09/27.

Parameter	Localizer RWY 09	Localizer RWY 27
Runway Length (ft)	8,946	
Frequency (MHz)	209.5	108.7
Setback (ft)	1,093	1,028
Elevation (ft)	296.7	251.1
Array Type	14 LPD	14 LPD

Using these parameters, the amount of degradation predicted is shown in Figure 2. The maximum structure roughness is 38 ua at a location of 0.16 nmi from threshold. The flight inspection recording is shown in Figure 3 . The measurements indicate maximum degradation at 0.17 nmi of 37 ua. The roughness prior to Threshold is due to degradation from another source since it is present when the Runway 27 is turned off.

Characterization Analysis

Since the simulation results with the modified receiver processing algorithm showed agreement with flight measurements provided by the FAA, additional simulations were performed to characterize the nature of the degradation from the opposing localizer and determine if guidelines could be established to minimize this degradation. Three parameters are examined; these are frequency difference, setback distance, and course roughness.

These results are as expected. The amount of degradation decreases as the localizer is located further away from the threshold since the aircraft passes over the antenna array at a higher altitude thus the interfering signal is reduced in signal strength. The start of the interference and duration is also as expected. Acceptable interference level is obtained if the opposing localizer is at least 1,200 feet from the threshold.

Frequency Difference

The frequency of the desired localizer guidance is fixed while the undesired localizer frequency is adjusted to determine if the degradation could be minimized with frequency separation. The results are provided in Table 2. These results indicate that the degradation can be minimized if the two localizers are separated by at least 0.015 MHz and significant degradation (1/2 full scale deflection) will be caused if the localizers operate on the same frequency.

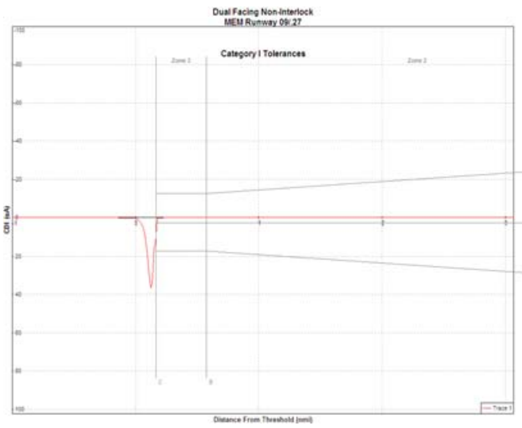

Figure 2. Simulation results for MEM case

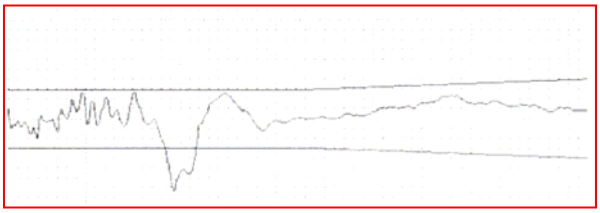

Figure 3. FAA Flight Inspection Measured Results for MEM

Table 2. Predicted Degradation as a function of Frequency Separation

Frequency Separation (MHz)	Predicted Degradation (ua)
0.000	77
0.004	62
0.005	37
0.010	36
0.015	35
0.020	35
0.350	35
0.600	35
0.750	35
0.800	35
0.095	35
1.000	35
2.000	35
3.000	35
3.800	35

Setback Distance

The location of the roughness is largely influenced by the distance of the opposing localizer antenna array from the approach threshold. Various positions are simulated and the results summarized in Table 3.

Table 3 Predicted degradation as a function of setback distance

	Degradation			
Localizer Setback Distance (ft)	Amount (ua)	Start (ft)	Peak Point (ft)	Duration (ft)
1,000	35	2304	764	5,200
1,100	25	2954	1254	5,950
1,200	12	4654	2164	6,540
1,300	7	5104	3154	6,650
1,400	4	6204	4004	6,750
1,500	2	6804	4404	7,000

Course Roughness

When the aircraft on approach passes over the opposing localizer antenna array, the aircraft displacement from centerline will also show different results since the interfering DDM level will vary across the array. The variation will depend on the desired localizer course guidance quality if the aircraft is coupled to the ILS signal. Table 4.provides a summary of the interfering level based on the course guidance quality of the desired array.

Table 4. Degradation as a function of Localizer guidance quality

Desired Localizer Course guidance quality (uA)	Amount of Degradation (uA)
0	0
5	3
10	4
15	7
20	8
25	10
30	13

As also expected, if the aircraft stays aligned with the centerline when it flies over the opposing localizer antenna array the amount of degradation is significantly reduced. If the aircraft can stay within 1/5 full-scale deflection when it flies over the array, the amount of degradation caused by the opposing localizer will remain within Category I signal-in-space tolerances [4].

CONCLUSIONS

Based on some preliminary parametric simulation results, optimum locations and other parameters can be found for opposite runway localizers when an interlock is not in place. The following conclusions are reached on the parameters.

1. Frequency assignments of the localizer arrays provide limited immunity. Maximum degradation occurs if the frequencies are on the same or adjacent channels. All other frequencies provide similar immunity.

2. The opposing localizer distance from the approach threshold affects the location, magnitude, and duration of the degradation. The further the array is from the threshold, the more the degradation is reduced. If array distance is at least 1,200 feet from the threshold, the amount of degradation is acceptable.

3. The course guidance quality of the on-course localizer will determine how close the aircraft flies on centerline. As the aircraft flies farther away from the centerline the magnitude of the degradation also increases. This is reduced if the aircraft flies closer to the extended centerline when the aircraft over-flies the opposing localizer array.

ACKNOWLEDGEMENTS

The authors acknowledge Messrs Dale Courtney and Mike Flemming of the FAA for their invaluable assistance with this project.

REFERENCES

[1] FAA Order 6750.16d, February 14, 2004, Siting Criteria for Instrument Landing Systems, Federal Aviation Administration.

[2] Odunaiya, Simbo and Quinet, David; Localizer Receiver Proximity and Capture; Digital Aviation Systems Conference, 2007

[3] Odunaiya, Simbo, David Quinet, 2004, Calculations and Analysis of Signal Processing by Various Navigation Receiver Architectures, Digital Aviation Systems Conference.

[4] Quinet, David, Simbo Odunaiya, 2005, Analysis of ILS Receiver Output Data and Comparison to U.S. Flight Inspection Tolerances.