Grenze International Journal of Engineering and Technology, Jan Issue

Electromagnetic Interference Analysis on Localizer Beam for Various Obstacles at Expanded Airport

Shashi Kanta Tripathy[1] and Soumyashree Mangaraj[2]
[1]MTech, Instrumentation and Electronics Engineering, OUTR, Bhubaneswar, Odisha, India
Email: shashikanta.tripathy3@gmail.com
[2]Asst. Professor, Instrumentation and Electronics Engineering, OUTR, Bhubaneswar, Odisha, India
Email: smangarajie@cet.edu.in

***Abstract*—Civil aviation is developing by and large across the globe due to vast population and increased demand of flight services. Unplanned expansions or alterations of existing buildings/ infrastructure at the close vicinity of runway result into undesired electromagnetic interference on the Instrument Landing System (ILS) which is designed for safe and planned landings at center of runway of that airport. ILS subsystem Localizer (LOC) which provides the guidance in the horizontal position of an aircraft , emits two types of signals, a carrier signal and sideband lobes modulated by a 90 Hz and a 150 Hz tone. The accuracy of the LOC is given by the difference in the depth of the modulation (DDM). But, their signals are influenced by obstacles, such as large hanger, terminal buildings and aircraft and result in the DDM errors.The ILS electromagnetic interference analysis at airport is mainly based on the results of test flight testing and air calibration which are highly time consuming and costly too. In this paper, CST studio suite is used to design and simulate localizer antenna by introducing five obstacles of different geometrical shapes. Then, how much interference/deviation observed on main lobe of Localizer beam due to presence of each obstacle along the extended runway is recorded. This result is very useful for planning of additional infrastructure development especially along the extended runway direction in order to minimize electromagnetic interference on LOC (ILS) path.**

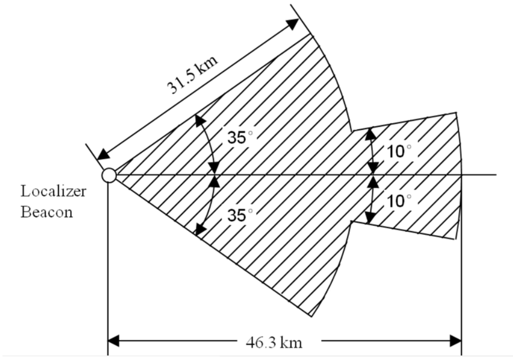
***Index Terms*— ILS, DDM, threshold, beam, extended runway, main lobe, predominance region.**

I. INTRODUCTION

Due to rapid modernization and upgradation in aviation industries across the globe, expansion of airport infrastructure and alteration of existing building is very common. But this infrastructure at the close vicinity of runway leads to severe interference of signals to instruments/radio systems which are installed near or in line to extended runway. One of such equipment is Instrument landing system which transmits EM signals both horizontally and vertically to approach aircrafts even up to 18 to 22 Nm from the threshold point of the runway. ILS system basically consists of three types of navigational beacons which are VHF Localizer (for lateral guidance), UHF Glide Path (for vertical guidance) and Markers (for distance information of aircraft from runway). A localizer beacon transmits approach parameters to aircrafts that are in-line with runway for landing. In this paper, electromagnetic interference analysis of Localizer beam under different obstacle conditions at extended Airport is analysed.

Grenze ID: 01.GIJET.9.1.525_1

Localizer antenna is basically a Log periodic dipole antenna which provides good coverage in vertical direction depending upon the azimuthal angle of radiation. The operating frequency of Localizer is from 108 MHz to 111.95 MHz(VHF).The antenna effective range is NMT 46.3 km in the Azimuth of ± 10 ° and NMT 31,5 km in the Azimuth of ± 10~35 ° as shown in figure[1].



igure1. Localizer beam[2]

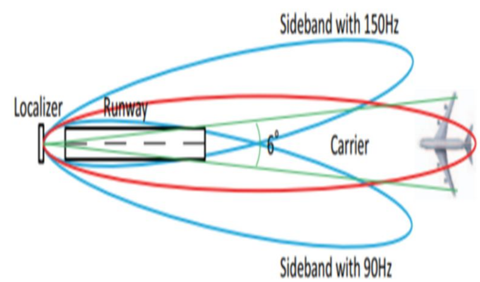


Figure 2. Localizer radiation pattern[3]

A. Localizer Signal analysis (ILS Subsystem)

LOC beacon transmits two VHF modulation signals by a horizontal polarization signal beam with certain deviation to the landing direction of the runway and overlapping signal regions. In the overlapping signal regions, if the amplitudes of two received signals are equal, the aircraft is on the runway centre line extension (desired path).If the signal strength of 150 Hz is more than that of 90 Hz, then aircraft is right to the course line and hence pilot should steer to left (fly left) to align with course line. If the signal strength of 90 Hz is more than that of 150 Hz, then aircraft is left to the course line and hence pilot should steer to right (fly right) to align with course line[3] as shown in figure 2.

B. LOC specification

It is expressed by the difference in depth of modulation (DDM). Its value must be less than 0.155 (=150µA) which is regulated by ICAO. The value of DDM is computed by difference of M90 and M150, where M90 and M150 are the depth of modulation of 90 Hz and 150 Hz signals, respectively. In general, the value of DDM becomes zero when the aircraft moves along the straight line of runway centre line. Moreover, if the obstacles are present in the vicinity of the runway, multipath is caused by buildings and aircraft. Scattered waves caused by surrounding obstacles result in the DDM distortion. The value of DDM shall be satisfied with categories (CATs) which are regulated by ICAO. The value of DDM shall be less than the limit value of CATs[3].

II. Design of Localizer Antenna Model

In this paper, a Yagi antenna model is used as a simplified LOC directional antenna[1]. This antenna is composed of a reflector, a dipole (driven element) and four directors. Basically, these reflector and directors transform the signal radiation field of the dipole oscillator from omnidirectional to directional. For designing this Yagi antenna model, CST studio suite software is used. Parameters considered for this design are given as:

TABLE I. Parameters of LOC Antenna

Parameter	Formula used	Symbol used
Frequency	110MHz	f
Wavelength	2725.39 mm	wl
Reflector	0.482* wl	lr
Dipole	0.446* wl	ldi
Director	0.459* wl	ldr
Radius	0.005* wl	r
Gap	Ldr/200	g

Based on the above parameters, a simplified LOC antenna (Yagi antenna for this paper) as shown in figure 3 is designed and simulated first without the presence of any obstacle to find out the direction of main lobe in far field region. Then, this LOC antenna is simulated by introducing five obstacles of different geometrical shapes one by one in and around its heading direction to find out the quantum of interference in terms of deviation in degrees (with respect to main lobe heading direction) and are recorded for further analysis. Simulations of each obstacle are shown in figure 4 to 8.

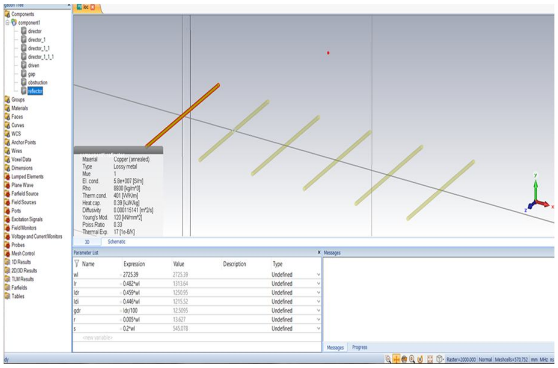


Figure 3. Simplified LOC antenna

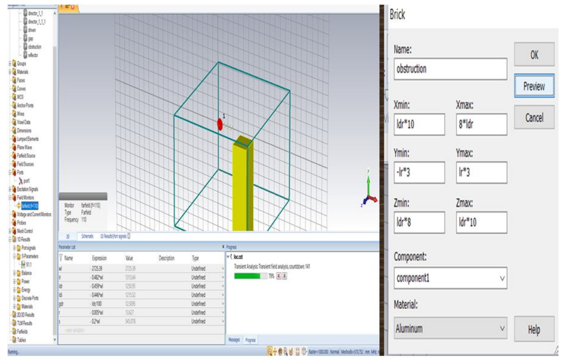


Figure 4. LOC antenna with Cuboid obstacle

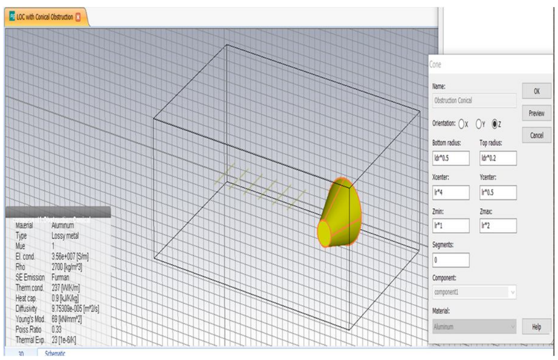


Figure 5. LOC antenna with Conical obstacle

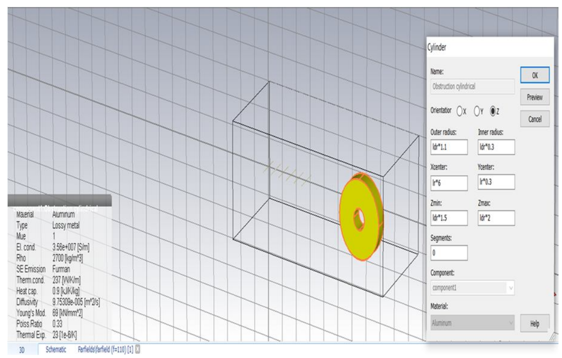


Figure 6. LOC antenna with Cylindrical obstacle

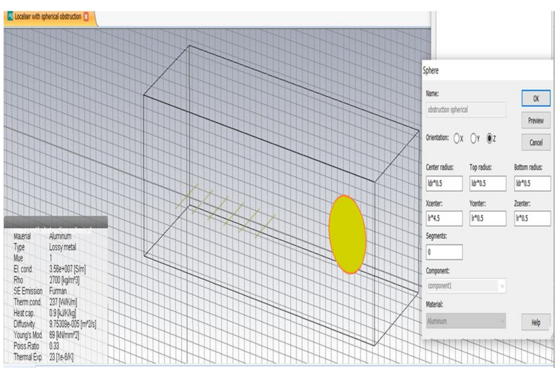


Figure 7. LOC antenna with Spherical obstacle

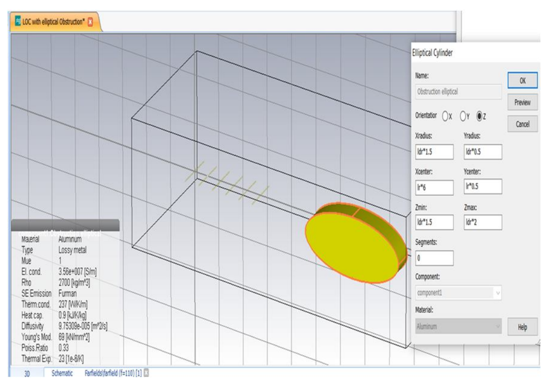


Figure 8. LOC antenna with Elliptical obstacle

III. SIMULATION RESULTS OF LOCALIZER ANTENNA MODEL

A. S11 Parameters of LOC antenna under different obstacle conditions

Reflection coefficients (S11 parameter) of LOC antenna under different obstacle conditions are shown in figure 9 to 11.

B. Far-field gain (in dB) of LOC antenna under different obstacle conditions

Far-field gains (in dB) of LOC antenna under different obstacle conditions are shown in figure 12 to 14.

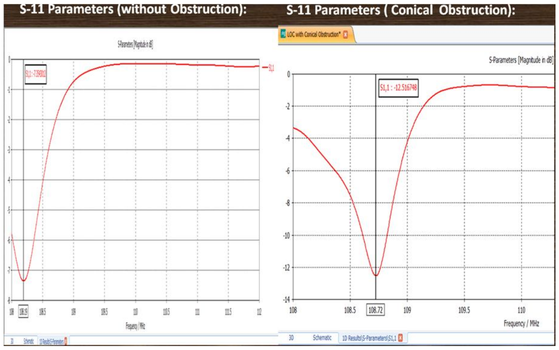


Figure 9. S11 parameter of LOC antenna with conical obstacle

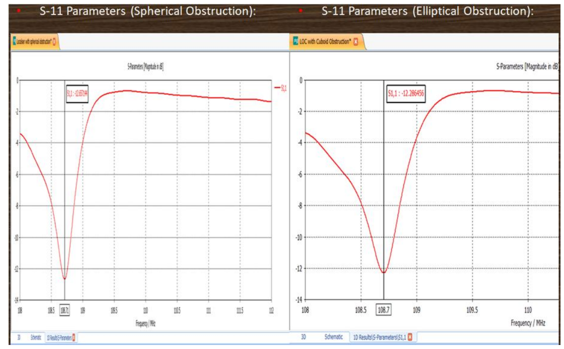


Figure 10. S11 parameter of LOC antenna with spherical and elliptical obstacles.

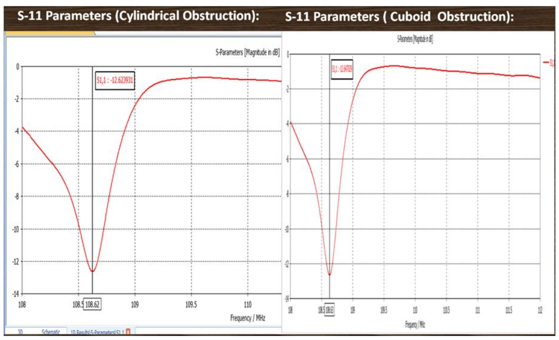


Figure 11. S11 parameter of LOC antenna with Cylindrical obstacles

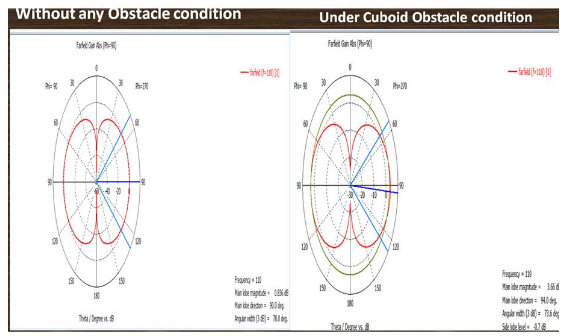


Figure 12. Far-field gain (in dB) of LOC antenna and with Cuboid and Cuboid obstacles

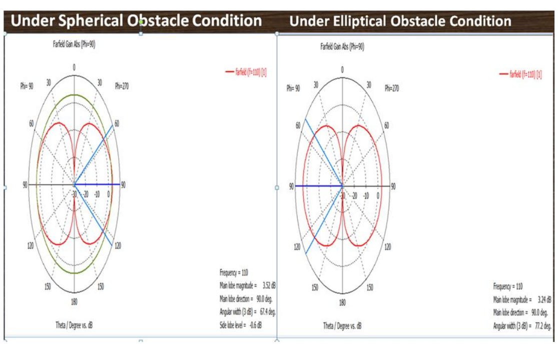


Figure 13. Far-field gain (in dB) of LOC antenna with spherical and Elliptical obstacles

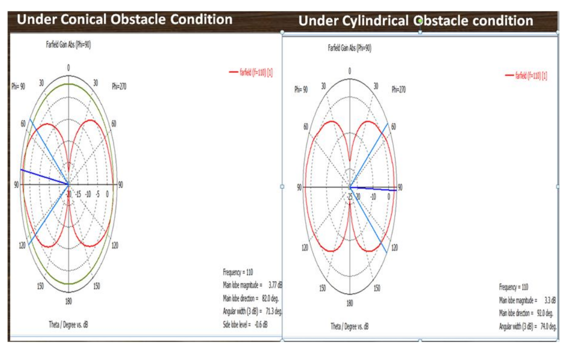


Figure 14. Far-field gain (in dB) of LOC antenna with Conical and Cylindrical obstacle

C. Far-field directivity of LOC antenna under different obstacle conditions

Far-field directivity of LOC antenna under different obstacle conditions is shown in figure 15 to 17.

IV. Electromagnetic Interference Analysis on LOC Beam

Error calculation of various types of obstacles that cause interference on LOC beam

VI. Conclusions

In this project, one Localizer antenna is designed using CST Studio suite and interference analysis is done by introducing five obstacles of Cuboid, Conical, Cylindrical, elliptical and spherical shapes .Material used for each obstacle is Aluminum, as this metal is generally used in most of the buildings and infrastructure projects .It is

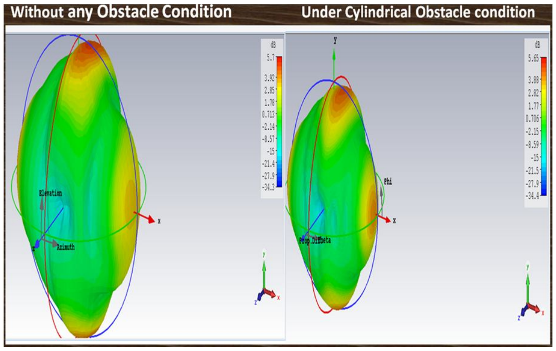


Figure 15. Far-field directivity of LOC antenna and with Cylindrical obstacle

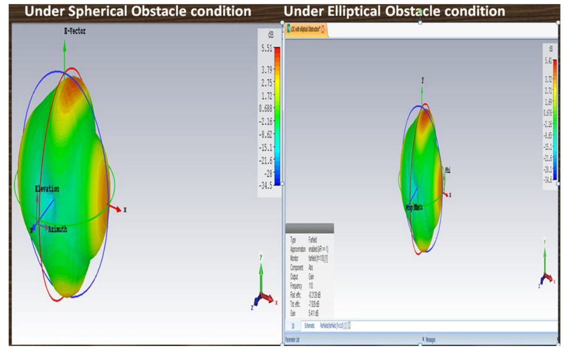


Figure 16. Far-field directivity of LOC antenna with spherical and Elliptical obstacles

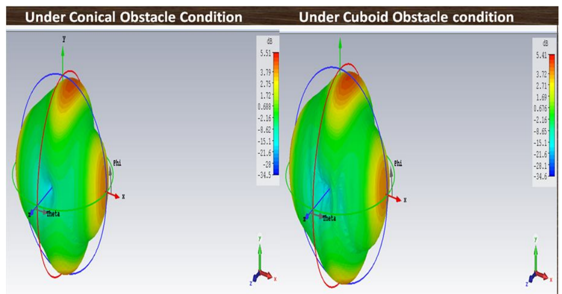


Figure 17. Far-field directivity of LOC antenna with conical and cuboid obstacles

TABLE II. INTERFERENCE ON LOC BEAM DUE TO VARIOUS OBSTACLES

Type of Antenna	Main Lobe Direction in degree	Shifting of Main lobe due to obstruction	Maximum offset value admissible	Error value after offset adjustment
Localizer without obstruction	90^0	Nil	3^0	Nil
With Cylindrical obstruction	92^0	2^0	3^0	Nil
With Conical obstruction	82^0	-8^0	3^0	-5^0
With Cuboid obstruction	94^0	4^0	3^0	-1^0
With Elliptical obstruction	90^0	Nil	3^0	Nil
With Spherical obstruction	90^0	Nil	3^0	Nil

TABLE III. IMPACT OF INTERFERENCE ON ANTENNA GAIN AND S11 MAGNITUDE

Type of Antenna	Antenna Gain in dB	S11 Magnitude in dB
Localizer without obstruction	5.7	-7.3543012
With Cylindrical obstruction	5.65	-12.623931
With Conical obstruction	5.51	-12.516748
With Spherical obstruction	5.51	-12.657144
With Elliptical obstruction	5.41	-12.286456
With Cuboid obstruction	5.41	-12.287029

observed that due to interference with obstacles, there is a change in direction of main lobe and far-field directivity. However, it is then analyzed that smoother the shape of obstacle, lesser the interference on LOC beam (least for spherical obstacle).

This change in direction of main lobe will lead to reception of incorrect DDM (difference in depth of modulation) values by approaching aircrafts and will prompt the Pilot to land on an incorrect threshold point i.e. other than the center of runway .This may lead to erroneous landing of aero plane on grass areas of air field and can damage onboard passengers including the aero plane too. The results of this simulation provides fastest way to identify nature of electromagnetic Interference on LOC beam without going for costly air calibration and flight testing procedure by Airport authority[4-8].

FUTURE SCOPE

The concept of interference analysis on LOC beam due to obstacles can further be explored by introducing obstacles at different location around runway other than considered in this paper. An attempt can be made to further increase the size and number of director elements that will improve the gain of antenna. Further, optimization can be done by controlling height, material and shape of obstacles to get a lower interference on LOC beam at extended runway.

ACKNOWLEDGMENT

The confidence and encouragement that accompanies the successful completion of this project work would be incomplete without introducing the people who made it possible and whose constant guidance and support crowns all efforts with success. I am extremely grateful and express my profound gratitude and indebtedness to my Project guide, Mrs. Soumyashree Mangaraj, Assistant Professor, Department of Instrumentation and Electronics Engineering ,Odisha University of Technology and Research (OUTR) , Bhubaneswar for her constant support, invaluable and inspiring guidance throughout the progress of this project. I would also like to express my deepest gratitude to our friends and all faculties for their motivation, emotional support and guidance at various stages of my project work.

REFERENCES

[1] A. Hemalatha, G.Gandhimathi “Design Optimization of Yagi - Uda Antenna using Antenna Toolbox,” International Journal of Engineering Research & Technology (IJERT) ,ISSN: 2278-0181, Special Issue - 2019.

[2] Qu, C.Q.," Research on Signal of Field Monitor of 7220A Localizer Beacon Subsystem of ILS.", Open Journal of Antennas and Propagation", 2015. **03**(04): p. 37-50.

[3] Honda, J., et al., "Influences of 3D Aircraft Model to ILS Localizer, in 2016 10th International Conference on Complex, Intelligent, and Software Intensive Systems (CISIS)". 2016. p. 180-185.

[4] Ely, J., "Electromagnetic Interference to Flight Navigation and Communication Systems: New Strategies in the Age of Wireless", in AIAA Guidance, Navigation, and Control Conference and Exhibit. 2005.R. Nicole, “Title of paper with only first word capitalized”, J. Name Stand. Abbrev., in press.

[5] Li, Z., et al., "A Parallel CE-LOD-FDTD Model for Instrument Landing System Signal Disturbance Analyzing". IEEE Transactions on Antennas and Propagation, 2019. **67**(4): p. 2503-2512. [7] M. Young, The Technical Writer's Handbook. Mill Valley, CA: University Science, 1989.

[6] Dhulipudi, D.P. and R. Ks, "Geospatial Object Detection Using Machine Learning-Aviation Case Study", in 2021 Integrated Communications Navigation and Surveillance Conference (ICNS). 2021. p. 1-8.

[7] Corputty, R., R.N. Kaikatui, and Muriani," Analysis of the Aircraft Guide Signal Interference in Mopah Airport". IOP Conference Series: Materials Science and Engineering, 2021. **1125**(1).

[8] Aeronautical Information Manual Official Guide to Basic Flight Information and ATC Procedures, U.S. Department of Transportation, FAA, October 12, 2017.