Effect of Building on VHF Propagation above Airport Surface

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***Abstract* - GBAS is the next generation navigation system for aircraft landing using GPS, and is being developed. VDB of GBAS ground subsystem is utilized to send correction information for positioning and integrity monitoring of GPS. VDB coverage is required not only in the air but also above runways to support an auto-land and a roll-out. This paper clarified the effect of buildings on VHF propagation in the distinctive placement of components on an airport surface. Ray-tracing simulation and measurement show that a pair of dips in electromagnetic field intensity above runways was observed. The results provide the data which can be utilized for GBAS VDB antenna installations at various airports in the future.**

***Index Terms* — GBAS, VDB, VHF propagation, building, airport surface, ray-tracing,**

1. Introduction

GBAS (Ground-Based Augmentation System) is a navigation system for aircraft landing using GPS. GBAS sends correction information for positioning and integrity monitoring of the GPS from VDB (VHF Data Broadcast) antenna on the ground to aircrafts. The coverage of VDB is required not only in the air but also above a runway to support an auto-land and a roll-out[1]. The installation position of the VDB antenna is currently being examined. One of the proposals is installation at a low position because an antenna at a high position creates an insensitive area in the upper air due to the ground reflection. Coverage examination is very important to maintain safety of aircraft landing. Previous researches of the propagation at the low antenna position focused on path losses in an urban environment[2]. However, location relations of buildings and runways on an airport surface are distinctive and different from the urban environment. So, this paper clarifies the effects of the buildings on VHF propagation above the runway surface by ray-tracing simulation and measurement.

2. Basic analysis of VHF propagation above an airport surface

There are many buildings such as a control tower, passenger terminals, and a fire department on an airport surface. These buildings are almost aligned in a line. Moreover, distance between the buildings and the runway is very large. Also, there is no structure between buildings and the runways because an apron area and taxiways exist. The effects of buildings under these conditions were clarified by the ray-tracing method. A basic analysis model to estimate the basic propagation behavior is shown in Fig.1. An electromagnetic wave which arrives at a runway behind the buildings is composed of principal 4 rays as shown in Fig.1. Diffracted waves at the upper surface of the buildings become small because VDB uses horizontal polarization. The smallest building size is generally 10m or less on the airport surface. d2 become extremely large relative to the building size. So, the attenuation due to buildings in the case of large d2 (900m) was compared with small d2(60m). The simulation results are shown in Fig.2. Attenuation in Fig.2 means the difference between the received power with and without a building. The results show narrow dips are observed in the case of small d2. On the other hand, a pair of wide dips occurs in the case of large d2. These wide dips may be a problem of the VDB coverage. The phase difference between Ray1 and Ray2 are shown in Fig.3(a). The results show the variation in the case of d2=900m is smaller than that of 60m. Fig.3(a) also shows that the dips occur at the runway position of 50m,-50m because the phase difference becomes π, -π. Fig.3(b) shows the received power of Ray1 and Ray2 for d2=900m. Other dips are not observed because the difference of the received power between Ray1 and Ray2 becomes larger at 3π,-3π. The relation between Ray3 and Ray4 is the same as Ray1 and Ray2.

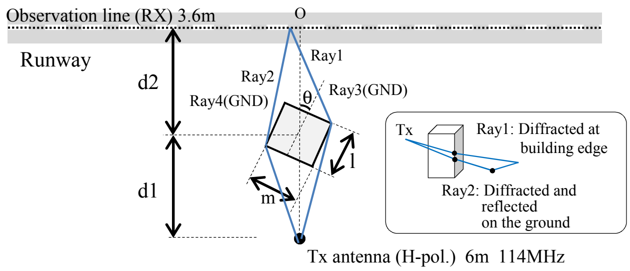


Fig. 1. Basic analysis model of a building on an airport surface

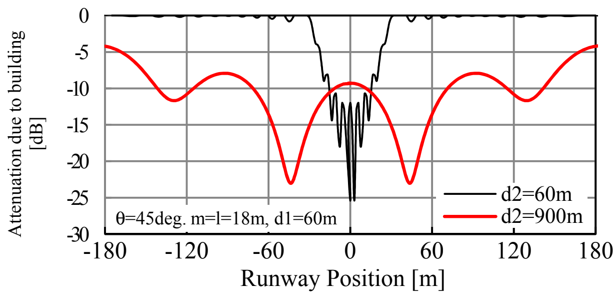
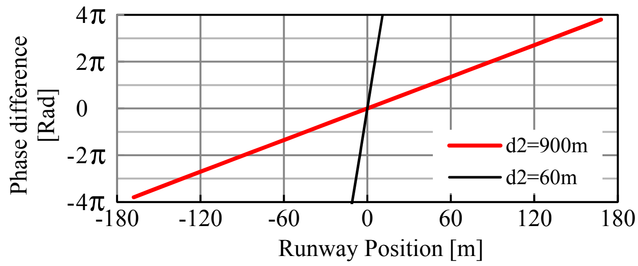
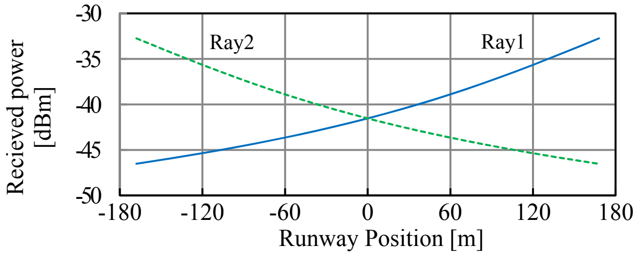


Fig. 2. Dips caused by a building on an airport surface

Fig.4 shows the received power variation by θ. The results show the received power behind the building for θ = 0 degree becomes small in the wide area. The received power becomes larger in the case that the θ is more than 15 degrees though the dips are observed. Fig.5 shows the received power variation based on the size of buildings. The results show that large size buildings give narrow dips and small size buildings such as 12m and 18m give a pair of wide dips.



(a) Phase difference between Ray1 and 2



(b) Amplitude

Fig.3 Electromagnetic field at observation line

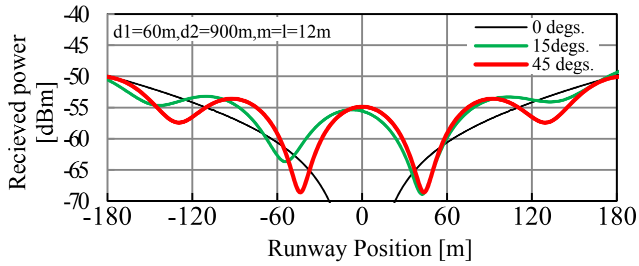


Fig 4 Received power variation by θ

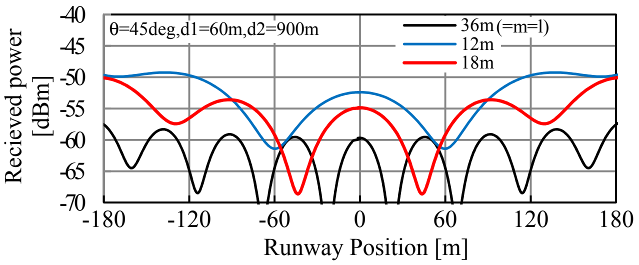


Fig.5 Received power variation by building size

3. Measurement and ray-tracing simulation at Ishigaki airport

GBAS prototype was installed at Ishigaki airport (Fig.6) for validation of the baseline development SARPs (Standards and Recommended Practices)[1]. Electromagnetic field intensity from the VDB antenna was measured by a measurement vehicle. Measured results are shown by the blue line in Fig.7. The results show that a pair of deep dips is observed and the field intensity cannot meet the specification of -72 dBm. There are 5 buildings between the VDB antenna and the runway. The smallest one is the control tower whose size is 11.8m by 5.5m. The distance between the control tower and the runway (d2) is approximately 700m. θ is 55 degrees. Ray-tracing simulation was conducted in order to clarify the cause of dips. Only the control tower was taken into account (modeled). The results show by the red line in the Fig.7. The results clarify the cause of dips are due to the control tower because the dip position in the simulation results agrees with the measurement results. Here, the difference of the power level between the measurement and the ray-tracing was observed in Fig.7. This reason is considered to be the complex land shape around the runway because Ishigaki airport was built on the ground by piling up earth at an inclined surface. Principal rays were composed of 4 rays diffracted by the edge of the lower floors as shown in Fig.8. Other dips by the larger buildings such as the passenger terminal are not observed because the dips become narrow and considered to be disappeared by scattered waves from various structures. This study showed that small buildings should be brought to attention when a GBAS VDB antenna is installed.

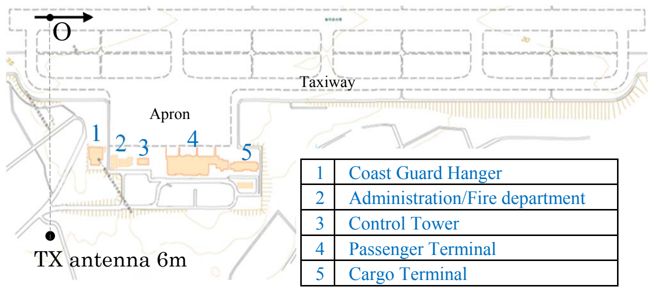


Fig. 6 Location of buildings in Ishigaki airport

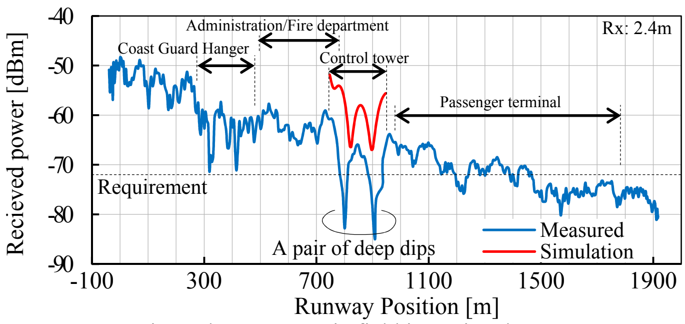


Fig.7 Electromagnetic field intensity above runway

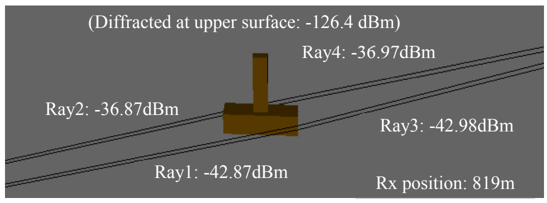


Fig. 8 Principal rays diffracted at the edge of control tower

4. Conclusion

This paper clarified that a pair of wide dips in electromagnetic field intensity occurs above runway surfaces due to the distinctive placement of components on airport surfaces. The results provide the data which can be utilized for GBAS VDB antenna installation at various airports in the future. The future works are the inspection whether or not the dips meet the GBAS system requirements.

References

[1] T. Murphy et al., ICAO NSP WGW, 17-28th May 2010

[2] M. Kaji et al., Proc. IEEE AP-S, Vol.23, pp.835-838, 1985