2D2-1

Measurement of Propagation Effects from Low Altitude Airship in Urban Area Applicable for Stratospheric Platforms

Jaroslav Holis, Pavel Pechac
Department of Electromagnetic Field, Czech Technical University in Prague,
Technicka 2,166 27 Praha 6, Czech Republic, holisj1@fel.cvut.cz
Phone: +420 224 352 250, Fax: +420 233 339 958

1. Introduction

This paper deals with a trial focused on a path loss measurement in urban area using a low altitude airship. Experiments were proposed at 2.0 GHz, 3.5 GHz and 5.5 GHz representing the frequency bands for 3G, mobile WiMAX and WiMAX systems. The trial was aimed at rooftop diffraction loss and penetration loss measurements. The goal was to obtain experimental data that can be used for planning of communication systems delivered via High Altitude Platforms (HAPs) [1].

One of the factors motivating the measurement from low altitude platforms is the lack of propagation prediction models for HAPs. The Free Space Loss empirical model (FSL) is commonly used for HAPs. This model is sufficient under the Line of Sight (LOS) conditions that are required in the millimetre frequency band. However, HAPs will be also used to provide 3G mobile services in the frequency spectrum allocated to terrestrial 3G networks (around 2 GHz). LOS connections are not required here. The shadowing effects of buildings have a crucial impact on signal level, which is why the FSL model is too optimistic for our purposes. It is possible to model cities based on statistical information and to calculate the shadowing effects of buildings [2], but it would appear very important to verify any results by measurements.

2. Payload and Low Altitude Airship

The special payload was developed for this kind of measurements. The signal was transmitted with 26 dBm CW generators using patch antennas. A spectrum analyzer was used as a receiver. Fig. 1 shows the dismantled payload.

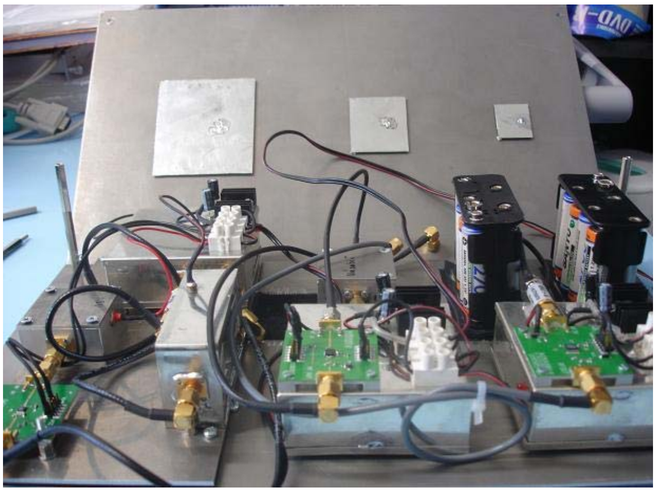


Figure 1: Dismantled Payload

ISBN: 978-4-88552-223-9 C3055©IEICE

The remote control airship [3] was used for the measurement as a carrier of the payload. This 9 m long remote controlled airship has been developed at the CTU Prague at the Faculty of Mechanical Engineering [3] (Fig. 2). The most important parameters for our experiments are the maximum altitude and the payload. The payload is about 6 kg and the altitude is now limited by the visual contact of an operator with the remote controlled airship, i.e. the altitude could be up to around 1 km. New improvements to the airship, such as a special stabilization platform to equalise inclinations caused by wind gust were developed for these measurement trials. The experiments was planned to take place at a variety of elevation angles in urban environments. The wide-ranging options offered by airship transport enable us to measure in rural areas as well.

The main parameters of the airship are as follows:

- length 9 m
- max. diameter 2.3 m
- hull volume 24 m^3
- hull surface 52 m^2
- total mass without batteries 17 kg
- payload (batteries included) 7 kg
- hull filling helium
- hull structure 2 layers - top coat (tear proof) + bladder
- operating speed 20 km/h
- propulsion 2 x AC 3 Phase brushless motors (2 x 700W)

Figure 2: Remote Control Airship

Fig. 3 illustrates an example of the airship track while measuring rooftop diffraction effects in the centre of the city of Prague in the area of the CTU (the red cross represents the location of the receiving stations conducting measurements of rooftop diffraction loss).

Figure 3: An Example of Airship Track during Measurement of Rooftop Diffraction

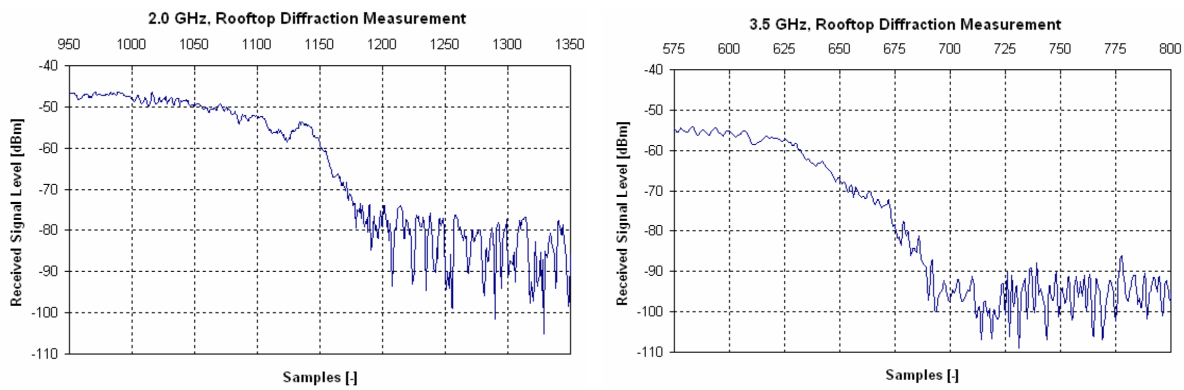
A ground plane antenna for mobile measurement (linear polarization) and spiral broadband antenna for stationary measurement (circular polarization) were used concurrently to receive the transmitted signal (Fig. 4). The level of the received signal was measured by spectrum analyzers.

(a) (b)

Figure 4: Receiver Station in the Street (a), Airship during the Measurement (b)

3. Rooftop Diffraction Measurement

The mativation for the rooftop diffraction measurement was to verify a propagation modelling in the streets from High Altitude Platforms as a function of an elevation angle. The measurement was done on a gamble and flat roof. Fig. 5 shows and example of measured data on the gambled roof. The measured level of about -50 dBm indicates the LOS connection with the airship, lower values show the impact of the diffraction loss then.

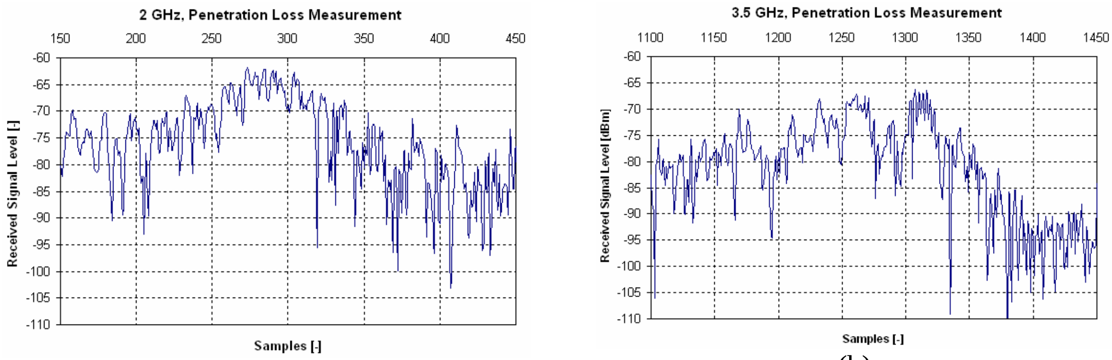


(a) (b)

Figure 5: Rooftop Diffraction Loss at 2.0 GHz (a) and at 3.5 GHz (b)

4. Penetration Loss Measurement

The target of this measurement scenario was a determination of a penetration loss as a function of elevation angle and as a function of a storey number in the buildings as well. Fig. 6 illustrates an example of received signals at 2.0 and 3.5 GHz during a flight of the airship over the building. In comparison with diffraction loss measurement the larger scale of fade margin is distinguishable from this figure. An empirical model for the building penetration loss at 2.0 GHz for high elevation angels was presented in [5].



(a) (b)

Figure 6: Penetration Loss at 2.0 GHz (a) and at 3.5 GHz (b)

4. Conclusion

The path loss measurement trial in urban area using a low altitude airship was presented in this paper. The trial was focused on the propagation effects in the streets including the penetration loss into the buildings. Two scenarios – rooftop diffraction and penetration measurements – were measured as a function of the elevation angle. The measurement was accomplished at 2.0, 3.5 and 5.5 GHz frequency bands. The results can be applied for High Altitude Platforms propagation predictions. The trial has demonstrated that the application of Line of Sight propagation model for simulations of mobile services provided by High Altitude Platforms in urban scenarios is absolutely unrealistic.

Acknowledgments

This work was partially supported by the Czech Ministry of Education, Youth and Sports under projects OC092 - COST Action 297 and MSM 6840770014.

References

[1] T. C. Tozer, D. Grace, "High-altitude platforms for wireless communications," IEE Electron. Commun. Eng. J., vol. 13, no. 3, pp.127-137, June 2001
[2] J. Holis, P. Pechac, "Propagation Prediction for High Altitude Platforms in 3G Frequency Band," in Symposium Wireless Personal Multimedia Communications – WPMC'06, San Diego, USA, pp. 1219-1221, Sep. 2006
[3] http://www.airshipclub.com/
[4] ITU, "Revised Technical and Operational Parameters for Typical IMT-2000 Terrestrial Systems Using High Altitude Platforms Stations and CDMA Radio Transmission Technologies," Document 8-1/307-E, March 1999
[5] D.I. Axiotis, M.E. Theologou, "An empirical model for predicting building penetration loss at 2 GHz for high elevation angles," IEEE Antennas and Wireless Propagation Letters, vol. 2, pp. 234-237, 2003