*URSI GASS 2021, Rome, Italy, 28 August - 4 September 2021*

# Prediction of Operative Parameters of Signals from Flying Vehicle in Land-Atmospheric Communication Links

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As was declared in our previous research published during 2006-2014 [1] [2], processes which distort information due to fast fading, as the source of the multiplicative noise, passing in wireless communication links are the most important to understand. All investigations were related mostly to terrestrial communication links (sub-urban and urban). Less effort was dedicated to land-atmosphere and atmosphere-land communication links, where the same processes occur with much stronger influence of the multiplicative noise on the data stream parameters, because of higher Doppler effects caused by flying vehicles (e.g., aircrafts, helicopters, drones, etc.) with higher velocity comparing to land moving vehicles (cars, buses, trains, etc.). Moreover, the previous publications strictly and analytically obtained the time delay standard deviation, the bandwidth of coherency and the Doppler shift speeding not only for primitive time-harmonic signals, usually analyzed in the literature, but also for bandpass signal consisting both modulated signal and the carrier signal.

In this work, we analyze the same operational parameters of the channel, such as the bandwidth of coherency of the channel, as well as the characteristics of the modulated signal fading, such as the time delay signal deviation in the time domain and the Doppler shift spread in frequency domain. Various scenarios occurring at the terrestrial environment are considered, such as the density of buildings, their overlay profile and orientation with respect to stationary or moving ground vehicle, etc.. We also consider various parameters of the flying vehicle and the subscriber (which may be mobile), such as height of the moving atmospheric vehicle, the elevation and heights of subscribers' antennas, and the height of the ground vehicle comparing with build-up profile, and the distance between the ground vehicle and the obstructions surrounding it.

It is shown that the time delay of the bandpass signal in the land-atmospheric can be ranged from several to tens microseconds - higher than that occurring in land communication links. This effect depends on the height of the atmospheric moving vehicle, its speed and orientation to the ground-based vehicle. The Doppler shift spread, changes at the ranges not exceeding several kHz with maximum Doppler shift ranged from several kHz to tens kHz, depending on the speed and spatial orientation of the moving atmospheric vehicle. In all scenarios of consideration the bandwidth of coherency was ranged from tens to hundreds kHz, that is, wider than the Doppler spread bandwidth. This allow to conclude that even for the land-atmospheric communication links flat fast fading is observed, which does not strongly depend on the frequency of the carrier signal. In other words, the multiplicative noise is not so predominant with respect to flat noise.

## References

[1] Blaunstein, N. and C. Christodoulou, *Radio Propagation and Adaptive Antennas for Wireless Communication Networks - Terrestrial, Atmospheric and Ionospheric* (2nd ed.), Wiley, New Jersey, 2014.

[2] N. Blaunstein, S. Arnon, N. Kopeika, and A. Zilberman, *Applied aspects of optical communication and LIDAR*. CRC Press., 2009.