Radiowave Propagation Measurements Using Remote Control Airship

http://propagation.elmag.org

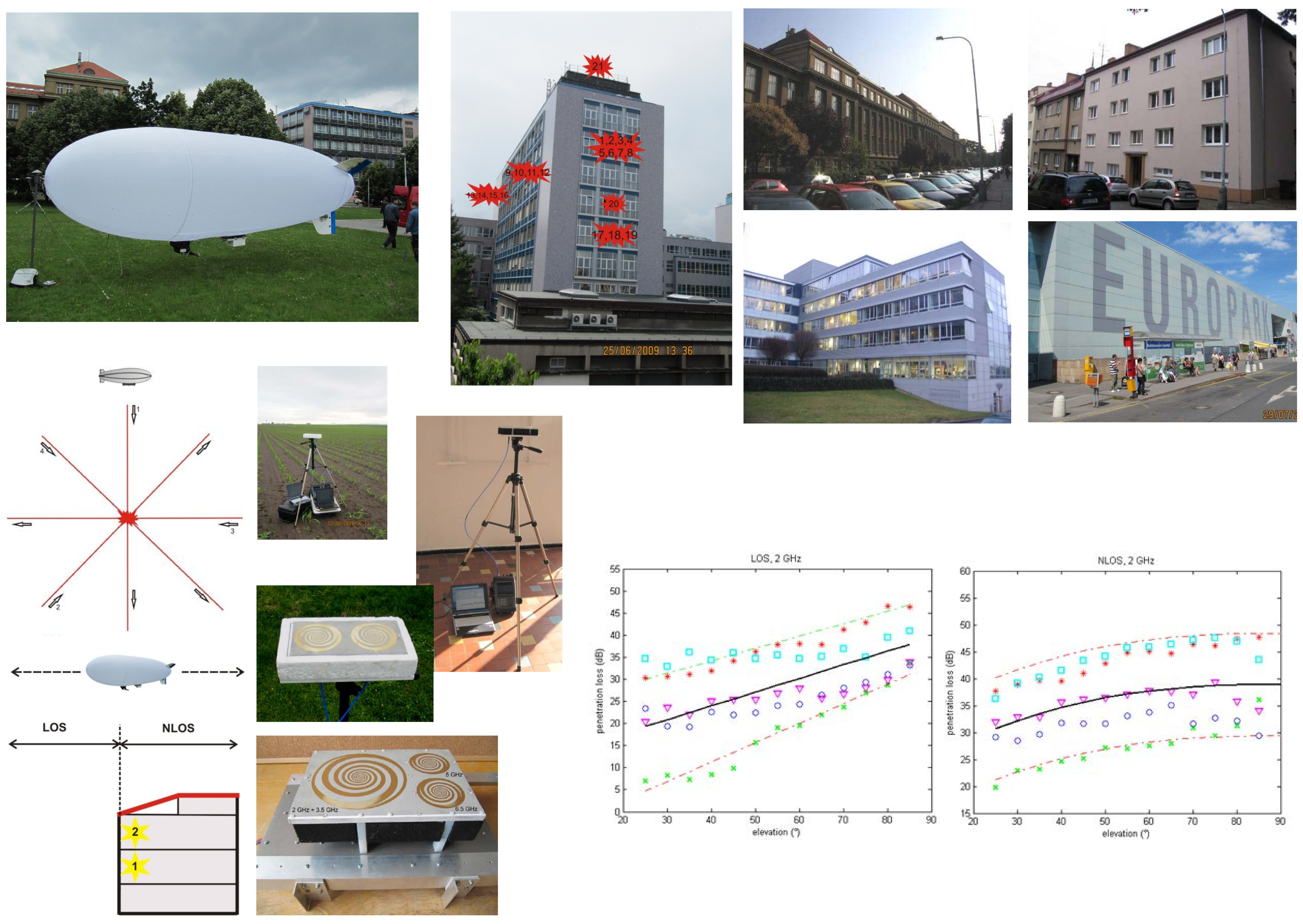
The Airship (www.airshipclub.com)

Basic parameters of the 11m-long class ACC09E

length	11 m
max. diameter	2.48 m
hull volume	39 m3
hull surface	73 m2
hull filling	Helium
hull structure	2 layers - top coat (tear proof) + bladder
propulsion	2 x BLDC motor
cruising speed	24 km/h
total mass + one battery pack	27 kg
max. payload	14 kg
endurance per one battery pack	40 – 70 min.

Satellite-to-Indoor Measurement Campaign

The building penetration loss is one of the key factors in planning future satellite-to-indoor/HAP-to-indoor communication links. An extensive measurement campaign, covering a representative set of typical buildings in an urban area and aimed at building penetration loss for high elevation angles at L-, S- and C-band, was performed in Prague in 2009. Throughout the measurements, a remote-controlled airship (http://www.airshipclub.com) was used as a pseudo-satellite carrying a transmitter which provided unmodulated continuous wave left-handed circularly polarized signals at 2.0 GHz, 3.5 GHz, 5.0 GHz, and 6.5 GHz. Based on a thorough analysis of the resulting experimental data new elevation dependent empirical models were introduced at corresponding frequencies.

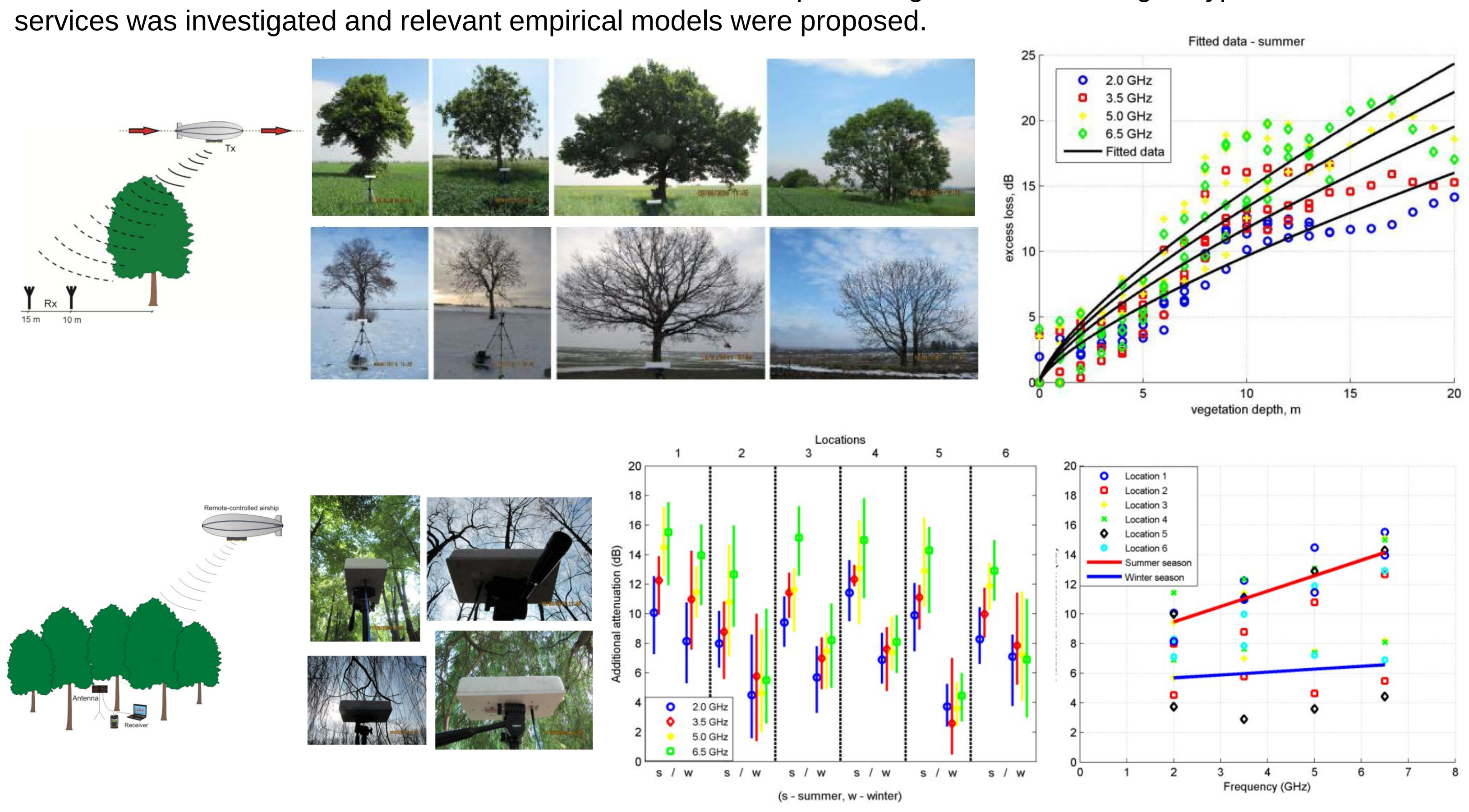


Supported by
- Building Penetration Measurement and Modelling for Satellite Communications at L, S and C-Band, ESA PECS project No. 98069, 2009-2010.

Selected papers
- Kvicera, M. - Pechac, P.: Building Penetration Loss for Satellite Services at L-, S- and C-band: Measurement and Modeling, IEEE Transactions on Antennas and Propagation. 2011, vol. 59, no. 8, p. 3013-3021.
- Kvicera, M. - Horak, P. - Pechac, P. - Perez-Fontan, F.: On a Definition of Building Penetration Loss for High Elevation Angles, IEEE Transactions on Antennas and Propagation. 2010, vol. 58, no. 12, p. 4115-4118.

Measurements of Shadowing by Vegetation for Satcom & Satnav Systems

Vegetation shadowing is one of the key aspects of how the local environment influences satellite mobile services in L-, S- and C-bands. The measurement focusing on high elevation angle links with a nomadic ground terminal were carried using the same setup as for the Sat-to-Indoor measurement campaign. Two basic scenarios, a terminal shadowed by a single tree and a terminal completely shadowed inside woodlands, were addressed both in summer and winter when trees are in full leaf and defoliated. The complete range of elevation angles typical of satellite/HAP services was investigated and relevant empirical models were proposed.

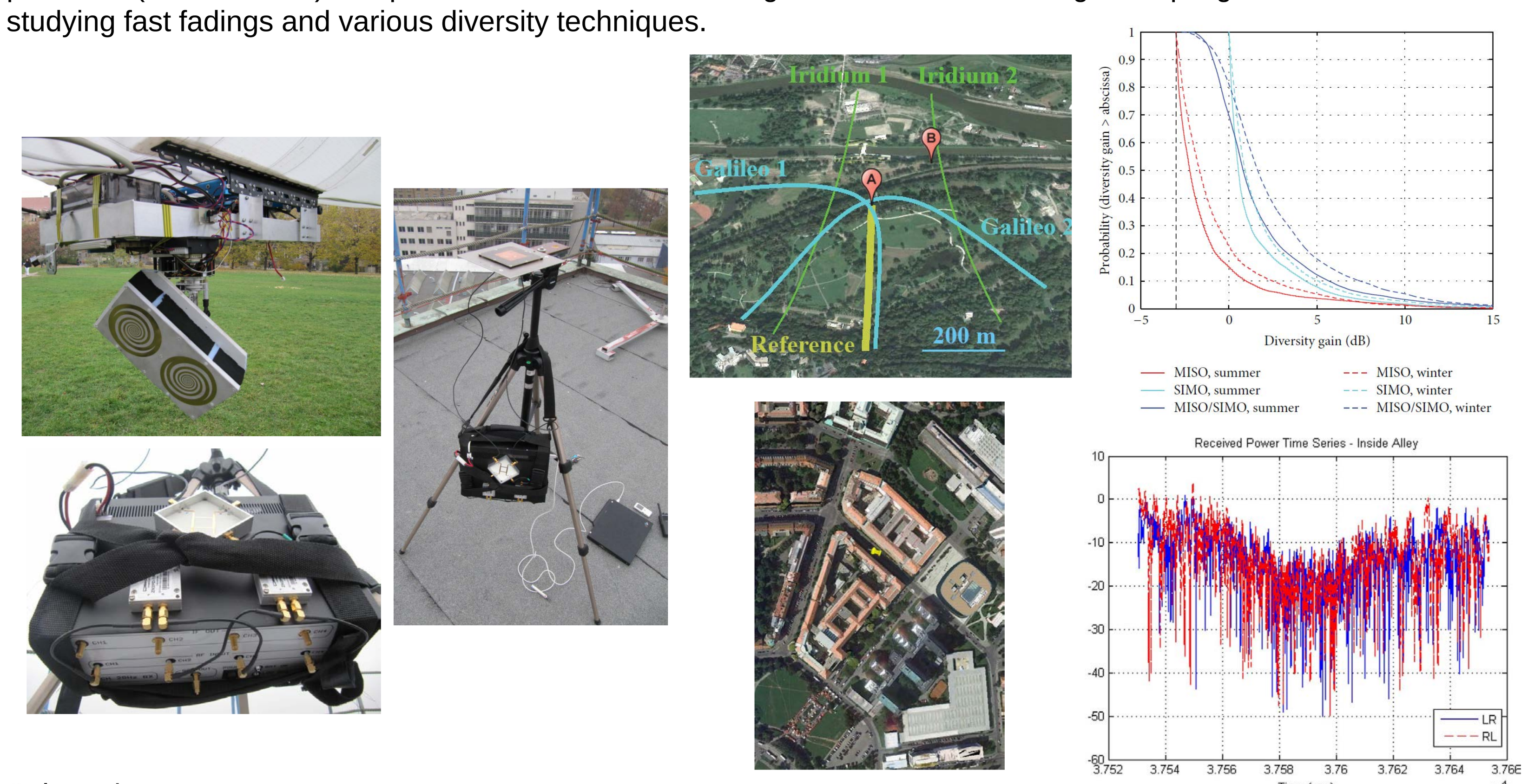


Supported by
- Propagation Modeling of Shadowing by Vegetation for Mobile Satcom & Satnav Systems, Czech Ministry of Education, Youth and Sports, grant no. OC09074, 2009-2012.
- COST Action IC0802, Propagation tools and data for integrated Telecommunication, Navigation and Earth Observation systems, 2008-2012.

Selected papers
- Horak, P. - Pechac, P.: Excess Loss for High Elevation Angle Links Shadowed by a Single Tree: Measurements and Modeling, IEEE Transactions on Antennas and Propagation. 2012, vol. 60, no. 7, p. 3541-3545.
- Horak, P. - Pechac, P.: Seasonal Additional Attenuation in Woodlands for Satellite Services at L-, S- and C-Bands, IEEE Transactions on Antennas and Propagation. 2011, vol. 59, no. 12, p. 4865-4867.
- Horak, P. - Kvicera, M. - Pechac, P.: Frequency Dependence of Attenuation Due to Vegetation for Satellite Services. IEEE Antennas and Wireless Propagation Letters. 2010, vol. 9, p. 142-145.

SIMO/MISO Measurements for High Elevation Links

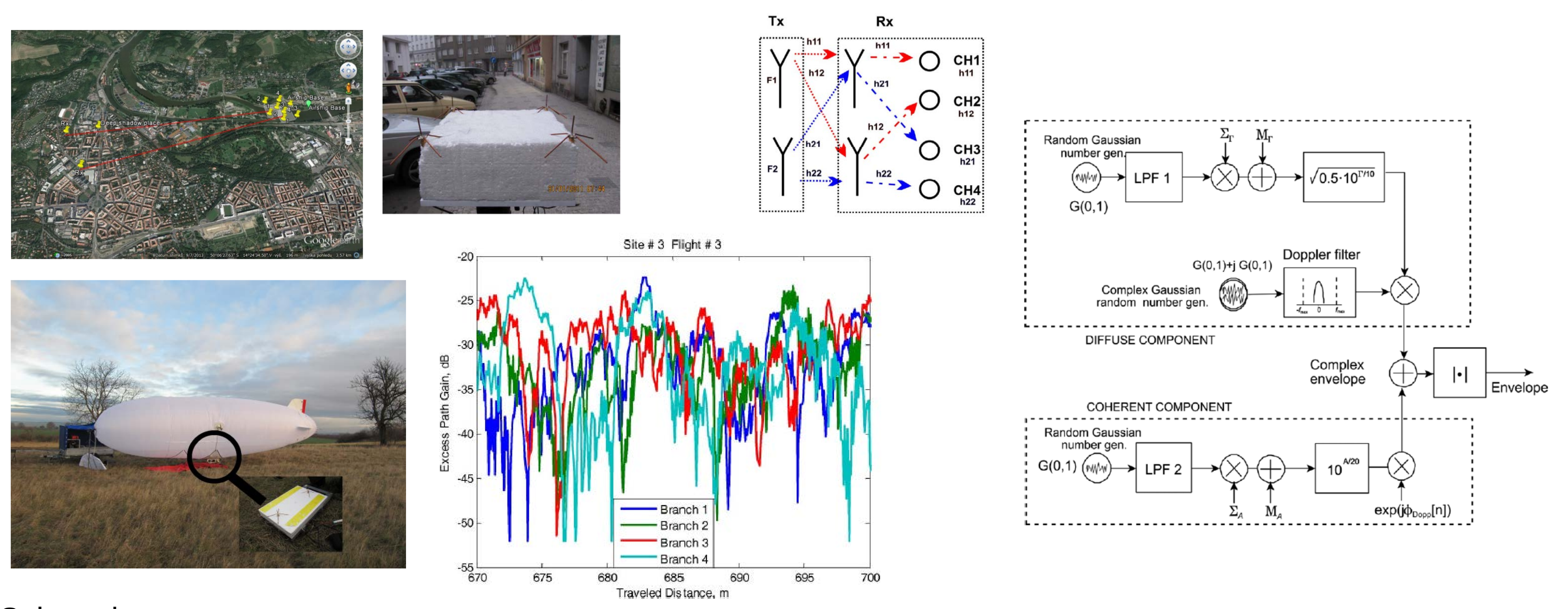
To characterize the propagation channel for high elevation links, typically satellite links, a new measurement setup at 2.0 GHz was introduced in 2011. In order to perform dual polarization measurements, the RHCP and LHCP polarized signals are transmitted at 2.00106 GHz and 2.0086 GHz by antennas placed at an automatic positioner at the bottom of the airship. This enables to instantly point the transmitting antenna towards the receiver position, resulting in propagation conditions closer to a common satellite to earth scenario and constant antenna characteristics, namely the polarization. By using a dual polarized patch antenna connected by a hybrid coupler and two power splitters to a four-channel sensitive radio receiver tuned to the two slightly shifted transmitting frequencies, SISO, SIMO, MISO and MIMO (combined MISO/SIMO) configurations with both co- and cross-polarized (LHCP/RHCP) components of the transmitted signals are received. A high sampling rate of 10 kHz allows studying fast fadings and various diversity techniques.



Selected papers
- Kvicera, M. - Pechac, P.: First-Order Statistics Prediction for a Propagation Channel of Arbitrary Non-Geostationary Satellite Orbits, Radioengineering. 2015, vol. 24, no. 1, p. 93-97 .
- Kvicera, M. - Pechac, P.: Seasonal Variations of Polarization Diversity Gain in a Vegetated Area considering High Elevation Angles and a Nomadic User, International Journal of Antennas and Propagation. vol. 2015.
- Kourogiorgas, Ch. - Kvicera, M. - Skraparlis, D. - Korinek, T. - Sakarellos, V. - Panagopoulos, A.D. - Pechac, P.: Modeling of First-Order Statistics of the MIMO Dual Polarized Channel at 2 GHz for Land Mobile Satellite Systems under Tree Shadowing, IEEE Trans. on Ant. and Propagation. 2014, vol. 62, no. 10, p. 5410-3410.

SIMO/MISO Measurements for Low Elevation Links

Unmanned aerial vehicles (UAVs) are deployed in many surveillance missions as they are safe and inexpensive. These aircrafts need a high data rate communication link for direct evaluating or storage of data which the control link cannot guaranteed. Due to the specific elevation angle this link can be classified as a “low elevation link.” Similar measurement system is utilized as for the SIMO/MISO high elevation scenarios, the main difference is the use linearly polarized antennas. Specific propagation channels are studied for various environments.



Selected papers
- Simunek, M. - Fontan, F. P. - Pechac, P. - Otero, F.: Space Diversity Gain in Urban Area Low Elevation Links for Surveillance Applications, IEEE Trans. on Antennas and Propagation. 2013, vol. 61, no. 12, p. 6255 - 6260.
- Simunek, M. - Fontan, F. P. - Pechac, P.: The UAV Low Elevation Propagation Channel in Urban Areas: Statistical Analysis and Time-Series Generator, IEEE Trans. on Ant. Prop. 2013, vol. 61, no. 7, p. 3850 - 3858
- Simunek, M. - Pechac, P. - Fontan, F. P.: Excess Loss Model for Low Elevation Links in Urban Areas for UAVs. Radioengineering. 2011, vol. 20, no. 3, p. 561-568.

Measurements of Horizontal Variations of Radio Refractivity

The refractive index of air is of a crucial importance for all refractive effects occurring in the troposphere. Refractivity structure of lower parts of the atmosphere has been studied for decades, mostly by means of radiosounding. Vertical dependence of refractivity is relatively well understood in terms of vertical refractivity profiles including their statistics. When assessing the influence of refractivity distribution of the atmosphere on radiowave propagation, usually a single refractivity profile is considered along the whole path of the link. Horizontal change in the refractivity profile can be important in a certain percentage of time, however. These measurements attempt to quantify the horizontal change of refractivity.

Supported by
- Basic Research of Propagation of Electromagnetic Waves in the Atmospheric Boundary Layer for Low Elevation Links, Czech Science Foundation grant no. P102/14-01527S, 2014-2016.