Computational Study of Antenna-Platform Interaction in the Presence of Random Rough Surfaces

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The physical size of typical vehicular antennas in HF-VHF frequency range is quite large. Thus, they contribute to large visual and radar signatures and often interfere with power lines, bridges and other low-hanging structures. The concealment of those antennas improves vehicle mobility while protecting the crew members. This is especially valuable for emergency and military vehicles. One of the possible approaches to this problem is to move the mounting position of the antennas from their present locations to a new place. For example, the bottom of many vehicles is planar and can potentially host (electrically) relatively large antenna. Also, the vehicle sides including the doors can support directional flush-mounted antennas. By following this approach, antennas get closer to the Earth surface which increases ground loss and alters their electrical properties. However, one needs to remember that in the HF band any antenna on a vehicle is electrically close to the ground. Besides the effect of soils on the signal propagation might be acceptable in the proximity of the vehicle, which is also of a great interest.

In this paper we present the results of computational studies of the interaction between an omni-directional source and vehicular platform. The study is focused on the distribution of the electromagnetic field in the proximity of the vehicle, which distinguishes this study from others. In the beginning the antenna-platform interaction is considered in the presence of a flat Earth surface. Results show that there is a frequency range where the radiation of the bottom side source has good omni-directionality compared to the sources at the rear end which is the most common place for mounting these antennas. To analyze the obtained data and understand the scattering mechanisms we apply the concept of Fresnel zones. The analysis reveals clear correlation between the theoretical and calculated omni-directionality of near and far-field patterns. This indicates that even in the presence of complex scattering configurations, the simple models can be accurately analyzed using the Fresnel zones thus significantly reducing the associated computational costs, while at the same time determining the approaches for mitigation of high omni-directionalities. Another part of the study relates to the effects of rough perfectly electrically conducting surfaces on wave propagation. The random rough surfaces having Gaussian power spectrum are characterized by means of root-mean-square height and correlation length. The results of calculations are analyzed by means of statistical analysis. The average attenuation of the signal due to the scattering of the electromagnetic waves from the surface is computed.