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Scenario Modules and Ray-Tracing Simulations of Millimeter Wave and Terahertz Channels for Smart Rail Mobility

Nowadays, rail traffic is expected to evolve into a new era of "smart rail mobility", which requires a seamless high-data rate wireless connectivity with up to dozens of GHz bandwidth. Such a huge bandwidth requirement motivates the exploration of the underutilized millimeter (mm) wave and Terahertz (THz) bands. In this paper, six scenario modules for mm wave and THz train-to-infrastructure channels are defined and constructed for the first time. All the main objects, such as tracks, stations, crossing bridges, tunnels, cuttings, barriers, pylons, buildings, vegetation, traffic signs, billboards, trains, etc., are modeled according to the typical geometries and materials in reality. Preliminary ray-tracing simulations in the 60 GHz band with 8 GHz bandwidth show that these objects that might not be so impacting on lower frequency channels indeed influence mm wave channel properties, and therefore, they can even play a more important role in the channels at higher frequency bands – THz. The modules presented in this paper are constructed through abstracting commonness of typical rail traffic scenarios. They can be independently used for site-specific verification of new communication regimes. Or, they can be combined in various ways for getting statistics of smart rail mobility in comprehensive rail traffic scenarios. The three-dimensional (3D) models of these six modules are publicly available and freely downloadable for link and system level simulations.

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