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Overview

Communications-based train control (CBTC) systems are aimed at providing reliable, wireless rail signaling and train navigation via a number of access points (transponders), which cover the entire area of the railway network. The scope of CBTC system planning and installation is to ensure that the number and the position of access points will maintain wireless connectivity for the trains. To that end, a detailed radio survey, whereby wireless propagation measurements are carried out over the entire railway network, precedes the installation of CBTC systems.

This work is focused on the development of a powerful software package that can significantly accelerate radio survey, using advanced propagation modeling techniques to optimize the distribution of access points for CBTC systems. On the theory side, two independent methods are applied: an image-theory based ray tracer, augmented with a reflection coefficient correction factor that guarantees its accuracy and convergence over long distances [1]; and a vector parabolic equation solver with numerical error control [2] and a novel methodology to incorporate antenna patterns in this solver [3]. The use of two independent propagation-modeling methods to derive the optimal positions of the CBTC access points enhances the reliability of the optimization process. Moreover, these two methods can be hybridized to model the CBTC signals (at 2.4 GHz) from a station environment (modeled via ray-tracing) to a tunnel (more efficiently modeled via VPE), as discussed in [4].

Figure 1. Point cloud for a tunnel in the London Underground (credit: Thales Canada).

On the measurement side, data from two measurement campaigns performed by Thales Canada, at Edmonton, AB, Light Rail Transportation System and the London (UK) Underground are used for validation studies of our models. The latter campaign was complemented by a laser survey to collect point cloud data sets of the tunnel geometry. Figure 1 depicts one representative example of a point cloud data set, which was used to build the input file for the ray-tracer and the vector parabolic equation solver. For the image-based ray-tracer, in particular, the points of the cloud are used to discretized the tunnel geometry into quadrilaterals; notably, all ray interactions with these quadrilaterals are mapped to image sources, whose positions can be readily computed once this facetized tunnel model is available (see Fig. 2).
An example of the results we have derived, which will be extensively discussed in our presentation, is provided in Fig. 3. Good agreement is shown between the two methods and the measured data. The graph also includes the -70 dBm threshold identified as the minimum received power needed for the CBTC system under study to operate at an acceptably small error rate. Notably, the area when the received power level goes below this threshold is accurately identified by both methods.

Results such as those of Fig. 3 can be employed for the optimal distribution of the CBTC access points [1], electromagnetic compatibility analyses (in the presence of other transmitters) and even network-level simulations.

References

