Determination of Percentage of Linear Coverage Area in Railways

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Railway communications have recently attracted much interest. In the last few years, most of the literature focus on the propagation issues for link budget. However, the railway coverage is different from the cellular radio systems. It is well-known that due to effect of shadow fading, some locations within a coverage area will have a received signal below a particular threshold. Computing how the boundary coverage relates to the overall percentage of coverage area is very useful for the link budget. While this problem has been well solved for the circular coverage of cellular systems, there is a lack of the determination of percentage of coverage area in the narrow-strip-shaped railway cells, i.e., the linear coverage. It is of interest to determine the percent of locations within a linear rail track in which the received signal strength from a radiating base station antenna exceeds a particular threshold.

We apply Reudink's method (D. O. Reudink, IEEE Trans. Veh. Technol., 23, 1974, pp. 143-159) to railway application by considering a narrow-strip-shaped cell, instead of a circular cell. The percentage of linear coverage area for railway can thus be simplified as an integral over linear distance. By introducing the normally distributed shadow fading (dB scaled), a close-form equation can be derived from the edge outage probability and channel parameters, and simulation of percentage of coverage area with different channel conditions can be performed.
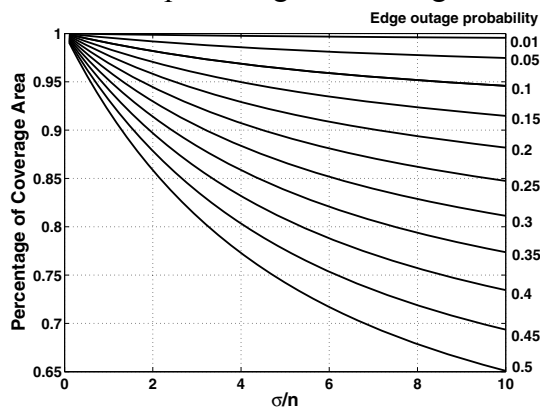

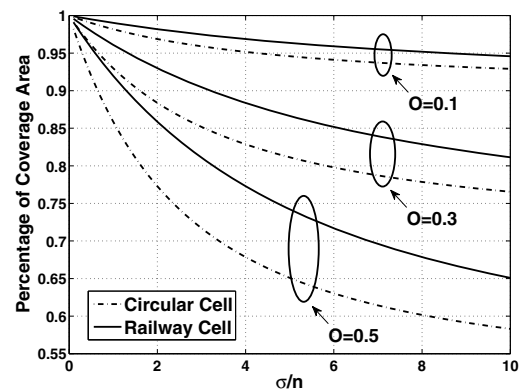Fig. 1 Family of curves relating percentage of linear coverage area in railways.

Fig. 2 Comparison between circular cell and railway linear cell.

Fig. 1 shows a plot of the family of curves relating percentage of linear coverage area for railway link budget, which can be used for designing and optimizing the linear coverage of railway communications. Difference channel conditions are considered, for example, if path loss exponent n=4, standard deviation of shadowing sigma=8 dB, and outage probability O=0.2, the percentage of linear coverage area of railways is close to 96\%. In Fig. 2, the percentage of coverage area for a circular cell is plotted for comparison. It is found that the linear coverage of railways has a higher percentage of coverage area than the circular cell. For example, if n=3, sigma=9 dB, and O=0.3, the percentage of coverage area is around 90\% and 85\% for linear coverage of railways and circular coverage of cellular systems, respectively. We also note that the difference between the two curves in Fig. 2 increases with O. This shows that over-coverage of the network planning would occur if the link budget of the cellular systems is directly applied for the railway systems.