

A Hyperloop Communication with Reconfigurable Intelligent Surfaces

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Abstract— To address the growing demand for short-, medium-, and long-distance ultra-high-speed mobility in future societies, diverse transportation technologies are being actively developed worldwide. Among them, enclosed systems similar to the Hyperloop, which operate within large cylindrical tubes with diameters ranging from several to tens of meters, have gained considerable attention as next-generation ultra-high-speed transportation solutions [1]. However, such tube-based infrastructures are often fundamentally isolated from the external environment or constructed deep underground, rendering them inaccessible to conventional terrestrial wireless communication infrastructures. Consequently, the development of novel wireless communication technologies capable of ensuring stable and highly reliable connectivity inside the tubes has become indispensable [2]. In this context, [3] modeled the wireless channel in high-speed railway communication systems by treating the surrounding terrain as point scatterers and introduced a semi-deterministic channel model [4] that accounts for all propagation components. However, while [5] has reported the scattering patterns of passive elements within reconfigurable intelligent surfaces (RIS), channel modeling for high-speed railway systems that incorporates such effects has not yet been addressed in the literature. Passive reflective elements (PREs) can provide additional line-of-sight (LoS) paths, thereby contributing significantly to the enhancement of communication performance.

In this paper, we propose a novel channel model for Hyperloop communication systems, a promising next-generation mobility solution, by incorporating PREs inside the tube. The proposed model characterizes the tube itself and the pod as point scatterers as in semi-deterministic channel modeling, and derives a wireless channel model that incorporates PREs similar to RIS inside the tube. Furthermore, simulation results verify that the proposed model captures the unique propagation characteristics of each component and achieves improved ergodic channel capacity performance compared to conventional Hyperloop channel models.

Keywords— 6G, Hyperloop communications, Reconfigurable intelligent surfaces (RIS), Semi-deterministic channel modeling, Ergodic channel capacity.

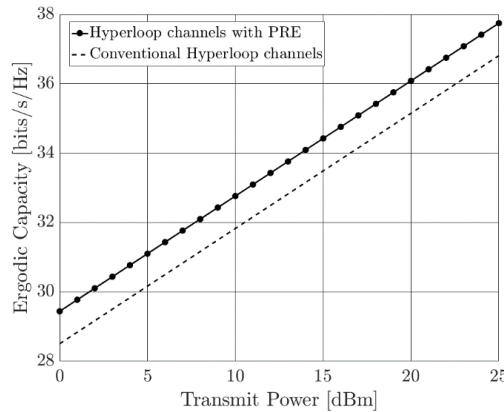


Figure 1. Ergodic capacity of Hyperloop channels with passive reflective elements.

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