MOBILE COMMUNICATION EXPERIMENTS IN RAILWAY TUNNELS OF WESTERN INDIA

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ABSTRACT

Mobile radio wave propagation in railway tunnels is very complex and is not well understood unlike urban propagation. This study features the mobile communication train experiments conducted in railway tunnels of western India in the UHF band. The results describe the propagation characateristics and the losses suffered due to tunnels of varying lengths.

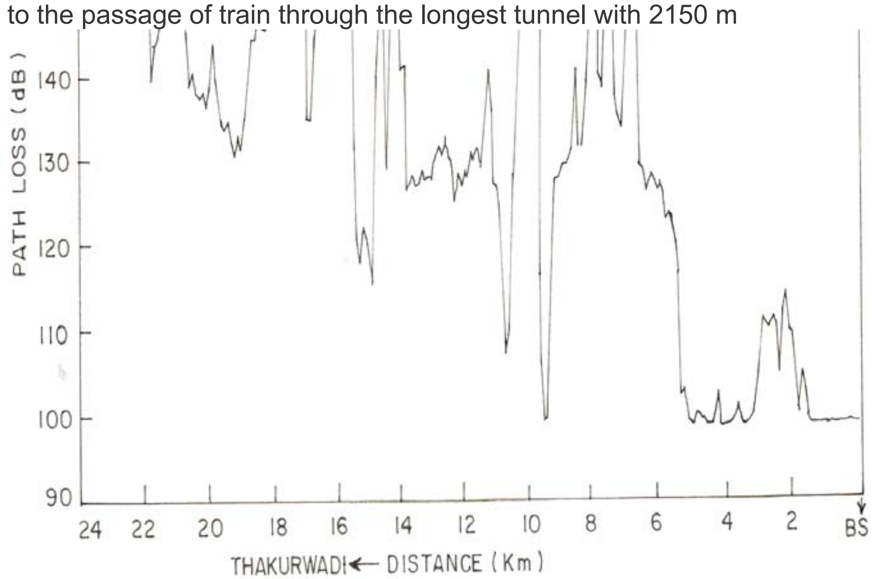
INTRODUCTION

A knowledge of mobile radio wave propagation is necessary to implement versatile mobile communication systems. Extensive studies involving theoretical modeling and experimental measurements have been undertaken by many workers in different environments [1-2]. Radio propagation in railway tunnels is an unique situation and it is a challenging task for RF engineer to understand the complex mobile radio environment. Measurements and coverage predictions on this aspect are very meagre. Mobile communications in tunnels is becoming increasingly important due to the high density of trains passing through them and communication in empty tunnels is totally different from that of obstructed ones. Some work on theoretical approaches and measurement in radio wave propagation in railway tunnels has been carried out by Zhang etal [3] averaged signal over 100 m isconverted into path loss value. The coverage is calculated by division of the number of samples exceeding threshold by the total number of samples.

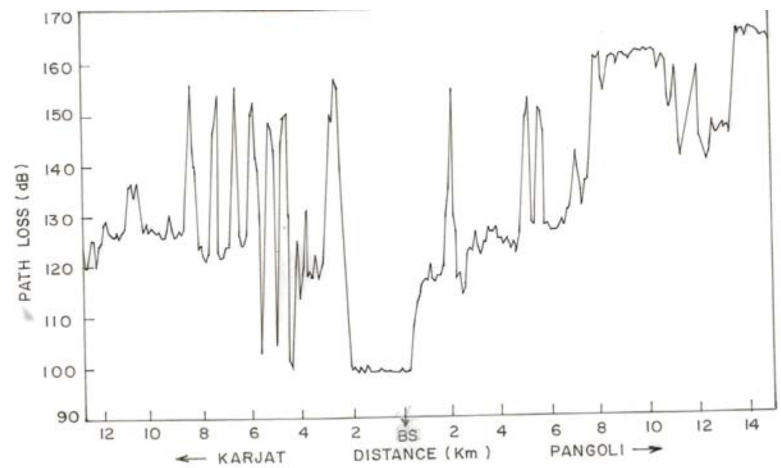
RESULTS:

Figures 1 to 2 depict the observed signal level converted into path loss as a function of distance for Karjat, Thakurwadi base stations in the down line direction. In all these cases transmitting antenna is located at a distance much beyond the tunnel entry point. In all the figures the path loss increases sharply whenever the train enters the tunnel. Another common feature is the fluctuation of path loss rapidly due to multiple reflections from the walls of the tunnel during the passage of train through the tunnel. Deep and large fades are noticed in all these figures. The fading appears to be dependent on the frequency and tunnel«s curvature and dimensions. When the train with mobile antenna enters the tunnel, received signal suffers slight degradation if it is in LOS (line-of-sight) region with the transmitting antenna. In the non LOS region, severe degradation occurs due to the blockage of the signal . In the present case severe degradation is noticed as the mobile is in non LOS range with the transmitting antenna. Large variability and greater loss limits the usage of this frequency for mobile communication in tunnels. In the longer tunnels the path loss is higher by 40 dB compared with the shorter tunnels.

In figure 1 as the distance increases, the path loss increases. Between 6 and 8 km from the base station highest path loss of 160 and 167 dB are observed. This is when the train passes through tunnels T7A, T8A of lengths 514 and 436 m. The deep fades at 10 km is due to the presence of tunnels. These are due to the effect of tunnels T23A, T23B with lengths of 212 and 67 m. Continuously large path loss of 168 dB is noticed between 21 and 24 km from base station. This is due to the passage of train through the longest tunnel with 2150 m



(T25C). Here the variability of path loss is less. Figure 2 depicts the path loss as a function of distance recorded from Thakurwadi base station. At a route distance of around 2 km from the base station towards Pangoli side slow and deep fades of 35 dB is seen due to the presence of tunnels T16A and T17A. At a route distance of 7 km from the base station the path loss rises steeply by 30 dB and remains around 162 dB till around 123 km.This is due to the passage of train through the tunnels T24C and T25C of lengths365 and 2150 m. A comparison of figures 1 and 2 showed that in the cases of boththe base stations at distances of 7 km path losses of 168 and 163 dB are observed.This shows that path loss is mainly dependent on the dimensions of the tunnel. In the case of Pangoli base station towards the left side
(i.e. towards Thakurwadi side) lot of rapid signal fluctuations resulting into fast and deep fades are seen between and 9 and 6 km. The path loss steeply increases by 45 dB due to the passage of tunnels T11, T12, T13 and T14. Out of all these tunnels tunnel 13 has got highest length of 408 m. Also larger median path losses of 150 to 160 dB are seen when the train passes through tunnels T1 to T10. Since measurements are taken before and after the presence of tunnels it is seen that tunnels can easily introduce an extra loss of 45 to 55 dB depending on their physical dimensions.



curvature, shape and and dimensions of the tunnel. Tunnels located in down line direction caused fast and deep fading with not much change in median path loss caused slow and shallow fading. Fast fading with moderate fade depths are seen when the train enters a series of short distance tunnels one after the other. Slow and very deep fades are seen when the train travels a distance through the lengthy tunnels. The major cause of attenuation in these tunnels are bends and obstructions.

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