MEASUREMENTS AND MODELLING OF RADIO PROPAGATION IN SUBWAY TUNNELS

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INTRODUCTION

• Modern railway lines have 20 to 50% of tunnels.
• Radio communications in tunnels have high importance for ERTMS or CBTC.
• We proposed antenna solutions and repeaters for communications in tunnels with better performances and 1/10 cost reduction compared with leaky feeder.

OBJECTIVE

• Accurate modeling of propagation in railway tunnels is mandatory.
• Development of radio models from 900 to 5700 MHz in different types of tunnels.
• Development of antenna solutions for tunnels
• Test and measurements of narrow band (GSM-R) and Broadband (LTE) telecommunications systems.

METHOD

• Proprietary test and measurement system developed for this purpose.
• Measurements system composed of broadband transmitter, receiver and acquisition software.
• Base stations transmitting 980/2400/5700 MHz at same time, narrow and broadband.

RESULTS

<table>
<thead>
<tr>
<th>Frequency (GHz)</th>
<th>0.9</th>
<th>2.4</th>
<th>5.7</th>
</tr>
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<tbody>
<tr>
<td>At (dB/100 m)</td>
<td>4.05</td>
<td>2.95</td>
<td>2.15</td>
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</tbody>
</table>

DISCUSSION

• Accurate and high resolution measurements have been conducted at several common locations in Metro Madrid subway.
• Different types of tunnels and situations have been measured: straight/ curved/ tunnel to open area/ station / trains passing / broadband signals.
• Measurements have been precisely referenced to the environment to enable correction and improvement of the existing propagation model.

CONCLUSION

• Measurements have permit to develop and accurate propagation model for radio planning of antenna solutions in subway tunnels.
• It has been shown the higher attenuation rates in curves and places where changes in cross section or slope cause the blockage of the line of sight.
• Some exceptions to well-known phenomena have been found in complex environments, like passing from open to tunnel or tunnels cross.