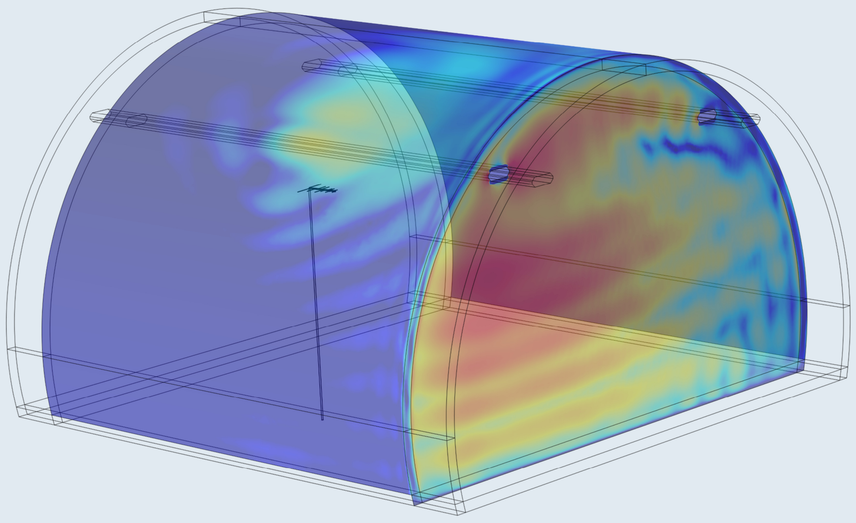

A Cost-Effective Approach for DAB+ Digital Radio Coverage Inside Tunnels

The “direct RF radiation” approach has been investigated as alternative and cheaper solution to the radiating cables (“leaky feeders”) for providing digital radio broadcasting service inside motorway tunnels.

B. Sacco, A. De Vita
Centre for Research, Technological Innovation and Experimentation,
RAI - Radiotelevisione Italiana, Torino, Italy

Introduction

Solutions employing radiating cables (“leaky feeders”) installed along the tunnel ceiling has been used for decades by RAI in FM band to provide a special radio programme for motorways called “Isoradio”.

However, due to the cable loss and attenuation, very long tunnels would require expensive adaptations. As an alternative, a promising and cheaper approach is represented by the “direct RF radiation” using antennas positioned near tunnel’s entrance, either internally or just outside it. To evaluate the feasibility of this solution, test measurement campaigns have been carried out by RAI in cooperation with ASPI (Autostrade per l’Italia) [1].

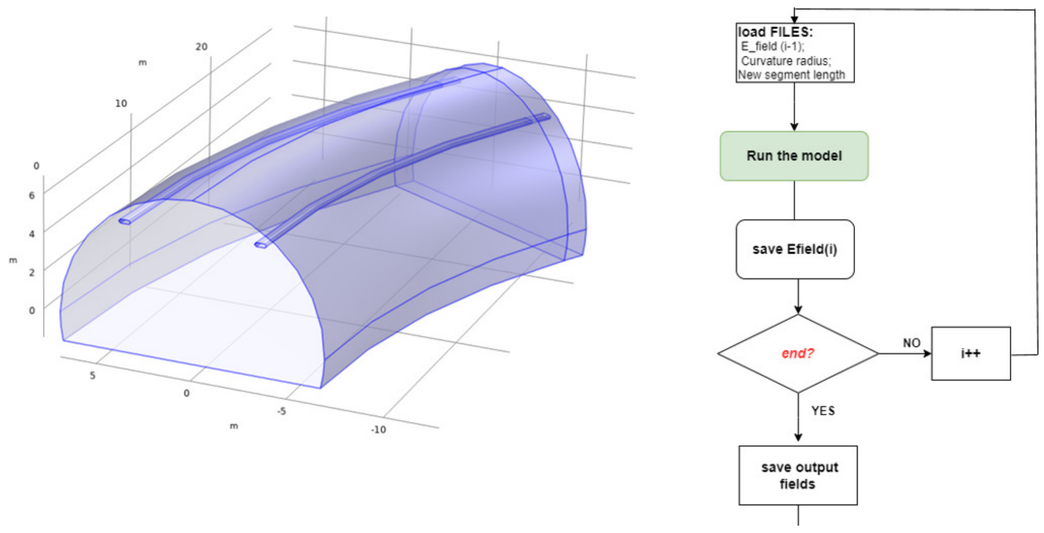

FIGURE 1.
Parameterized tunnel segment model (on the left) and a simplified flow chart for the modelling with *LiveLink™ for MATLAB®* (on the right)

Methodology

FEM approach is particularly useful for arbitrarily shaped tunnels, but it requires a large amount of computer memory and a long computation time to solve the final matrix equation [2,3]. Since a typical three-lane motorway tunnel has a quite large section, a basic tunnel segment model has been designed using COMSOL Multiphysics® with appropriate parametrization of the geometry’s section, length of the segment, and radius of curvature. The simulative analysis of the whole tunnel has been carried out as a sequence of such parametrized sections (Fig.1), using the COMSOL module *LiveLink™ for MATLAB®.*

Results

The mode analysis performed on the tunnel cross section(Fig.2a) provided a fairly good estimation of the wave propagation attenuation.

FEM simulation of the three antennas (Fig.2b) used during the measurement campaign, allowed to evaluate the "effective" antenna factor to improve accuracy of the measured field.

Results obtained from the tunnel model showed an excellent agreement with the data gathered during the field tests (Fig.2c) along the Apennine trunk of the A1 motorway between Bologna and Florence (Puliana tunnel) [1].

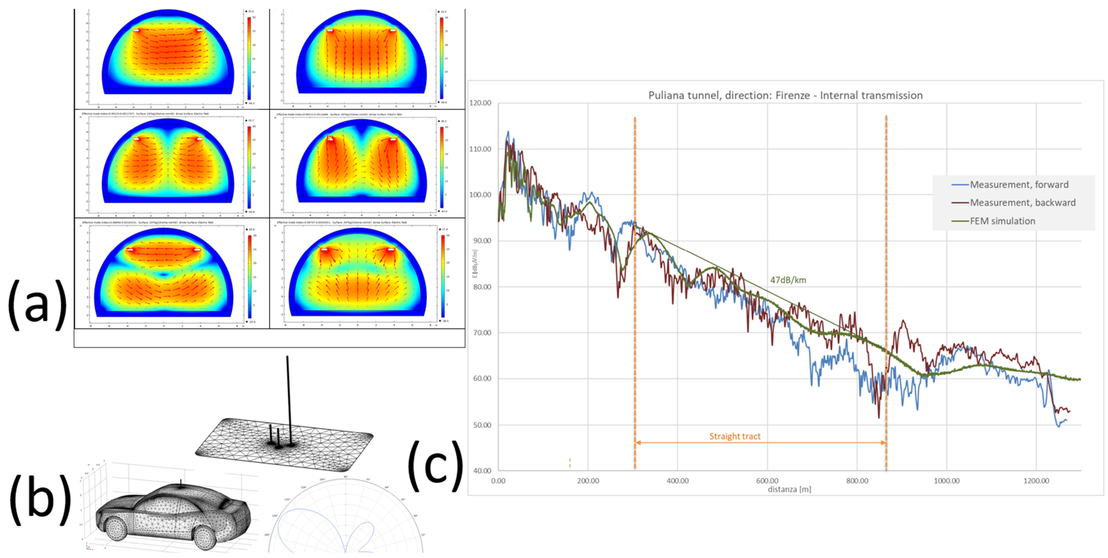

FIGURE 2. (a): Field configurations of the first six modes; (b):Three antennas system adopted in test fields and its corresponding radiation pattern; (c): Comparison between test measurements and simulations.

REFERENCES

A. Morello, S. Ripamonti, M. Tabone, G. Vitale, “DAB+ Signal Propagation in Tunnels,” *EBU Tech. Report*, March 2017 – Geneva.
2. L. Deryck, “Natural propagation of electromagnetic waves in tunnels,” *IEEE Trans. on Vehicular Tech.* vol. 27, NO. 3, pp. 145-150, August 1978.
3. Y. Yamaguchi, T. Abe, T. Sekiguchi, J. Chiba, “Attenuation Constants of UHF Radio Waves in Arched Tunnels” *IEEE Trans. on Microwave Theory and Tech.* vol. MTT-33, NO.8, pp. 714-718, August 1985.

Excerpt from the Proceedings of the COMSOL Conference 2023 Munich