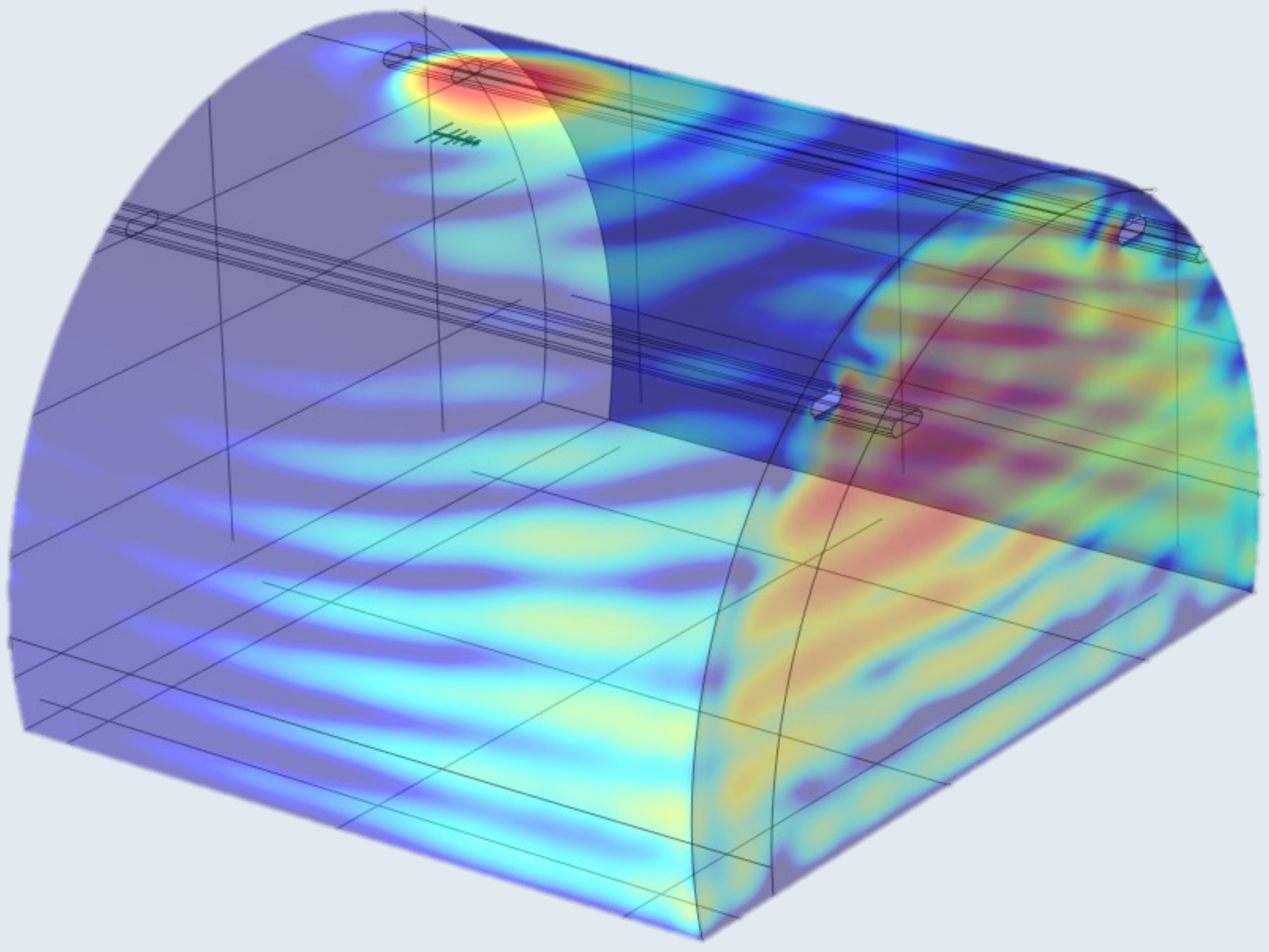

On the Influence of Some Geometric Parameters for DAB+ Signal's Propagation in Tunnels

The impact of the *curvature radius* of the tunnel's section, the *incidence angle* of the incoming wavefront, and the different types of *illumination* used with internal or external antenna have been further investigated for the "direct RF radiation" approach proposed in (Ref 1), in order to improve the 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

The direct RF approach represents a cheaper alternative solution than that typically adopted so far - "leaky-feeders" i.e. radiating cables installed along the tunnel ceiling - by the Italian Public Broadcaster (RAI) for providing a special radio programme for motorway called "Isoradio", based on a single FM frequency (103.3 MHz).

Simulating the Puliana motorway tunnel between Bologna and Florence (Italy), interesting highlights have been found in terms of field's attenuation as a function of distance for different tunnel's radii of curvature, incidence angle of the incoming wavefront, type of illumination as well as the type of polarization supported.

To this end, the anti-intuitive result was verified, already resulting from field tests carried out by RAI in cooperation with ASPI (Autostrade per l'Italia) (Ref. 2), that the best coverage in terms of distance in the tunnel is obtained by transmitting in horizontal polarization (H-Pol), although the receiving antenna works in vertical polarization (V-Pol).

FIGURE 1. Motorway tunnel simulated in COMSOL® and van equipped with antenna system used for reception tests.

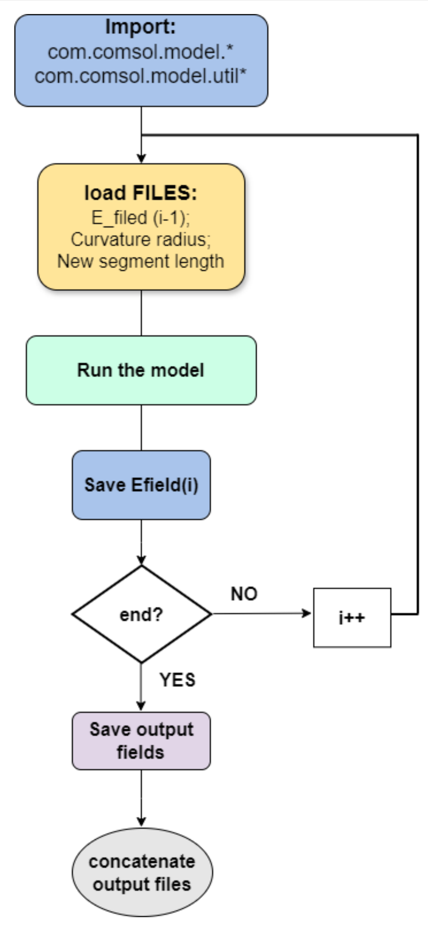

FIGURE 2. Process flow chart for COMSOL® model

Methodology

Due to large amount of memory required - depending on the volume of the model in relation to the wavelength - the simulative analysis has been carried out with COMSOL Multiphysics® as a sequence of parametrized segments (Fig. 2) leveraging the LiveLink™ *for* MATLAB® capabilities.

To analyse the influence of the incidence angle of the incoming wavefront on the gallery's entrance, a straight tunnel with an oblique wavefront has been considered. Instead, to explore the effect of varying the curvature radius of the tunnel section, a plane wave with orthogonal incidence (θ = 0°) was applied at the tunnel's entrance surface.
After the simulation of each segment, the surface integration of the power densities on the input and output transverse sections, as well as road and vault surfaces were calculated.

Results

The power densities leaking from the lateral surfaces (vault and road surface), show an initial oscillatory trend, suggesting the presence of multiple reflections on the surfaces of the tunnel which then disappear when the higher modes are finally attenuated.

With orthogonal incidence (θ=0°), the curves of the power density leaking through the vault and the road surface show low values. This indicates that the grazing reflection on the internal surfaces of the tunnel is more effective in containing the field inside it. Differently (angle θ=20°), higher power fluxes are observed which constitute an energy loss towards the external surface, with consequent lower signal propagated towards the end of the tunnel.

The fundamental mode carries horizontal polarization, which is better reflected (and therefore less transmitted) by horizontal surfaces.

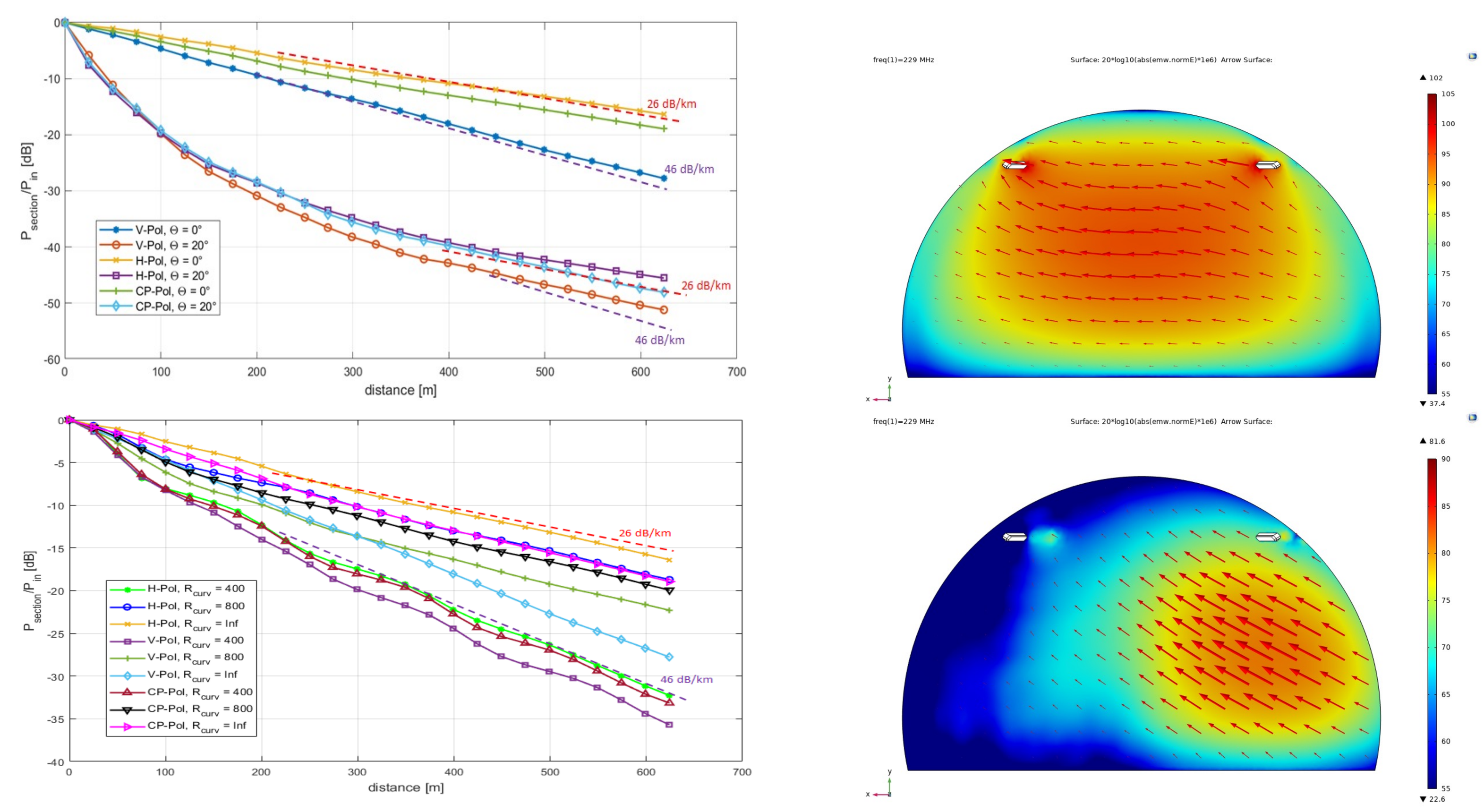

FIGURE 3. Left: Power flow through the transverse surface, normalized to the power input flow for different angles of incidence (top) and different radius of curvature and polarization (bottom). Right: Example of relevant field distributions at the far end of the last segment.

REFERENCES

1. B. Sacco and A. De Vita, "Exploring a cost-effective approach for digital radio broadcasting service coverage inside tunnels," Proceedings of the 2023COMSOL Conference, Munich, 2023.
2. A. Morello, S. Ripamonti, M. Tabone and G. Vitale "DAB+ Signal Propagation in Tunnels", EBU Technical Review, 2017.

Rai CRITS