PS-69 [15:00]

Calculated, simulated, and measured RF EMF exposure in the proximity of cellular base station antenna sites between 800 MHz and 2600 MHz

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Keywords: Dosimetry (computational), RF/Microwaves, Completed (published)

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Regulatory bodies most often evaluate compliance around base station antenna sites with local regulations and international guidelines using calculations or simulations. In this study, we compared calculated with and simulated and measured exposure around selected base station antenna sites in Flanders. We measured the RF exposure around base station antennas using a spectrum analyzer and a triaxial probe, calculated the exposure based on the far-field radiation patterns of the base station antennas, and applied the FDTD method to simulate the exposure. We observed that variations of up to 30 dB between calculated, measured, and simulated exposures at locations that were in non line-of-sight of the base station antennas.

Introduction

Governmental bodies often rely on calculations based on far-field radiation patterns to evaluate compliance around base station antenna sites with local regulations in international guidelines. Advances in wireless technologies for cellular communications (LTE, GSM800, 4G, and 5G) and advances in base station antenna design required an evaluation of the calculation based exposure assessment methodology against measurements and full-wave 3D electromagnetic wave simulations.

Therefor, in this study, we compared the calculated RF exposure in the proximity of base station antenna sites with narrow band measurements and FDTD simulations for current radio-frequency communication technologies in the frequency range from 800 MHz to 2600 MHz.

Materials and methods

We experimentally and numerically assessed the exposure around selected base station antenna sites in Flandres. In the first method, the exposure was calculated based on the far-field pattern of multi-band panel antennas.

The measurements were performed at site and in accordance with the Flemish Ministerial Decree of 12 May 2014 [1]. We used two narrow-band measurement setups consisting of a spectrum analyzer and a triaxial probe. The spectrum analyzers were the Rohde & Schwarz FSL6 and the Narda SRM-3006. The triaxial probes were Rohde & Schwarz TS-EMF Isotropic Antenna and the Narda three-axis antenna (E-field) 3501/03.

For the simulations, we employed the finite-difference time-domain (FDTD) solver implemented in the multi-physics simulation platform Sim4life v5.2 (Zurich MedTech, Zürich, Switzerland). For each site, we modeled generic base station antennas based on the radiation characteristics of the base station antennas installed at the considered site. We also took into account the environment at the base station antenna site by creating simplified 3D models of the building on which the base station antennas are installed. We simulated the exposure once with and without the simplified 3D environment.

Results

As an example, Figure 1 shows the FDTD model of the structure on the roof of a building at one of the sites where the base station antennas are mounted against the walls. At the considered site, the calculated, simulated and measured exposure was compared at four locations in the proximity of the base station antennas for the cellular communication frequencies of 800MHz, 900 MHz, 1800 MHz, and 2100 MHz.

Figure 2 shows the RMS electric field calculated, measured, and simulated at one location at the site considered in Figure 1 for the cellular frequencies 800 MHz, 900 MHz, 1800 MHz, and 2100 MHz for a base station antenna input power of 1 W. We observed differences as well as similar trends in the RF EMF exposure with frequency between calculations, measurements, and simulations. For this site, variations of up to 30 dB in terms of power density were observed for evaluated locations which are not in line-of-sight of the base station antennas. But, for locations in line-of-sight of the base station antennas, differences between simulations and measurements varied between 0.8 dB and 14.7 dB. The exposure assessed by FDTD simulations underestimated as well as overestimated the measured exposure depending on the location and operating frequency. Comparing the radiation pattern based calculations with the measurements and the full-wave simulations, we observed that the calculated exposure tended to underestimate both measured and simulated exposure (between 2.4 dB and 20.2 dB) for the site in Figure 1.

Conclusion

We compared the exposure assessment in the proximity of base station antenna sites using calculations based on the radiation pattern of the installed base station antennas, 3D electromagnetic simulations (FDTD), and on-site measurements. Large variations between calculated, measured, and simulated exposure values were observed. The largest variations (up to 30 dB in terms of power density) were observed at locations in non line-of-sight of the base station antennas. A better agreement was obtained for locations in line-of-sight of the base station antennas between simulated and measured values (up to 14.7 dB).

References

[1] Flemish Government, Environment, Nature and Energy. Ministerial Decree to determine the measurement procedure and measurement strategy for electromagnetic waves in the vicinity of fixed antennae, 12 May 2014.

Figures

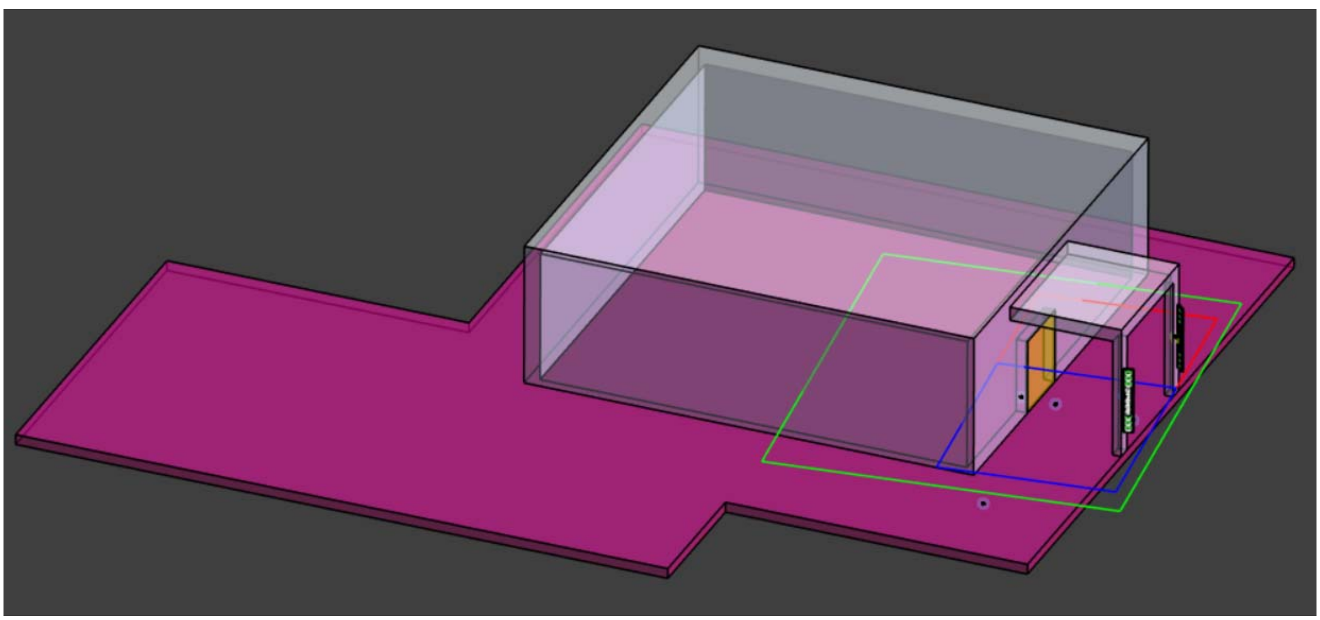

Figure 1. Model of the structure on the roof of a building at site 1 where base station antennas are mounted against the walls. The green area shows the part of the site that was simulated using the FDTD method.

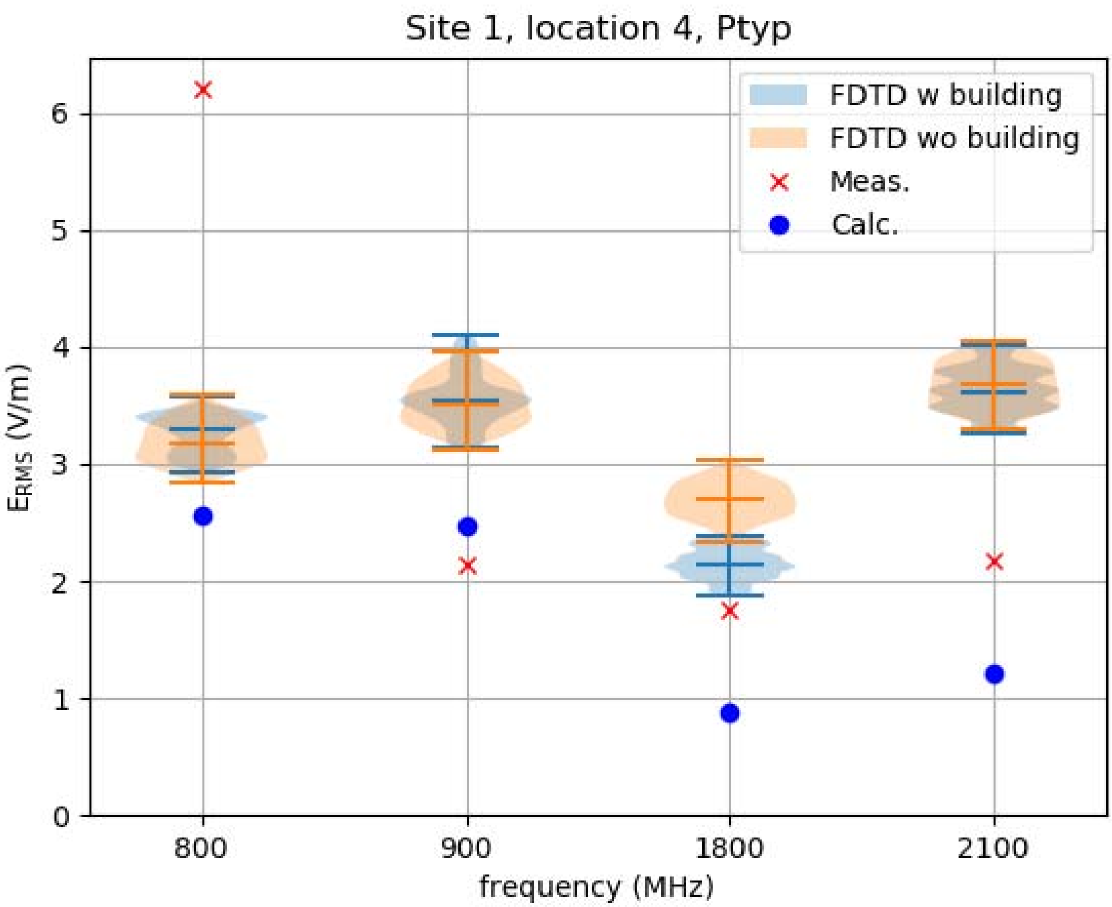

Figure 2. Example of the RMS electric field calculated, measured, and simulated at one location in the proximity of one of the considered sites at the cellular frequencies 800MHz, 900 MHz, 1800 MHz, and 2100 MHz. The base station antenna input power was set to 1 W.

PS-70 [15:00]

Effect of High Peak Power Microwaves (HPPMs) on bovine coronavirus (BCoV) survival in solution

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Keywords: In vitro, RF/Microwaves, Completed (published)

Presented by: Jody Cantu

BioEM 2021

26 - 30 Sep 2021, Flanders Expo, Ghent, Belgium

The Joint Annual Meeting of The Bioelectromagnetics Society and the European BioElectromagnetics Association

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