Measurement of the electromagnetic field exposure in indoor environments by spectrum analyzer and exposimeters

Günter Vermeeren, Francis Goeminne, Wout Joseph, and Luc Martens
Department of Information Technology, Ghent University / IBBT, Ghent, Belgium
*Corresponding author e-mail: Gunter.Vermeeren@intec.UGent.be

INTRODUCTION

The demand for wireless connectivity anywhere and increased data transfer drives the development of new wireless communication technologies and the expansion of wireless networks. Humans are exposed to all these radio-frequent (RF) sources. Little information is available on exposure from wireless data communication systems in indoor environments. This study will fill this gap and investigates exposure in sensitive environments (schools, day nurseries, homes and offices) at different locations and during time. Hence, we focus on the temporal variation of the exposure in these environments.

MATERIALS AND METHODS

A measurement campaign of the RF exposure in indoor environments is performed in Belgium. This campaign also aimed at the assessment of exposure in sensitive environments such as schools and day nurseries besides homes and offices. A two-tier measurement method is proposed and used in order to account for the time evolution of the exposure. The exposure is assessed by a spot measurement with a triaxial probe and spectrum analyzer, while the time evolution is recorded by exposimeters during a whole week. Combining the measurement data of spectrum analyzer and exposimeter allow to extrapolate the spectrum analyzer data to another point in time. The methodology consists of the following steps: 1) surface scan of the room with broadband probe to determine the location of maximum exposure; 2) safe placement of the exposimeter (if possible at the spot of maximum exposure) and start of the exposimeter measurement; 3) perform narrowband measurements using spectrum analyzer and triaxial probe at the location of maximum exposure and at the location of the exposimeter; 4) collection of the exposimeters after one week.

In this study the SATIMO exposimeter EME Spy 140 are used. This exposimeter measures the field in 15 bands. The method to assess the time evolution together with initial results is presented in [1]. From the exposimeter data, the time evolution is quantified by a scale factor (*SF*). *SF* equals the ratio of the instantaneous exposure and the maximum exposure over the measurement period. An averaged *SF* (over all the measurement in a certain environment, e.g., schools) can then be used to extrapolate the spectrum analyzer data to another point in time.

A total of 56 exposimeter measurements and 112 narrowband measurements were performed from December 2011 till February 2012.

RESULTS

As an example, Table 1 lists the exposure measured in the schools in Belgium using the spectrum analyzer setup. n (in %) is the ratio of the number of times an RF signal is above the sensitivity of the small-band measurement setup and the total number of measurements. E_{avg}, $p_{95}(E)$, and std(E) denotes the average, 95th percentile, and standard deviation of the rms

electric field value, respectively. Table 1 shows that the most prominent signals in Belgian schools are FM, TDAB, and GSM900 downlink (DL). The indoor wireless communication network WiFi was only significant available in 25 % of the positions indicating that WiFi is not yet frequently installed in schools.

Table 1: Results of the narrowband measurements in the schools in Belgium.

RF signal	**Schools in Belgium (10 locations, 40 positions)**			
	***n* (%)**	**E_{avg} (V/m)**	**p_{95}(E) (V/m)**	***std(E)* (V/m)**
FM	87.50	0.29	0.77	0.27
TV3	40.00	0.03	0.09	0.02
TDAB	57.50	0.11	0.61	0.19
TETRA	50.00	0.02	0.11	0.04
PMR	10.00	0.01	0.01	0.00
TV4&5	32.50	0.04	0.11	0.03
GSM900 DL	100.00	0.17	0.76	0.29
GSM1800 DL	57.50	0.05	0.16	0.05
DECT	20.00	0.04	0.15	0.05
UMTS DL	70.00	0.04	0.14	0.04
WiFi 2G	25.00	0.05	0.24	0.07
Total	**-**	**0.39**	**1.24**	**0.36**

Figure 1 show the time evolution for a 6-min and 30-min time interval over an average day for the GSM900 DL frequency. The time evolution is shown in terms of the scale factor (*SF*) of 95th percentile of the exposure measured by the exposimeter and after applying robust ROS [2] in every time interval. For GSM900 DL downlink there is a clear day-night difference of the exposure. Furthermore, two peaks are observed in the time evolution, one in the morning (between 10:30am and 12 noon), a second peak is observed in the late afternoon (from 5:00pm till 6:30pm).

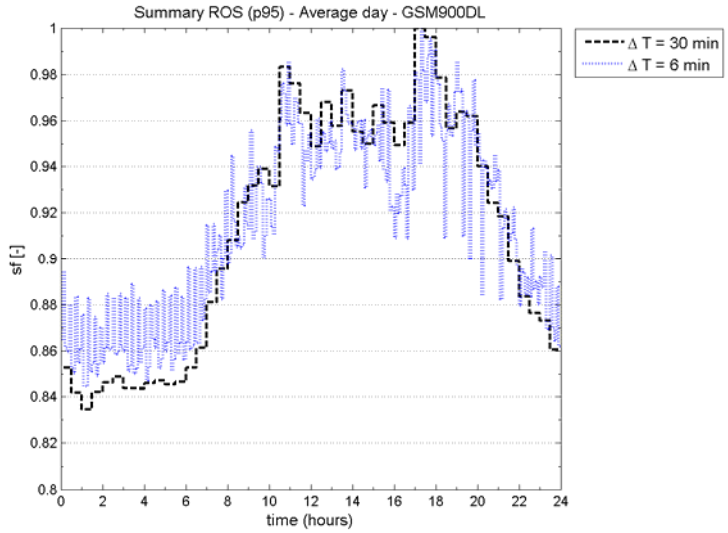

Figure 1: The scale factor of $p_{95}(E)$ for GSM900 DL and for an average day.

CONCLUSIONS

The exposure to current and emerging wireless communication technologies in indoor environments (schools, homes, day nurseries, homes and offices) is assessed in Belgium between December 2010 and February 2012. A measurement campaign is performed in 28 indoor environments in Belgium. The time evolution of the exposure is recorded by exposimeters and is used to estimate the exposure at another period in time.

ACKNOWLEDGMENT

“The research leading to these results has received funding from the European Union's Seventh Framework Programme ([FP7/2007-2013]) under grant agreement n° 244149”. W. Joseph is a Post-Doctoral Fellow of the FWO-V (Research Foundation–Flanders).

REFERENCES

[1] G. Vermeeren, I. Markakis, W. Joseph, T. Samaras, and L. Martens. Measurement of the time-evolution of the exposure to electromagnetic fields by exposimeters. 33rd annual meeting of the Bioelectromagnetics Society (BEMS), Halifax, Canada. PA-119, 2011.

[2] M. Roösli, P. Frei, E. Mohler, C. Braun-Fahrländer, A. Bürgi, J. Fröhlich, G. Neubauer, G. Theis, and M. Egger. Statistical Analysis of Personal Radiofrequency Electromagnetic Field Measurements With Nondetects. Bioelectromagnetics. 29:471-478, 2008.