Evaluation of the Correlation between RF Exposimeter Reading and Real Human Exposure

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***Abstract*— This project is dedicated to investigate the correlation between RF exposimeter readings and real human exposure. Both numerical simulations and measurements are performed. Field levels at the location of the exposimeter close to the human body are compared to the averaged field levels at the location of the body not being present. Preliminary results are given.**

I. Introduction

It has been demonstrated in the frame of an international study that the feasibility of epidemiological studies on possible effects of low level radio frequency electromagnetic fields depends strongly on the availability of reliable exposure assessment methods [1]. Data on individual exposure is needed for such studies, but available information on this topic is scarce. It is therefore very important to improve knowledge on the RF exposure distribution of the population. Preliminary investigations have shown that frequency selective exposimeters are very promising tools for that purpose, but it has to be taken into account that they indicate a field value measured close to the human body, but not the exposure of a person. Before starting to use such devices for large scale epidemiological studies it is therefore necessary that the reliability of such devices is investigated.

A few approaches were made in the last years to develop ‘exposimeters’, devices suitable to record the individual RF exposure of the general population. Two different concepts for separation of the exposure contributions from technical relevant RF bands, e.g. GSM 900 and UMTS were brought up in Germany and France. The reliability of these devices was investigated in first pilot studies. It was demonstrated that the devices are suited for individual exposure assessment, however also some shortcomings were observed. Examples are false summation of signals within the same band, out of band responses and high calibration factors in a few frequency bands. No profound investigation on the relation between real exposure and exposimeter reading was found in literature. In addition to the investigations mentioned above some other studies investigated workers exposure or exposure level on outdoor ground level, but the concepts are not suitable to assess individual exposure of the general population. New concepts of textile antennas and arrays of body worn receivers were shown; such approaches might be promising for the future, but are so far not advanced enough to be used in epidemiological studies.

II. Objective

The aim of this project is to examine the correlation between values measured by exposimeters and the effective human exposure for a representative selection of exposure scenarios. This will be achieved using numerical software tools suitable to replicate the electromagnetic field distribution within the human body in the vicinity of RF sources, e.g. mobile telephone base stations. Measured and calculated field values are compared in reproducible scenarios, i.e. an anechoic chamber equipped with defined scattering objects. Investigations are performed for different common exposure conditions, e.g. line of sight (LOS) and no line of sight (NLOS) for GSM, UMTS, WLAN and broadcasting frequencies.

III. Methodology

The project consists of four parts:

1) Collection of information on available investigations on evaluations of RF exposimeters, definition of a representative selection of exposure scenarios to be investigated
2) Validation of numerical approaches by measurements
3) Simulations, definition of correlation between exposimeter reading on one hand and the human exposure on the other
4) Recommendations for the use of exposimeters in epidemiological studies and for further development

IV. Preliminary Results

Approaches selected to define the correlation between exposimeter reading and the exposure are described in this chapter. The so called "4-Square Scenario" was chosen to be representative for realistic exposure conditions for GSM, UMTS and DVB-T. Four cuboids (40m x 40m) with a height of 20m represent buildings with the enclosed street canyons. 21 different receiver locations were chosen to deliver results which can be linked to the simulation tool solving the Maxwell equations to calculate the averaged electric field strength at the location of the human body (not being present) and at the location of the antennas of the exposimeters close to the model of the human body (being present) to investigate the relation between whole body exposure and exposimeter reading (see also [2]). Both LOS (Line Of Sight) and NLOS (Non Line Of Sight) conditions can be investigated in this basically simple scenario. Different heights of the receiver grids represent locations (positions of persons) on the ground (1m) or on the balcony (10m) or even on the rooftop (21m – 1m above the rooftop). Fig 1 shows the examined scenario where the red squares represent the receiver grids and therefore the position of the person under investigation. The dimensions of the scenario can be seen in Fig. 2. The two transmitter positions (TX1 and TX2) are located in a height of 23m and 10m, the antennas are not transmitting at the same time. The first run of simulations is done with only the transmitter on the rooftop (TX1) active, called "Scenario 1". Base stations mounted on rooftops are often located on the corner of building tops therefore this was considered as a typical scenario set up. The second transmitter (TX2) is located at a height of 10m on the side of a building and can be compared to micro cells mounted on building fronts to supply smaller regions like street canyons, called "Scenario 2" (see Fig. **Fehler! Verweisquelle konnte nicht gefunden werden.**3). The second run of simulations was done with just this transmitter (TX2) active.

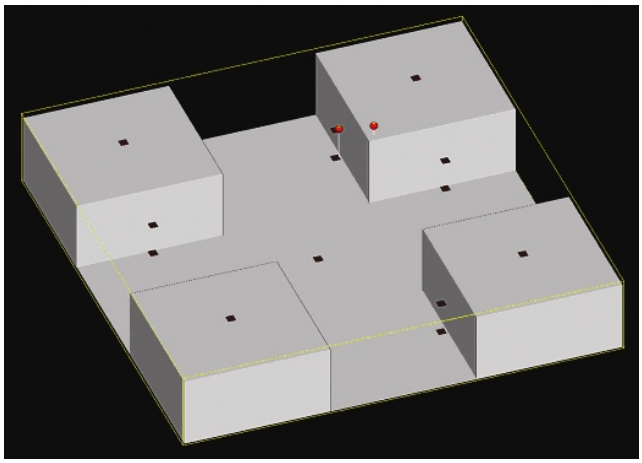

Fig. 1 Scenario with four cuboids (height 20m) representing buildings with the enclosed street canyons. The antennas are positioned on top and on the side of one building (red spheroids). Locations under investigation corresponding to the location of an exposed person are marked with black squares

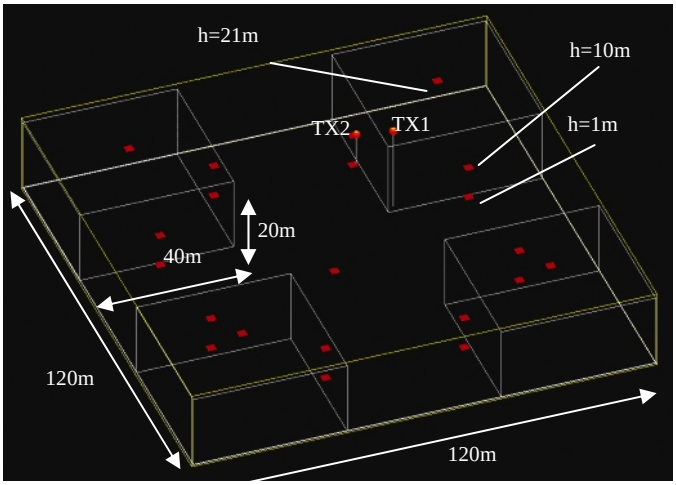

Fig. 2 Dimension of the scenario with the receiver grids located in a height of 1m, 10m and 21m (red squares indicate receiver grids, red spheres transmitters (TX)

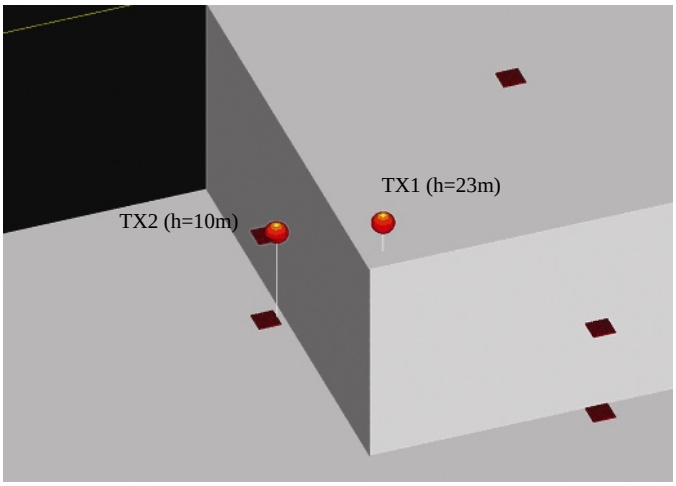

Fig. 3 Transmitting antennas: TX1 in a height of 23m and TX2 in a height of 10m

To generate information which is used later on for simulations using the *SEMCAD* platform, receiver grids with a dimension of 2m x 2m with a grid step of 10cm were chosen to provide the needed data. In sum 21 receiver grids were positioned in the whole scenario: 9 in a height of 1m (two on two sides of each building and one in the middle of the ground), 8 in a height of 10m (two on two sides of each building) and 4 on top of each building (in the centre of each building top), see also Fig. 2.

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