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# THE PATTERN OF THE ELECTROMAGNETIC FIELD EMITTED BY MOBILE PHONES IN MOTOR VEHICLE DRIVING SIMULATORS

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**Abstract**
**Introduction:** The paper reports the results of the determinations of UMTS EMF distributions in the driver's cab of motor vehicle simulators. The results will serve as the basis for future research on the influence of EMF emitted by mobile phones on driver physiology. **Materials and Methods:** Two motor vehicle driving simulators were monitored, while an EMF source was placed at the driver's head or on the dashboard of the motor vehicle driving simulator. For every applied configuration, the maximal electric field strength was measured, as were the values at 16 points corresponding to chosen locations on a driver's or passenger's body. **Results:** When the power was set for the maximum (49 mW), a value of 27 V/m was measured in the vicinity of the driver's head when the phone was close to the head. With the same power, when the phone was placed on the dashboard, the measured maximum was 15.2 V/m in the vicinity of the driver's foot. Similar results were obtained for the passenger. Significant perturbations in EMF distribution and an increase in electric field strength values in the motor vehicle driving simulator were also observed in comparison to free space measurements, and the electric field strength was up to 3 times higher inside the simulator. **Conclusions:** This study can act as the basis of future studies concerning the influence of the EMF emitted by mobile phones on the physiology of the driver. Additionally, the authors postulate that it is advisable to keep mobile phones at a distance from the head, i.e. use, whenever possible, hands-free kits to reduce EMF exposure, both for drivers and passengers.

**Key words:**
**Electromagnetic fields, Mobile phones, UMTS, Traffic accidents**

## INTRODUCTION

One of the concerns connected with mobile phone use is their influence on motor vehicle drivers. Distraction experienced by the driver receiving a call may increase the risk of an accident. Approximately 1.3 million people die each year on the world's roads, and between 20 and 50 million suffer non-fatal injuries. In 2004, road traffic injuries were the ninth leading cause of death, and the WHO predicts that they will become the fifth by 2030 [1]. It is generally recognized that hazards in road traffic due to the use of mobile phones result primarily from longer reaction time and lower detection rate of cues related to driving information changes as a result of the attempt to perform two tasks simultaneously: driving a motor vehicle and

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receiving a call [2–6]. While analyzing the influences of various aspects of phone calls on driving, such as the call time (short vs. long) or the type of call (simple vs. complex) [7], the question arises whether the driver's impaired performance may be further adversely affected by the influence of the electromagnetic fields (EMF) emitted by mobile phones on the physiology of the driver. This influence is practically unknown, although it is generally recognized that such EMFs affect the central nervous system. It has already been demonstrated that EMFs may affect EEG recordings in subjects performing complex mental tasks [8,9], as well as modify human working memory and cognitive functions [10,11]. Thus, it seems reasonable to suppose that an EMF emitted by a mobile phone while driving a motor vehicle may adversely affect a driver's response to road traffic situations. So far, no such results from studies have been accessible and, therefore, it was necessary to start such research under well-controlled conditions, with suitable control of the driver's physical and mental condition and of the EMF emitted by the cellular phone. This study provides dosimetric data which will serve as the basis for further research intended for the coming years on the influence of EMFs emitted by mobile phones on the physiology of drivers.

## MATERIALS AND METHODS

The study was performed in the Nofer Institute of Occupational Medicine using two motor vehicle driving simulators produced by ETC PZL (Warsaw, Poland): a Mercedes Actros Truck and an Autosan A1010. EMF exposure was facilitated using a commercial Nokia 6650 mobile phone controlled by Phoenix Software (maintenance software dedicated to Nokia products), set to emit an UMTS test signal [12]. The source used in our experiment enabled the generation of a signal identical to that occurring in real conditions, with full repeatability and stability ensured.

Mobile phones are usually held close to the ear while talking, despite this being prohibited in some countries, or are placed on a dashboard as a part of a hands-free kit. In the exposure system employed in this study, both above-mentioned configurations were considered. The phone was placed at the position of the driver's head or on the simulator's dashboard. For the purpose of this project, the power emitted by the phone was set at 49 mW delivered to the antenna (full power – which represents its use in rural areas with a poor base station signal) or 9.7 mW (approximately 20% of maximum power – which represents urban areas with good base station coverage). For the measurements of the electric field strength (magnitude and distribution), an NBM-550 broadband field meter with an EF1891 isotropic electric field probe (NARDA Safety Test Solutions, Pfullingen, Germany) was applied; the range of measurements was 0.6–35 V/m (true RMS) in the frequency range 3 MHz–18 GHz, accuracy ±0.76 dB. The measurements were performed with the holder to make sure that the person performing them did not disturb the EMF. For every applied configuration, the maximal value of the electric field strength was measured, as


**Photo 1.** The setup of the exposure system for line measurements inside the Mercedes Actros simulator

were the values at 16 measurement points corresponding to parts of the body of a driver (Mercedes Actros truck and Autosan A1010 bus) or passenger (Mercedes Actros truck) (see Tables 1 and 2). All measurements were performed at least 3 times.

Additionally, linear measurements (Photo 1) using a data logger with the NBM-550 meter placed on a holder at 1 cm intervals along a line crossing the cab (such as one connecting the antenna with the front window, as presented in photo 1, were performed in the Mercedes Actross truck and Autosan A1010 simulators, and in the free space outside the cabins.

## RESULTS

The stability of the source was confirmed. During 1 h of continuous emission of the test signal, the electric field strength measured in the chosen point was constant.

The results of the spatial distribution of the electric field are presented in Tables 1 and 2. For all measured locations,

**Table 1.** Exposure of the driver and the passenger of the Mercedes Actros truck driving simulator to the UMTS test signal emitted from a Nokia 6650 mobile phone

| No. and description of measurement points | | Electric field strength, E [V/m] | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | driver's exposure | | | | passenger's exposure | | | |
| | | telephone at the driver's head | | telephone on a dashboard | | telephone at the driver's head | | telephone on a dashboard | |
| | | P = 49 mW | P = 9.7 mW | P = 49 mW | P = 9.7 mW | P = 49 mW | P = 9.7 mW | P = 49 mW | P = 9.7 mW |
| Max | at the right ear | 27.0 | 13.3 | | | | | | |
| | elbow, right | | | 8.6 | 4.1 | | | | |
| | shoulder, left | | | | | 7.4 | 3.3 | | 2.8 |
| | neck | | | | | | | 5.6 | |
| 1 | head top | 6.4 | 2.3 | 4.0 | 1.9 | 2.4 | 1.2 | 3.2 | 2.0 |
| 2 | front | 17.4 | 9.0 | 5.7 | 2.3 | 2.7 | 2.2 | 4.0 | 1.9 |
| 3 | chin | 14.3 | 7.6 | 2.8 | 2.5 | 3.9 | 1.3 | 4.3 | 1.7 |
| 4 | neck | 7.2 | 4.2 | 7.5 | 3.7 | 3.2 | 1.1 | 5.6 | 1.8 |
| 5 | heart | 10.4 | 4.2 | 7.7 | 3.3 | 4.2 | 1.9 | 4.5 | 2.3 |
| 6 | gonads | 14.9 | 2.6 | 4.8 | 1.8 | 2.9 | 1.1 | 4.0 | 1.2 |
| 7 | knee, right | 6.0 | 2.4 | 7.0 | 3.0 | 3.8 | 2.0 | 3.0 | 1.4 |
| 8 | knee, left | 5.6 | 2.5 | 6.5 | 2.5 | 4.5 | 2.1 | 3.8 | 1.6 |
| 9 | foot, right | 5.0 | 2.1 | 4.5 | 1.9 | 3.8 | 1.5 | 2.4 | 1.2 |
| 10 | foot, left | 5.0 | 1.9 | 3.8 | 1.1 | 4.8 | 2.2 | 4.4 | 1.7 |
| 11 | shoulder, right | 7.3 | 4.0 | 7.0 | 2.9 | 3.1 | 1.7 | 4.6 | 2.3 |
| 12 | shoulder, left | 5.4 | 1.8 | 5.1 | 2.5 | 7.4 | 3.3 | 5.1 | 2.8 |
| 13 | elbow, right | 7.7 | 3.9 | 8.6 | 4.1 | 4.0 | 2.9 | 5.4 | 1.8 |
| 14 | elbow, left | 6.6 | 2.0 | 4.0 | 1.5 | 5.0 | 1.5 | 5.1 | 2.1 |
| 15 | hand, right | 7.6 | 3.0 | 5.9 | 2.5 | 6.0 | 1.8 | 3.4 | 1.2 |
| 16 | hand, left | 3.5 | 1.2 | 3.8 | 1.1 | 5.4 | 1.7 | 4.0 | 2.1 |

P – power delivered to phone antenna.

**Table 2.** Exposure of the driver of the Autosan A1010 bus driving simulator to the UMTS test signal emitted from a Nokia 6650 mobile phone

| | No. and description of measurement points | Electric field strength E [V/m] | | | |
|---|---|---|---|---|---|
| | | telephone at the driver's head | | telephone on a dashboard | |
| | | P = 49 mW | P = 9.7 mW | P = 49 mW | P = 9.7 mW |
| Max | at the right ear | 27.0 | 13.3 | | |
| | foot, right | | | 15.2 | 6.2 |
| 1 | head top | 6.9 | 2.4 | 3.2 | 1.3 |
| 2 | front | 11.2 | 5.2 | 2.2 | 0.7 |
| 3 | chin | 14.6 | 7.0 | 3.0 | 1.8 |
| 4 | neck | 4.3 | 2.1 | 3.8 | 2.5 |
| 5 | heart | 7.0 | 4.2 | 4.8 | 1.7 |
| 6 | gonads | 7.0 | 3.6 | 7.0 | 2.7 |
| 7 | knee, right | 4.3 | 1.9 | 8.8 | 4.2 |
| 8 | knee, left | 4.6 | 2.1 | 6.2 | 2.5 |
| 9 | foot, right | 6.3 | 2.8 | 15.2 | 6.2 |
| 10 | foot, left | 4.2 | 1.8 | 7.1 | 3.0 |
| 11 | shoulder, right | 5.2 | 3.5 | 3.8 | 2.1 |
| 12 | shoulder, left | 6.7 | 2.9 | 3.8 | 2.0 |
| 13 | elbow, right | 3.1 | 2.6 | 3.9 | 1.7 |
| 14 | elbow, left | 5.8 | 2.4 | 3.5 | 1.5 |
| 15 | hand, right | 5.9 | 3.5 | 8.5 | 4.6 |
| 16 | hand, left | 5.0 | 2.6 | 5.5 | 2.4 |

P – power delivered to phone antenna.

standard deviations equaled less than 5% of the value presented in the tables.

When the power was set for the maximum (49 mW), a value of 27 V/m was measured in the vicinity of the driver's head when the phone was close to the head. With the same power, when the phone was placed on the dashboard, the measured maximum was 15.2 V/m in the vicinity of the driver's foot.

The selected results of the linear measurements performed in the Mercedes Actross and in the free space outside the simulators are presented in Figure 1. Significant perturbations in EMF distribution were observed, as well as an increase in the measured electric field strength values in the simulator, in comparison to free space measurements: for instance, 9 EMF peaks were observed at a distance of 1 m from the mobile phone and the electric field strength was up to 3 times higher inside the simulator. Those values are elevated mainly due to the induction of EMF in the simulator's metal parts and EMF rebounding from metal exterior planes. Our results correspond to those published by other authors, showing an increase of exposure inside a motor vehicle compared to the theoretically calculated free space conditions [13].

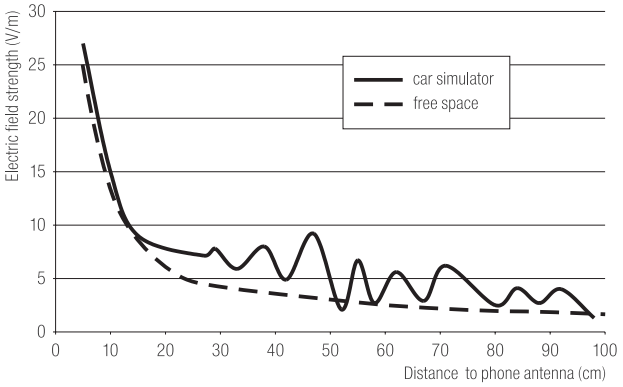


**Fig. 1.** Electric field strength from the Nokia 6650 mobile phone set for the UMTS test signal emission (P = 49 mW) inside the Mercedes Actros simulator and in the free space outside it

## DISCUSSION

The obtained exposure system provides very stable levels of EMF inside the driver's cabin of a vehicle simulator. The intensity and distribution of EMF forms the basis of future studies of the EMF emitted by mobile phones and their influence on driver physiology. However, at this stage, SAR evaluation without specific personal data is practically impossible: the participation of human subjects is needed for precise presentation of the results.

Considering that mobile phones constitute an almost indispensable element of the outfit of every contemporary person, reduction of the exposure to mobile phone EMF should be regarded as a benefit by every mobile phone user. In particular, considering that RF EMFs, which comprise *inter alia* the frequencies used by mobile phone systems, have been classified by the International Agency for Research on Cancer (IARC) as an agent possibly carcinogenic to humans (group 2B) [14], such an attitude seems to be reasonable. Therefore, irrespective of the future results of research on the possible effects of EMF on driver physiology, it is reasonable to postulate, based on the results of this pilot study, that it is advisable to keep mobile phones at a distance from the head, and to use hands-free kits whenever possible to reduce EMF exposure, both on the part of the drivers and the passengers.

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