Assessment of ELF Current Distribution induced in the Human Head from UMTS and GSM Mobile Phones

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Background

Over the past years, numerous scientists, engineers, epidemiologists, and physicians have investigated the possible effects of high and low level electromagnetic fields (EMF) on humans. Studies were conducted addressing the identification of potential biological effects due to exposure to low-level EMF in a broad frequency range covering extreme low frequencies (ELF) to radio frequencies (RF). Although there are various findings of biological effects reported in the low frequency (LF) and RF ranges, a concrete mechanism has not yet been established. Thus, the effects from a particular frequency range cannot be disregarded when assessing the exposure to complex devices such as mobile phones, generating fields in various frequency ranges (LF and RF).

Currently, mobile phones operated at the human head are considered the strongest source of human exposure to RF EMF, i.e., worst-case exposure can be close to the established safety limits. Over the past decade, the majority of exposure assessment studies focused on the exposure to the strong RF EMF generated by the phone's antenna operating at frequencies between 400MHz and 3GHz. However, LF EMF, i.e. lower than 20kHz, are also generated by other elements of the phone, e.g., by the supply currents or the audio speaker. There are considerably fewer studies dealing with the characterization of exposure to these fields from mobile phones used in the normal operating mode, i.e., at the head.

While there is very limited knowledge about LF exposure from mobile phones, there is no data at all in the literature on LF exposure from phones using the Universal Mobile Telecommunications System (UMTS) communication system. Despite this, UMTS technologies are becoming more and more common and Global System for Mobile Communications (GSM) technology is slowly being phased out. Characterization of the RF output power of UMTS phones has shown that the average exposure to RF EMF of this technology is smaller than in GSM by more than a factor of 100. Nevertheless, a recommendation for this technology cannot be made without evaluation of the LF exposure, which has the potential to be higher than for GSM due to the higher current consumption of UMTS signal processors.

Objectives

The aim of this project is to evaluate the maximum and the average usage-dependent induced electric fields and currents due to the exposure to LF magnetic fields created from mobile phones operated at the human head. The objective is to establish a scientific basis to compare the overall LF and RF exposure of different mobile communication technologies (GSM and UMTS). The induced LF fields from mobile phones will be compared to international safety limits and to common sources of LF EMF exposure in order to classify the relevance of mobile phones with respect to the total dose in the LF range.

Methods

Initially, the spatial distribution of LF magnetic field around ten mobile phones using the GSM and UMTS communication systems will be experimentally assessed. The magnetic field distribution at every location will be measured in the frequency and time domains. The experimental data from this selection of mobile phones will be used to develop equivalent sources for numerical simulations. The equivalent sources will be simulated using a sufficiently large sample of anatomical head models to enable the extrapolation to cover the entire user population, i.e., to assess the average and variations as functions of the human anatomy. The high-resolution head models of the Virtual Family, designed for this type of application, will be used for the numerical simulations. The LF EMF induced in the heads will be extracted and averaged following the schemes described in three prevalent international guidelines and

standards limiting EMF exposure (IEEE C95.6, ICNIRP 1998, ICNIRP 2010), allowing the results to be compared to the current basic restrictions limiting human exposure to LF EMF. In addition, the induced EMF in the various tissues of the human head and in functional sub-regions of the human brain will be determined using post-processing algorithms based on the Talairach Atlas. The numerical and experimental results will be combined with data from extensive evaluations of the RF output power as function of technology, user behavior, environment, and base-station density, allowing the assessment of the maximum ELF exposure as well as the average exposure as a function of the environment and user behavior.

Expected Results

The conducted research will provide valuable information regarding EMF exposure to the general public and the scientific community, as well as to the mobile communication industry. The results obtained will allow the knowledge gaps with respect to LF exposure from mobile phones to be closed. Furthermore, using the acquired data of absorption in anatomical human heads, the exposure to LF EMF from mobile phones will be compared with the exposure to other LF near-field sources. The results will also provide rationales for recommendations of appropriate designs for biological studies addressing health risks due to LF exposure. The method of analysis that will be used during the project will ultimately provide insight into how the various safety regulations (ICNIRP and IEEE) differ for realistic LF near-field exposure. Finally, this project will provide the industry with information on how to reduce LF exposure, and will also lead to conclusions for the public and health agencies on usage requirements to minimize the combined exposure to both LF and RF EMF from mobile phones.