



## Final Report

Project reference: C2012-01

Applicant's name: Jürg Fröhlich

Project title: Novel Approaches to Assess the Contribution of Close-to-Body Devices of the Personal Radiofrequency Electromagnetic Field Exposure

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### 1. State of Research

#### 1.1 Research activities performed, milestones and deliverables accomplished

*Please list against the background of the research proposal.*

The objectives of the project were:

- Improvement of the hardware of the exposure measurement device in order to allow for more variable measurement protocols
- Development of Smartphone Apps collecting additional exposure relevant data on the use of close-to-body devices
- Validation of device in laboratory measurements and an epidemiological cohort study on adolescents

The project consisted of two modules:

#### **Module A: Hardware and Software Development and Experimental Testing**

Within this module the following activities within 5 work packages were carried out:

##### Workpackage 1/2: Evaluation and preliminary testing of hardware and software concepts; Implementation and manufacturing

The hardware of the ExpoM exposure meter was improved with respect to:

- Improved analog crosstalk suppression on all bands
- Addition of the ISM 5.8 and U-NII 1-2e bands (5.150 - 5.875 GHz)
- Addition of FM band (87.5 - 108 MHz)
- Addition of integrated GPS module
- General performance improvements regarding sensitivity and dynamic range for frequency bands above 2.5 GHz (LTE2600 & WiMax, ISM5.8)
- Separate measurement of uplink and downlink of the 'LTE 2600' band

The hardware was extensively tested. The new devices include all the enhancements. In addition to the hardware enhancements several improvements regarding the manufacturing were implemented.

Further hardware concepts were developed and tested:

- Envelope tracking (20 MHz video bandwidth)
- Signal peak detection
- Simultaneous detection of peak and RMS value for advanced signal pattern analysis

##### Workpackage 3: Testing and calibration of devices

A standardized test and calibration environment using an anechoic chamber and a TEM cell for the FM band was set up.

##### Workpackage 4/5: Determination of correlations between operational data and EMF values for close-to-body devices; Application of new and improved features to new and previously collected data

Extensive tests in controlled environments as well as in representative real-world scenarios were carried out. These include measurements in an anechoic chamber, in a moderately reflecting environment, in a reflecting environment and on a route around the University Hospital Zurich and through the ETH campus. All experiments were performed with a test person carrying three exposure meters.

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## **Module B: Validation study in an ongoing epidemiological study of adolescents**

The devices were used within an ongoing epidemiological study on adolescents (HERMES). The aim of the study was to investigate whether exposure to RF-EMF emitted by mobile phones and other wireless communication devices causes behavioural problems. Within this study an RF-EMF exposure surrogate for epidemiological research was developed and the data of more than 100 volunteers was collected. The results are presented in the publications by Roser et al. (2015).

### **1.2 Findings**

*Comment on achieved scientific insights.*

The technological improvements resulted in an increased performance of the personal exposure measurement device. The uncertainty regarding crosstalk was reduced and the sensitivity could be improved. The extensive study in different environments showed a high degree of repeatability of the measured values recorded using the exposure meter devices. The laboratory and outdoor measurements (see Annex) resulted in a procedure for the reduction of the uncertainty regarding the use of close-to-body devices. However, this procedure requires the recording of operational data of the devices used by the person whose personal exposure shall be tracked.

Within the epidemiological study on adolescents data from 90 adolescents were of sufficient quality to be analysed. The study participants were between 13 to 17 years and measurements were conducted between May 2013 and April 2014. Main contributors to the total personal RF-EMF measurements of  $67.1 \mu\text{W}/\text{m}^2$  ( $0.16 \text{ V}/\text{m}$ ) were exposures from mobile phones (63.2%) and from mobile phone base stations (18.7%). For those not using the mobile internet on their mobile phone downlink is the most relevant contributor to the measured exposure. WLAN in school and at home had little impact on the personal measurements (WLAN accounted for 3.3% of total personal exposure). According to the dose calculations, exposure from close to body sources contributed on average 93.6% to the brain dose and 90.2% to the whole-body dose. In summary, the measurements and subsequent dose calculations demonstrated that for adolescents, on average, the exposure from environmental sources plays a minor role compared to the exposure from the use of wireless communication devices. By comparing the measurements with studies in adults, we did not find indication that adolescents are higher exposed than the average population despite their frequent wireless device use.

### **1.3 Problems**

*Expand on research, financial or schedule problems, if any. For the intermediate report: please include problems that might occur in the upcoming period.*

## **2. Annex**

### **2.1 Publications**

*Please enclose the scientific publications produced in the context of the project.*

Roser K., Schoeni A., Bürgi A., Rösli M., (2015), Development of an RF-EMF Exposure Surrogate for Epidemiologic Research, Int. J. Environ. Res. Public Health, No. 12, pp. 5634-5656.

Roser K., Schoeni A., Struchen B., Zahner M., Fröhlich J., Rösli M., (2016), Personal radiofrequency electromagnetic field exposure measurements in Swiss adolescents, under preparation.

Rösli M., Roser K., Schöni A., Rechsteiner D., Foerster M., Verhaltensprobleme durch Handynutzung? Bildung Schweiz 2014; 3: 7-8.

Zahner M., Fröhlich J., ExpoM - A Personal RF-EMF Exposure Meter, Workshop on " New avenues in epidemiological exposure assessment", BioEM 2014, Annual Joint Meeting of the Bioelectromagnetics Society ([BEMS](#)) and the European BioElectromagnetics Association ([EBEA](#)), Cape Town, South Africa, June 2014.



Forschungsstiftung Strom  
und Mobilkommunikation  
Research Fndn for Electricity  
and Mobile Communication

Zahner M., Fröhlich J., EMF exposure metering: Dealing with pulsed RF signals, BioEM 2014, Annual Joint Meeting of the Bioelectromagnetics Society ([BEMS](#)) and the European BioElectromagnetics Association ([EBEA](#)), Cape Town, South Africa, June 2014.

## 2.2 Documents

*In case publications are not yet available or cover only part of the funded research, please include:*

- submitted papers (confidentiality is secured), or
- concise internal documents that inform about your research work, or
- a short progress (2-3 pages) or final report that summarises the state of research

Zahner M., Fröhlich J., Evaluation of Proxies for the Determination of the RF-EMF Exposure Caused by Close-to-Body Devices, Report on Laboratory and Outdoor Measurements, 2016

## Date and Signature

Zürich, 29.3.2016