

**COST EMF - MED (Action BM1309):  
European network for innovative uses of EMFs in biomedical applications**

STSM Report:

**Mechanistic Modeling, Optimization and Risk Assessment of Electro-Muscular  
Incapacitation Devices (EMD)**

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**Abstract:**

The Foundation for Research on Information Technologies in Society (IT'IS) and the research team of the Faculty of Technical Sciences, University of Novi Sad (FTN-UNS) are developing a collaborative project on the mechanistic modeling, optimization, and risk assessment of human electro-muscular incapacitation devices (EMID). The goal of this project is to gain a better understanding of the fields generated by EMIDs and how they interact with the human body to elicit neuromuscular incapacitation and unwanted cardiac stimulation. The project represents a unique opportunity for FTN-UNS to develop capacities in an area of expertise very much in demand by working on a very timely topic.

**A. Purpose of the STSM**

The primary objective of the proposed STSM visit was to enable Dr. Nikola Djuric and the FTN-UNS team to acquire in-depth knowledge of and training in the technologies developed by the IT'IS Foundation in the areas of dosimetric sensors and computational life sciences and their applications to exposure, safety, and effectiveness evaluation, in particular EMIDs.

The second objective was to broaden Dr. Djuric's knowledge base on which to build scientific and technical expertise for future research at his home institution, in particular, to identify additional collaborative projects on the medical applications of EMFs that are relevant to the priorities identified within this COST Action.

**B. Work Description**

Dr. Djuric's STSM lasted two weeks according to the following work plan:

1. Introduction to IT'IS experts and their core research activities –1 day:

During the first meeting, Dr. Esra Neufeld presented the core IT'IS research activities, with particular emphasis on Computational EM (CEM) technology, as well as Health Risk Assessment – Interaction Mechanisms and Exposure Systems. Additionally, some wonderful presentations were given regarding IT'IS research in:

- a) Hyperthermia in Oncology
- b) Wireless Power Transfer
- c) Coupled EM-Neuron Dynamics Modeling.

The CEM modeling tools and computational phantoms (Virtual Population (ViP), SEMCAD X, and Sim4Life) were presented by Elaine Barretto. Those presentations were the basis for the next few days of intensive training on CEM tools.

2. Extensive training with CEM modeling tools – 5 days:

The Sim4Life simulation software package was the focus of my training. On the first day, several details on installation, setup, and licensing were presented to me, in order to properly run Sim4Life on a single PC, as well as in a network environment. Also, the Sim4Life package was installed on my laptop, and I was introduced to its working environment.

During the first two days of training, I was introduced to the essentials on working with Sim4Life Modeling, Simulation, and Data Analyses modules. The Model environment, Materials, EM solver, Data Analysis & Post Processing, Segmentation and Python Scripting Environment were analyzed in detail using specific examples given in the Sim4Life manual.

During the next two days of training, I worked with specific problems presented through the tutorial, such as:

- a) SAR in a Flat Phantom – analyzing EM-FDTD solver on the flat phantom and the symmetric dipole antenna of the DASY5 system;
- b) SAM Phantom with Generic Phone – simulating the average peak SAR of the Specific Anthropomorphic (SAM) Phantom exposed to the radiation of a generic mobile phone;
- c) Electro Static solver – to calculate the electric field and potential between two metallic spheres;
- d) Transcranial Magnetic Stimulation – analyzing the field in the brain generated with a current loop placed above the head;
- e) Bifurcating Blood Vessel – simulating the blood flow at the branch of the abdominal aorta into the common iliac arteries.

On the last day of training, the ViP computational phantoms were presented, as well as details on installation in a PC environment and their import as a digital model into Sim4Life and SEMCAD X.

3. Introduction to IT'IS research on dosimetry for partial body and local EMF exposure, demonstration of probes and training with DASY52 NEO; meeting with appropriate IT'IS team members to discuss potential collaboration through international consortiums (e.g., COST framework, SCOPES call, and, in the future, HORIZON 2020) – 2 days.

I had opportunity to see first-hand a functioning DASY52 NEO and become familiar with its basic functionality during a system testing and working session with an IT'IS team member. The DASY52 system was installed in a chamber and some specific tests were performed with a liquid medium and SPEAG probes. However, since those tests were for internal research, I was only an observer.

During the second day meeting, the potential collaboration within consortiums was discussed for HORIZON 2020. Moreover, some specific details on the SCOPSE framework were considered, specifically, a potential bilateral research collaboration between Switzerland and the Republic of Serbia.

4. Presentation of the current FTN-UNS research activities and curriculum - 1 day

During this meeting I presented basic information about FTN-UNS and our current research. During the discussion, several ideas were considered on the further enhancement and expansion of FTN-UNS research in bioelectromagnetics.

Special attention was given to a new study program, Bioelectromagnetic Engineering, launched in 2013 at FTN-UNS. As a relatively new program at our University, there is a wide range of possibilities to consider for curriculum improvement and innovation, as well as for the creation of new courses. Moreover, the idea to introduce the IT'IS CEM tool to the students was also considered.

#### 5. Preparation of a draft proposal for a joint project - 1 day

During June-July, the Ministry of Education, Science and Technological Development of the Republic of Serbia will announce a public call for national project proposals for the period 2016-2020, where a special section will be devoted to Electronics in Biomedical engineering – effects of electromagnetic radiation and its application in medicine.

Since this topic is highly relevant and is relevant to our COST MB1309 Action work-plan, we discussed the possibility to draft a proposal for a joint project focusing on advanced mechanistic research of neuron stimulation triggered by incapacitation devices and on the optimization of neuroprosthetic applications.

Moreover, the ideas related to hyperthermia in oncology and EM-neuron dynamics modeling were considered potentially fruitful.

We have agreed to make the final decision on the joint project topic in the next period, when the official call will be available to researchers.

### C. Results

The main achievement of this STSM was my intensive training with IT'IS CEM modeling tools, Sim4Life, and ViP computational phantoms. IT'IS agreed to provide a Sim4Life package to the FTN-UNS team members for training at home.

We highly appreciate this very kind offer, since the FTN-UNS team will have opportunity to work extensively with Sim4Life, which will help us to better prepare a joint proposal for the expected project call.

Another valuable outcome from my visit was the introduction to the specific research activities of the IT'IS team, especially regarding risk assessment of human EMID devices, hyperthermia in oncology, as well as wireless power transfer and the evaluation of compliance of wireless power transfer systems with respect to human electromagnetic exposure limits.

Finally, the mutual understanding and agreement to prepare a joint proposal is a highly valuable result of this visit, as well as the inspiring discussions with IT'IS team members on the improvement of FTN-UNS research in bioelectromagnetics and new course designs for the Biomedical Engineering study program at FTN-UNS.

### D. Future collaboration with host institution

The intensive work on the joint project proposal will start very soon, while full collaboration and joint research will start in 2016.

Besides the research activities, collaboration through the education and training of the FTN-UNS team members is open, as well as joint participation in future consortiums for HORIZON 2020.


### E. Expected Publications

The number of publications is foreseen in next few years, regarding common research work, especially in top-rated peer-review journals. We expect to publish at least two papers in 2016: one at an international scientific conference and one in a peer-reviewed journal.

F. Other Comments**Confirmation by the host institution of the successful execution of the STSM:**

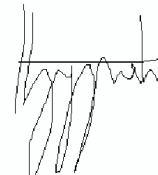
We confirm that Dr. Nikola Djuric has performed the research work as described above. The CEM training was conducted in accordance with the working plan, while discussions during several meetings resulted in numerous ideas regarding collaboration. Dr. Djuric also broadened his knowledge base on which to build his expertise for future research at his home institution.

NIELS KUSTER



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