

## Scientific Report

Reference	<b>CyberParks ECOST-STSM-TU1306- 26848</b>		
Name	Jugoslav Jokovic		
Home institution	Faculty of Electronic Engineering (FEE), University of Nis, Nis, Serbia(RS)		
STSM Topic	Propagation and distribution of electromagnetic field from ICT devices in public spaces		
Period	from	23/05/2015	to 31/05/2015
Host institution	Universidad Autonoma de Barcelona (UAB), Department of Geography, Barcelona, Spain (ES),		

### (1) Abstract

This scientific mission is proposed in order to analyze the relevance of the propagation and determination of electromagnetic (EM) field level from RF (radio frequency) and microwave sources (broadcasting transmitters, base station for mobile networks, local networks), in particular the service area determination and EM field exposure, in terms of planning, management and usage of public spaces. EM field exposure, caused by the increased and unavoidable presence of RF and microwave radiation from ICT devices as various sources of EM field, has emerged as an important social and public issue. Since the necessity of EM field monitoring in context of using ICT in public spaces, as well as the public promotion and education on the risk of EM field exposure, represent a significant social goal, the several technical challenges have been foreseen in the development of the proposed research: from the method for exposure assessment in case of broadband monitoring approach and modelling of EM field in vicinity of RF and microwave sources - base stations, broadcasting transmitters, local wireless networks, together with the distribution of EM field from ICT devices used by visitors of public spaces, through the appropriate measurement and exposure assessment methods, to the adequate software support for geo-visualization, acquisition of the data, their processing and public dissemination. Accordingly, the expected achievements of this STSM were formulated as following: specification of research strategy for joint development of solutions for determination of EM field exposure in public spaces, research of methodology suitable for mapping

by GIS (Geographic Information Systems) approach - in order to creating a map of public spaces with levels of EM field exposure, and preparation of first draft of joint scientific publication in an International Conference or a Journal.

## (2) Purpose of the STSM

The relevant issues and open questions related to exposure to electromagnetic fields from base station antennas - in relation to public spaces:

- What levels of electromagnetic fields are found in the public spaces?
- How do these levels to electromagnetic fields comply with standards and regulations regarding Quality of Service and potential health effects?
- How does the planning, management and using of public spaces relate to geo-spatial distribution of exposure levels?

The aims of mission are defined as:

- Analyze the relevance of the propagation and determination of electromagnetic (EM) field level from RF and microwave sources (broadcasting transmitters, base station for mobile networks...) - service area determination and EM field exposure, in terms of planning, management and usage of public spaces.
- Analyze the use of ICT devices and EM field exposure in public spaces – modelling and measurements, verify conclusions about the abilities of numerical methods as a tool for determining the effects of EM fields from ICT devices used as terminals in public spaces.

## (3) Description of the work carried out during the STSM

Work: ***Determination of EM fields exposure from RF sources - in relation to using of public spaces***

Time table of the STMS:

24.05. Internet research and literature review on STSM topic

25.05. Meeting with Montserrat Pallares-Barbera; Working on the methodology of the researches

*26.05. Skype Meeting with Fernando Alvarez and Montserrat Pallares-Barbera; Working on the methodology of the researches*

*27.05. Working on the methodology of the researches; Creating the review for standards and regulative regarding STSM topic*

*28.05. Field work – Plaza Catalonia: Measurements*

*29.05. Creating documentation from the researches and measurements*

*30.05. Analyses of results; Writing report from the field work*

Stages:

1) Internet research and literature review on STSM topic

Electromagnetic (EM) field in public spaces is considered in terms of Quality of Service (QoS) providing using of ICT, as well as potential health effects.

The review of previous works related to topic and analyses of results were done, as a outcome of this stage:

- Review on the level of exposure (frequency, modulation) in the European Union –
- Classification - exposure of sources far from the body - fixed sources, and body-close portable sources - Mobile phones and Short range wireless devices, broadband vs narrowband
- Implementation in science, guidelines, standards and regulations:
- *International Commission for Non-Ionising Radiation Protection (ICNIRP) - guidelines on exposure limits for electromagnetic fields in the frequency range from 0 Hz up to 300 GHz.*
- *IEEE Standard for Safety Levels with Respect to Human Exposure to RF Electromagnetic Fields, 3 kHz - 300 GHz,*
- *CENELEC, Human Exposure to EM Fields, High Frequency (10 kHz to 300 GHz), European Prestandard.*

Reference levels for the general public at 900 and 1800 MHz:

	900 MHz limits		1800 MHz limits	
	Electric field	Power density	Electric field	Power density
	V/m	W/m <sup>2</sup>	V/m	W/m <sup>2</sup>
ICNIRP	41.25	4.5	58.3	9.0
IEEE	47.6	6.0	67.3	12
CENELEC	41.1	4.5	58.1	9.0

- EM field exposure prediction models, measurements
- Trends of the EMF exposure – future technologies

2) Methodology of the researches - Determination of electromagnetic (EM) field level using numerical method and mapping by GIS approach

The technical setting up for modeling of geo-spatial variability in electric field strengths for public space – case study, has been considered, in terms of methodology, tools and input data.

Using a developed software tool based on *Recommendation ITU-R P.1546-5 - Method for point-to-area predictions for terrestrial services in the frequency range 30 MHz to 3 000 MHz*, EM field in vicinity of mobile base station can be determined, using input data from mobile phone network operators data: *base station coordinates, height, horizontal direction, vertical tilt, antenna type/radiation pattern, operating frequency, output power of antenna.*

*LIDAR -Digital map of public spaces – case study: Forum de Les Cultures / Carrer d’Enric Granados, Barcelona*

3) Fieldwork – survey and measurements

*EM level measurement: application G-MoN is used to determine parameters of received signal from RF sources for different places in Barcelona.*

The mobile service RX level:

-83 dBm

The measurements of WiFi RX level:

Distance(m)	1	2	2	3	3	5	5	5	7.5	7.5
Line of sight / Obstruction	LoS	LoS	Table	LoS	Table	LoS	Table	Wall	LoS	Wall
RX level (dBm)	-42	-48	-51	-55	-58	-60	-63	-67	-67	-74

#### (4) Description of the main results obtained

##### 1) Interpretation of data / comparison with measurements

Data treatment and analysis:

- Comparison modeling result and measurements
- Comparison obtained results with reference levels defined by ICNIRP (International Commission for Non-Ionising Radiation Protection)

##### 2) Discussion of the preliminary results and preliminary conclusions

Conclusion related to the relevance of EM field level in public spaces and recommendations for further studies:

- Exposure levels in the public areas in the vicinity of base stations are varying by several orders of magnitudes, due to differences in the input power of the antenna, different types of antennas,

variation of location of the measuring position in respect to the antenna and different environmental or shadowing factors.

- Detailed analyses of data is only possible if type and characteristics RF sources are included as well terrain characteristic.
- Variations in EM field level (temporary, type of areas...) should be taken into consideration. Nevertheless, these variations and uncertainties have no impact in terms of conclusion that exposure levels were well below the reference levels of the ICNIRP guidelines.

For precise measurements of EM field, as a minimum, specification of the methods used should be reported, with details about frequency range, resolution bandwidth, sample time, method of averaging, antenna type, antenna direction and antenna height over ground, as well as type of surroundings such as inner city first floor balcony or open spaces. The standardized report of measurement includes: purpose of the measurement (compliance, comparison or scientific), and site selection method (random, close vicinity of a specified base station, etc.), type of area (inner city, rural area etc.), site characteristics (indoor or outdoor, ground level or on roof/terrace/balcony), and further details of the exposure situation. If a particular base station is identified, the distance should be included. Also, the time of measurement must be specified (year, weekday/weekend, time of day). The measurement results include the highest power density and respective frequency, and the sum of all power densities in the appropriate (and specified) frequency bands.

#### **(5) Follow-ups - future collaboration with host institution and foreseen publications or papers for conferences/congresses resulting or to result from the STSM (if applicable)**

Within the future collaboration with host institution -UAB Department of Geography, together with WG1 leader as technical tutor of this STSM, the several issues might be concerned:

- Share the all knowledge about EM field exposure in public spaces – standards and regulations, geo-spatial modeling, measurements; within the project partners of the COST Action 1306 CyberParks.
- Specify of research strategy for joint development of solutions for determination of EM field exposure in public spaces - modeling of EM field propagation and distribution (possibility of including

one of the case studies of Barcelona - depending on availability of input parameter of base station antenna), mapping by GIS approach (creating a map with levels of EM field exposure) and verification by measurements.

- Prepare a draft for publication or policy paper for a Journal or Conference – related with EM field technologies and wireless networks management, as well as impact to environment;

From a technical point of view, research that started during this mission in Barcelona, in collaboration with the host institution of the STSM and WG1 leader as technical tutor, allow further analysis of the use and the results obtained by measurements and modeling. The framework for future collaboration will be proposed with the MTWC team from FEE Nis, Serbia (the group of researchers who are working at the EM field propagation), based on comparison of results obtained from geo-spatial modeling data with measured values, which could be used to improve the efficiency of the use of data within the spatial planning and design. As a result, the paper on the STSM topic will be proposed, with coauthoring of prof. Montserrat Pallarès Barberà from the Host Institution and Fernando Alvarez as WG1 leader and technical tutor of this STSM. In addition to those technical objectives, the public promotion and education on the risk of EM field exposure, as well as the necessity of EM field monitoring in public spaces, as a significant social issue, could be presented and discussed within CyberParks Project partners.

## **(6) Personnel Benefit and mutual benefits for the Home and Host institutions:**

Since the relationship of ICT devices and public spaces is very interesting and up-to-date interdisciplinary topic, this STSM was very motivated for me in improving my knowledge and exchange experience, particularly in the scope of the main objectives of WG1 CYBERPARKS Action. From a personal point of view, being my start in the area of research targeting public spaces, this experience was very enriching and I will continue reading the publications and to perform research in this topic. The possibility of participating in the STSM was very important because it allowed me to define the future work in the area of research and participate in discussions with other participants in person.

The additional value to this mission is related with the future collaboration between the Home and Host institutions, in terms of performing practical initial research and development of the solutions for determining and mapping of EM field exposure for the most widely used ICT services in public spaces. In this scope, benefits for the Home and Host institutions is on integration of the work of groups at FEE Nis and UAB in joint research and development of efficient solutions for inclusion of information of EM field exposure in GIS based applications, when considering public spaces.

## **(7) Other comments (if any)**

Although the time for preparation and realization of the STSM was too short, I had no problems in application thanking necessary support by MC Chair Dr Carlos Costa Smaniotto, STSM coordinator Gabriela Maksymiuk and members of Executive Board. I would like to highlight the support provided by Dr. Montserrat, the representative of Host institution, and WG1 leader Dr Fernando Alvarez who supported my stay in Barcelona helping me in realization of this mission and defining future cooperation framework. Although the results of research in a short period of this mission do not illustrate the importance of topic, I hope that results of this STSM provide a challenge for further research creating framework for future joint works that will justify support to me by the members of Cyber Parks COST Action



## (8) References

[1] ICNIRP 1998. International Commission on Non-Ionizing Radiation Protection, Guidelines for limiting exposure to time-varying electric, magnetic, and electromagnetic fields (1 Hz - 300 GHz). Health Physics 1998; 78: 494-522.

[2] IEEE 1999. C95.1-1999, IEEE Standard for Safety Levels with Respect to Human Exposure to RF Electromagnetic Fields, 3 kHz - 300 GHz, IEEE Inc. 345 East 47th Street, New York, SH 14878.

[3] CENELEC 1995. ENV 50166-2, Human Exposure to EM Fields, High Frequency (10 kHz to 300 GHz), CENELEC, European Prestandard, ICS 29.020, January 1995.

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TO WHOM IT MAY CONCERN

I confirm that Jugoslav Jokovic, Ph.D., from the Laboratory for Microwave Technique and Wireless Communication, Faculty of Electronic Engineering, University of Nis, Serbia worked in our Department of Geography at Universitat Autònoma de Barcelona, from May 23 to May 31, 2015; doing research work related to "Propagation and distribution of Electromagnetic field of ICT devices in public spaces and social implications, under my supervision and Dr. Fernando Álvarez, U. de Extremadura supervision. This work has been done under the hospice of COST ACTION TU 1306, Short Terms Scientific Mission program.

The visit has been very successful and the results are described in this report, which I confirm.

  
  
Universitat Autònoma de Barcelona  
Departament de Geografia

Prof. Montserrat Pallarès Barberà

31/05/2015