III Feasibility Study for the EMF sensor network construction

INTRODUCTION

The previous decade was marked by an intensive development of wireless communications systems and devices, such as public mobile systems: GSM, DCS, UMTS, LTE, or widely prevalent WLAN networks and other systems like: FM radio, TV, TATRA, DVB, CDMA and other. Wireless radio systems use emission of electromagnetic waves as the basis of communication. The consequence of such use is increase of the level of electromagnetic radiation in the environment. There is a general fear among the population of the effects of such radiation. On the other hand, wireless systems are nowadays irreplaceable part of modern life that cannot be ignored. For these reasons, it is very important to objectively detect the level of electromagnetic radiation in the environment and to regularly monitor the exposure of human beings to radio-frequency electromagnetic fields, especially due to an expected traffic increase in the future wireless networks and the foreseen dense installation of small cells, with base stations being set-up closer to the users.

Radio-frequency electromagnetic radiation is a type of so-called non-ionizing radiation. There is a difference between non-ionizing radiation and ionizing radiation, since their effects are completely different, even though these two types of radiation are very often thought of as being the same. Non-ionizing radiations are electromagnetic radiations with photon energy less than 12,4eV, that cannot ionize atoms and molecules. Beside radio-frequency electromagnetic radiation, to the group of non-ionizing radiations also belong observable ultraviolet light and infrared light, as well as low-frequency electric and magnetic fields. On the other hand, to the group of ionizing radiations belong X-radiation and radioactive materials radiation. Unlike nonionizing radiations, ionizing radiations can produce ions and cause damaging effects to human and environmental health.

An increased concentration of electromagnectic energy in radio-frequency bands cause effects in human beings that can be roughly classified in two basic categories: thermal and stimulative effects. Thermal effect is reflected in the change of body temperature in the area exposed to an increased electromagnetic emission concentration (tissue is warming up), the effect being stronger in less vascularized body tissues. The reason for this is quite simple: blood vessels function as body thermoregulators. Exposed to increased exterior temperature, blood vessels dilate and transmit more energy to the surrounding tissue. Adversely, at lower exterior temperatures, blood vessels contract and less energy is transmitted to the surrounding tissue. Thermal effect depends on incident electromagnetic field parameters (frequency, intensity, polarization, immediate/ remote exposure area), the exposed body's characteristics (size, internal and external geometry, dielectric features of different tissues) and reflecting effects of other objects in the immediate area of the exposed body part.

Stimulative effect is a short-term effect characteristic for approximately up to 100kHz frequency band, manifested as stimulation of neurons and muscle cells, causing in certain cases extreme irritability and fatigue, particularly during a longer exposure to high concentrations of electromagnetic energy.

Electromagnetic radiation from modern wireless devices belongs to radio-frequency electromagnetic radiation with dominant thermal effect.

In order to control the influence of electromagnetic radiation on human beings, international and domestic regulations set forth standards which prescribe limited exposure to electromagnetic fields from telecommunications devices. These standards define limits, denoted by basic cut-off values and derived reference cut-off levels for human exposure to electromagnetic fields. In order to make sure that this requirement is fulfilled in practice, measurements and occasional calculations pertaining to electromagnetic fields from wireless radio-system transmitters are carried out.

Allowed values of electromagnetic emissions were established based on extended research during some last thirty years. The established cut-off values for radio-frequency electromagnetic radiation are based predominantly on the research of thermal and stimulative effects on the human body. It is noticeable that the set cut-off values are significantly below those representing electromagnetic field intensity for which possible harmful effects have been observed. Over the last few years, there have been discussions on whether there are other effects that can negatively affect the human body. However, no substantial proofs of that have been presented so far. The research in this direction will surely continue in the future.

Fast development of wireless telecommunications services is increasingly in the spotlight, among other, due to the fear over electromagnetic radiation resulting from the use of these services, possibly endangering the general population's health. In that respect, the Regulatory Agency for Electronic Communications and Postal Services (RATEL) has launched an initiative for the development of electromagnetic radiation monitoring system in the environment. Accordingly, the subject of this project is Feasibility Study for the construction of EMF sensors, which would enable monitoring of electromagnetic radiation on the defined locations. The Study should show if it is socially reasonable to purchase such a system and should define clear guidelines for the selection of system elements. Furthermore, the Study shall provide an overview of available technical solutions and sensor features, including software and hardware platforms for collection and public presentation of measurement results pertaining to the monitoring of electromagnetic radiation levels.

The general population is, most usually, not acquainted with physical features of the electromagnetic field and is unaware of the effects caused by it. For that reason, people have ungrounded but strong fear from electromagnetic radiation, increasingly influencing growing resistance to the development of wireless networks, representing *de facto* infrastructure of each country. Studies have shown that significant percentage of the population is afraid of possible electromagnetic field effects. Likewise, it has been established that people are commonly more afraid of the impact of base stations, i.e. system radio-transmitters, than of user devices. All of this creates lack of trust between the general population on one hand and wireless telecommunications service operators, on the other.

The solution to this problem is monitoring of electromagnetic radiations by means of measurement and by maintaining communication between all interested parties. The system of monitoring of electromagnetic radiation levels in the environment, under the auspices of the state (in this case RATEL), should contribute to the establishment of trust between the general population, wireless telecommunications service operators and state organs. The main goals of such system are: transparent presentation of measurement results, launch of

public discussion and education on electromagnetic radiation, understanding of basic effects and establishment of trust between all interested parties.

The system for monitoring of electromagnetic radiation levels in the environment must fulfill three basic requirements: objectivity, reliability and continuity. The objectivity is achieved through public announcement of measurement results, whenever measurements are performed. The reliability results from harmonization with international standards pertaining to electromagnetic fields measurements and from exclusive use of calibrated measurement equipment by accredited laboratories. Continuous performance of objective and reliable measurements (24 hours/ 365 days) enables permanent monitoring of electromagnetic radiation levels and maxiumum transparency. Knowing that electromagnetic radiation is visually undetectable, nor can it be perceived by sensory means, continuous measurement results are of utmost importance to the genaral population, since they represent the only unbiased indicator of the real radiation level and its short-term and long-term variability, and therefore contribute to the establishment of trust between all interested parties.

CONCLUSION

The previous decade was marked by an intensive development of wireless communications systems and devices, such as public mobile systems: GSM, DCS, UMTS and LTE, or widely prevalent WLAN networks and other systems like: FM radio, TV, TATRA, DVB, CDMA and other. Wireless radio systems use emission of electromagnetic waves as the basis of communication. The consequence of such use is increase of the level of electromagnetic radiation in the environment. There is a general fear among the population of the effects of such radiation. On the other hand, wireless systems are nowadays irreplaceable part of modern life that cannot be ignored. For these reasons, it is very important to objectively detect the level of electromagnetic radiation in the environment and to regularly monitor the exposure of human beings to radio-frequency electromagnetic fields, especially due to an expected traffic increase in the future wireless networks and the foreseen dense installation of small cells.

In order to control the influence of electromagnetic radiation on human beings, international and domestic regulations set forth standards which prescribe limited exposure to electromagnetic fields from telecommunications devices. In the Republic of Serbia, the limits for exposure to electromagnetic radiation in the areas of increased susceptibility are seth forth in the Law on protection from non-ionizing radiation („Official Gazette of RS“ No. 36/2009) and Rulebook on limits of exposure to non-ionizing radiations („Official Gazette of RS“ No. 104/2009). Outside the areas of increased susceptibility, the existing standards in Serbia are defined by ICNIRP Recommendation. These standards set limits, denoted by basic cut-off values and derived reference cut-off levels for human exposure to electromagnetic fields.

Fast development of wireless telecommunications services is increasingly in the spotlight, among other, due to the fear over electromagnetic radiation resulting from the use of these services, possibly endangering the general population’s health. The general population is, most usually, not acquainted with physical features of the electromagnetic field and is unaware of the effects caused by it. For that reason, people have ungrounded but strong fear from electromagnetic radiation, increasingly influencing growing resistance to the development of wireless networks, representing *de facto* infrastructure of each country. Studies have shown that significant percentage of the population is afraid of possible electromagnetic field effects. Likewise, it has been established that people are commonly more afraid of the impact of base stations, i.e. system radio-transmitters, than of user devices. All of this creates lack of trust between the general population on one hand and wireless telecommunications service operators, on the other.

The solution to this problem is monitoring of electromagnetic radiations by means of measurement and by maintaining appropriate communication between all interested parties, performed by an institution trusted by both sides. The development of the system for electromagnetic radiation monitoring in the environment by RATEL is therefore socially justifiable. The legal framework for this system’s development is the Law on Electronic Communications („Official Gazette of RS“ Nos. 44/2010 and 62/2014), which prescribes that RATEL shall perform measuring of electromagnetic field levels pertaining to electronic communications networks, associated means, electronic communications equipment and terminal equipment, in accordance with cut-off values set in separate regulations. The development of the system of monitoring of electromagnetic radiation levels in the

environment, under the auspices of the state (in this case RATEL), should contribute to the establishment of trust between the general population, wireless telecommunications service operators and state organs. The main goals of such system are: transparent presentation of measurement results, launch of public discussion and education on electromagnetic radiation, understanding of basic effects and establishment of trust between all interested parties.

In the study, a technical solution for the system for monitoring of electromagnetic radiation in line with the international practice and ITU Recommendations (ITU-T K.83 and ITU-T K.113, fulfilling the three basic requirements: objectivity, reliability and continuity was proposed. The objectivity is achieved through public announcement of measurement results, whenever measurements are performed. The reliability results from harmonization with international standards pertaining to electromagnetic fields measurements and from exclusive use of calibrated measurement equipment. Continuous performance of objective and reliable measurements (24 hours/ 365 days) enables permanent monitoring of electromagnetic radiation levels and maxiumum transparency. Knowing that electromagnetic radiation is visually undetectable, nor can it be perceived by sensory means, continuous measurement results are of utmost importance to the genaral population, since they represent the only unbiased indicator of the real radiation level and its short-term and long-term variability, and therefore contribute to the establishment of trust between all interested parties.

In the study, a technical solution for sensor network on the territory of the Republic of Serbia was given. This solution combines a network of stationary sensors, subsystem of nomadic sensors, subsystem of mobile sensors (*drive test* measurements) and subsystem of personal sensor units. The proposed solution comprises installation of 92 broadband stationary sensors and 8 band-selective stationary sensors on the territory of the Republic of Serbia, according to the principle of uniform regional distribution. Stationary sensors provide continuous monitoring of electromagnetic radiation in the place of their installation. Subsystem of nomadic sensors includes 2 band-selective stationary sensors, designed to carry out time-limited measurement campaigns (3 months per location) at specific locations, in accordance with the needs or special demands by the citizens, legal persons, public institutions or local administrative bodies. Subsystem which is used for *drive test* measurements consists of one mobile sensor and is designed for map generation of RF electromagnetic field intensity in big geographic urban areas and other state territories. Subsystem of personal sensor units has five personal sensors (exposimeters) and is designed to measure the exposure directly linked to everyday human activities (3 units) and exposure in certain important outdoor and indoor areas of human movement (2 units).

The suggested architecture of the distributed software system and the proposed technical solution for centralized management software platform and operation of the sensor system consist of 5 modules: module performing the parsing of text or binary data from sensors, module receiving data from parsel module and registering them to the base, module acting as an intermediary between the presentation and the base, module acting as a client responsive web application and module representing an admin panel for the entire server application administration.

In order to ensure construction and unhindered operation of the sensor network system, it was proposed that 2 new employees on a permanent basis (with Bachelor degree

in Engineering) be hired, with some of the existing employees in the legal, financial and marketing departments to be partially tasked with new activities. In addition, the proposition of training courses that the employees need to take in order to be able to operate the system was given.

It was planned that the project of sensor network for monitoring of electromagnetic field levels be realized in 4 phases, each lasting 12 months (in total 4 years). The total planned capital investment for the realization of the electromagnetic radiation monitoring system amounts to 1,594,400.00 EUR. In the Study, an overview of capital investments per implementation phase and corresponding means is given, as well as an overview of all operation costs related to the network maintenance, projected for a future 10-year period.

Construction of the sensor network for monitoring of electromagnetic field levels is a non-profit, socially responsible investment project, with an aim to provide transparent public information regarding the existing levels of non-ionizing radiation in the Republic of Serbia. Even though this project, by its nature, does not generate operations profit, its realization is socially justifiable, since it is expected to decrease the growing popular fear of electromagnetic radiation and establish trust between the general population, wireless telecommunications service operators and state organs. As a consequence, this is supposed to reduce the ever growing resistance to the development of wireless networks, being *de facto* infrastructure of each country, and foster the development of the country.

The strategic goal of the EMF sensor network project is the environmental and human health protection, which also represents one of the EU and other institutions' and countries' priority investments. This project's program promotes RATEL and its activities, including cooperation with international organizations and alignment with modern standards applied in this important strategic area. From the accounting point of view and project value assessment, this project does not generate operations profit by its nature, its accounting value being rather reflected in the balance sheet as accumulated intangible and inalienable assests, increasing the value of the Agency, commonly known as *goodwill*. Improved reputation of the Agency and expertise of its employees, trust and confidence of the public and international cooperation in the area of environmental and health protection, altogether contribute to the increase of RATEL's significance and influence. These inalienable intangible assets are of utmost importance for the future business operations of the Agency both at national and international level.