PRINCIPLES OF SYSTEM ECOLOGY FOR CELLULAR RADIO

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Abstract. The paper formulates basic system approach principles to environmental safety solutions in cellular radio communication, it dwells on possibilities to ensure necessary conditions to achieve its environmental safety by virtue of technical, organizational and managerial solutions at different hierarchical levels - from international (regional radio frequency) to individual (user-related), as well as at various stages of mobile radio communication systems lifecycle.

Introduction

Electromagnetic emission (EME) of mobile stations (MS) in the mobile radio networks (cellular, trunking, area, etc.) has a definite negative influence of the health of people, using communication services. In the time of conversation the MS is positioned in the immediate vicinity of the human head, affecting with electromagnetic emission the eyes, the brain, the blood and blood vessels, as well as other systems within the human body. In those cases, when MS EME power is high, this influence may become inadmissible [1-3]. MS EME power depends on a number of principle factors, and these factors are of a systematic nature. In the mobile radio communication systems of 2nd generation of higher the MS EME power is set by the system itself reasoning from the basic radio wave propagation (RWP) loss value between the basic station (BS) and the MS (determined by the area profile, where this MS is operated, by the sizes of sites in the network and the MS position within a site), from the intrasystem and industrial electromagnetic radio interference (noise) levels around the MS location, which to a great extent is depends on the cluster size, accepted in the network during its frequency planning, as well as on the traffic intensity (in CDMA networks).

This paper summarizes the materials [4-7], illustrating principle solutions for environmental safety for the radio networks based on the systematic approach to this issue - when their implementation principles are being chosen, during their development and system design in case of reasonable choice of principles and boundary conditions (restrictions) for their implementation and operation. This approach to the environmental safety for the mobile communication systems requires the least expenditure and is the most efficient.

Basic principles

Below we briefly formulate the principles of the systematic approach to ensuring the environmental safety of mobile (cellular) radio communication.

1. The principle of MS EME hazard

The environment is characterized by the presence of the natural electromagnetic background (EMB), generated by electromagnetic emissions of the ground, atmospheric and space origin at frequencies from ultra-low (lower than 1Hz) up to X-ray and gamma radiation frequencies. The level of the natural EMB can be tolerable and even essential for normal existence of living organisms, or harmful at least for certain life forms (for instance, in places with an increased gamma-radiation level, or electric or electromagnetic fields, etc.). Considerable enhancement of the EMB intensity in individual frequency bands due to the operation of radio devices renders a hazard for living organisms owing to the fact that this factor changes the basic characteristics of the habitat.

2. The principle of system conditionality of the MS EME parameters

Occurrence of EME with radio devices is inevitable and determined by the major principle of their operation - by the application of the electromagnetic field for data transmission and/or retrieval. EME parameters of radio system elements (EME power, operating frequency band, modulation parameters, etc.) are defined based on the required radio system specifications – the coverage, the data transmission range, minimal signal reception level needed with respect to the external noise level, and of the receiver internal noise, etc.). In particular, in cellular communication networks of the 2nd generation and higher the MS EME power is set by the system forcibly based on the value of RWP losses between the MS and the BS (the distance between the MS and the BS and the radio path parameters), as well as on the intrasystem RF noise level and the minimal "signal-to-(interference + noise) ratio» needed at the BS receiver input. Therefore, the MS EME power depends solely on the conditions of how the MS is located with respect to the BS and on the cellular network system characteristics (the site sizes, the quality of frequency planning in the network under conditions of a limited nature of the allocated RF resource, the kind and the quality of the used multiply access, the RF signal reception and the processing, and the system settings of the MS and BS, etc. [4-7]). The boundaries and the resolution of the MS EME power regulation are defined by the proper cellular communication standard, and for the sake of the efficient network functioning, undoubtedly, these should not depend on any individual characteristics of the MS modes (its design, weight, etc.).

3. The systemic principle of measures to ensure environmental safety of cellular communication

For the MS EME power is conditioned solely by the system requirements and settings of the cellular network,

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the environmental safety of the latter should be ensured by making proper system solutions. Cellular radio communication has a hierarchical structure both in terms of its arrangement and legal and normative regulations, and in terms of design and development of technical means, also in terms of rendering and using services, therefore at each of these hierarchical levels of each of the said areas it is possible to find solutions and take measures contributing to the improvement of the cellular radio communication environmental safety.

4. The principle of medical and biological determination for the MS EME environmental hazard criteria

The extent of hazard and the extent of admissibility of increasing the EMB intensity because of radio devices functioning should be based on the results of deep, wide-scale and comprehensive medical and biological studies of the EME influence on the biological tissues and systems, including studies of the long-term consequences by medical statistics approaches. Thus the only objective and practically viable criteria of EME environmental safety are the adopted sanitary norms that contain definitions of the maximum permissible levels (MPL) of EME under divergent conditions, within different frequency bands and for various groups of population, as well as the weighing up rules for EME intensities of a diversity of systems within different frequency bands with different modulation formats (frequency-time characteristics) considering the hazard extent of each individual EME and of the total EME to calculate the aggregate EME MPL when assessing the boundaries of the sanitary-protected zones and of the zones restricted by buildings around complex radio objects and systems, as well as when evaluating the environmental safety of individually used EME-generating devices.

5. The principle of common analysis to ensure environmental safety for all the EME sources

Wide spreading of radio systems belonging to various services (radio broadcasting, fixed mobile, radar, radio navigation, etc.) that provide information services to the public, solve industrial, economical, defense and other tasks, makes the aggregate artificial EMB in densely populated places much higher that the level of the natural EMB. The hand-on practice of establishing the sanitary and hygienic EME MPL standards [8, 9] implies that EME levels from stationary and mobile EME sources are restricted separately. In view of massive use of the cellular communication, when the number of cellular communication MS in many places exceeds 100% of population, it is essential to analyze the aggregate environmental hazard of all the technical devices with EME [6]. Intensive convergence of technologies, systems and services in the area of rendering information services to the population and economy, a growing spread of various-purpose radio interfaces, evidence two facts: 1) urgency to develop the analysis and normalizing procedures for the aggregate EMB from all the EME sources, and 2) the necessity to promote alternative technical systems of information services, (such as cable, fiber-optics) when there is no alternative to the mobile communication systems.

6. The systematic principle for the MS EME environmental hazard criteria

Since environmental safety of the cellular communication network is determined solely by its system characteristics and settings, the environmental hazard criteria should be directly related to possible restrictions for the technical, structural, organizational and other characteristics of the cellular radio network. In this sense a restriction related to the MS EME power could be used as the most convenient requirement of environmental safety for a certain cellular radio network in terms of its feasibility and controllability. However, this restriction, at least in cases of 2G-3G networks, would lead to reduction in the communication reliability. Besides, from the point of ensuring environmental safety of the cellular communications under natural and artificial EMB conditions, limiting the maximum permissible electromagnetic field intensity around the human body, as well as restricting in terms of duration and/or time percentage of the aggregate intensity of EMB from all kinds of sources exceeding EME [6], is considered to be a more convenient environmental safety criterion. From the system point of view, such a widely-used MS environmental safety criterion as "SAR" is unacceptable, for it is indirectly related to both the MS EME power [3], and to intensity of the electromagnetic field, generated at a certain distance from the MS. In addition, the value of SAR characterizes only one of several mechanisms of how the MS EME affects the human body systems [1-3] namely the EME absorption by biological tissues at a certain part of the human head. In this connection the SAR value, can undoubtedly used as an individual «environmental» parameter of the MS, but this parameter cannot be accepted as a systemic criterion for the cellular communication environmental safety.

7. The principle providing a concurrence of interests and creation of favorable tendencies

The telecommunication business is refers to the most profitable ones, no one doubts that the economic interests of its participants are prevailing. Therefore it is essential to strive for such solutions, when satisfying the economic interests of the telecommunication companies will naturally lead to a reduction in environmental risks. An example: development of the cellular network when the allocated RF resource is restricted [4], and the urge to expand the users number is accompanied by splitting the sites and decreasing the MS EME power in the network.

8. The principle of independent the environmental expertise

The system to organize the telecommunication industry should ensure a possibility of independent and unprejudiced environmental expertise of cellular radio networks in terms of systemic solutions, technical settings, rates and plans of the infrastructure development, efficiency of use of the allocated radiofrequency resource and other issues, directly affecting the extent of the cellu-

lar network environmental safety. In the cases when the interests of the state as an owner (shareholder) of the cellular network may conflict with the users interests in terms of investing into the measures to ensure the network's environmental safety, the expertise of its environmental safety should be performed by independent non-governmental organizations.

Systemic hierarchy of conditions and possibilities to ensure environmental safety for the mobile radio communication

1. Global (worldwide, regional) level
- Selecting the frequency range for the promising RF technologies by the environmental (ecological) criteria;
- Selecting the multiple access technology by the environmental (ecological) criteria;
- Development of promising «convergence» technologies for public information services that minimize the environmental risks;
- Creating conditions for rapid radio network development (manufacture of the equipment, design procedures base, investment security and attraction, etc.);
- Arrangement of independent research into issues related to environmental aspects of the mobile communication systems, justification of environment-friendly solution and alternatives (techniques, procedures) to implement these systems,
- etc.

2. National (governmental) level
- Determination (selection) and implementation of ecologically optimal strategies of the cellular radio communication development considering rapid rates at which all human activity spheres become saturated with emitting technical devices (mobile and fixed communication means, various broadcasting systems, wireless radio access systems, remote control radio interfaces and RF identification, PC, industrial and medical equipment in high frequencies, etc.);
- Introduction of ecologically reasonable tariffs for the RF resource (spectrum) usage by certain radio systems and services considering their environmental hazard – particular (for certain radio systems) and general (taking into account their contribution into the generated «electromagnetic smog»);
- Introduction of reasonable restrictions on the scope of the RF resource allocated to each cellular network;
- Licensing considering electromagnetic ecology of telecommunication business, including assessment of the profitability and the capability of the candidates to fulfill the correspondent requirements of the communications Administration, concerning the pace of the network development to environmentally safe level;
- Determining the order, the pace and the characteristics of deploying and functioning of the network considering the need to ensure the minimal environmental requirements within the shortest terms possible and of complete environmental safety in future, including reduction of EME BS power with growth of their territorial density;
- Introduction of «environmental» restrictions of technical parameters for the mobile radio communication equipment;
- Introduction of «environmental» restrictions of MS usage on objects with high EMB/EME intensity;
- Introduction of «environmental» restrictions of technical parameters for the mobile radio communication equipment;
- Avoiding to construct powerful EME sources in the vicinity of built-up areas and on their territory;
- Working out of justified sanitary and hygienic standards for the maximal permissible parameters of the aggregate electromagnetic field intensity for various categories of population taking into account the EMB, generated by powerful radio objects,, massive spread of mobile communication means, massive application of household technical appliances (microwave ovens, PC, television sets, etc.), creating incidental EME, as well as intensive application of the wireless radio access means and divergent radio interfaces;
- Encouraging refusal (where it is acceptable) of constructing departmental radio communication networks (conventional, trunking, etc.) for the sake of using cellular radio communication for office, industrial purposes;
- Creation of necessary conditions for unhampered development of the network infrastructure (encouraging an increase in spatial density of BS, reduction of limitations for placing of BS in the built-up area, etc.);
- Creating conditions to increase the traffic on the wireline communication networks in built-up areas, including equalization of tariffs for intranetwork calls and for cross-bridge connections with the users of the wireline network, ensuring the possibility for readdressing to the wireline networks, etc.;
- Introduction of independent monitoring of environmental safety, of environment-friendly construction and functioning of the cellular network, including evaluation of the distribution of the MS and BS EME level values over the territory and inside the built-up area residential, administrative, industrial), assessment of the operation modes (validity of the BS EME levels, adjustment of the MS EME power regulation function, etc.), the network structure regularity degree, etc.;
- Supporting merges of smaller operators, not capable to independently provide intensive cellular network infrastructure development, support of cellular communication investors;
- Supporting research, development and manufacture in the area of environmental (ecological) safety of cellular radio networks,
- etc.

3. Cellular communication network (operator) level
- Realization of all the system possibilities for dynamic regulation of the MS EME power;

- Qualitative frequency network planning to drop down the intra-network noise level;
- Planning and regularization of the spatial network topology;
- Decrease of the BS EME power in the course of the network development to lessen the intra-network noise level;
- Reasonable integration with wireline communication networks, for instance, using DECT-standard radio interface in places where BS is shielded – indoors, inside dense urban area, etc.
- Network planning considering MS antenna pattern distortions by the abonent protection means against MS EME;
- Steady shifting certain elements in the network infrastructure from radio relay link to fiber-optic communication lines in the course of the network development, at least in built-up areas;
- etc.

4. The level of a cellular communication abonent (individual user)

- Selection of the network by the environmental (ecological) criteria (how advanced the network is, standard (GSM, CDMA, UMTS, etc.), frequency band, environmental expertise results, etc.);
- Observance of the public electromagnetic hygiene rules and the ethics of the mobile phones use in public places;
- Observance of individual electromagnetic hygiene rules - reasonable tactics of the mobile phones use (when answering an abonent call, when calling an abonent, when using in a car, in places of shading and at a large distance from the BS, etc.);
- Refusal of conversation in favor of the data transfer;
- Purchasing the most environment-friendly MS model;
- etc.

5. The level of the manufacturer (developer) of the mobile communications systems and equipment

- Performance of the research and development work, development of system and technical solutions, development and manufacture of MS with improved environmental characteristics (minimal SAR value, MS EME shielding in the direction of the abonent head, working out of technical solutions that ensure removal of the MS antenna from the abonent head under conditions of an increased MS EME power (when communicating from a car, from industrial, office, residential and other premises, from zones of shading by dense urban built-up, in rural area at a considerable distance from BS, etc.);
- Development of system solutions, ensuring reliable link under conditions when the MS antenna pattern differs considerably from circular, and when fast and deep MS signal fluctuations are possible due to MS EME orientation variations (for instance, when the signal is received by several BS with neighboring responsibility zones);
- Introduction in the MS of the functions that warn an abonent (probably both abonents on the line) about the danger considering the actual communication conditions;
- Introduction into the MS software of the function that records the danger of using the MS with a classification by the danger degree and the time;
- ets.

Conclusion

The considerations suggested above are the result of the primary generalization of a number of sufficiently efficient individual attempts [4-7] the application of a systemic approach to analyzing and ensuring the cellular radio communication environmental (ecological) safety. The author believes in efficiency of such an approach and will appreciate any further efforts, aimed at development, detailing and extension of the presented material. The results of this article may be useful when making decisions in the course of development, design, planning, adjustment and operation of the mobile radio communication networks, also when justifying the approaches to normalizing the cellular radio networks characteristics by environmental indicators.

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