Strategies for the Improvement of Critical infrastructure Resilience to Electromagnetic Attacks

**Reporting**

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Periodic Report Summary 2 - STRUCTURES (Strategies for the Improvement of Critical infrastructure Resilience to Electromagnetic Attacks)

Project Context and Objectives:
Vulnerability of electric/electronic systems to high power electromagnetic interference has been known for several decades, in particular relating to military applications and the High-altitude ElectroMagnetic Pulse (HEMP, originating from nuclear explosions) and lightning (LEMP). Countermeasures to these kinds of interferences, characterized by quite low frequency ranges, have been studied, proved and reported in Standards and Guidelines Handbooks.

On the contrary, the growing availability of sources (that are also characterized by low cost and small dimensions) that can produce high power e.m. radiation at very high frequencies, together with the growing dependence of civil society on susceptible electronic systems, the growing phenomenon of terrorism, and so on, suggests that attention should be drawn to the Intentional ElectroMagnetic Interference (IEMI) problem.

Civilian infrastructures and services (such as energy systems, banks, transportation etc.) are main potential victims of IEMI due to the presence of many points-of-entry (POE) both intentional (e.g. antennas) and inadvertent (e.g. imperfect shielding on cables) and due to the use of commercial electronic systems that are usually neither designed nor tested to resist to high frequency interference (which, for example, are not foreseen by the current EMC standards).

In such an environment it is crucial to understand the level of risk produced by IEMI to critical infrastructures and to provide guidelines for their protection.

The Project, relevant to the theme “Critical Infrastructure Protection”, is focused on the following functions:
- Risk assessment, modelling and impact reduction
- Situation awareness and assessment

Within the framework of “Risk assessment, modelling and impact reduction”, the research focuses on the following main capabilities and technologies:

a. Capabilities
- Classification of intentional electromagnetic environments (IEME, radiated and conducted);
- Classification of critical infrastructures with respect to IEMI threats;
- Risk assessment of the occurrence of threat events and their most likely modalities;
- Classification of e.m. susceptibility levels of equipment, systems and infrastructures;
- Validated electromagnetic modelling tools for risk assessment and design;
- Dedicated measurements (mainly to estimate IEMI susceptibility levels and to validate modelling algorithms);
- Investigation of current protection effectiveness;
- Optimal design criteria to make infrastructures more robust against IEMI; IEMI shielding for structures, systems, sub-systems etc.
- Design of components and strategies for protection (with preference given at first to low cost solutions);
- Pre-regulatory and organizational material to support IEMI affected parties and for policy makers: recommendations, guidelines, methodologies, and procedures (e.g. regarding shell materials and redundancy architectures).

b. Technologies
- EMC evaluation and hardening;
- IEMI measurements;
- Simulation tools for analysis (risk assessment) and design (protection improvement);
- Structural and smart materials able to improve IEMI protection.

Within the framework of “Situation awareness and assessment”, the research focuses on the following capabilities and technologies:
a. Capabilities
- Permanent monitoring of environment (all-weather and day-night);
- Link to protection elements in order to set-up active protection strategies;
- Produce domain specific prediction models to facilitate pro-active intervention;

b. Technologies
- Various sets of IEMI sensors

Possible points of contact with the “Detection, identification and authentication (of IEMI sources)” are also explored.

Project Results:
In the first period of the project the following main achievement were obtained.
• The IEMI related threats have been analysed from all interesting points of view:
  o HPEM sources for radiated e.m. field (features and physical limitations)
  o HPEM sources for conductive interferences (features and physical limitations)
• The critical items typically present in CI’s have been identified and their susceptibility with respect to IEMI has been assessed both from qualitative and quantitative points of view.
  Susceptibility thresholds of the most common electrical/electronic components/sub-systems/systems have been collected from open literature, together with the interference configuration which has been applied to reach the critical susceptibility levels.
  Past known experiences with EMI due to high power e.m. (intentional and unintentional) have been reviewed in order to gain feeling about the problem of interest.

The items and the interference conditions for which susceptibility thresholds are not currently available have been identified and listed for next measurement activities dedicated to items characterization with respect to IEMI.
• Classical protection concepts to EMI have been reviewed with respect the requirements posed by IEMI (frequency, power...), by also assessing the weak points, to be further worked out in the next phase of the project.
• The IEMI to CI’s problem has been also analysed from the point of view of the Business Continuity Management, mainly in order to understand the perception which managers of CI’s have about IEMI
threat.
• 6 main types of CI’s have been analysed in terms of: i) functionalities, ii) physical arrangement, iii) susceptible items. A set of reference configurations has been assessed for the analysis by modelling activity to be performed in WP7. Also a common approach for the IEMI problem representation applicable to every CI’s has been identified and an application policy has been fixed.
• The electromagnetic coupling paths from the interference source to the susceptible item have been identified and analysed into their single physical effects. On such basis, all the at the state of the art analysis/modelling techniques (analytical and, mainly, numerical methods) have been reviewed and discussed in order to identify the computational chains which are able to model the relevant coupling paths. Approximations and limitations are identified and highlighted, to allow the team members to check their computational chains on a common reference configuration used to check the analysis methodologies at disposal of the Team.
• Experimental set-ups suitable to perform the measurement activities which have been above mentioned, have been discussed and identified.

At the end of the second period the following main achievements were obtained:
The phase 1 of the project, consisting on the physical and analysis scenario assessment, was totally completed. Risk investigation section of phase 2 started with the implementation of WP6 and WP7 and risk awareness investigation went on with the prosecution of WP9.
More in detail, the following goals have been achieved:
• Characterization through measurement of the typical susceptible equipment located in the infrastructure of interest (WP6); such data will be extensively used in the frame of WP7 to estimate the risk associated to the considered threats and infrastructures;
• Full identification and modelling of the elements present in the signal propagation path, from the threat antenna up to victim equipment (WP4.3);
• Preliminary simulation on a reference infrastructure (WP4.3 - WP4.4) aimed at proofing the available modelling capabilities:
o Evaluation of the field distribution produced by a threat antenna in the presence of an even large infrastructure;
- Coupling through walls;
- Coupling through windows.
o Evaluation of interference signal produced at the equipment electric interfaces for both the front and back door case:
- Field to wire coupling estimation;
- Field propagation along cables.
Both measurements and preliminary results will drive the next work packages, starting from WP7.

Potential Impact:
STRUCTURES introduces the aspects summarized under the acronyms “HPEM, IEMI” threats into the large topic of “Critical Infrastructures’ Protection”, considering and in harmonization with existing directives and standards.
Important impacts are expected from the point of view of the electromagnetic analysis methodologies of complex systems, by foreseeing the application of state of the art modelling tools whose basic capabilities could be improved on the basis of the following keywords: “parametric analysis”, “high computational
performance” and “hybrid methods”, in order to be able to manage both “vertical and horizontal” complexities characterizing such complex environment.

To overcome the partial lack of data about components and materials behaviour at HPEM excitations (frequencies in the range of 1-10 GHz, spatially localized impinging e.m. field etc.) some dedicated measurements are planned.

From a strategic point of view STRUCTURES is expected to have impact because it contributes to the development and assessment of:

Knowledge development. The project promotes knowledge development and scientific and technological innovation in several fields (CI’s protection, computational electromagnetism, EMC, measurements etc.) thus opening opportunities to the related professionals, research institutes and industries. A good balance characterizes the project plan in its different components of “analysis”, “research”, “synthesis”, “consolidation of the state of art” and “innovation”.

Economic development and employment growth inside Europe. The guidelines, the analysis procedures and tools and the innovation in the field of CI’s protection to IEMI will be pro-active for:
- the expansion of the European industry providing services in the field of e.m. protection, providing protection systems and sensors;
- the training of technicians operating in the above mentioned field of applications;
- the training of young researchers in the field of electromagnetism.

Critical Infrastructures’ safety. The guidelines, the analysis procedures and tools and the innovation in the field of CI’s protection to IEMI will be pro-active for:
- inducing more awareness and understanding by policy makers;
- providing a reduction of e.m. hazards and therefore allowing for higher safety levels of CI’s;
- introducing the concept of “active protection” thanks to the identification of IEMI sensor networks which not only provide awareness about IEMI threat but also help the users to locate the e.m. high power source, so allowing for further security actions.

List of Websites:

http://www.structures-project.eu/

Other report summaries

Periodic Report Summary 1 - STRUCTURES (Strategies for the Improvement of Critical infrastructure Resilience to Electromagnetic Attacks)

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