THE EU FRAMEWORK V PROJECT "GEMCAR": PRACTICAL EVALUATION OF THE GEMCAR GUIDELINES

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Abstract: This paper provides a brief description of the evaluation of the GEMCAR Guidelines that was carried out by CETIM. The test case selected for this evaluation was an industrial vehicle, and the experience developed in using the Guidelines was used to provide feedback for their further development.

1. Introduction

CETIM (the Technical Centre for the Mechanical Engineering Industries) represents around 7000 French companies. Its main mission is to satisfy the research and development needs and associated technology transfer requirements of the French mechanical engineering industries. Since 1987 CETIM has developed knowledge to support French manufacturers in EMC design and compliance engineering. In particular, the manufacturers of mobile machine (agricultural, lifting and earth moving machinery) have expressed considerable interest in the use of simulation to support their EMC engineering activities.

During the two first years of the project CETIM's main role has been to observe and understand the general GEMCAR activities. Since CETIM's initial experience in EM modelling and simulation was very limited, this provided the opportunity to assess the available techniques. This observation and analysis of partners' activity permitted us to anticipate potential problems and to identify the best people to work on the evaluation to be carried out at CETIM.

A further important effort has been to inform the French companies about the goal and interest of GEMCAR project and to obtain the users requirement expression from some of them. A series of presentations were made to a number of relevant professional commissions in order to describe the progress and objectives of the project.

2. Application of the GEMCAR Guidelines

The user requirements expressed by a variety of organisations involved in EMC have been analysed and compared with the direct experience of our specialists. It was found that the immediate needs of mobile machine manufacturers are related to the requirements of the EMC and Machinery Directives.
The expected contribution of EM modelling and simulation techniques is perceived to be in the development of knowledge concerning the distribution of EM fields in and around the machine. This information is expected to be of considerable benefit for the improvement of cabling strategies.

More efforts were necessary to convince French mobile machine manufacturers to participate in the GEMCAR project as suppliers of practical examples. Given the limited experience and lack of publications on EM modelling in the field of mobile machines the selection of a case study proved to be very difficult. Finally, two manufacturers accepted the invitation to collaborate and to provide real industrial examples.

The GEMCAR Guidelines enabled the CETIM engineers to increase their knowledge and understanding of existing EM modelling and simulation tools. The comparative tables provided for different EM modelling approaches (ie. volume or surface meshing, in time or frequency domain) provided an understanding of the relative merits and limitations of the different numerical techniques, as well as their computing requirements.

The experience of other partners had demonstrated that a crucial issue in EM modelling is in the exploitation of manufacturer's CAD data to develop the mesh representing the vehicle. The existing team EMC at CETIM has therefore been enhanced with an engineer with CAD skills. This engineer also had a significant role in the selection of suitable EM simulation software.

Meetings were organised with potential software suppliers from amongst the GEMCAR consortium. The capabilities and the match with the technical requirements were then analysed. The final choice of software for EM modelling was made with regard to following criteria:

- technical performance issues;
- match to existing CETIM CAD tools and skills;
- geographical factors (ie. language and location of software support staff).

The offer of the consortium members to put EM modelling software at CETIM's disposal during the period of the evaluation tasks permitted us to delay the investment. The necessary training for the CETIM engineers, both EMC and CAD, was organized within the GEMCAR project.

A return on this experience was provided to the consortium in order to complete the guidelines with information about training aspects in terms of:

- minimum required skills;
- duration and cost;
- practical difficulties.

3. Practical case study

After consulting the members of consortium it was decided to begin with the modelling of a small industrial vehicle (a fork lift truck) rather than a large vehicle (the alternative was an aerial work platform with a 16 m vertical mast).

The use of STEP format CAD files from mobile machine manufacturer raised a number of problems:

- too many mechanical design details (eg. holes);
- how covert the STEP data to I-DEAS ".UNV" file format.

A two-stage approach was therefore adopted in the evaluation study, based on models of increasing complexity.

3.1 Simplified model

Inspired by the GEMCAR Guidelines, a simplified model has been developed and meshed. It comprises:

- a ground plan representing the base of the machine
- a solid metallic parallelepiped (representing the battery compartment);
- an empty metallic compartment (containing supports for the electric motors);
- a central vertical metallic plate representing the support for the electrical and electronic parts;
- two vertical metallic plates for the rearward part of the machine (operator safety parts);
- the electrical harness between the steering gear and the electronics.

The resulting synthetic geometry for the vehicle is illustrated in Fig. 1 below.

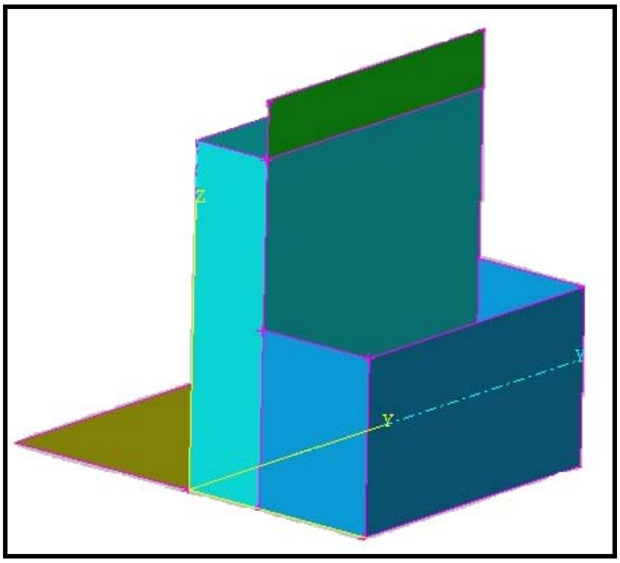

Fig. 1: Simplified model of fork-lift truck

The ASERIS–BE software was used to calculate the distribution of the EM field around the harness tube for two different positions. The illumination was implemented using both an ideal plane wave and the field produced by a model of the "EMCO 3109XP" antenna (in the range of 20-200 MHz).

The ASERIS-NET software permitted the currents in the cable bundles to be estimated: the output data obtained from ASERIS-BE were imported and used to excite the harness model.

3.2 Complex model

The STEP format CAD file, with small details removed, was used to build the more realistic "complex" model. The same calculations as in the simple case were also carried out for this model and the results compared. Using the method indicated in the GEMCAR Guidelines, the global difference measure (GDM) reflecting the similarities between the simple and complex case results was estimated for predefined measurement points.

The influence of the rear metallic parts and of the electric motors (direction and traction) in the front compartment were estimated separately. In the frequency range under investigation in this work the screening effect of the vertical metallic parts behind the electric motors seems to be more significant than the screening provided by the metallic parts of the motors themselves.

3.3 Worst-case definition

The position and polarization of the illuminating antenna were varied in order to find the maximal values of the induced current in the harness. The highest induced currents were obtained under vertical illumination at particular frequencies.

3.4 Measurement of induced RF current

A prototype of the forklift truck was equipped with measurement wires terminated using three different load impedances: short circuit, 50 Ω and open circuit.

Measurements were made in a semi-anechoic chamber equipped with ferrite absorbers. The illumination conditions applied in the model were also applied in the measurements and currents were measured at positions on the wire corresponding with those used in the simulations.

4. Validation of the GEMCAR Guidelines

The criteria for the evaluation of the Guidelines were defined by CETIM after consulting various manufacturers of mobile machines:

- enhanced EMC performance;
- reduced development time and cost;
- avoidance of EMC problems.

All these criteria are satisfied and have been quantified.

The Guidelines have also been analysed by the manufacturers of mobile machines: they appreciated it and ask for more adapted information in accordance with their technical levels. The only criterion that is not addressed by the Guidelines is how one can correlate the simulation results with standard EMC test techniques and levels.

5. Conclusions

The general outlines proposed by the guideline have been observed and applied successfully.

The main difference between our approach and the GEMCAR Guidelines consisted in the comparison of results between simple and complex cases and not systematically between measured and computed results.

The simulation permitted the manufacturer to define the optimal position of the harness and the type of cables to be used before having built the prototype.

The definition of the worst case has minimized the number of radiated immunity tests required and consolidated the manufacturer's confidence in the safety of the vehicle.

CETIM's participation in this project has created new skills and permitted the dissemination of GEMCAR results to French manufacturers of mobile machines.

6. Acknowledgements

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