PROJECT

GEMCAR

Guidelines for electromagnetic compatibility modelling for automotive requirements

Funding: European (5th RTD Framework Programme)

Duration: Jan 2000 - Mar 2003

Status: Complete with results

Background & policy context:

Future vehicle electronic systems will provide many more safety related functions to aid the driver, as well as advanced telematics facilities to support activities such as traffic management. In addition, more sophisticated control systems will be used to optimise vehicle performance and emissions. Thus, electromagnetic compatibility (EMC) represents an increasingly significant issue for the function, safety and reliability of modern vehicles.

The success of future vehicle technologies which aim to improve transport and to minimise its environmental impact will therefore be critically dependent on the efficient and successful handling of automotive EMC issues. This was recognised by the automotive industry’s CO2perate Programme, which provided a letter of support for the GEMCAR proposal.

Automotive EMC engineering has traditionally been an experimental activity. However, the advent of electric and hybrid-electric vehicles, and the increasingly wide range of systems and frequencies which are used in vehicles, are expected to make automotive EMC an increasingly onerous burden to vehicle manufacturers in future. It is considered that the adoption of numerical modelling techniques will provide the most cost effective approach for improving the efficiency of future automotive EMC engineering.

Although tools and techniques have been developed which are suitable for this purpose, further research was required to establish practical modelling issues such as:

- the requirements for EMC modelling in automotive applications;
- the level of model detail that is required;
- the uses and potential benefits of automotive EMC modelling;
- how to maximise the efficiency of vehicle scale simulations.

Objectives:

The project aimed to develop a comprehensive set of guidelines for practical electromagnetic modelling in automotive applications, based on detailed validation of models of real vehicles.

This was to be achieved by critical comparison of model results and measurements. A range of modelling techniques and vehicle test cases were used for this purpose. The test cases were derived from production vehicles, and were staged at three levels of complexity. The wiring harness and vehicle structure were also considered, both individually and in combination.

The guidelines were intended to be widely disseminated with the aim of speeding the adoption of EMC modelling techniques within the European automotive industry, thus improving competitiveness. It was also expected that the guidelines would be of value in other transport sectors, most notably the rail and aerospace industries.

Methodology:

The core of the project was concerned with the critical evaluation of numerical predictions against measured results obtained for a range of generic test objects. Only available modelling tools were used in this project, which was concerned with establishing the basis of a practical modelling process rather
than the development of new tools and techniques. Tool development has already been the subject of considerable research activity, and efforts were considered necessary to capitalize on this work by promoting the practical use of existing modelling capabilities. A range of suitable analysis techniques was therefore used by the partners, to enable the relative merits of these different tools to be assessed.

This work was based on an initial requirements specification generated in the first few months of the project, which aimed to identify the type of information which would be required for various automotive EMC engineering activities. The test cases were based on a production vehicle, and the model validation activities were staged at different levels of complexity corresponding to various build stages of the vehicle.

For EMC purposes it is also necessary to integrate the modelling of complex structures and wiring harnesses. Thus, these two elements were considered both independently and in combination, at each stage of complexity. Three levels of complexity were investigated, and at each stage an extensive comparison between models and measurements was made. This resulted in a total of 9 test cases to be evaluated in considerable detail during the project.

The use of increasingly complex test cases ensured that the modelling approach was progressively refined, taking account of knowledge obtained from work at the lower levels of complexity. In the final stage of the validation activity a second vehicle, obtained from a different manufacturer, was introduced at the highest level of complexity. The aim of this was to ensure that the knowledge gained in work on the first vehicle was transferable. In parallel with this, studies were also carried out to investigate issues such as how and where to integrate electromagnetic modelling within existing vehicle engineering processes, and how best to carry out such simulations in an efficient manner.

The results of this work formed the basis of the GEMCAR guidelines, which were developed and augmented over the duration of the project. In the final months of the project, one of the partners,

**Parent Programmes:**
FP5-GROWTH KA3 - Land transport and marine technologies

**Institute type:** Public institution

**Institute name:** European Commission, Directorate-General for Research (DG Research)

**Funding type:** Public (EU)

**Partners:**

Belgium:
Hevrox

France:
CETIM; EADS; ONERA

Sweden:
Volvo TDC

Switzerland:
EPFL

United Kingdom:
Ford Motor Company; MIRA Limited; QinetiQ, The United Kingdom

**Organisation:** Mira Ltd.
**Address:** Watling Street
**Zipcode:** CV10 0TU
**City:** Nuneaton, Warwickshire
**Contact country:** United Kingdom
**Telephone:** (+44) 24 7635 5551
**Fax Number:** (+44) 24 7635 8551

**Key Results:**

The main purpose of the project was to develop and disseminate a body of knowledge concerning the use of electromagnetic modelling in automotive EMC engineering applications. The range of numerical
methods used in this work was deliberately very wide, in order to develop knowledge that would be as
generic as possible, and therefore of benefit to all potential users of these techniques. More than 200
copies of the GEMCAR Guidelines have been distributed to interested parties around the world, both
industrial and academic. A total of 34 papers were published by the consortium during and after the
project, comprising 4 scientific journal papers and 30 scientific conference papers. A GEMCAR project
workshop was included in the programme of a major international electromagnetic compatibility
conference (15th International Zürich EMC Symposium, Zürich, Switzerland, February 2003). Other
collaborative proposals and successful projects have subsequently developed from the results and
relationships developed during the GEMCAR project. For example, the SEFERE project (“Simulation of
Electromagnetic Field Exposure in Resonant Environments”), which is currently supported by a UK
government research programme.

Technical Implications

The main technical implications are the following.

1. Potential user requirements assessed – including development of methods for categorizing
requirements by model application, identification of result and source data accuracy requirements,
and including consideration of vehicle development life-cycle, user/exploiter of results and
computational resource issues. Additional applications that could be considered using the same
basic models include installed antenna performance and assessment of human exposure to
electromagnetic fields in vehicles.

2. Realistic vehicle EM models demonstrated – using models developed from vehicle CAD data for
simulations based on a wide range of currently available numerical techniques, at different levels
of complexity.

3. Efficient simulation strategies proposed – approaches based on optimizing the algorithms used in
simulation software, combining various numerical techniques to exploit the strengths of different
approaches, and improving the modeling methodology to obtain the maximum benefit from each
simulation.

4. Model validation evidence developed – comparison of measured and computed data obtained from
a variety of numerical techniques for a range of models at varying levels of complexity. A body of
evidence demonstrating the underlying reliability of the numerical methods will be essential in
promoting industrial uptake of simulation-based methods for vehicle EMC engineering.

5. Integration into vehicle engineering processes – investigation of opportunities for exploiting vehicle
electromagnetic model data based on existing standard development processes employed by
vehicle manufacturers involved in the project: who, how, when, where, why and with what.

6. Practical pilot study carried out – as part of a real-world project to design and develop a new
industrial vehicle. This exercise provided valuable feedback and additional explanatory material for
the GEMCAR Guidelines.

7. Optimisation and parallelisation of NEC2 code – development of a freely available early (thin-wire)
version of the Numerical Electromagnetics Code (NEC) to handle electrically large problems (eg.
vehicles). The resulting code has also been made freely available by EPFL.

8. Hybridisation of FVTD and FDTD codes – development was undertaken to allow a more accurate
unstructured (body-fitted) local mesh to be used in a

Policy implications

The main policy implications are the following.

1. It is considered that savings of 40% on automotive immunity test costs should be achievable
by using simulation to identify “worst case” configurations for automotive immunity testing,
and hence reduce reliance on physical measurements. This is a particularly significant issue in
the automotive industry, where tests must be repeated for each system on the vehicle.

2. Current industry practice is to apply a uniform immunity specification to all sub-systems,
which may result in considerable over-engineering of some sub-systems without guaranteeing
that all sub-systems have adequate levels of immunity. An important application of simulation
is therefore to quantify the anticipated electromagnetic environment for each sub-system,
and hence derive specific immunity requirements. Industry sources suggest that relaxing the
immunity specification of an electronic sub-system may reduce the cost by around €10 per
unit, which could represent savings of more than €1 million for manufacturers of large volume
products such as passenger cars.

3. The benefits to be gained from exploiting electromagnetic modelling in design studies are
less easy to quantify, since the range and extent of potential problems is unlimited. Savings
can be made through the avoidance of rework and repeat testing, which become increasingly
costly towards the end of a vehicle development programme. An analogous situation exists in
the aerospace industry, where it is reported that potentially enormous product recall costs
have been avoided through the identification of completely unexpected aircraft construction
problems during electromagnetic modelling of lightning strikes. Estimates suggest that if
modelling can be used to optimise the design of aircraft such that the cost of EMC protection
is reduced by 20%, saving for the European civil aviation industry could amount to €7 million
per year. It is also considered that savings of up to €1 million could be achieved in the
development of each aircraft by using modelling to reduce reliance on physical EMC testing.

Documents:
- Final Technical Report (Other project deliverable)

STRIA Roadmaps: Cooperative, connected and automated transport
Transport mode: Road transport
Transport sectors: Passenger transport, Freight transport
Geo-spatial type: Other