KOTEL 111: Virtual and Physical Environmental Testing for Shock and Vibration in Finland (VPETFIN)

1. INTRODUCTION

Recent international technological development and national Finnish research efforts have shown that numerical simulation combined with physical environmental testing can produce significant advantages in product development. The use of numerical simulation for environmental testing and verification is called Virtual Environmental Testing. This new area of technology enables important advantages in the form of improved product development and testing and in the control of product reliability. Useful results can be already achieved with relatively simple numerical models which are smartly combined with traditional testing. Here the efficient work process and understanding of both the mathematical and physical test methods are in the key role. However, more significant advantages may be achieved with advanced numerical and experimental methods and with standardized work processes. It is seen, that Virtual Environmental Testing offers a rewarding research and development area having various high technology applications in the core of product qualification, requirement management, and reliability control.

Environmental testing may concern various products with different environmental factors such as dust, humidity, temperature etc. However, in this project the focus is in mechanical shocks and vibrations of electronic equipment. Typical problems of physical environmental shock and vibration testing are the costs of prototype development, expensive testing facilities, challenges of fixture design and limitations of the testing equipment and instrumentation. With advanced computer based simulation techniques it is possible to avoid the development of physical product prototypes, test set-ups, test fixtures, etc. and to use physical testing and experimental methods mainly for simulation validation and verification.

In addition to the improvement of the traditional environmental testing simulation techniques can be used to develop new physical testing practices, methods and processes which can be combined with virtual testing methods. Furthermore, Virtual Testing combined with Test Tailoring can be used for the estimation of realistic environmental input loads and the definition of test profiles not typically available. This approach for the development of realistic tailored test requirements is an exciting new possibility for the testing of product and its components, modules and substructures.

Virtual techniques may be used in different phases of product development. However, early product design and final qualification testing the new methods may provide the most dramatic advantages. However, it is acknowledged that virtual testing can replace physical testing only in special cases and more often the best results are achieved with the combination of both methods. In this work the main focus is in environmental vibration and shock testing, but the developed general level processes can also be applied for other environmental factors. Furthermore, in the conducted work the influences of e.g. product requirements, manufacturing, packaging and new networked working practices are taken into account. The internationally high level of research and development is ensured with the participation into European EUREKA-project E!5430 PRO-FACTORY VPET/VIBRA.

2. PROJECT GOAL

The goal of the project is to gain competitive edge with the development of internationally accepted Virtual Environmental Testing process with the corresponding recommended methods and techniques. The results enable reduction of physical environmental testing efforts and improvement of current testing practices by using computer simulation methods. In addition, new possibilities for product design and control of product reliability are obtained.

The work is conducted with international cooperation and in Finland the focus is in the implementation of the Virtual Environmental Techniques into real life products and secure reliable and high quality results with the emphasis on the model validation and control of the level of uncertainty. The work is based on the Finnish national research work conducted in recent years and with the planned European cooperation this new project will produce important advances in research and product development.

The focus of the work is on mechanical shocks and vibrations. However, the other environmental factors such as temperature, humidity etc. are taken into account as natural extensions of the developed methods and processes.

3. PROJECT RESULTS

Virtual Environmental Testing enables new level of product verification having important contribution to cost effective product testing and development with more controlled safety and reliability.

Virtual Testing can be used to "test" products before they are manufactured or before physical testing of an existing product take place. Thus, one can avoid mistakes, design better testing procedures and optimize the actual product itself. Particularly, with simulation one can reduce over- and undertesting, enable better detection of potential failures and give basis for more advanced testing methods such as force limited testing. Difficulties and uncertainties due to physical limitations of test machines may be avoided and an unlimited set of “virtual transducers” may be placed into the structure in order to give more detailed information of the tests. In addition, one can “test” products which would otherwise be impossible to test in full scale due to their size, mass etc.

With the planned international research and development effort Virtual Environmental Testing will get commonly agreed procedures based on rigorous studies and this new area of technology can be taken into wider global practise.

The results of the project will be in form of

- Handbook
  - guidelines on how to conduct Virtual and Physical Testing
  - product, testing system and environmental load modeling
  - design rules
  - examples and reference cases

- Virtual Testing methods

- tools and processes
- software development
    - control software
    - modelling software
- development of a Virtual Testing framework
- replacement or reduced need for physical testing

- Improvement/advanced physical testing
    - more efficient physical testing
    - vibration control systems and principles
    - advanced measurement techniques
    - advanced signal analysis
    - new testing methods

- Benchmarks
    - test structures for verification, validation and demonstration
    - essential for production of certified Virtual Testing services

- Industrial case studies
    - practical real life applications ensure realistic and practical results
    - industrial product testing and development cooperation

- European level networked cooperation
    - industrial and research organization networking
    - competitive edge for global competition

- Initialization of standardization work
    - European harmonization of industrial practices
    - Basis for wider applications and new markets

The handbook will help to conduct Virtual Environmental Testing giving background information, work process, methods and examples. The developed physical benchmark test structures will be used in the work process development and to give physical platform for the study of the simulation of environmental testing. Both the handbook and the benchmark test structures are also useful for education and give basis for future research, development and standardization work. Real industrial case studies will ensure practical usability of the results. In addition, industrial case studies integrate the developed processes and methods into actual product development and testing practices of the participants.

4. PROJECT PHASES

A precise project timetable with particular tasks and resources will be constructed after the selection of the cases and updated project plan.

The major effort in Finland will be in the development of Virtual Environmental Testing work processes, verification of the simulation results and implementation of the updated Virtual Environmental Testing practices to the participating organizations. The plan is to have proven working processes and methods available for project participants at the end of the project.

The overall project schedule:

TASK	2011	2012	2013
1. Project plan update	** *	*	*
2. Project material collection and knowledge base development	********	******	***
3. Handbook development and International Work Packages	**********	**********	**********
4. Industrial case studies in Finland	*******	**********	**
5. International industrial case studies	**	**	**
6. Benchmark development	********	********	**
7. Eureka VPET/VIBRA Project coordination	**********	**********	**********
8. Dissemination and implementation of the results	****	****	********

5. UTILIZATION OF THE RESULTS

Virtual Environmental Testing techniques are seen useful for everyone dealing with environmental engineering: typically people connected to testing, requirement management and product development. In addition, Virtual Environmental Testing practises are seen to effect e.g. consulting practices, laboratory and field measurements and software development. In this work the focus is in shock and vibration testing, but the approach is universal and gives also a base for the virtual testing of other environmental factors such as temperature and humidity.

Today, there are numerical simulation tools available to support physical testing, but the use of these is typically used with limited application areas and without good integration into product development and testing processes. It is seen, that there do not exist enough guidelines and benchmarks available in the markets to enable the use of Virtual Environmental Testing at its full potential. In order to get the full benefit of Virtual Testing commonly agreed reliable procedures are needed and this is important part of the project.

The developed methods will be taken first into practise within the participating organizations and their customers. In the longer term the markets and application areas will be significantly larger as Virtual Environmental Testing will get wider international acceptance. Thus, dissemination of the research and development results will be in key role in the project. The industrial case studies ensure the true benefits of the results and automatically deepen the knowledge of the participants.

Here are listed some use and benefits of the results:

Industry

The approach of this project is generic and can be used for various products. Thus, there exist many potential market segments such as:

- automotive
- aircraft and space
- electronic equipment.

The results of the collaborative R&D project benefit businesses by having potentially tangible impact on profits, competitiveness and company growth.

- new possibilities to innovate on your existing products or develop new ones.
- give company competitive edge, increasing your sales and turnover
  - productivity
  - skills and know how
  - quality of products/services
- ability to access new customers and new markets.
- ability to deepen your knowledge and know-how in a field of research you are eventually going to confront sooner or later: the possibility to be in the front line of today’s top research.

- ability to operate in high technology networked product development environment with subcontractors and distributed manufacturing of components.
- need for efficiency and high quality.
- possibility to reduce unnecessary expensive physical testing
- basis for more high tech instrumented testing and model verification.
- faster development of subsequent standards

Universities and research institutes

VPET R&D project benefit universities and institutes by offering a rich source of long term research challenges and new innovative opportunities. The obtained new capabilities can be used to serve future research as well high tech testing and product design services for industry. With the obtained new results and capabilities critical competitive knowledge will be disseminated to European industry.

- build lasting cooperation with RTDs at European level
- with a European project consortium you will gain access to new industry and research partners.
- the prestige associated with being part of an important transnational research project
- Virtual Testing offer a rich source of educational and research activities.
- opportunity for graduate student research and doctoral thesis work.
- base for more global research and development cooperation.

6. RESOURCES AND ORGANISATION

A management group and a responsible leader are formed in the beginning of the VPETFINN project. KOTEL workgroups will support the project work and VTT will control the production of the handbook, general benchmark structure studies and international cooperation.

The project will participate into an European project E!5430 PRO-FACTORY VPET/VIBRA which is synchronized with the Finnish project with the same timetable of starting 1.1.2011 and ending 31.12.2013. The European cooperation project is at its final application phase for a full Eureka project and has a planned overall budget of 2,9 MEur and a steering committee with the following members:

VTT Technical Research Centre of Finland (Finland)
Markku Juntunen
Project coordinator and Main Participant

LASQUO – ISTIA, University of Angers (France)
Abdérafi Charki

Royal Military Academy - Patrimony (RMA-PAT, Belgium)
Kristof Harri

Vrije Universiteit Brussel (VUB, Belgium)
Patrick Guillaume

LMS International (Belgium)
Bart Peeters

REDEN (The Netherlands)
Marco Ezendam

SOPEMEA (France)
Bernard Colomiès

Acusttel – Acústica y Telecomunicaciones SL (Spain)
Vincent Marant

7. TIMETABLE

Project is implemented between 1.1.2011 – 31.12.2013.

A more detailed project timetable with particular tasks and resources will be constructed after the selection of the cases and updated project plan.

8. RISKS

The main risks of the project are seen to be the studied wide area of technologies, the available project resources and the management of the project activities. Furthermore, the challenge in Virtual Testing is not only how to apply simulation techniques in environmental testing. It is a question of combining different working cultures and practices of people who very often operate in different sections of their companies and organizations with only limited interaction. International cooperation will produce significant addition to the resources and knowledge base to the project, but also challenges in the project management and costs.

However, it is seen that with efficient project management and with motivated participants the upcoming challenges can be dealt with. Already with small resources the first most essential virtual environmental testing capabilities can be created giving basis for further development. Furthermore, with international cooperation good results are ensured. The planned Eureka project VPET/VIBRA (Virtual and Physical Testing/Vibration) has the same timetable and very similar objectives as VPETFIN-project, thus giving significant support to the work. At the moment VPET/VIBRA has eight members from four different European countries and is at the final stage of preparation where most participants are applying for national funding. For the international interaction the continuous participation of KOTEL to CEEES (Confederation of the European Environmental Engineering Societies) work and projects will also provide forum for expert co-operation.

8. COST ESTIMATE and FUNDING

The Finnish project cost estimate for the project is 200 000 €.

COST without value added tax (VAT)

Research party	
Salaries (with general expenses)	170 000 €
Travelling	14 000 €
Materials	6 000 €
Overall	190 000 €
KOTEL ry	
Management (overall)	10 000 €
Overall	**200 000 €**

FUNDING	
TEKES (50 %)	100 000 €
KOTEL ry (50 %)	100 000 €
Overall	**200 000 €**

As and example with 4 KOTEL members the funding share would be 25 000 € + VAT for each partner within the three year duration of the project. Thus, the approximate yearly cost for each participant would be 8 400 € + VAT.