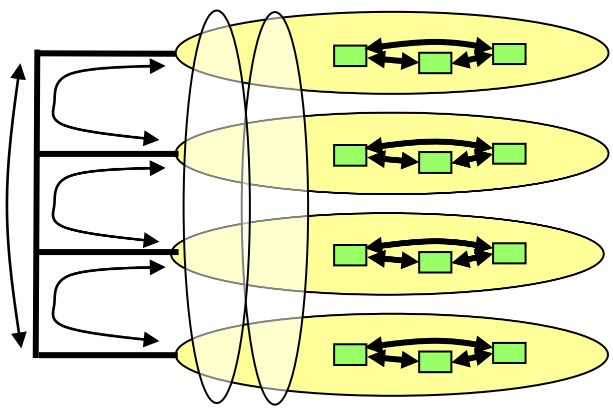
FFI

DFEA2020 – Dependable and Flexible Electrical Architecture 2020



Project within the FFI collaboration program Vehicle Development

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Content

FFI in short

FFI is a partnership between the Swedish government and automotive industry for joint funding of research, innovation and development concentrating on Climate & Environment and Safety. FFI has R&D activities worth approx. €100 million per year, of which half is governmental funding. The background to the investment is that development within road transportation and Swedish automotive industry has big impact for growth. FFI will contribute to the following main goals: Reducing the environmental impact of transport, reducing the number killed and injured in traffic and Strengthening international competitiveness. Currently there are five collaboration programs: **Vehicle Development, Transport Efficiency, Vehicle and Traffic Safety, Energy & Environment and Sustainable Production Technology.**

For more information: www.vinnova.se/ffi

1. Executive summary

Purpose and objectives

DFEA2020, Dependable and Flexible Electrical Architecture 2020, has developed new methods and concepts for the design and verification of vehicle electronics with both a holistic perspective in the form of a reference architecture, and detailed analyses in specific technology areas that are fundamental to the context. This has been implemented in the form of a horizontal project between VCC, expert organisations and universities to facilitate knowledge transfer between different industries. The background is the increasing demands for environmental friendliness ("Green"), safety ("Safe"), and society's demands for information exchange ("Connected") which drive an exponential growth of automotive electronics and software. This leads to an ever-increasing complexity which, in addition to increased demands on system safety and reliability, sums up to a need for new approaches to the design and verification of automotive electronics. All this is included in the concept of electrical architecture for vehicles. The purpose of DFEA2020 is to create solutions and new preconditions for the electrical architecture to support the expected development. Another purpose is to increase competence in the field of electrical architecture for vehicles.

The basic objectives of DFEA2020 are to

- secure fast Time-To-Market for new innovations while safeguarding VCC core values
- manage a quickly evolving business environment
- achieve cost efficiency and standardization

for the electrical architecture in vehicles built 2017 - 2025.

DFEA2020 has achieved its purpose and objectives by studying, developing and evaluating:

- Technologies, strategies, and solutions for electrical architectures consolidated in a reference architecture
- Models of electrical architectures to support development and simulation
- Methods and technologies for essential system characteristics such as functional safety and system safety
- A methodology for model-based development of the electrical system

Project results

The project has created comprehensive results in the field of electrical architecture for vehicles. Elaborate analyzes and thoroughly gone through solutions have been realized within the project areas, supporting opportunities to make leaps in the development. A new electrical architecture for vehicles has been created, including the realization of new communication protocols, the development of AUTOSAR for the control units, and advanced features for communication and software management in workshops. We have integrated the new standard for functional safety, ISO 26262, in the development process and in parallel influenced the standard on both international and national level.

Principles for the development of an electrical architecture for vehicles have been developed, as well as a prototype of an infotainment system based on the Android operating system. This prototype attracted much attention. During the development of the infotainment prototype we managed to demonstrate a high development pace along with responsiveness to customer needs by applying an agile approach.

The Royal Institute of Technology (KTH) as well as Chalmers University of Technology (CTH) were involved in the project, mainly connected to separate sub-projects of DFEA2020. At KTH the Division of Mechatronics and Embedded Control Systems within the School of Industrial Engineering and Management (ITM) participated, and at CTH the Division of Networks and Systems within the Department of Computer Science and Engineering was part of the project.

CTH focused on fault-tolerant distributed execution of functions for error handling, graceful degradation, and diagnosis in real-time systems for vehicles. KTH focused on the design of an electrical architecture for vehicles, which can host future advanced features for collaborative driving, such as platooning, and other autonomous functions.

Central to DFEA2020 is the creation of knowledge in the field of electrical architecture. Analyses and studies, seminars, designs and reports have created comprehensive knowledge among participating companies and universities. The project has organized eight seminars, where organisations not participating in the project were invited as well. Furthermore, results from the project have been presented at various national and international conferences.

The importance of DFEA2020 in creating business opportunities and jobs can not be underestimated! The contribution from the project to the development of electrical architectures has a direct connection to new functionality to be realized in future Volvo car models and thus to the sales figures of Volvo Car Corporation. Already while the project was running, jobs were created by the investments from Volvo Car Corporation, as well as through the business opportunities that emerged for the companies Knowit, Mecel and Semcon.

Thesis projects contribute by creating jobs and enhancing skills within the project area. Several thesis projects have been carried out within the framework of DFEA2020.

Project organisation

DFEA2020 consisted of seven partners:

- Volvo Car Corporation

- Semcon
- Mecel
- Knowit Technology Management
- SAAB AB (Saab Aerosystems)
- Royal Institute of Technology
- Chalmers University of Technology

divided into four sub-projects:
- SP0: Project Coordination
- SP1: TEChnologies for electrical Architecture (TECA)
- SP2: Methodologies for ARCHitecture development and evaluation (MARCH)
- SP3: FUnctional Systems Safety (FUSS)

DFEA2020 was led by Volvo Car Corporation and acted like an "umbrella" over the fairly large sub-projects. The intent of this organisation was to ensure that the project's overall purpose and objectives were met and to exploit possible synergies between the sub-projects. Through DFEA2020 the progress and resource allocation of the sub-projects was monitored and DFEA2020 was responsible for the common reporting of results.

2. Background

Functional growth and increased requirements on safety and reliability lead to an increased complexity of electrical systems in vehicles. The ability to manage this complexity is a prerequisite for handling the future technical development and to manage a transition from mechanical solutions to mechatronics. The cross-industry initiative AUTOSAR is an example of how the automotive industry chooses to address the foreseen complexity. The standard ISO 26262, which addresses functional safety, is another initiative in the same trend.

New technology drives and provides new opportunities in
- Safety, such IVIS and ADAS solutions where IVIS reads "In-Vehicle Information System" and ADAS "Advanced Driver Assistance Systems", respectively,
- eco-driving: both hybrid and electric powertrains supporting the driver to change behaviour,
- connected vehicles (V2V, V2I, I2V etc., Where V = "Vehicle" and I = "Infrastructure").

These applications share many realising technologies. It is the task of the electrical architecture to utilize synergies between the technologies and to create conditions for responsive and rapid innovation, while the electrical system stays safe without uncontrolled dependencies. The electrical architecture sets the preconditions for what is possible to achieve with the vehicle's electrical system and must hence support the future development and growth of functionality. This is the way that DFEA2020 contributes to environmentally friendly, safe and connected vehicles.

An electrical architecture and the methodology for the development of the electrical system are closely related, since the electrical architecture of a vehicle defines the preconditions for the development of the entire electrical system. DFEA2020's composition of activities is very well suited to address the scope of technical innovations and the development of advanced methods as a whole, supporting a world class functional development.

3. Objective

One purpose of DFEA2020 is to create solutions and new preconditions within the area of electrical architecture to support the expected development in safety, eco-driving and connected vehicles (Green, Safe, Connected). Another purpose is to increase the competency in the geographical region in the field of electrical architecture for vehicles.

An overarching objective of the project is to create new business opportunities and thereby new jobs in both short and long term.

4. Project realization

Because of the size of the project and possibly different purposes for each partner to participate in DFEA2020, different approaches developed in the separate project elements. The universities/institutes conducted their work on strictly academic principles, while the approach of the companies was focused on innovation.

There were regular project meetings with the company partners VCC, Knowit, Mecel and Semcon. These meetings were open to the academic partners, as well. At these project meetings common project issues were coordinated and issues were prepared for the steering group of DFEA2020. The steering group consisted of representatives from all participating parties, except SAAB Aerospace, which was represented by Knowit. The project manager was accountable to the steering group. The project organisation is described in the summary.

The various sub-projects had different characteristics, partly depending on the content of each sub-project, partly depending on the parties who participated in the sub-projects. Of course, there was a lot of "cross-talk" between the sub-projects, as e.g. the development of system safety within the FUSS sub-project neither can nor should be an isolated part of the development work, or as there is a natural interdependence between the architectural work of TECA and the development of modelling methodology in MARCH.

This work was followed up by regular reporting within and out from DFEA2020. Progress was followed up with milestones and in cases where it was appropriate Volvo Car Corporation's project management model GTDS, Global Technology Development System, was applied.

Active cooperation between the parties was given high priority to maximize the payback of the project. Through the cooperation the parties spurred and inspired each other, which in turn strongly contributed to achieving the purposes of the project.

Since increasing the competence in the field of electrical architecture is an essential part of the project, the seminars organised by the project should be mentioned again. These were an important tool to inform organisations not participating in DFEA2020 of the questions at issue within the project and for them to become involved in the exchange of competence. In addition to participating organisations also representatives from Autoliv, BorgWarner, Haldex, Saab Automobile, Scania, Sics, SP, the Swedish Transport Administration, the Viktoria Institute, Vinnova and Volvo AB were invited.

5. Results and deliverables

5.1 Delivery to FFI objectives

DFEA2020 has contributed to the following FFI objectives:

- Opportunities for the industry to competitively engage in knowledge-based production in Sweden.
- Contribute to a competitive automotive industry in Sweden.
- Conduct development measures relevant to the industry.
- Contribute to technology and competence development for the industry
- Contribute to the security of employment, growth and strengthened R & D activities.
- Strengthen the collaboration between the automotive industry and government agencies, universities and research institutes
- Ensuring the national supply of competency and establishing internationally competitive R & D activities
- Objectives defined within the national policies of transportation, energy and environment.

The project has contributed to the FFI objectives by:

- Increasing the expertise in the field of electrical architecture for vehicles, and this knowledge will be implemented in products that are manufactured in Sweden.
- Selecting of the key words Green-Safe-Connected for the project, based on the competitive situation in the automotive industry.

- Focusing on the area of electrical architecture which is very relevant from an industrial perspective, since the electrical architecture sets the preconditions for customer features which will provide a competitive advantage.
- The project focused on the development of technology and competency within electrical architecture.
- The project has positive effects on employment and growth in the short and long term: the participating parties have during the project made efforts and received assignments while solutions developed within DFEA2020 will be realized in the vehicles produced in Sweden. The R & D activities among participating organisations have very clearly been strengthened by DFEA2020, not least during the consequences from the financial crisis in 2008.
- Universities and companies in DFEA2020 have actively cooperated. Most likely this cooperation will be continued after DFEA2020, through contacts established during the project. In addition, the invitation of organisations outside the project to the DFEA2020 seminars has contributed to strengthen the collaboration between the automotive industry, universities and research institutes.
- The presentation of findings at the DFEA2020 seminars and at external conferences, as well as the delving of participating organisations into the areas of DFEA2020. The participating universities/institutes have been inspired, which will influence the education at these universities/institutes. Moreover, there is no doubt that DFEA2020 conducted research with international competitiveness, since some of the results have been presented at international conferences, and since Volvo Car Corporation operates in an internationally competitive market.
- DFEA2020 develops enabling technologies that contribute to save energy and to reach the objectives defined within the national policies of transportation, energy and environment.

The definition of DFEA2020 is based on the following FFI objectives:

- Continued development of strategically important base technologies.
- The development of innovative concepts in areas such as automotive electronics.
- The development and introduction of more efficient development methods.
- The effective usage of new construction materials.

Among these objectives DFEA2020 addresses the first three, where the project has created comprehensive results.

5.2 Examples of key findings from DFEA2020

Within DFEA2020 a completely new electrical architecture for vehicle has been created, where all preconditions were challenged and future needs thoroughly analyzed. The result is an architecture which for many years will carry very competitive functionality. This is a critical success factor, as more features than today are expected to be realized with the electrical system and the solutions require the different parts of the electrical system to interact.

To realize the architecture, extensive results have been developed within communication protocols (Ethernet, FlexRay), the structure of software in control units (AUTOSAR), and software download to vehicles. In addition to being a prerequisite for the realization of future functionality in vehicles, the results will also improve the customer experience when dealing with the workshops. One example is the development of a WLAN link associated with the Ethernet development in the project.

A reference architecture has been created to support technologies, strategies and solutions in a context. The reference architecture gathers experiences and knowledge from the electrical architecture and argues for selected solutions. It strongly influences the future development of the electrical architecture by describing the direction of this development. Through DFEA2020 the reference architecture has been established and will maintain its role in the future work.

A simulation environment for the architecture has been created for MIL, SIL and HIL testing of functions to be realized in the electrical system. The opportunities created by this environment are essential to streamline the lead times in the growing complexity arising from the upcoming feature growth in the electrical system.

The reduction of CO_2 emissions from vehicles has been addressed by defining conditions for the consumption of electrical energy. A new concept for state management has been developed, as well as a Simulink model to simulate the energy balance of the car. Beyond reducing the CO_2 footprint through optimization of the electrical energy consumption, an improved design of components is accomplished, e.g. the wiring cross-sectional areas, which in turn reduces the CO_2 emissions by optimizing the weight of components.

The new standard for functional safety ISO 26262 has been influenced on a national and international level, and also incorporated into the development process. One of the results in these achievements is that the engineers performing the development of the electrical system have complete guidance to fulfil the standard by following the development process, without explicitly having to familiarize with the ISO 26262 standard. Another important and internationally observed result is the test methods for ISO 26262 created within the project.

State-of-the-art methods and tools for model-based development of embedded control systems have been developed and implemented. Particular focus has been on structural modelling based on a logical decomposition of the electrical architecture. This work has evolved to include support for the design of the electrical system, i.e., beyond the support for architectural work. By showing how UML can be used in a very hardware and supplier dependent context, designers receive a language that streamlines the development process.

It turned out that the universities/institutes within DFEA2020 could find issues that were more complex than expected at the start of the project. In these cases, it has resulted in more "profound" research and potentially to a greater development step. The academic partners of the project have been inspired by questions that participating companies are struggling with, and especially by identifying specific areas at VCC where academic research is still lacking. By formulating academic research and presenting results the participating universities/institutes make a substantial contribution to knowledge in the field of electrical architecture for vehicles.

One important lesson from the development of a prototype of an infotainment system based on the Android operating system is the use of Scrum as a way to organise the work. One conclusion is that agile collaboration can be used advantageously in an FFI project, because in an FFI project one should have ambitious goals, and still have a good control over the direction of the project. The method also supports the ability to present project findings at any time, which favours the dissemination of knowledge.

6. Dissemination and publications

6.1 Dissemination of knowledge and results

Results from DFEA2020 already have and will continue to be established in the participating organizations. The questions at issue in this project are highly relevant and the results must be managed well in a competitive environment.

Within Volvo Car Corporation the results and experiences from DFEA2020 will be built into future car models, and changes in methodologies will propagate within the development organisation. Volvo Car Corporation has a number of projects, where the results of DFEA2020 will be further developed and realized.

Knowit, Mecel and Semcon benefit directly from the increase of competence in DFEA2020 by turning it into new business opportunities. These companies therefore have an interest of their own to spread the gained knowledge internally and through new assignments sprung from competence building in DFEA2020.

6.2 Publications

The following publications have been created within DFEA2020:

Chalmers University of Technology:

Barbosa, R.
Monitoring Local Progress with Watchdog Timers deduced from Global Properties
Reliable Distributed Systems, 2010 29th IEEE Symposium on, vol., No., Pp.131-140, October 31-November 3 2010, doi: 10.1109/SRDS.2010.23 URL http://ieeexplore.ieee.org/stamp/ stamp.jsp? tp = & arnumber = 5623387 & ISNUMBER = 5623379

Johan Karlsson
To agree or not to agree - on the design and analysis of real-time consensus protocols
"Keynote speech" at Workshop on architecting Safety in Collaborative Mobile Systems
SAFE COMP, Magdeburg, Germany, 25-28 september, 2012

Raul Barbosa, Johan Karlsson
Opportunities from Standardization in the Automotive Safety Assessment
EDCC-2010, 28-30 april 2010, Valencia, Spain
CARS '10 Proceedings of the 1st Workshop on Critical Automotive applications: Robustness & Safety, 27 april 2010, pp. 61-63, ISBN: 978-1-60558-915-2, doi: 10.1145/1772643.1772661

Negin Fathollahnejad, Raul Barbosa, Emilia Villani, Risat Pathan, Johan Karlsson
On probabilistic analysis of disagreement in synchronous consensus protocols
Technical report No. 2012:14, Department of Computer Science and Engineering, Chalmers University of Technology

Negin Fathollahnejad, Raul Barbosa, Emilia Villani, Risat Pathan, Johan Karlsson
A framework for formal verification of redundancy management protocols for automotive systems
Technical report No. 2012:15, Department of Computer Science and Engineering, Chalmers University of Technology

Johan Karlsson, Negin Fathollahnejad, Raul Barbosa, Emilia Villani, Risat Pathan
An architectural framework for fault tolerance and on-line diagnosis in automotive systems
Technical report No. 2012:16, Department of Computer Science and Engineering, Chalmers University of Technology

Royal Institute of Technology:

Alam, A.; Sagar BeHere et. al
Cooperative Driving According To Scoop
Real Time in Sweden (RTIs) 2011
Technical report, Royal Institute of Technology
Trita-EE, ISSN 1653-5146; 2011:051

Martensson, J.; BeHere Sagar, et. al.
The development of a cooperative heavy-duty vehicle for the GCDC 2011: Team Scoop
Intelligent Transportation Systems, IEEE Transactions on, Vol.13, no.3, pp.1033-1049, Sept.. In 2012
doi: 10.1109/TITS.2012.2204876
URL:
http://ieeexplore.ieee.org/stamp/stamp.jsp?tp=&arnumber=6236179&isnumber=6289408

BeHere, Sagar, Törngren, Martin, Chen DeJiu
A reference architecture for cooperative driving
Preliminary accepted for publication in the Journal of Systems Architecture, Special Edition on Embedded Software Design

Martin Toerngren, Stavros Tripakis, Patricia Derler and Edward A. Lee
Design Contracts for Cyber-Physical Systems: Making Assumptions Explicit Timing
Technical Report, University of Berkeley, USA,
URL: http://www.eecs.berkeley.edu/Pubs/TechRpts/2012/EECS-2012-191.pdf

DeJiu Chen, Lei Feng, Tahir Naseer Qureshi, Henry Maple, Frank Hagl
An Architectural Approach to the Analysis, Verification and Validation of Software Intensive Embedded Systems.
Accepted for publication in Computing Journal, Special Issue on Software Architecture for Code Testing and Analysis. Antonia Bertolino, Paola Inverardi, Henry Muccini (Eds.). Springer, 2012/13 (To Appear). ISSN: 0010-485X (Print) 1436-5057 (Online)

Sagar Behere
Vehicle Architectures for Increasing Autonomy
Elektronik i fordon 2012

Royal Institute of Technology and Semcon:

BeHere, Sagar (KTH); Liljeqvist, Björn (Semcon)
Towards Autonomous Architectures: An automotive perspective
Technical report, May. 2012, Dept.. of Machine Design, KTH
TRITA - MMK 2012:10, ISSN 1400-1179, ISRN/KTH/MMK/R-12/10-SE

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Knowit:

Michael Relbe
Architecture in Future Cars - a Challenge Supported by the Vinnova MARCH Project
MODPROD 5th Workshop on Model-Based Product Development, Linköping, 8-9 February 2011
URL:

Mecel:

Rolf Johansson, Mentor Graphics, Gothenburg, Sweden; Stefan Bunzel, Continental Automotive, Frankfurt, Germany; Marc Graniou, PSA Peugeot Citroen, Velizy, France; Henry Maple, Volvo Technology, Gothenburg, Sweden; Håkan Sivencrona, Mecel, Gothenburg, Sweden; Friedhelm Stappert, Continental Automotive, Regensburg, Germany
A road-map for enabling system analysis of AUTOSAR-based systems
CARS '10 Proceedings of the 1st Workshop on Critical Automotive applications: Robustness & Safety
ISBN: 978-1-60558-915-2

Semcon and Volvo Car Corporation:

Per Johannessen, Öjvind Halonen, Ola Orsmark
Functional Safety Extensions to Automotive SPICE according to ISO 26262
Proc. 11th Intl. Conf. SPICE 2011, Dublin, Ireland, May 30 - June 1, 2011, Software Process Improvement and Capability Determination Communications in Computer and Information Science Volume 155, pp. 52-63, ISBN: 978-3-642-21232-1
Presented at the "SPICE 2011, Dublin, Ireland, May / Jun 2011"

Semcon:

V. Izosimov and U. Ingelsson
Best Practices to Reduce Effort and Avoid Pitfalls in Adapting to ISO 26262: Illustrated by a Case Study from Requirements to Tool Qualification
Embedded Software Engineering (ESE) Convention, Sindelfingen, Germany, December 2012.

V. Izosimov, U. Ingelsson and A. Wallin
Requirement Decomposition and Testability into Development of Safety-Critical Automotive Components
SAFE COMP, Magdeburg, Germany, 25-28 september, 2012
Lecture Notes in Computer Science Volume 7612, pp. 74-86.

Wang, Q., Wallin, A., Izosimov, V., Ingelsson, U., Peng, Z.
Test Tool Qualification through Fault Simulation
European Test Symposium (ETS), Annecy, France, May 28-June 1 2012th

A. Astrom, V. Izosimov, O. Orsmark
Efficient Software Tool Qualification for Automotive Safety-Critical Systems
VDI Conference "Electronics im Kraftfahrzeug", Baden-Baden, Germany, 12-13 October, 2011, pp. 361-370 (nominated for best paper at the conference)

V. Izosimov
Automating Software Tool Qualification for Design and Testing of Safety-Critical Systems
Zuverlässigkeit und Entwurf (Zue), Hamburg-Harburg, 27-29 september 2011, pp. 20-24

Jens Pommer
Open Infotainment Labs
Elektronik i fordon 2012

<u>Volvo Car Corporation:</u>

Ola Örsmark
Functional Safety Assessment Process as an Extension to the Automotive SPICE
IQPC International Conference Experiences with ISO 26262
28-30 March, 2012, NH München Dornach, Germany

<u>Volvo Car Corporation, Knowit, Mecel, Semcon:</u>

Per Söderstam, Mikael Relbe, Håkan Sivencrona, Thomas Reichel
Dependable and Flexible Electrical Architecture 2020
Elektronik i fordon 2011

7. Conclusions and future research

DFEA2020 has created a substantial added value for participating organisations. The project has produced results that already have influenced and will influence the participating organisations. In the field of electrical architecture for vehicles there still are areas that require academic research, and this may become very interesting to the universities/institutes.

8. Participating parties and contact person

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