

AUTOMOTIVE SYSTEMS DESIGN

PEng projects 2016

The PDEng Automotive Systems Design is an accredited and challenging two-year doctorate-level engineering degree program. During this program trainees focus on strengthening their technical and non-technical competencies related to the effective and efficient design and development of technologies and applications for modern high-tech automotive systems. In particular, there is a focus on the multidisciplinary design aspects of project-based research and engineering in high-tech automotive systems, reflected in the key contributions by five TU/e departments. For more information please visit www.tue.nl/asd.

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AUTOMOTIVE SYSTEMS DESIGN - PDENG PROJECTS 2016

- 4** **Péter Bevíz PDEng;** Top-Down Design and Verification Methodology for Analog Mixed-Signal Integrated Circuits

- 6** **Brian Cano Martinez PDEng;** Advanced Front-lighting System for Heavy Duty Trucks

- 8** **Khaled Emam PDEng;** Modeling and Control of a Dual Clutch Transmission System - Wet Clutch Lifetime Estimation

- 10** **Seshadri Arjun Krishna PDEng;** Analysis of CVT Concepts

- 12** **Ilias Papaliouras PDEng;** Design and Implementation of Adaptive Cruise Control System for the TU/e Solar Powered Electric Car

- 14** **Asterios Pliatskas PDEng;** Control Mechanisms for Battery Energy Storage System Performing Primary Frequency Regulation and Self-Consumption Optimization

- 16** **Edwin Ross PDEng;** Heavy Duty Power Train Optimization with Waste Heat Recovery

- 18** **Vikram Sridhar PDEng;** Structure and Control Co-Design of a Robotic Manipulator - A Design Methodology

- 20** **Evangelos Stamatopoulos MSc PDEng;** Environment Model Creation for Trucks - Design and Implementation of a sensor fusion algorithm

- 22** **Sivasubramanian Velayutham PDEng;** Design of Next-Cycle & Intra-Cycle Control for Diesel Combustion with Multi-Pulse Injection

- 24** **Christos Vichas PDEng;** Design and Base Implementation of an Automotive Applications Testbed



Prof.dr.ir. M. Steinbuch
Dr. P.S.C. Heuberger

The fourth generation ASD trainees

With pleasure and pride we present you the results of the 2016 graduates of the PDEng program Automotive Systems Design. This program was started in 2011, motivated by the urgent need of the automotive industry for system architects, people who are not afraid to go beyond the boundaries of disciplines and who are willing to work together in project teams to achieve desired results in a structural manner.

This two-year post-master program educates its trainees in-depth in various automotive related disciplines, as well as in personal and professional development. This variation in disciplines is reflected in the 11 projects that lie before you. We see a wide range of applications and designs in the areas of Mechanical and Electrical Engineering, Mechatronics, Software and IC Design, Sensors and Actuators, Transmission Systems, Control, Modelling and Advanced Driver Assistant Systems (ADAS). These ADAS systems are playing a major role in automotive developments with the goal to enable fully automated driving within the next decades. One of the projects studies the implementation of adaptive cruise control on the TU/e solar cars; a second one created a Testbed that provides the basis for hardware-in-the-loop (HIL) simulation testing of ADAS and allows for easy and seamless shifting between HIL simulation testing and real world testing. Four projects deal with applications for heavy duty trucks: sensor fusion, advanced front-lighting systems, power train optimization and smart engine control. Another project combines automotive and robotics and studies the design of a robotic manipulator on an AGV. Two projects are in the area of transmission systems, one of these investigates possible topologies of new systems, the other one tries to improve knowledge of existing systems. Another project introduces a novel design and verification methodology for integrated circuits. The last project deals with a phenomenon that will attract a lot of attention in the near future, where many households are producing energy. It studies the storage of energy in batteries and the related control mechanisms.

These final PDEng projects, proposed and payed for by the high-tech industry are diverse, complex and challenging. They require our trainees to deliver products and designs that meet high requirements in a highly multidisciplinary setting. We are proud that that our trainees live up to the high expectations of the industry. We wish them all the best and a successful career.

Maarten Steinbuch
Scientific Director

Peter Heuberger
Program Manager



“Peter converted loosely defined ideas about new tools and methods for design and verification into running valuable prototypes. These results encourage us to take the next steps along this path, which should lead to more efficient design of our automotive products. Peter thank you for turning these ideas into concrete solutions.”

Ir. M.W.M. Oosterhuis
sr. Verification engineer, NXP Semiconductors, In Vehicle Networks,
Nijmegen, 20 September 2016

Challenges

The main challenges of this project were to find the applicable programming languages which can be used in AMS system-level modeling, and the integration of chosen tools and languages into a feasible top-down flow.

Results

A feasible top-down design and verification flow, with the integration of tools and modeling languages. Furthermore, a proof of concept study that realized an executable architecture description of a CAN chip with the novel flow. The implemented architecture merged analog, digital hardware and software functions into one executable model. The chip model was verified via simulation in Cadence Incisive environment.

Benefits

The case study proved that the developed methodology provides early design verification possibility with mixed-level simulation and supports seamless design refinement from specification to IP implementation. The novel methodology makes the work of AMS chip designers and verification engineers more organized and brings on step closer the desired standardized and automatized AMS design and verification flow.

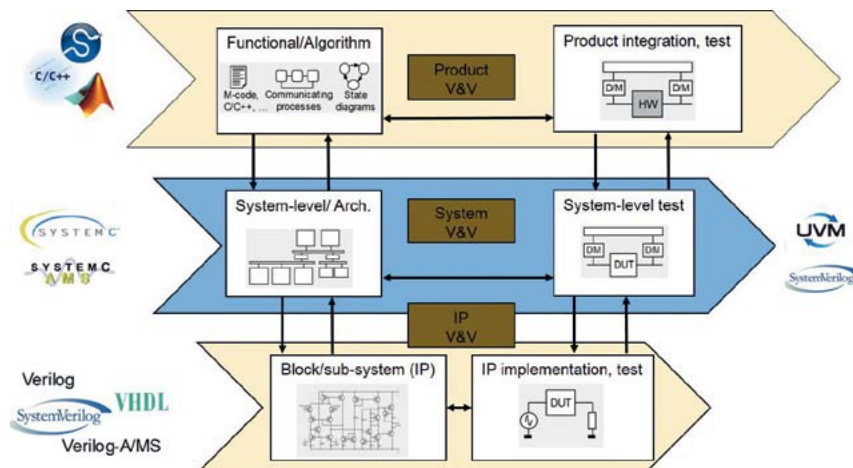
Péter Bevíz PDEng

Top-Down Design and Verification Methodology for Analog Mixed-Signal Integrated Circuits

The market for in-vehicle networking integrated circuits (IC) grows rapidly driven by the EE architectural evolution. In addition, there is a raise in the number of analog and mixed-signal (AMS) modules in automotive system-on-a-chips, due to the enhancing advanced driver assistant systems (ADAS) in modern vehicles. These novel trends challenge the chip designer and verification engineers. The traditional design and verification methodologies are not adequate anymore to satisfy the need of the market.



NXP Semiconductors is the world's leader company of integrated circuit development. Furthermore, the company is pioneer in the research of novel design methodologies. This project attempts to provide a new top-down design and verification flow for AMS chips, which brings the analog and digital design and verification worlds closer.



In order to prove the feasibility of the developed top-down design and verification process, a case study was implemented. The CAN chip based case study confirmed, that the developed top-down design and verification methodology provides the possibility of early design verification, creation of executable descriptions for higher abstraction level models, and mixed-level simulation. As result, the project has contributed in the standardization of a novel design methodology for NXP.

Challenges

The main goal was to build a functional prototype on vehicle that can demonstrate defined AFS algorithms to assess the system functionality.

Results

From the perspective of the requirements and expectations of the stakeholders, the proof of concept was realized and the functionality satisfyingly demonstrated.

Benefits

At night, AFS is just a vision assistant system that offers the driver one of the best systems that today the lighting technology can provide. As a conclusion, the driver should know that an Advanced Front-lighting System (AFS) is merely there to support her/him at night and cannot relieve her/him of the responsibility for her/his actions.



“Both DAF Sr. Management and the TU/e committee were quite impressed with his accomplishments. His sprint and perseverance was remarkable and a key factor that helped him to keep everything on track and follow the agreements.”

Kurosch Asghari
Lead Engineer, Specialist at DAF Trucks N.V.

Brian Cano PDEng

Advanced Front-lighting System for Heavy Duty Trucks

Nowadays, the competitive pressure and environmental concerns urge for reductions in energy consumption while the automotive users prompt for new and more reliable safety systems. For this reason, DAF Trucks N.V. is venturing in the emerging technology known as Advanced Driver Assistance Systems (ADAS). In the past years, DAF has been very active developing research projects towards the goal of automated driving. Among the ADAS applications, Advanced Front-lighting Systems (AFS) have been developed to improve the visibility and safety of the driver and other road users at night.



The potential safety benefit at night is particularly important for Heavy Duty Vehicles which face continuously complex traffic environments in all kind of weather conditions. Currently, AFS is a camera based lighting system, which enables the use of the high beam to fully illuminate the road at night without glaring oncoming or preceding vehicles by excluding them from the light pattern. Moreover, the changes in the vehicle's tilt angle are compensated to maintain the headlamp vertical range to provide good visibility to the driver.



Anticipating on development road map of automotive lighting technology, particularly for Heavy Duty Trucks in coming years, DAF started a feasibility study in the field of AFS systems.



“Khaled faced the challenging task to design a test plan and to execute that plan. Unfortunately the circumstances made the execution impossible, with the effect that Khaled had to focus more on the underlying methodology. In doing so he showed that he can work quite independently and works very hard on the problems that he faced. He consulted a lot of people both inside and outside the company. He created awareness within the company on the problem field and the company will certainly proceed with the work.”

Roëll van Druten
Manager R&D at Punch Powertrain N.V.

Challenges

The main challenge was to reach a definition for the lifetime of the wet multi-disk clutch. A methodology was followed to reach this definition as a standardized approach to assess the end-of-life does not exist in the literature. After reaching this definition, a design was established for a durability testing strategy to validate the definition, taking into consideration the level of testing and the limits of the testing facility.

Results

As an outcome of the project, a new promising durability testing strategy has been designed based on the defined lifetime criteria.

Benefits

Punch Powertrain learnt more about the effect of the design variations of the clutch system with respect to the lifetime expectancy. On top of that, Punch Powertrain can start testing for the system durability independent of the system suppliers.

Khaled Emam PDEng

Modeling and Control of a Dual Clutch Transmission System

Wet Clutch Lifetime Estimation

Punch Powertrain, headquartered in Sint-Truiden, Belgium, with a second R&D location in Eindhoven and with a production facility in Nanjing (China) offers a complete portfolio of powertrain solutions for the most popular passenger car segments (conventional, hybrid and full electric). These innovative products provide excellent driving dynamics, enhanced comfort, fun of driving and an ever improving fuel economy. As a leading independent supplier to the automotive industry, Punch Powertrain is expanding rapidly. In this context it is able to offer inspiring career opportunities for motivated engineers, of which this PDEng assignment was formulated.

The focus of this assignment was to investigate and assess the lifetime requirements of the wet multi-disk friction clutch used in Punch Powertrain's Dual Clutch Transmission (DT₁) so that the company is able to perform durability testing independent of the suppliers which opens more doors to future design and control development.



Challenges

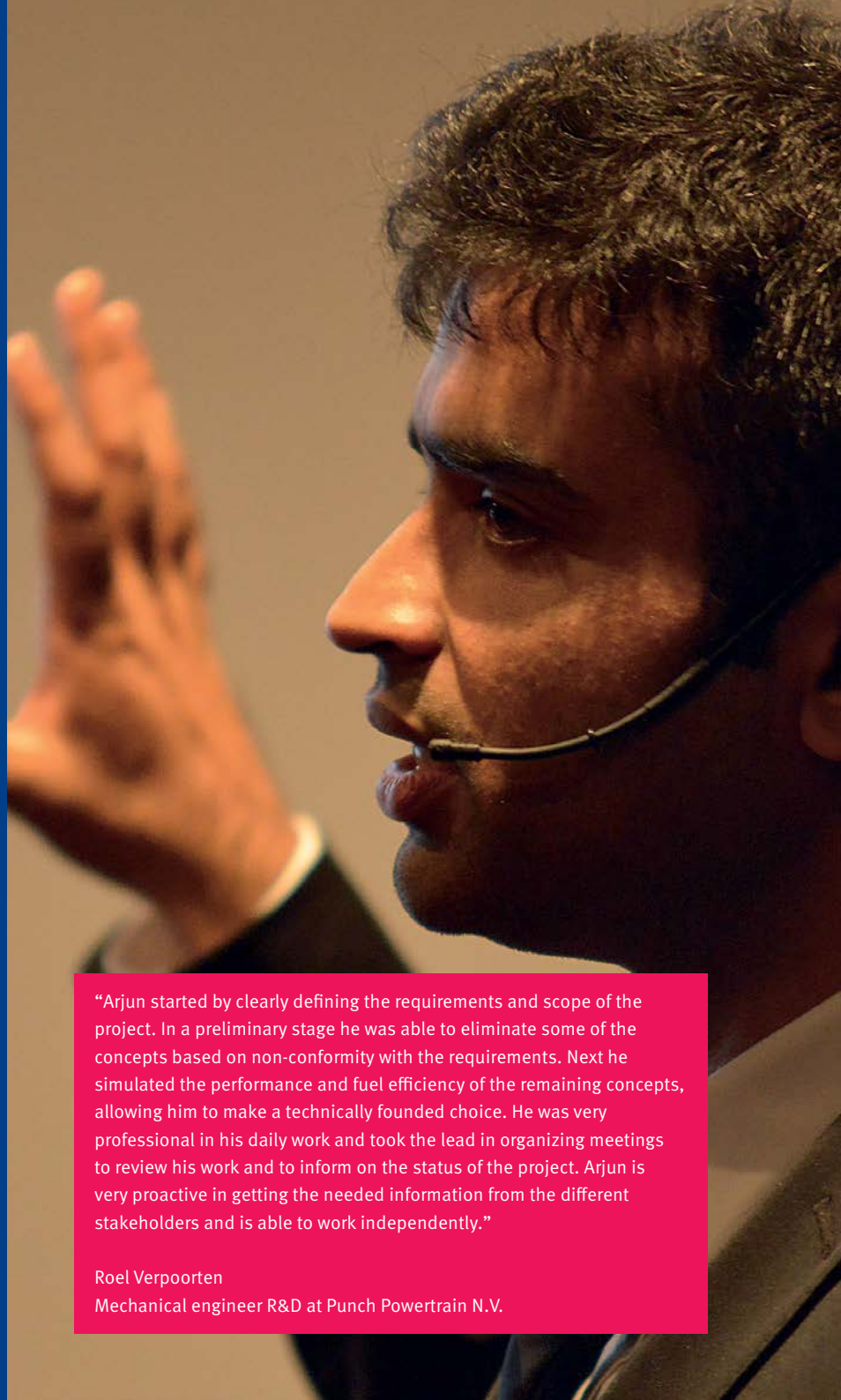
The main challenge of the project was its multidisciplinary aspect. Meetings with different personnel from different departments were required to obtain ideas and constraints that one needs to know as a baseline to evaluate these concepts. Asking the right questions and formulating a direction based on this knowhow was also quite challenging.

Results

2 concepts were recommended to Punch Powertrain, with respect to the direction they would like to take for their future product.

Benefits

The analysis gives Punch Powertrain insight into the potential behavior of the CVT concepts. The cost and the simulation models build for the selected concepts can be detailed further by Punch Powertrain for an even more detailed analysis of the selected concepts.



“Arjun started by clearly defining the requirements and scope of the project. In a preliminary stage he was able to eliminate some of the concepts based on non-conformity with the requirements. Next he simulated the performance and fuel efficiency of the remaining concepts, allowing him to make a technically founded choice. He was very professional in his daily work and took the lead in organizing meetings to review his work and to inform on the status of the project. Arjun is very proactive in getting the needed information from the different stakeholders and is able to work independently.”

Roel Verpoorten
Mechanical engineer R&D at Punch Powertrain N.V.

Seshadri Arjun Krishna PDEng

Analysis of CVT Concepts

With ever increasing competition and technological advancements and burgeoning markets in countries such as China and India, automotive transmission suppliers such as Punch Powertrain are always looking to improve their products in every way possible to give it an edge over its competitors. With each new product, Punch Powertrain strives to improve it in terms of certain parameters over its predecessor. Based on these parameters, 9 CVT concepts acting as potential successor to their current product were investigated in the project, ending with suggestions as to which concept is the best choice for Punch Powertrain for the future. The parameters used to evaluate these concepts were fuel consumption, performance, drivability, cost and sizing.

This project was performed for the Advanced Development group inside Punch Powertrain. The Advanced Development group as the name suggests, is responsible for exploring new avenues in the field of powertrains and determining its feasibility with respect to the goals and vision of Punch Powertrain.





“The PDEng Automotive Systems Design (ASD) program is part of the TU/e Smart Mobility strategic research area and aims to deliver solutions for clean, safe and sustainable smart mobility. Therefore, we are pleased with the project results that Ilias Papaliouras has contributed in the scope of this graduation project. There were also certain unforeseen challenges encountered during this project, which were tackled thanks to his technical and professional skills. The future recommendations to improve the ACC system for the solar car are also valuable for the current and future STE members.”

Dr. Yanja Dajsuren PDEng
Program Director PDEng Software technology

Challenges

The main challenges of this project were the implementation of Adaptive Cruise Control (ACC) system in the “Stella Lux” solar powered electric vehicle of Solar Team Eindhoven, while coping simultaneously with different hardware limitations.

Results

In this project, an Adaptive Cruise Control (ACC) system was designed and a prototype with “Stella Lux” solar electric vehicle has been created. Computer simulations have also shown that the combined use of the ACC system and Regenerative Braking instead of Electronic Braking System (EBS) on highway can provide significant increase in the energy efficiency of the solar car and thus extend its range.

Benefits

Solar Team Eindhoven has decided to use the results of the project as a basis in order to make their next solar car smarter, safer and more comfortable for the driver and the passengers and be again the leader in the next World Solar Challenge in Australia.

Ilias Papaliouras PDEng

Design and Implementation of Adaptive Cruise Control System for the TU/e Solar Powered Electric Car

The automotive industry has been under constant changes due to stricter emission regulations, technology driven trends, and new business models. Solar energy is considered to be a viable alternative energy source that can replace conventional energy sources which causes global warming and threatens and damages public health and environment. To contribute to realizing solar cars become practical day-to-day transportation device, Solar Team Eindhoven (STE), a student team from the Eindhoven University of Technology (TU/e), has built solar electric cars and became consecutive champions of the Bridgestone World Solar Challenge.

Besides the regulatory and customer demands for eco-friendly and clean cars, fully autonomous vehicles are expected to be up to 15 percent of new cars sold worldwide in 2030. To facilitate the transition from conventional cars to autonomous cars, Advanced Driver Assistance Systems (ADAS) are being introduced to the market albeit with impeding penetration rate. The solar electric cars are no exception to this technology trend, therefore in this project, an Adaptive Cruise Control (ACC) is designed and developed for the TU/e solar car.



Challenges

One challenge was to identify the interests of multiple stakeholders and translate them into a functional design with the proper abstraction level. Three different departments within Eneco Holding Group cooperated for this project, each one with its own domain of focus and requirements. Another challenge was the assimilation of all information on operational mechanisms of the complex Dutch energy market, and their classification on potential applications for the Tesla Powerwall.

Results

A systems engineering approach has resulted in selecting the suitable applications for the Powerwall and identifying the most mature market for its deployment. Based on the system requirements, two control strategies for the battery have been developed. A simulation using real-life measurements has yielded that the Powerwall is capable of providing the requested services successfully. A tool is now available for Eneco to evaluate the expected performance of the Powerwall.

Benefits

The insight in the energy flexibility markets and the potential applications for the Powerwall contribute to the realization of Eneco's vision of a sustainable future, with the integration of storage in daily life. This project also contributes with knowledge on the logic behind battery steering mechanisms and the optimization of the Powerwall utilization. The developed models can be extended to include additional services or investigate alternative ways of optimal control.



“The background for optimization models, the practical use of it, and the insight in flexibility energy markets, are valuable and tangible results for Eneco that strengthen our view to invest heavily in these new business models around stationary storage. Asteris impressed Eneco in clear presentations of his results and how easily and quickly he showed insight in these themes. We are thankful for his results and proud that he is also very committed and passionate about a renewable future!”

Dirk-Jan Middelkoop
Manager Solar & Storage, Eneco Innovation & Ventures

Asterios Pliatskas PDEng

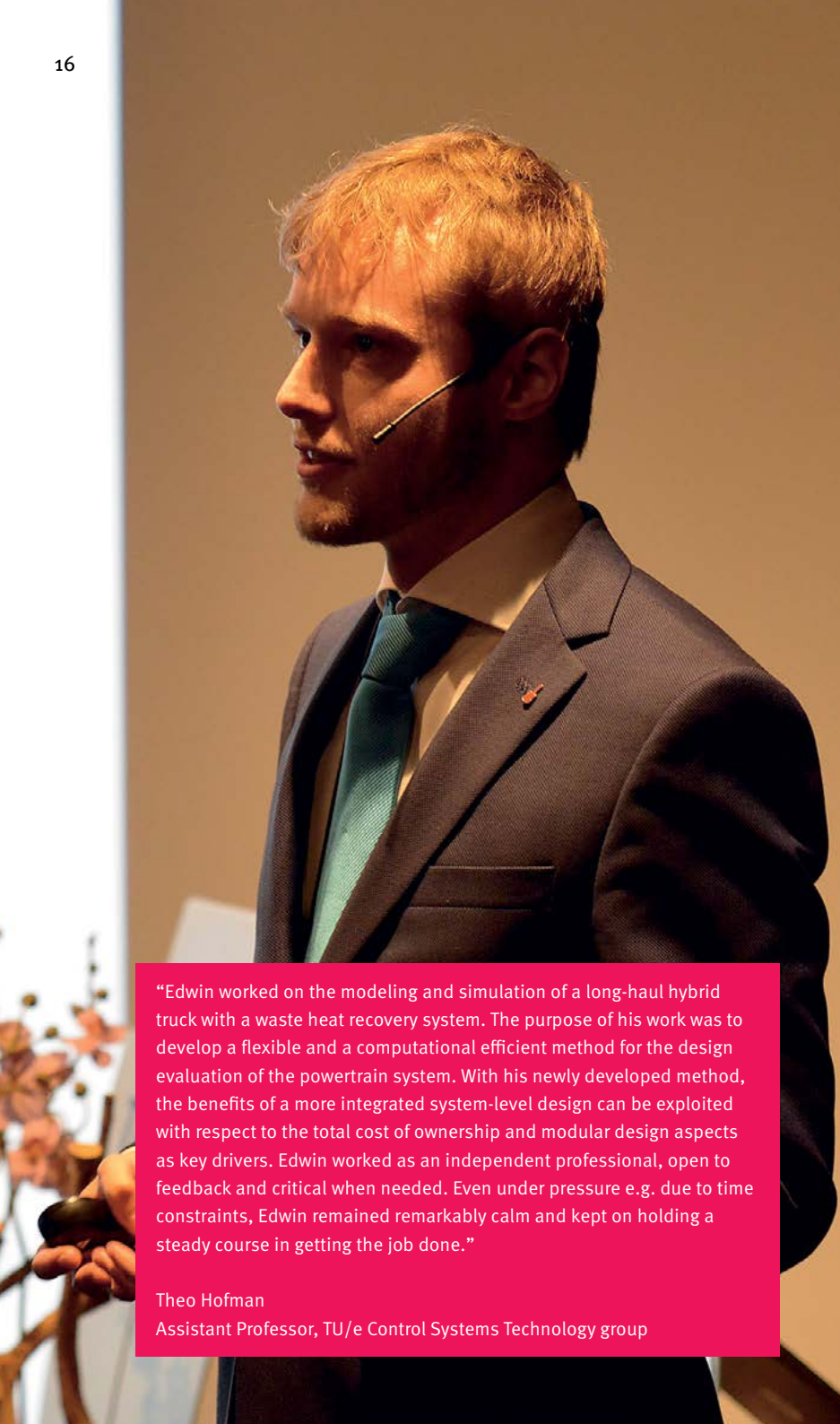
Control Mechanisms for Battery Energy Storage System Performing Primary Frequency Regulation and Self-Consumption Optimization

The scenery in sustainable energy is changing, with energy storage technologies becoming available at competitive prices and improved energy and power specifications. Eneco Holding N.V., a key player in sustainable energy solutions, has made a strategic deal with Tesla Motors to be the sole providers of the Tesla Powerwall home storage unit in the Netherlands. Their motivation for this project was to investigate possible revenue streams for both the homeowner and the utility provider, in order to find the way to optimally dispatch the Powerwall to the market.

An initial investigation on the possible applications for storage sheds light in the current state of the Dutch energy market and the ideal applications being the provision of ancillary services to the grid and improving the self-consumption of solar power for households. A systems approach is used to define the concept and architecture of the system to perform the desired applications, and the requirements that the system must comply to.

Two control strategies are developed for comparison on a modelling level, with respect to the chosen applications. The developed tool provides insight to the system's technical boundaries, tangible results on the system's performance and the basis upon which the optimal utilization of the Powerwall can be achieved.





“Edwin worked on the modeling and simulation of a long-haul hybrid truck with a waste heat recovery system. The purpose of his work was to develop a flexible and a computational efficient method for the design evaluation of the powertrain system. With his newly developed method, the benefits of a more integrated system-level design can be exploited with respect to the total cost of ownership and modular design aspects as key drivers. Edwin worked as an independent professional, open to feedback and critical when needed. Even under pressure e.g. due to time constraints, Edwin remained remarkably calm and kept on holding a steady course in getting the job done.”

Theo Hofman
Assistant Professor, TU/e Control Systems Technology group

Challenges

Powertrains are highly complex systems, and to optimize them for both component sizes and control requires a serious amount of computing power – especially if a waste heat recovery system is included. How do you keep computation times practical, while maintaining a sufficiently large scope and achieving a good model accuracy? Additionally, component models not only have to represent the component of one particular design, but should cover a range of component sizes, without losing accuracy.

Results

This project provided an initial analysis of the powertrain optimality, and gave insights in what aspects change once a waste heat recovery system is included in the powertrain design. In addition, a modular optimization platform has been created that will form the basis of an increasingly inclusive powertrain optimization tool.

Benefits

This study gave insight in the optimality of the demonstrator’s powertrain. This knowledge can then be used for a production vehicle. Furthermore, it forms the basis for a powertrain optimization tool that can optimize component sizes, control and topologies in an integrated manner.

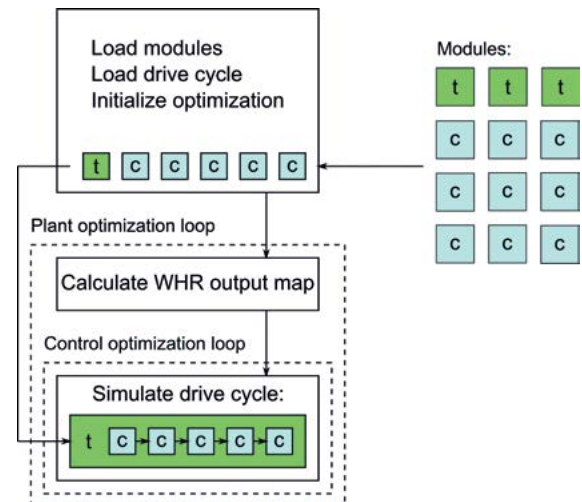
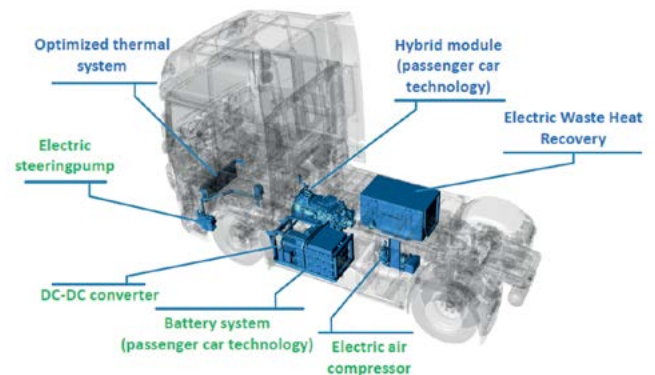
Edwin Ross PDEng

Heavy Duty Power Train Optimization with Waste Heat Recovery

Reducing greenhouse gas emissions remains one of the major challenges of the 21st century – one on which the automotive sector can have a significant impact. Hybrid power trains are a promising means of improving vehicle emissions, and are currently becoming more and more widespread. To further increase the powertrain efficiency of hybrid vehicles, increase their affordability and to bolster the European automotive industry's competitiveness, the EU has funded the ECOCHAMPS consortium to develop advanced powertrains that are, at the same time, cost effective as well – and to prove this by building demonstrator vehicles.

DAF Trucks and the TU/e are both part of this consortium, and work on a long haul demonstrator truck. Besides having a hybrid powertrain, the vehicle features a waste heat recovery system – a system which harvests waste heat, and turns it into mechanical or electrical power. Though the design has been completed, it is desirable to know what the potential of the used technologies is.

To find out, an optimization study of the powertrain was done, which was the main topic of this study. Both component sizes and their control were optimized in an integrated fashion. In addition to finding and elaborating on the potential gains that stand to be made, in terms of efficiency and total cost of ownership, the impact of including a waste heat recovery on the optimal design and control of a power train were investigated.



Challenges

The main challenge was to select the most influential decision parameters that reflect on the robots size, payload manoeuvrability, and energy consumption and integrate it into the co-design methodology. An additional challenge was to structure the entire co design approach into a large scale optimization problem.

Results

The potential of the developed methodology is demonstrated to estimate optimal structural and control parameters for the design of a robotic manipulator for an industrial use case. The methodology developed concurrently takes into account kinematics, dynamics and path planning to provide an optimal solution. The co-design methodology can also be used for limited redesign of a manipulator and other similar mechatronics systems.

Benefits

Optimal design for mechatronic systems can be realized through the application of co-design methodologies. Through the successful application of co-design, Flanders Make is assured that co-design can indeed be applied to complex large scale mechatronic systems requiring an optimal design paving the way for future projects.



“Vikram has been given a complex and challenging research problem to solve. During his time in Flanders Make, he has developed the required competences and provided satisfactory results. His attitude was always very positive as well as the cooperation among colleagues. His work has allowed us to better understand the potential of system and control co-design for robotic manipulators.”

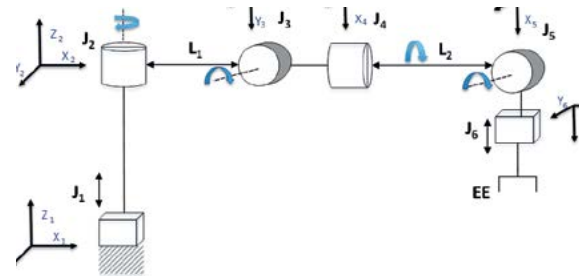
Albert Rosich
Senior Research Engineer, Flanders Make, Leuven

Vikram Sridhar PDEng

Structure and Control Co-Design of a Robotic Manipulator

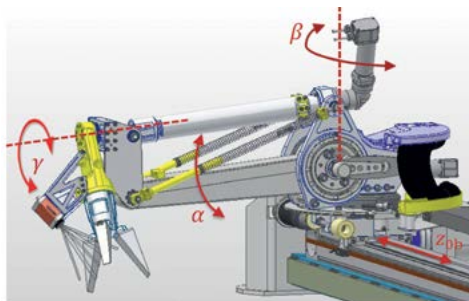
A Design Methodology

To cater to the increase in demand and to stay competitive, companies' are constantly improving the performance of the industrial robotic manipulators. Designers of robotic manipulators are faced with challenging requirements concerning higher accuracy, lower power consumption, increased payload manoeuvrability and lower total mass of the robot. Since design of robots involve multidisciplinary aspects. It is very hard to compare different concepts of robotic manipulators in the initial stages without adequate models and analysis tools. Specifically in order to make cross disciplinary decisions as a system architect to result in an optimal design. Robotic manipulators are devices that can be analysed with respect to multiple aspects such as dynamics, kinematics, path planning, materials, sensors etc.

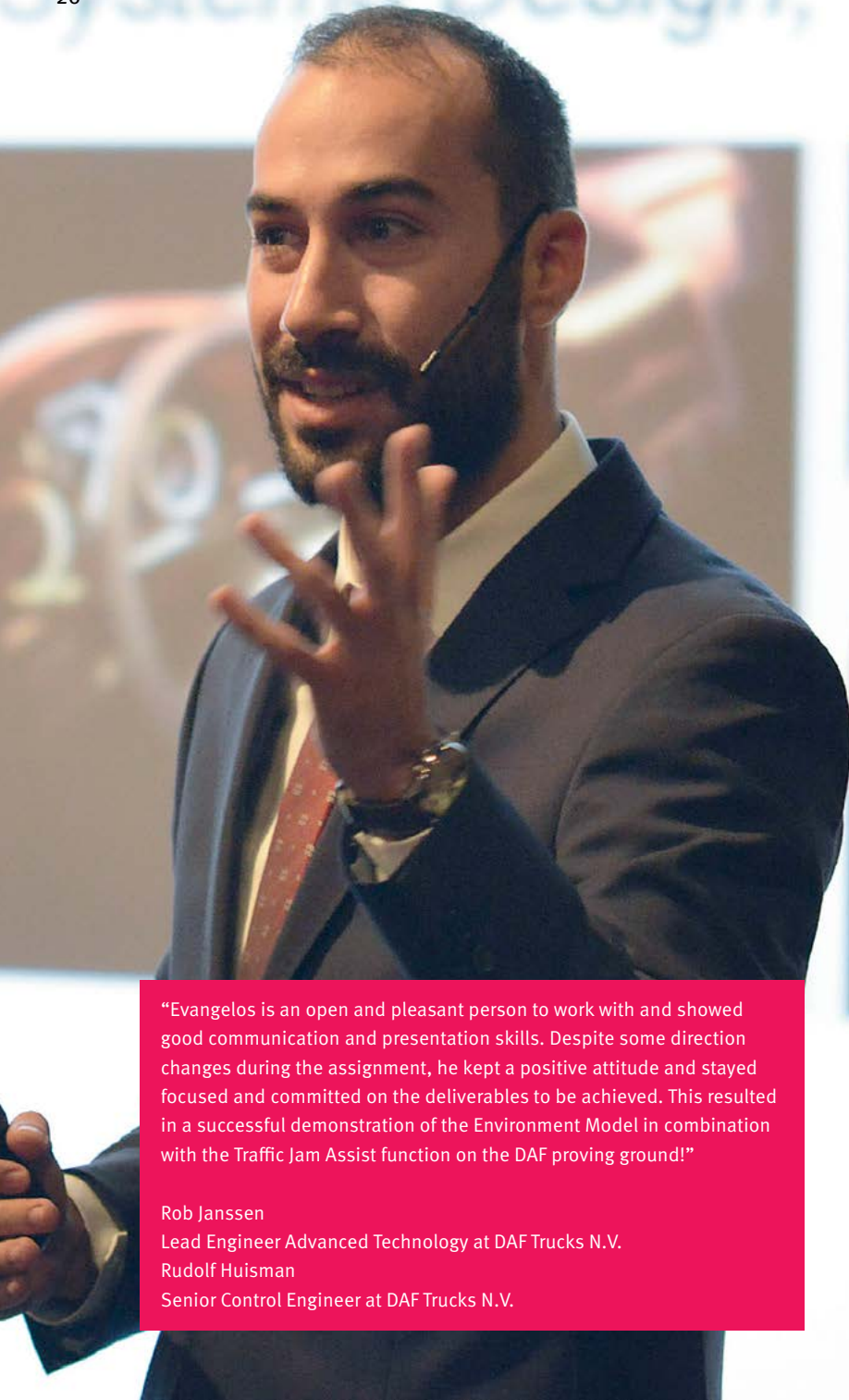


While designing such complex systems it is often too qualitatively and quantitatively difficult to compare concepts analyse and make decisions during the concept generation/selection phase. Optimal design in complex systems require exploring the synergy between structural and control parameters. This can be realized using co-design methodologies.

The development of the methodology is a part of the Model Based Systems Engineering for Mechatronics (MBSE4M) project funded by the Institute for the Promotion of Innovation through Science and Technology in Flanders (VLAIO), Belgium.



In this project a co-design methodology is developed, and it is aimed at aiding system engineers and architects by providing them with useful insights during the concept generation/selection phase. Some of the most important aspects such as kinematics, path planning, and dynamics are taken into account in this methodology. In this project, it has been successfully demonstrated that co-design methodologies can be applied to complex systems such as robotic manipulators.



“Evangelos is an open and pleasant person to work with and showed good communication and presentation skills. Despite some direction changes during the assignment, he kept a positive attitude and stayed focused and committed on the deliverables to be achieved. This resulted in a successful demonstration of the Environment Model in combination with the Traffic Jam Assist function on the DAF proving ground!”

Rob Janssen

Lead Engineer Advanced Technology at DAF Trucks N.V.

Rudolf Huisman

Senior Control Engineer at DAF Trucks N.V.

Challenges

The major challenge of this project was to cope with sensors limitations, while on the same time to develop an Environment Model that is capable to deliver essential environment information to several ADAS functions.

Results

A functional prototype that can provide several ADAS functions with important environment information has been created. The employed sensor fusion algorithm is able to combine information coming from several sensors and increase the completeness in the environment perception.

Benefits

Towards the road for development of fully autonomous trucks, a reliable and robust perception of the environment around the vehicle is of most importance. Demonstrating the functionality of the Environment Model enables the realization of more sophisticated ADAS functions in the future. For customers this means that safety, comfort as well as efficiency increase.

Evangelos Stamatopoulos MSc PDEng

Environment Model Creation for Trucks

Design and Implementation of a sensor fusion algorithm

The core activity of DAF is the development and production of light, medium and heavy-duty commercial vehicles. DAF offers tailor-made solutions for every application. Reliable, durable, efficient, with class leading driver comfort and backed by first class services.

The automotive landscape, passenger cars as well as trucks, is facing big changes due to the increased use of Advanced Driving Assistance Systems. DAF is faced with many challenges in this respect and one of these is the fact that autonomous functions rely on the environment observed by several individual sensors.



This project gave insight in the challenges related to defining and creating an environment model based on the signals supplied by several sensors. An environment model was designed, by means of sensor synergy and sensor data fusion, which ultimately resulted in a functional proof of concept on a prototype vehicle.

To test the designed system, it was implemented on a DAF Euro VI truck, making use of dSPACE Rapid Control Prototyping (RCP) hardware and software. The designed environment model have proven successful in providing essential environment information to enable the functionality of Traffic Jam Assist!

Challenges

Diesel combustion is a very complex process. There is a number of factors that influence the combustion process. The real-time nature of control enforces challenging requirements on the hardware and software components. With next-cycle control, data acquisition, computation, decision and communication has to be performed within 57 ms and intra-cycle control is further more challenging with a requirement of 1.4 ms.

Results

Next-cycle control was implemented using an FPGA-CPU based rapid prototyping system. Next-cycle control with multi-pulse fuel injection was successfully demonstrated on TU/e's single cylinder engine. The most challenging part of the project is the intra-cycle control concept. Potential benefits of intra-cycle control were identified from experimental analysis. Technical feasibility of this concept has been addressed with system design. A possible intra-cycle control concept with available test set-up has been proposed with an objective of reducing NOx emissions.

Benefits

Experimental analysis in the study shows that fuelling inaccuracies could increase NOx emissions and fuel consumption. Closed loop combustion control can compensate these disturbances, thereby engine performance can always be maintained at a desired value. The working prototype established in the project provides a solid platform to improve on the existing virtual sensors and control algorithm.



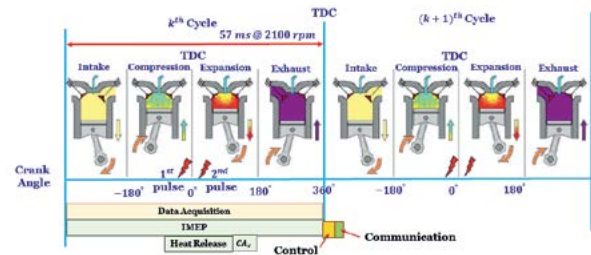
“Siva successfully implemented the first next-cycle combustion controller for multi-pulse fueling strategies on a single cylinder engine set-up. This is a crucial step in our research into ultra clean and efficient combustion concepts.”

Prof. Frank Willems
TNO Automotive

Sivasubramanian Velayutham PDEng

Design of Next-Cycle & Intra-Cycle Control for Diesel Combustion with Multi-Pulse Injection

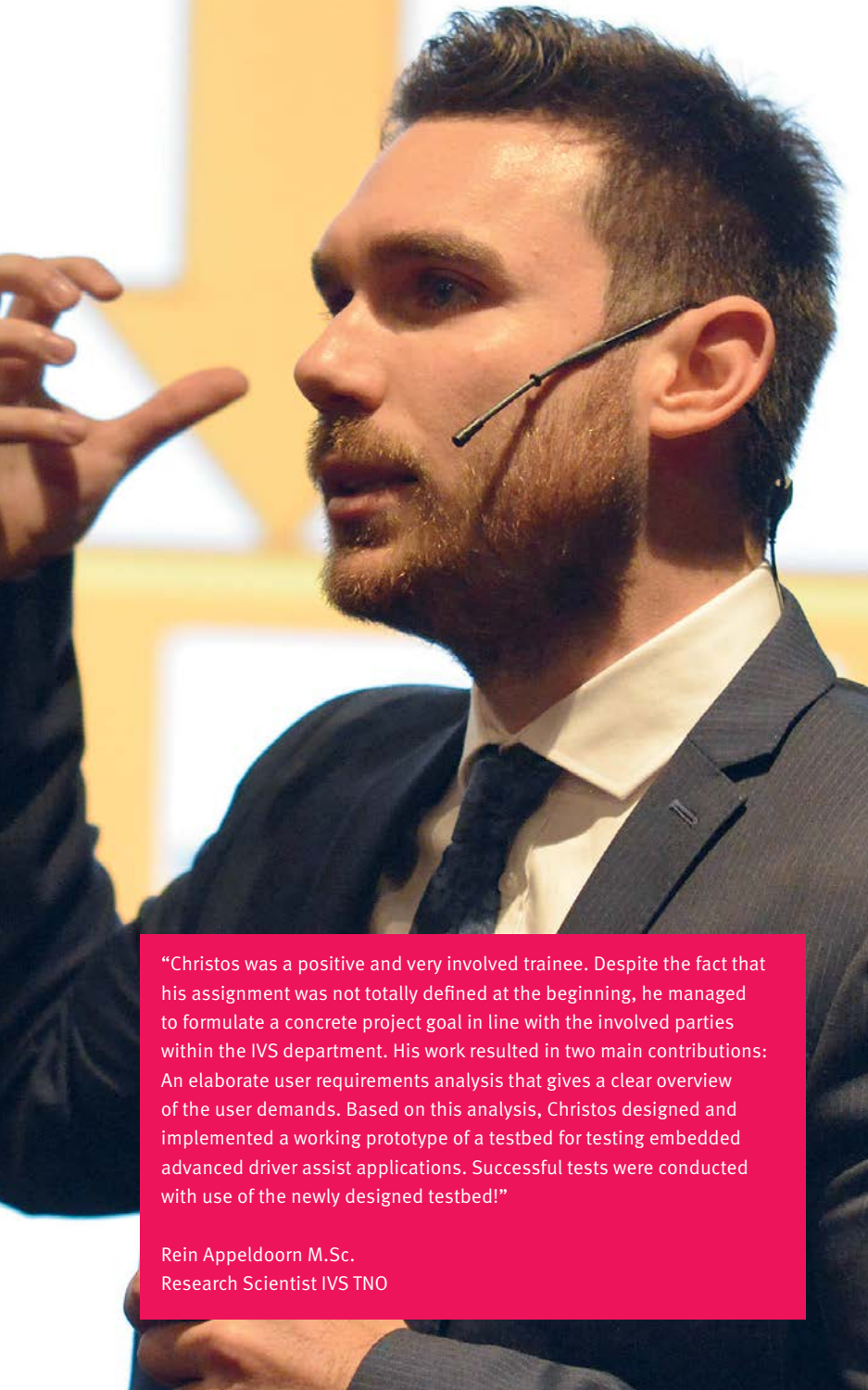
Over the period of years, the diesel engine system has become complicated to comply with strict emission standards and fuel consumption demands. Multi-pulse fuel injection is performed with modern diesel engines to lower the emission and noise levels. As the system gets complicated, the degree of control increases and impose challenging requirements on the engine control system.



Conventionally, the diesel engines are controlled open-loop based on feedforward of desired set-points. With the advent of in-cylinder pressure sensors, combustion characteristics can be estimated in real-time to perform closed-loop control. Cylinder pressure based control (CPBC) can automatically compensate for disturbances like variations in ambient conditions, fuel quality, ageing etc. This could lead to achieve optimal trade-off between fuel consumption and emissions. CPBC can also significantly reduce calibration time and cost that occurs with open-loop control.



The primary objective of the project was to realize CPBC for a single cylinder heavy duty engine. Two fuel path control concepts were investigated in this study: next-cycle control and intra-cycle control. In next-cycle control, fuel injection for the next cycle is adapted based on the combustion behaviour of the current cycle. Enhanced engine performance could be achieved with this concept due to the fast control response. Intra-cycle control is carried out by performing the control action in the same cycle. Fuelling decisions are made for the same cycle based on the partial results from the combustion process. The advantage of this type of control is better compensation for cycle to cycle variations and improved transient response.



“Christos was a positive and very involved trainee. Despite the fact that his assignment was not totally defined at the beginning, he managed to formulate a concrete project goal in line with the involved parties within the IVS department. His work resulted in two main contributions: An elaborate user requirements analysis that gives a clear overview of the user demands. Based on this analysis, Christos designed and implemented a working prototype of a testbed for testing embedded advanced driver assist applications. Successful tests were conducted with use of the newly designed testbed!”

Rein Appeldoorn M.Sc.
Research Scientist IVS TNO

Challenges

The main challenge of this project was to understand, structure and prioritize the needs and wishes of a large base of users with different backgrounds and goals in testing of ADASs. Another challenge was to design a generic and extendable framework that can facilitate the testing of various ADASs.

Results

The project resulted in the implementation of a prototype framework, called the Testbed, which allows the testing of virtually every ADAS in three different types (or modes): Hardware-in-the-loop simulation, real world testing and replay testing.

Benefits

TNO obtained a framework that will enable testing of ADASs in HIL simulation possibly reducing the number of needed real world tests and thus reducing the cost and effort for testing. Moreover, when the time for real world testing eventually comes, the deployment of the ADAS on the research vehicle will be possible without any change which was not possible until before the introduction of the Testbed.

Christos Vichas PDEng

Design and Base Implementation of an Automotive Applications Testbed

Advanced Driver Assistance Systems (ADAS) have become more complex than ever before. The development of such complex systems poses a lot of challenges when it comes to testing. These systems have to be tested exhaustively and under many different realistic test scenarios in order to guarantee their safe and proper operation. However testing a system in realistic scenarios usually means that the system has to be deployed on a research vehicle. Issues discovered in this stage are sometimes difficult and most of the times very expensive to be dealt with.

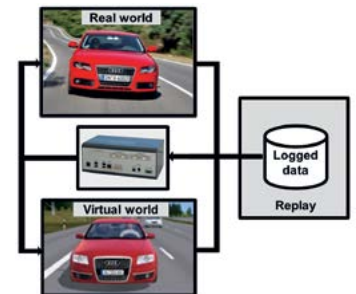
Therefore the aim is to have realistic enough testing as early in the process as possible such that issues can be discovered and dealt with early and with reduced cost and effort.

This goal can be achieved with Hardware-In-The-Loop (HIL) testing. This means that the system is deployed on the platform that is used for testing in the research vehicle (System Under Test Platform – SUT platform) but this time it is connected to a simulation environment instead of the research vehicle. The simulation environment simulates the vehicle in various levels of detail depending on the accuracy that is needed as well as the traffic around it. In essence HIL simulation is bridging the gap between pure Software-In-The-Loop (SIL) simulation and real world testing.

This goal was achieved in this project by creating a testing framework, the Testbed, which provides the basis for HIL simulation testing of ADAS but also allows for easy and seamless shifting between HIL simulation testing and real world testing, through a standardized interface which is used for the communication of the SUT platform with the simulation environment or the research vehicle. The Testbed also provides facilities that allow the engineers to perform tasks that are usually needed in testing such as logging of test data, inspection and plotting of test data and finally replaying of test data, in a simple way.



All the above was achieved by making use of modern open-source technologies from the field of robotics like the Robot Operating System (ROS) and the Gazebo simulator. The use of open-source technologies has proved successful and fits the profile of TNO which, being a research organization, can easily co-operate with universities and other research organizations that are using these popular technologies.



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