



PDENG PROJECTS 2019

Automotive/Mechatronic Systems Design

TU/e

EINDHOVEN
UNIVERSITY OF
TECHNOLOGY

The PDEng Automotive Systems Design is an accredited and challenging two-year doctorate-level engineering degree program. Since 2015 the subtrack Mechatronic Systems Design is part of this program. During these programs 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 and mechatronic systems. In particular, there is a focus on the multidisciplinary design aspects of project-based research and engineering in high-tech automotive and mechatronic systems, reflected in the key contributions by four TU/e departments. For more information please visit tue.nl/asd.

Automotive/Mechatronic Systems Design - PDEng Projects 2019

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PROF.DR. H. NIJMEIJER
DR. P.S.C. HEUBERGER

The 2019 generation ASD/MSD trainees

With great pleasure we present you the results of the thirteen 2019 graduates of the PDEng program Automotive Systems Design with tracks ASD (6) and MSD (7). After the start of the ASD program in 2011, motivated by the demand of the automotive industry for system architects and designers, an additional track, MSD, was started in 2015 with strong support of the TU/e High Tech Systems Center. The program is driven by the rapid changes in the Dutch high-tech ecosystem with huge challenges in terms of multidisciplinary product and process design and engineering. This two-year post-master program educates its trainees in-depth in various automotive and mechatronic related disciplines, as well as in personal and professional development.

This variation in disciplines is reflected in the 13 projects that are presented in this booklet. The subjects of these projects are in the areas of Advanced Driver Assistance Systems (ADAS), Heavy Duty Diesel Engines, Tribological studies on Transmission Systems and Contamination Control for High-tech Equipment, Modelling of Buses for energy saving, Nano-positioning, On Board Diagnostics, New Line Sorting concepts, Pedestrian Behavior Estimation, Medical Applications for Eye Surgery and Smart Patient Tables, and 5G mm-wave Demonstrations.

Two ADAS projects focus on the extension of advanced cruise control using advanced target analysis and lateral control strategies after exiting the high way by making use of predictive map information and car following information. A third ADAS related project studies pedestrian behavior to enable autonomous driving.

Sorting parcels and packages is becoming very important in the current economy and one project studies a new approach that enables larger speeds for the next generation of line sorters.

For large truck manufacturers a reliable prediction of the performance of their diesel engines is becoming essential with the increasingly strict emission regulations. One project focusses on the use of a single cylinder research engine for the exploration of new high-efficient and low-NOx combustion regimes, a second project in this area deals with Simulation Technologies for On-Board Diagnostics. On the other hand we see a considerable growth in electric mobility and one project aims at the modelling and control of the HVAC system of an electric city bus and the related thermal management system.



Tribology plays a critical role in many industries. One project focusses on the properties of polymeric parts in transmission systems. A second project deals with contamination on nanoscopic scale, in particular in the study of particle generation in high-tech equipment. Another project for the nano-precision industry aims at improving the positioning control of atomic force microscopes. 5G technology is about to conquer the world. In order to showcase the possibilities of this technology one project develops an application for robot soccer turtle robots.

Patient tables are widely used in modern hospitals, among other for imaging (radiology) purposes. In this application precise and easy maneuverability is essential. One project studies a motor assisted functionality for this purpose. A second application of the use of high-tech technology in medical applications focusses on a mechatronic solution to improve the treatment of a serious eye disease in prematurely born children,

These final PDEng projects, funded and proposed by the high-tech industry are diverse, complex and challenging. They require our trainees to deliver products and designs that meet high demands 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.

Henk Nijmeijer
Scientific Director

Peter Heuberger
Program Manager



“The possibility to drive autonomously through an urban environment has been a vision for many years. One of the many challenges of an autonomous vehicle is its safe operation through busy urban traffic. Therefore, the vehicle must be provided with an accurate description of the environment, such as the most probable position and intention of a Vulnerable Road User (VRU) now and in the future. Bahareh’s assignment involved the high-level design of the world description to estimate the current state and intention of the pedestrian. In this project, she used Openpose software to detect joints and then she estimated the state and intentions of the pedestrian. This model is sufficiently validated in a defined scenario. Bahareh has made a good effort in developing a user-friendly code, which is valuable to the Autopilot project.”

Marzieh Dolatabadi Farahani
TU/e PhD student, Control Systems Technology Group

CHALLENGES

Engineers and scientists have been working to remove the human from the control of the vehicles. To fulfill this goal, the system should be able to coexist and interact with road users. Regardless of different factors that affect these interactions, grasping pedestrian intention can help vehicles in decision making accordingly. The main challenge was the complexity of human behavior which makes the estimation of the intention a complicated task.

RESULTS

The concept of pedestrian intention estimation is investigated using images from a face-forwarding camera in autonomous driving systems. Estimating human intention is based on the pose of the human body and a set of features extracted from the pose. These features are used for estimating the current state or action that the pedestrian is involved in. Then, a sequence of states or actions is used to estimate the upcoming sequence of actions that show the intention of the pedestrian.

BENEFITS

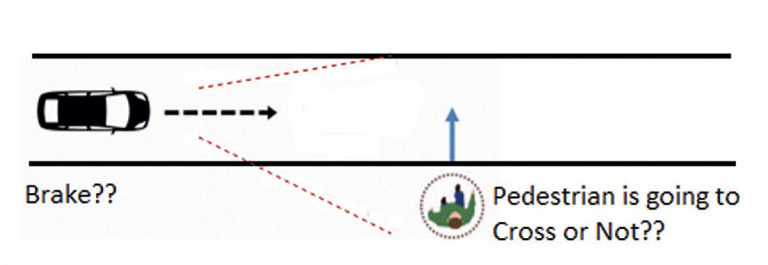
A primary prototype system is developed to estimate human intention. The estimations can be further incorporated with other environmental information such as distance and velocity to calculate the probability of potential dangers. It then can be used in making a decision for the vehicle and if needed to trigger the braking system early enough to reduce injuries.

BAHAREH ABOUTALEBIAN, MSc PDEng

Pedestrian Intention and State Estimation

The Robotics Laboratory at TU/e focuses on the fast-growing field of Robotics, among others on an intelligent driving system.

If a vehicle moves in urban areas, it needs to realize if the initiating braking system is required to prevent accidents or not. In fact, it must predict the probability of a collision on the future path of a vehicle with each pedestrian in a certain crucial area. Thus, it is not adequate to only detect the current location and distance. Various approaches exist to measure and detect those pedestrians. One reliable method is to use a camera to detect and track pedestrians and localize them in the world model. The world model contains information about the environment and the system that is necessary for the proper autonomous operation. After localizing pedestrians, the problem boils down to use detections and measurements to predict the future path or the intention. Images of pedestrians can open up the chance to extract a different kind of feature and information about the pedestrian. Analyzing human intention and behavior is a broad and complicated field of study. Whereas in self-driving systems the intention to stop or walk across the road is of great importance, the first effort should be around this subject. With this in mind, the main objective of the current project is to improve the autonomous system world model by providing information about pedestrian current and future movements or intention.



CHALLENGES

The Smart Carrier concept proposes the separate actuation of each shoe (the actuation component) in the Posisorter by means of an electric motor and a timing belt. To incorporate the Smart Carrier concept in the Posisorter, a robust and reliable communication link between continuously moving controllers and stationary controllers must be established. Furthermore, power has to be supplied to a significantly large number of mobile actuators.

RESULTS

A conceptual system design was created, detailing how the Smart Carrier concept can be incorporated into the Posisorter, according to a set of requirements given by Vanderlande. The design included the breakdown of the concept to sub-components, assigning functionalities to each sub-component and selecting the appropriate realization technologies. Each realization technology selected was theoretically assessed in terms of its technical feasibility and its ability to fulfill the given requirements.

BENEFITS

The developed system design can be used as a blueprint for the future development of the next generation of Posisorters. Furthermore, the developed design is generic, meaning that the same design can be applied to different types of line sorters, next to the Posisorter.



“Mohamed focused his work on a communication system between many controllers in the line sorter. This critical part of the system affects and is limited by almost all subsystems. This meant that Mohamed needed to understand the current architecture of line sorters, adapt and develop an architecture of distributed controllers. His thorough analyses in the early stage of the project resulted in good evaluation of possible solutions. The solution that has been chosen looks promising. Mohamed took every bit of advice and improved on it almost directly. He worked in an independent, well-structured and high-quality manner, for which I want to thank him warmly.”

Ir. Koen Grobбен,
System Architect at Vanderlande Industries B.V.

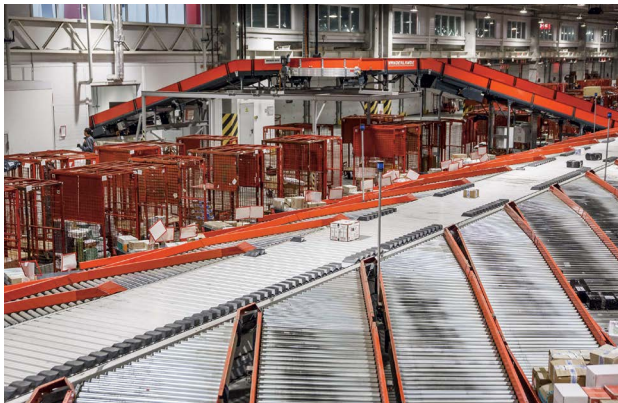
MOHAMED ALOSTA, MSc PDEng

The Smart Carrier

DESIGN OF A NOVEL APPROACH TO THE NEXT GENERATION OF LINE SORTERS

Online retailers need to prepare their supply chain operations for the anticipated rise in demand over the coming years. Supply chain operations carried out by such retailers in their distribution centers include but are not limited to: storage, transport, orders packaging and packaged orders sorting. Vanderlande provides companies like online retailers and package delivery companies with automated products sorting solutions. One of those sorting solutions is called the Posisorter. The Posisorter (also known as the shoe sorter) is a line sorting system that takes as an input a stream of packaged products and redirects each product into different output routes according to their required final destination. The current Posisorter system relies on the positive shoe sorting principle for the action of sorting products. Positive shoe sorting imposes physical restrictions on the Posisorter system. As a result, the current system is not flexible enough to cope with the increasing demands coming from online retail consumers.

The main objective of this project was to design a solution towards a new sorting principle, the Smart Carrier, to be used in the next generation of Posisorters. As opposed to the positive shoe sorting principle, which is a mechanically-oriented concept, the Smart Carrier is a more technologically advanced solution with a significantly higher number of integrated sensors and controllers. The new sorting principle will introduce more flexibility in the Posisorter. The improved system flexibility will render it more adaptable to the continuously changing requirements demanded by online retailers.





“Within the developed framework an approach is defined to incorporate Single Cylinder Engine measurement data to account for the combustion characteristics in the DAF used simulation tools. The framework will be used to analyze and assess the integrated performance of newly defined combustion and air management systems. Mohammad’s contribution in setting up this framework is highly appreciated and gives a solid base for integrated analysis and assessment of new combustion and air management developments.”

Jarno Strik
Head of The Engine Definition and Thermodynamics Team, DAF
Trucks N.V.

CHALLENGES

The challenges in establishing a valid simulation framework come from the structural differences between the Single-Cylinder and the Multi-Cylinder engines. A Single-Cylinder engine, unlike a Multi-Cylinder engine, is equipped with many auxiliary units to support its functions. Moreover, the Single-Cylinder engine, contrary to a standard Multi-Cylinder engine, is not equipped with a Turbocharger. The desired boost pressure and the pressure drop across the Single-Cylinder engine is set by auxiliary units that are not available on a standard Multi-Cylinder engine. Therefore, the framework has to be able to address these issues in a comprehensive and methodical manner.

RESULTS

The framework successfully predicts the Multi-Cylinder engine performance based on the Single-Cylinder test results. It also explicates two distinct turbo-matching approaches, one that provides insights into turbocharging potentials according to the test data, and another that is investigative and further explores the Multi-Cylinder engine performance over an operation spectrum beyond the tests.

BENEFITS

The simulation framework combines combustion system modeling and turbo-matching practices, and allows for a structured, methodical, and comprehensive Single-Cylinder to Multi-Cylinder correlation. Doing so, it helps engine simulation engineers make better choices for the engine sub-systems. Such a capability, massively accelerates the engine development process since the two types of the engines are brought closer together in simulations.

MOHAMMADSADEGH ARIANNAZAR, MSc PDEng

Single-Cylinder to Multi-Cylinder Engine Performance Simulation Framework

A STEP TOWARD MULTI-CYLINDER ENGINE PERFORMANCE PREDICTION USING SINGLE-CYLINDER ENGINE EXPERIMENTS

The engine development process usually includes making choices between a multitude of options for each engine component. Usually, different engine components influence each other's performance through the feedback they induce on each other. For example, the performance of the combustion system on a Multi-Cylinder engine is inextricably influenced by the turbocharger's performance.

The components' isolated performance study does not necessarily yield enough insight to properly select components for an engine. For example, the combustion system A could outperform B and C in an isolated performance study, however, once coupled with the turbocharger α , the combustion system B could be the top performer. The selection process is inherently a cumbersome task, since most of the times the number of options is large. This renders the testing of the engine performance under all imaginable combinations impossible. Moreover, usually the experiments are performed on a Single-Cylinder engine which is structurally different from a Multi-Cylinder engine. Moreover, correlating the Single-Cylinder test results and the Multi-Cylinder engine performance is hard and influences the selection task substantially.

The purpose of this project is to serve as a foundation that lays out the major steps in the establishment of a Single-Cylinder to Multi-Cylinder engine performance simulation framework. Such a framework is expected to bring the two types of engines closer in the simulations by combining combustion modeling and turbo-matching in one practice, to accelerate the engine development process.



CHALLENGES

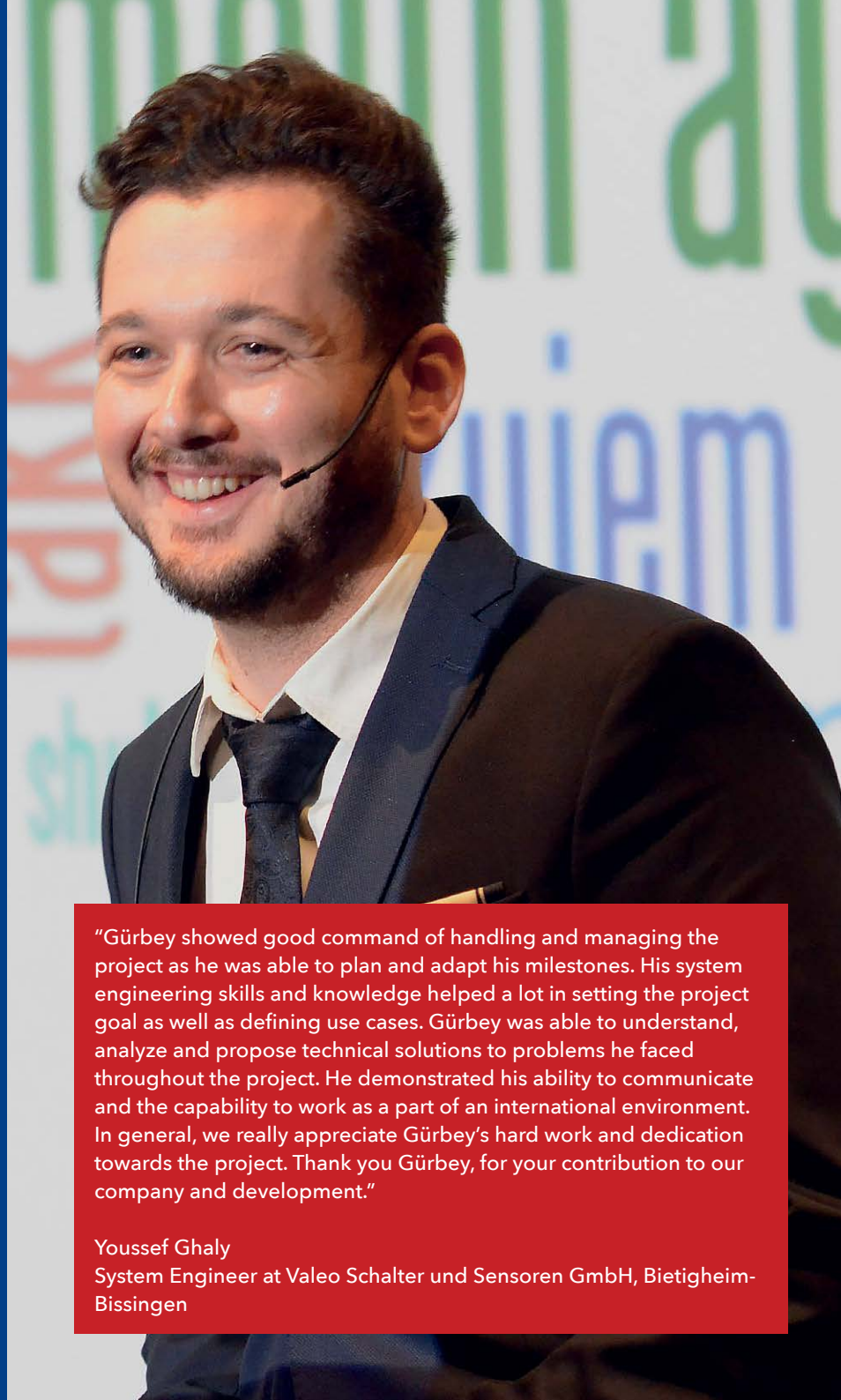
Although the camera-based functions perform well on the highway conditions, non-highway driving where the lane markers are not clearly visible to the camera can be challenging for the lateral assist systems. A proper abstraction of the methodology was necessary to develop efficient solutions with the available digital map data and the camera hardware, in order to handle the most common non-highway scenarios with minimal increase in the cost and complexity.

RESULTS

The map-based lateral control and target following strategies were developed and implemented on the Simulink platform. The proof-of-concept system was validated by using real-life test data in a simulation model where all the necessary inputs were successfully generated. The results showed that the digital map technology combined with target vehicle assessment is a potential advancement in lateral vehicle control.

BENEFITS

Valeo gained insights into the map-enhanced lateral assist functions which can provide prospective improvements in their existing lane centering systems. The developed techniques can be taken one step further and be integrated on Valeo's baseline platform.



"Gürbey showed good command of handling and managing the project as he was able to plan and adapt his milestones. His system engineering skills and knowledge helped a lot in setting the project goal as well as defining use cases. Gürbey was able to understand, analyze and propose technical solutions to problems he faced throughout the project. He demonstrated his ability to communicate and the capability to work as a part of an international environment. In general, we really appreciate Gürbey's hard work and dedication towards the project. Thank you Gürbey, for your contribution to our company and development."

Youssef Ghaly

System Engineer at Valeo Schalter und Sensoren GmbH, Bietigheim-Bissingen

GÜRBEY ÇEKEN, MSc PDEng

Development and Validation of Lateral Control Strategies After Exiting the Highway

EXTENDING THE LATERAL CONTROL IN NON-HIGHWAY SCENARIOS BY USING DIGITAL MAP AND CAR FOLLOWING STRATEGIES

In recent years, a major focus in the automotive field has been the development of advanced driver assistance systems, in order to improve the safety and efficiency of road vehicles. Valeo is one of the global market leaders in this domain, maintaining a vision of constantly improving their existing functionalities by utilization of the latest technological advancements. Hence, a project was initiated in collaboration with Eindhoven University of Technology, aiming to extend the current lateral assist systems in non-highway scenarios.

The main objective of the project was to extend the lane centering capability of the camera-based system by utilization of digital map data and supportively, car following strategies. As an input to the developed solution, the electronic horizon structure was available by the ADASRP software. The study aimed to transform this raw horizon information to an "ego lane representation", which should be compatible with the camera input in a way that a fusion of the lane information from two different sources (camera and map) could be enabled. Consequently, enrichment and extension of the existing camera-based driving horizon was accomplished. With the increased reliability of the fused ego lane detection, target assessment for car following purposes was also supported by using the existing ACC module along with the ADASRP's horizon structure.





"This project has led to the design of a demonstrator module that could assist the movement in both the lateral as well as the longitudinal direction simultaneously. We at Frencken are very happy with the way this project has been conducted by Sahar and the demonstrator that clearly shows the benefit of this function for the end customer."

Dr. Jan P. van den Brink
Director Frencken Engineering

CHALLENGES

Sometimes, motorized functionalities of the tables are used to move the area of interest to the focus point of the C-arms, or in some cases, operators manually position the patient by pushing and pulling the tabletop in the horizontal plane. Mostly, manual movement of the table with patient on the table requires a large input force from the operator, which can cause long term issues.

RESULTS

A user interface is designed to interact with the human, initiate the movement and generate the reference commands for the motor movements. Also, to show the performance of the design, a demonstration set-up of the functionality is implemented successfully.

BENEFITS

The results show that the control design provides power-assistance to the operator to move the table in the floating mode. Having the motor-assisted floating module, the input force required to move the loaded table is reduced to the force which is required to move the empty tabletop.

SAHAR ETEDALIDEHKORDI, MSc PDEng

Motor-Assisted Floating Function for Frencken High-End Patient Table

A SYSTEM ENGINEERING APPROACH FOR THE DEVELOPMENT AND IMPLEMENTATION OF MOTOR-ASSISTED FLOATING MODULE FOR A HIGH-END MEDICAL IMAGING TABLE

Although radiology is often thought of as a diagnostic field, it has become increasingly involved in the development and deployment of treatment modalities. It has been used in several minimally invasive therapeutic procedures in different applications like Interventional Radiology, Interventional Cardiology, and Interventional Neurology.

Cardio / vascular surgical procedures use X-ray images taken by C-arms during surgery as intervention guidance. Moving the patient into the best viewing position for scanning is a common surgical task, which requires experiences, time, and sometimes many X-ray shots until the desired image is obtained. Patient tables are used to orient the patient based on the area of interest during the scanning.



CHALLENGES

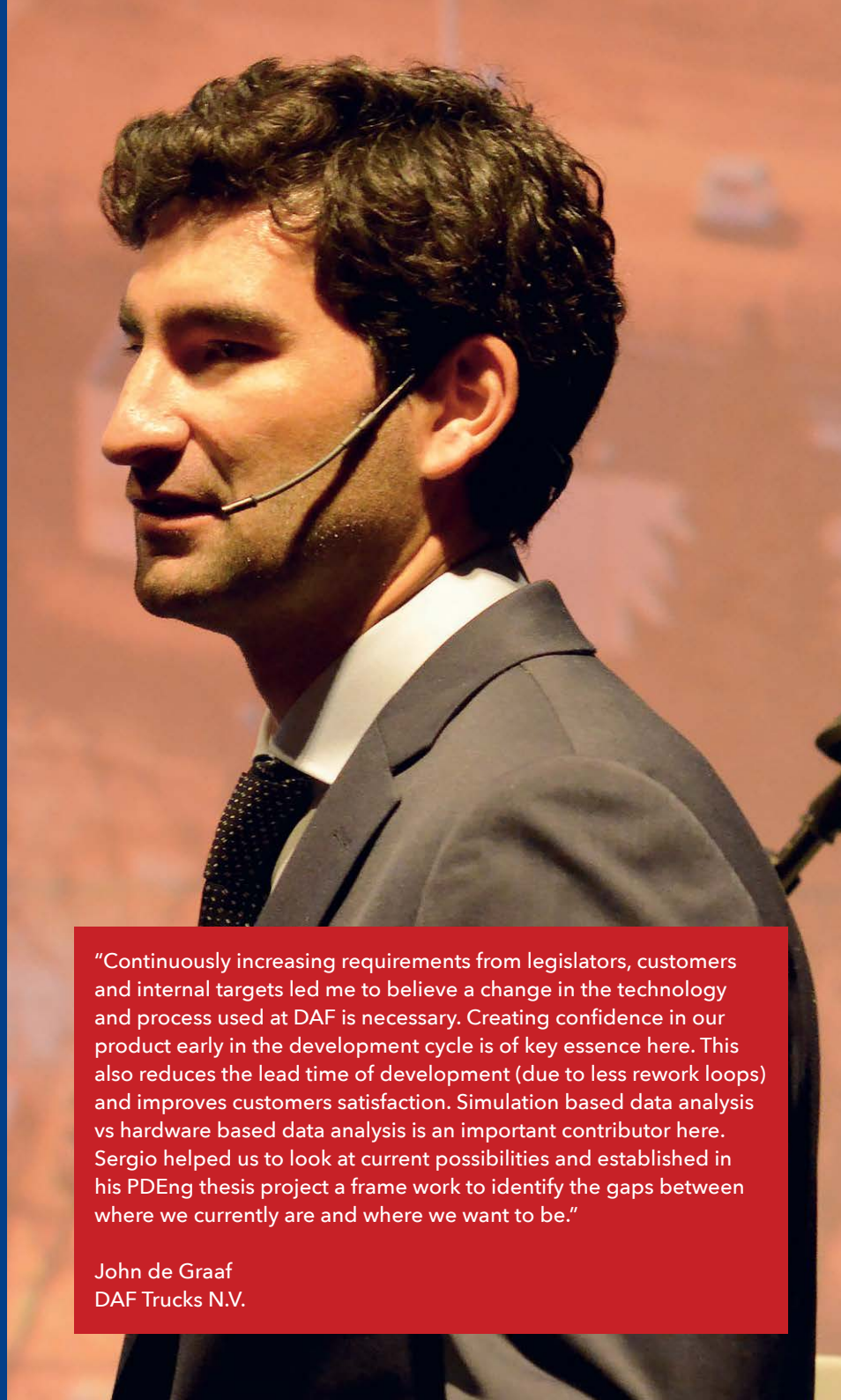
Powertrain simulation packages are aiming at the development of nominal systems. Understanding the different simulation approaches and adapting them to include subsystems with failures while maintaining simulation functionality meant using existing systems in ways outside of their normal scope.

RESULTS

A system architecture has been designed incorporating Model-in-the-Loop and Hardware-in-the-Loop facilities at DAF Trucks N.V. The new architecture adapts current technologies to include simulation of systems deviating from the expected behaviours. One failure mode has been compared to experimental data gathered from real powertrains with positive results.

BENEFITS

Using a simulation approach will enable the OBD team to start working earlier in diagnostic design and calibration as well as identifying the most critical cases which can be then tested and validated in a production powertrain. This will give engineers more time to work on diagnostics and to reduce callbacks and rework on the OBD system. It will effectively maximize the use of capital assets in the company.

A man with dark, curly hair, wearing a dark suit, white shirt, and patterned tie, is shown in profile from the chest up. He is wearing a thin, clear headset microphone. The background is a blurred, warm-toned setting, likely a conference or presentation stage.

"Continuously increasing requirements from legislators, customers and internal targets led me to believe a change in the technology and process used at DAF is necessary. Creating confidence in our product early in the development cycle is of key essence here. This also reduces the lead time of development (due to less rework loops) and improves customers satisfaction. Simulation based data analysis vs hardware based data analysis is an important contributor here. Sergio helped us to look at current possibilities and established in his PDEng thesis project a frame work to identify the gaps between where we currently are and where we want to be."

John de Graaf
DAF Trucks N.V.

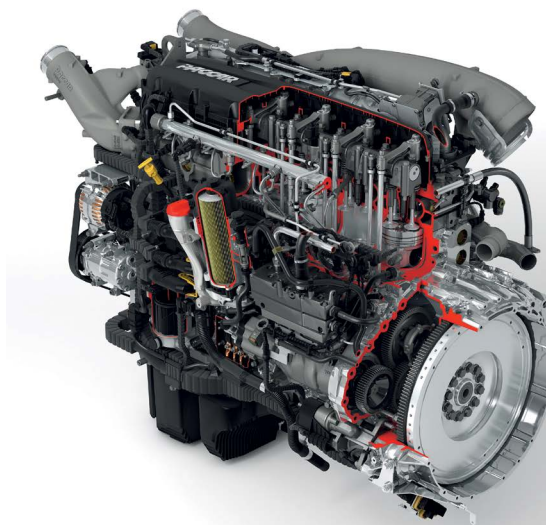
SERGIO FAJARDO QUINTERO, MSc PDEng

Enabling Simulation Technologies for On-Board Diagnostics Development

The impact that combustion engines have had on global warming and people's health has triggered governments into establishing controls in the emission levels allowed from powertrain operation. In order for an OEM to be able to sell powertrains for road use, an emission certificate must be obtained from the correspondent legislators in different areas of the world. Controlling emission limits is done by the vehicle's ECU while On-Board Diagnostics (OBD) monitor the emission levels and alert the driver of any violation to these so that the vehicle can be taken into service.

Developing OBD systems involves the physical availability of a production powertrain. Getting this powertrain with enough time to test for all the possible failure modes that can result in emission limit violations is one of the mayor challenges and concerns that the OBD team at DAF Trucks N.V. has to face with every new powertrain development.

This project focussed on a way to produce powertrain data without the actual powertrain. In order to do this, simulation technologies were used. Powertrain simulation is already established as a development approach at the company but using it for simulation of powertrain failures had never been done before.





"To aid in the development of high-tech industry modules, VDL ETG started a contamination control competence program with respect to particle generation, particle transport and the removal of particles. The work of Saeid Homayoun is the first step towards understanding the mechanisms behind the particle generation subject. He gathered a lot of useful knowledge and practical information which provided guidance into the wide scope of tribology related aspects of wear. During the project, general system engineering skills were successfully shown by Saeid and the amount of effort, determination and persistence of Saeid has to be mentioned specifically and is gratefully appreciated."

Ir. Kasper van den Broek
Tribology Expert & Contamination Control Architect at
VDL Enabling Technologies Group B.V., Eindhoven

CHALLENGES

Challenges

The best strategy to control the particle contaminants is to locate the producing origin and to eliminate the releasing source. The main source of particles is wear at the tribo-pairs where two surfaces in relative motion come in contact with each other. The wear process is a dynamic process and the key challenge in understanding these interfaces is that real surfaces are inherently rough and made up of smaller contacts between protruding surface features, or *asperities*.

RESULTS

Because of the small contact and microscopic surface roughness, the contact only occurs at the apex of local asperities. Therefore, by performing *in situ* single asperity scratch tests against another asperity/flat surface, the wear process takes place and is experimentally simulated in a controlled environment, allowing the wear mechanism to be isolated and studied independently for optimizing the particle contamination process.

BENEFITS

Particle contamination control during processing is crucial to make device manufacturing economical. The manufacturing yield and cost are directly dependent on the density of defects generated by the presence of such contamination and can therefore directly impact the accuracy and productivity of high-tech equipment. Hence, a deeper level of understanding of the particle contamination generation processes is essential for equipment designers/manufacturers to guarantee sufficient cleanliness in the production processes of contamination sensitive equipment.

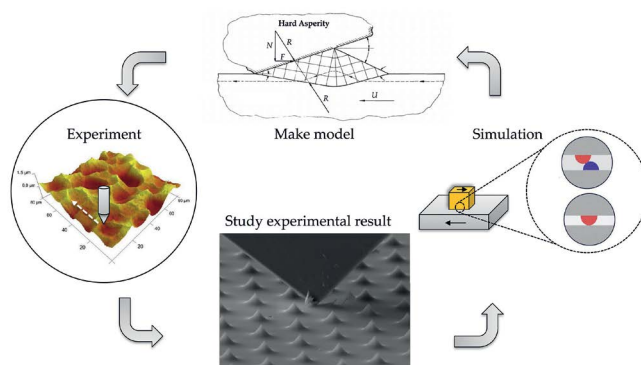
SAEID HOMAYOUN, MSc PDEng

Active Contamination Control for High-tech Equipment and Substrates

PARTICLE GENERATION

Constant high demands on the accuracy and productivity of high-tech equipment in the semiconductor industry, for instance, have led to strict requirements on the contamination level. Therefore, a deeper level of understanding of the processes in which particle contamination is generated is essential for equipment designers and manufacturers in order to guarantee sufficient cleanliness in the production processes of contamination sensitive equipment.

The main source of particles is wear at the tribo-pairs where two surfaces in relative motion come in contact with each other. This relative motion is the result of the vibration of each counter-part. The tribo-pairs are influenced by the contact force, operating parameters, and the material/surface properties etc. Moreover, due to the small contact force and the microscopic surface roughness, the contact occurs at the peaks of the surfaces, called asperities. The interactions of the asperities should be studied for a clear understanding of the particle generation mechanisms. Therefore, by performing *in situ* single asperity scratch tests against another asperity/flat surface, the wear process takes place in a controlled environment, allowing the wear mechanism/operating conditions to be isolated and studied independently. Consequently, a single sliding asperity study could potentially help to unravel the mechanisms behind the generation of contamination particles. This understanding helps to build a single asperity computational model that can be extended to a multi-asperity model which represents the actual contact.



Wear mechanisms can be investigated via a combination of computer modelling with *in situ* experimental single asperity sliding testing. Direct observation inside an SEM elucidates deformation/fracture processes occurring at the sliding interface. By conducting such an *in situ* experiment, the influencing parameters could be isolated and optimized independently for controlling the particle contamination. The results potentially provide deep insight into the material's behaviour under simultaneous normal and lateral stresses, augmented by direct observation via electron microscope imaging and surface topography imaging.

CHALLENGES

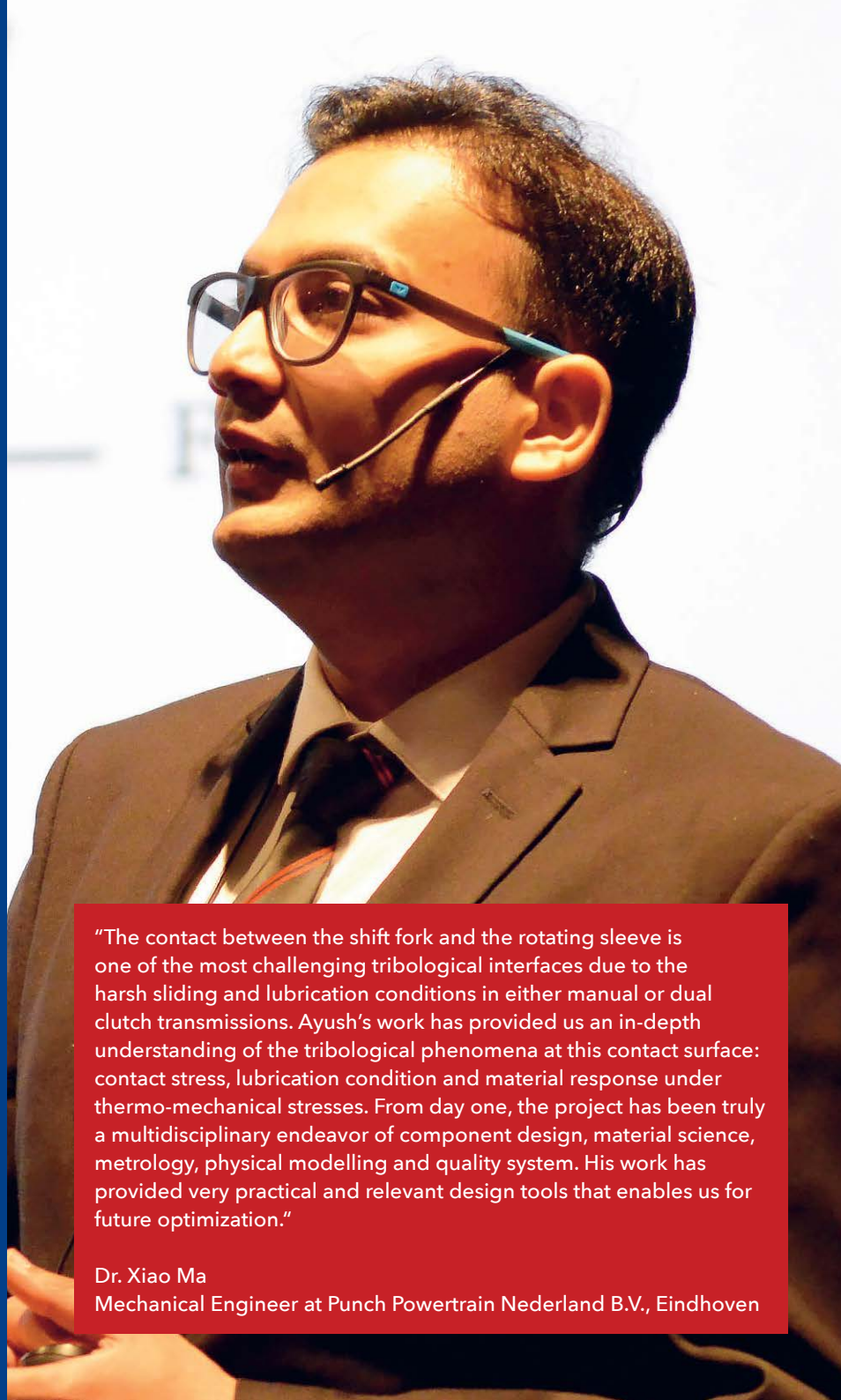
There were two main challenges. First, the accurately modeling of the tribological behavior. Simulations in tribology are challenging and unlike other domains there is no well-defined model that fits all the situations. Extensive research and multi-disciplinary knowledge were required. Secondly, the project timeline had a very limited buffer to absorb any delays, so there was pressure to plan everything well in advance and execute these tasks without leaving any scope of errors.

RESULTS

Tribological design tools were developed to convert part requirements into design parameters and to enable their optimization. The pad design was also validated in module-level tests. For the validation tests, a set-up was designed and test specifications were defined. The validation tests showed that the pad design meets the defined requirements.

BENEFITS

Following the proposed V-cycle and the developed design tools, design engineers can optimize the part design for correct tribological performance at the early design stage itself instead of relying solely on the tests and then re-designing the part in case of a detected failure. This ensures 'first-time-right' design and a shorter development timeline.



"The contact between the shift fork and the rotating sleeve is one of the most challenging tribological interfaces due to the harsh sliding and lubrication conditions in either manual or dual clutch transmissions. Ayush's work has provided us an in-depth understanding of the tribological phenomena at this contact surface: contact stress, lubrication condition and material response under thermo-mechanical stresses. From day one, the project has been truly a multidisciplinary endeavor of component design, material science, metrology, physical modelling and quality system. His work has provided very practical and relevant design tools that enables us for future optimization."

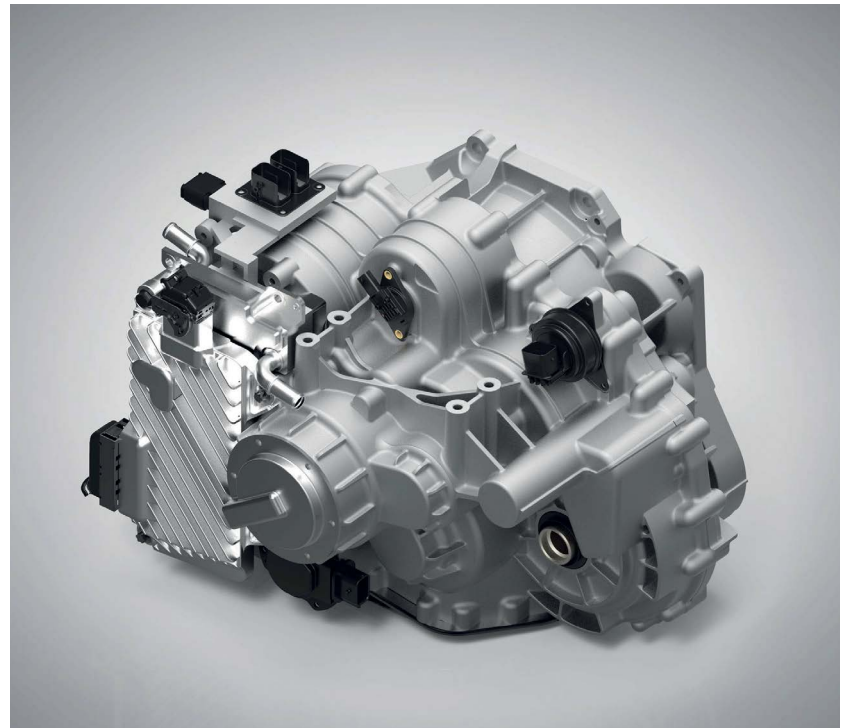
Dr. Xiao Ma
Mechanical Engineer at Punch Powertrain Nederland B.V., Eindhoven

AYUSH JAIN, MSc PDEng

Tribological investigation of polymeric Shift Fork Contact pad

Punch Powertrain is a leading independent supplier of transmissions to the automotive industry. To keep pace with the growing demand for fuel-efficient vehicles and electric/hybrid vehicles, Punch Powertrain is developing a new generation hybrid Dual Clutch Transmissions (DCT). Punch Powertrain faced a lot of challenges in correctly designing the contact between the shift-fork pad and synchronizer sleeve due to harsh operating parameters and lubrication conditions.

During this project, a new development V-cycle was proposed for designing the shift-fork pad contact. Part level tribological design requirements were derived from the high-level requirements. Design tools have been developed to meet these tribological requirements and to enable the designer to optimize the design of the shift-fork pad. Validation tests on module-level were performed to evaluate the performance of the shift-fork contact design and the chosen material.





“Combining the robotics platform of TU/e’s RoboCup team with the latest research on mm-wave 5G from the blueSPACE project, Aditya undertook the task to bridge the gap and learn the languages of both robotics and telecommunications. Faced with the difficulties of relying on the outputs of a research project, many hurdles had to be overcome, before a demonstration system could be implemented. Nonetheless, Aditya successfully implemented a demonstration system, showing what value 5G can have for robotics - and along the way contributing to everyone’s understanding of the challenges faced and processes to be completed to combine the involved fields!”

Dr. Simon Rommel
PostDoc Researcher, blueSPACE

CHALLENGES

This project involved the translation of the requirements from blueSPACE and Tech United in order to propose a feasible and demonstrable application. This required an extensive theoretical and application based study of 5G, which is still in the research phase. Once a design was proposed, another challenge was to work with open source communication software, which is still under development and went through multiple revisions throughout the project.

RESULTS

The implemented prototype is a proof-of-concept of the proposed system and proves its feasibility. The results clearly show that using 5G, data acquisition can be decoupled from its computation process operating at a 1000 Hz, while meeting timing requirements and real-time performance of the robot. This decoupled system reduces the CPU requirements of the robot’s on-board computer significantly. Finally, the proposed validation methodology successfully verifies the KPIs of the network.

BENEFITS

Multiple stakeholders can benefit from this project. Firstly, the implemented system is a valid robotic test bench for any communication hardware developed by blueSPACE. Secondly, the proposed system reduces computations on the robot computer, while providing unlimited computing capabilities either on a remote computer or in the cloud. This allows the Tech United robots to reliably share large amounts of data, perform complex computations like neural networks and improve overall performance.

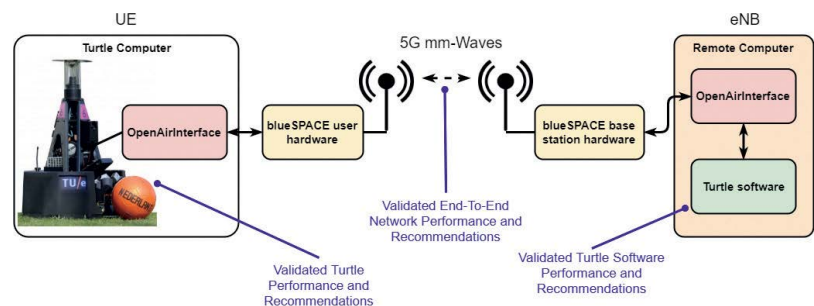
ADITYA KAMATH, MSc PDEng

Enabling Remote Computation for Soccer Robots using 5G mm-Waves

DESIGN, DEVELOPMENT AND VALIDATION OF A ROBOTIC TEST BENCH FOR 5G MM-WAVE DEMONSTRATIONS

5G is the 5th generation of mobile communication standards and is expected to provide significantly higher bandwidths, lower latencies and higher user capacity. This will be an enabler for technologies in multiple sectors such as VR/AR, Autonomous Driving, Healthcare, and Robotics. In the field of robotics, 5G communication is expected to provide a huge opportunity for collaborative teams of robots, which is crucial for Industry 4.0.

The motivation of this assignment is to develop a proof-of-concept for a robotic demonstrator using 5G mm-wave communication hardware designed and developed by blueSPACE. Using Tech United's world champion soccer robot platform - TURTLE, and an experimental mobile network, this project shows that the robot can offload its computations entirely, while maintaining its original real-time performance. This project also presents a proven validation methodology, for measuring and studying the performance of the 5G network and the decoupled robot system.



CHALLENGES


One of the major challenge was to choose the design tradeoffs of the validation that was subject to constraints related to the requirements, manufacturing, and assembly process and using existing controller hardware.

RESULTS

A validation setup has been developed and experiments have been performed to replicate the disturbances created due to the eye movements by applying input signals related to the eye frequency spectrum in closed loop. Moreover, the performance of the vision-based servo algorithm has been improved and the preliminary mechanical integration of the optical system is done.

BENEFITS

The system developed during this project will certainly help Eindhoven Medical Robotics to validate the laser delivery module and hence accelerate the development of the hand held device for ROP.

A man with dark hair and glasses, wearing a dark suit, white shirt, and patterned tie, is speaking at a podium. He has a small microphone clipped to his lapel. The background is a blurred stage with colorful geometric shapes.

“Retinopathy of Prematurity is a leading cause of childhood blindness. Early detection and treatment of this retinal detachment in neonatal infants using precision medical devices provides a better alternative to only relying on few highly skilled surgeons who have to undergo years of training to achieve good outcomes. Siddharth developed a prototype to validate laser delivery for the retinal ablations. In a very short period of time, he collaborated with an ecosystem of partners worldwide - ROP surgeons in India, engineering partners in The Netherlands, suppliers in Europe and USA to develop a solution which was mature enough to start pre-clinical engineering tests. Within a short period he was able to bring complex concepts in mechatronics, optics and software into a well-integrated working solution meeting the stringent goals of affordability, reliability and precision. He now is a valued employee of our company and we look forward with him to launching many successful surgical robotic solutions enabling surgeons to do the impossible.”

Anupam Nayak
Founder, Eindhoven Medical Robotics

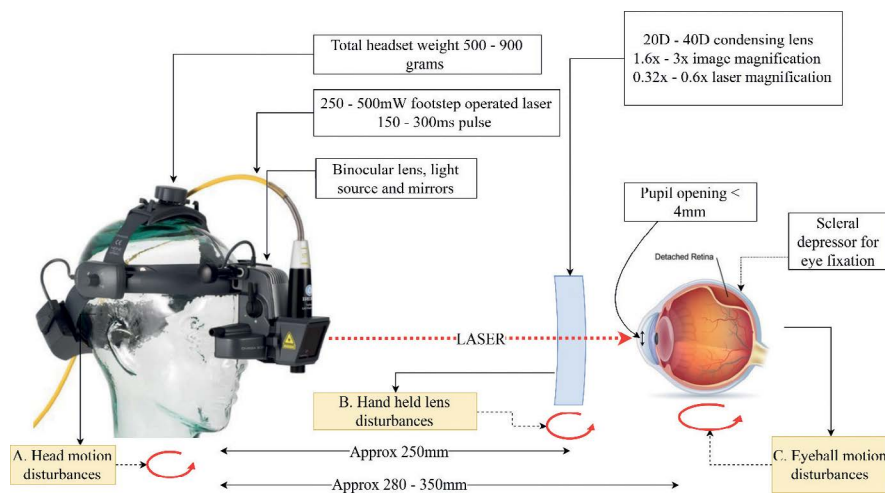
SIDDHARTH KHALATE, MSc PDEng

Design of an experimental setup to validate ROP Laser Surgery Device

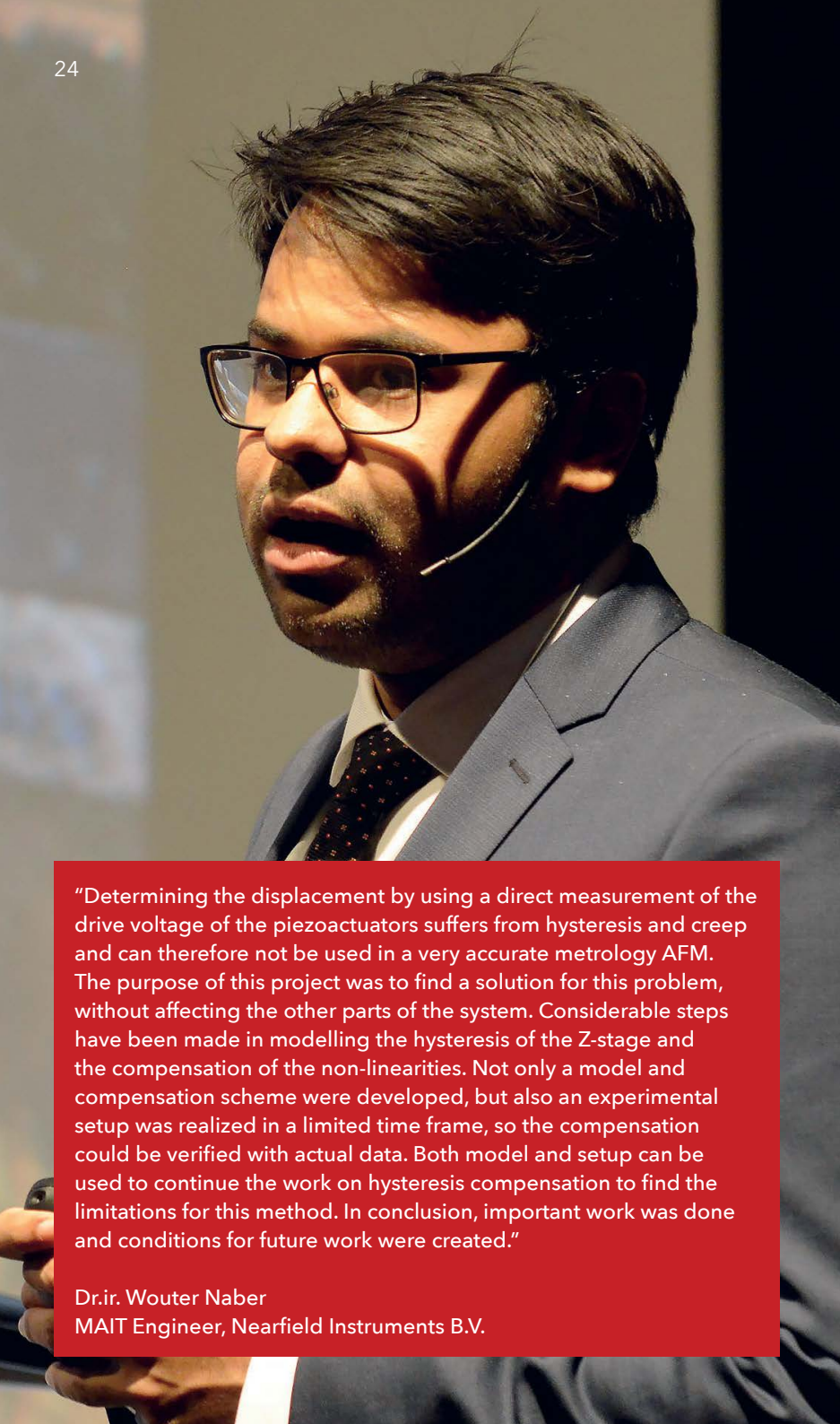
ROP is a disease associated with the vision loss of premature babies and a major cause of childhood blindness around the world. This disease is uniquely characterized by the retinal detachment due to abnormal growth of retinal blood vessels and leads to an irreversible visual deficiency in premature babies. Approximately 15 million babies per year are born premature, out of which thousands develop severe ROP and become blind.

The existing solution to treat ROP is called Laser Indirect Ophthalmoscopy, here a laser is shot into the retina to prevent the retina detachment. This ROP surgery process is depicted by the figure below and has several drawbacks as a result of which the treatment is less accurate, leads to high fatigue on the doctor and the patient, and eventually a lower number of patients can be treated.

To this end, Eindhoven Medical Robotics (EMR) has initialized in 2017 a project in for developing a new laser delivery surgical device to diagnose and cure ROP. This new device is primarily intended to be fast, accurate and autonomous.



The primary scope of this project was to design a setup that can validate the position accuracy of the laser delivery considering the eyeball disturbances. Moreover, the secondary scope was to improve the existing vision based servo control algorithm and finally to integrate the optical system with the laser delivery module.



“Determining the displacement by using a direct measurement of the drive voltage of the piezoactuators suffers from hysteresis and creep and can therefore not be used in a very accurate metrology AFM. The purpose of this project was to find a solution for this problem, without affecting the other parts of the system. Considerable steps have been made in modelling the hysteresis of the Z-stage and the compensation of the non-linearities. Not only a model and compensation scheme were developed, but also an experimental setup was realized in a limited time frame, so the compensation could be verified with actual data. Both model and setup can be used to continue the work on hysteresis compensation to find the limitations for this method. In conclusion, important work was done and conditions for future work were created.”

Dr.ir. Wouter Naber
MAIT Engineer, Nearfield Instruments B.V.

CHALLENGES

The resolution requirement of the system was in sub nanometer range with a bandwidth of around 100 kHz. Building an experimental set-up with these specifications was required in the first place. This was a challenging task as at nanoscale it becomes extremely important to understand various sources of noise and their impact. In MAFM, the major challenge was to provide a solution that doesn't impact the performance of other components.

RESULTS

The experimental test set-up was successfully realized and it was used to measure the hysteresis and to validate the result. From the measurements the hysteresis was successfully modelled and inverted. Finally, the hysteresis compensation scheme was validated with the test set-up, which showed considerable reduction in hysteresis. This improves the precision of the system.

BENEFITS

The solution methodology proposed doesn't interfere with the operation of other components. The solution is cost-effective for NFI for parallel scanning, as a similar piezoactuator is used in all the MAFMs and offline calibration of one actuator prior will be sufficient. The experimental test set-up can be used in future for the analysis of the Z-stage.

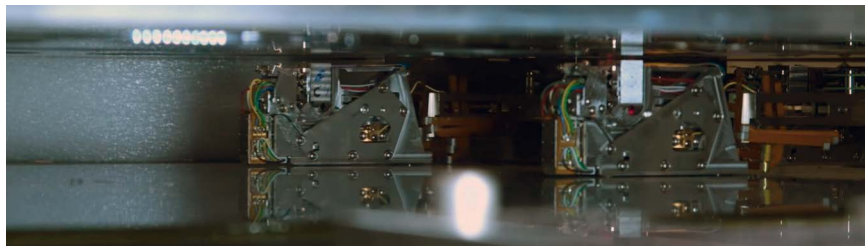
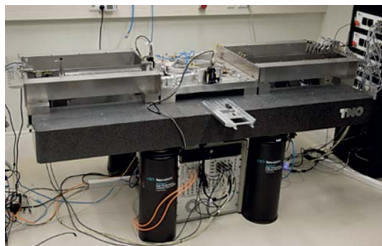
SABYASACHI NEOGI, MSc PDEng

Position Control of Nanopositioning Scanning Stage

DESIGN AND IMPLEMENTATION OF HYSTERESIS COMPENSATION SCHEME WITH REAL TIME IMPLEMENTATION

The Semiconductor industry has gone through an enormous growth in the last 40 years, which has led to a revolution in the fields of communication, defense, robotics, autonomous driving and many more. With the developing technology, the size of a transistor has almost reached an atomic scale and with the latest 3-D IC architecture in use billions of transistors can fit in an IC with an area of a few mm^2 . It has been predicted that the benefits of miniaturization will be outweighed by cost and reliability issues.

The motivation for this assignment was to improve the precision of the Miniature Atomic Force Microscope (MAFM) developed at Nearfield Instruments by removing non linearities.



CHALLENGES

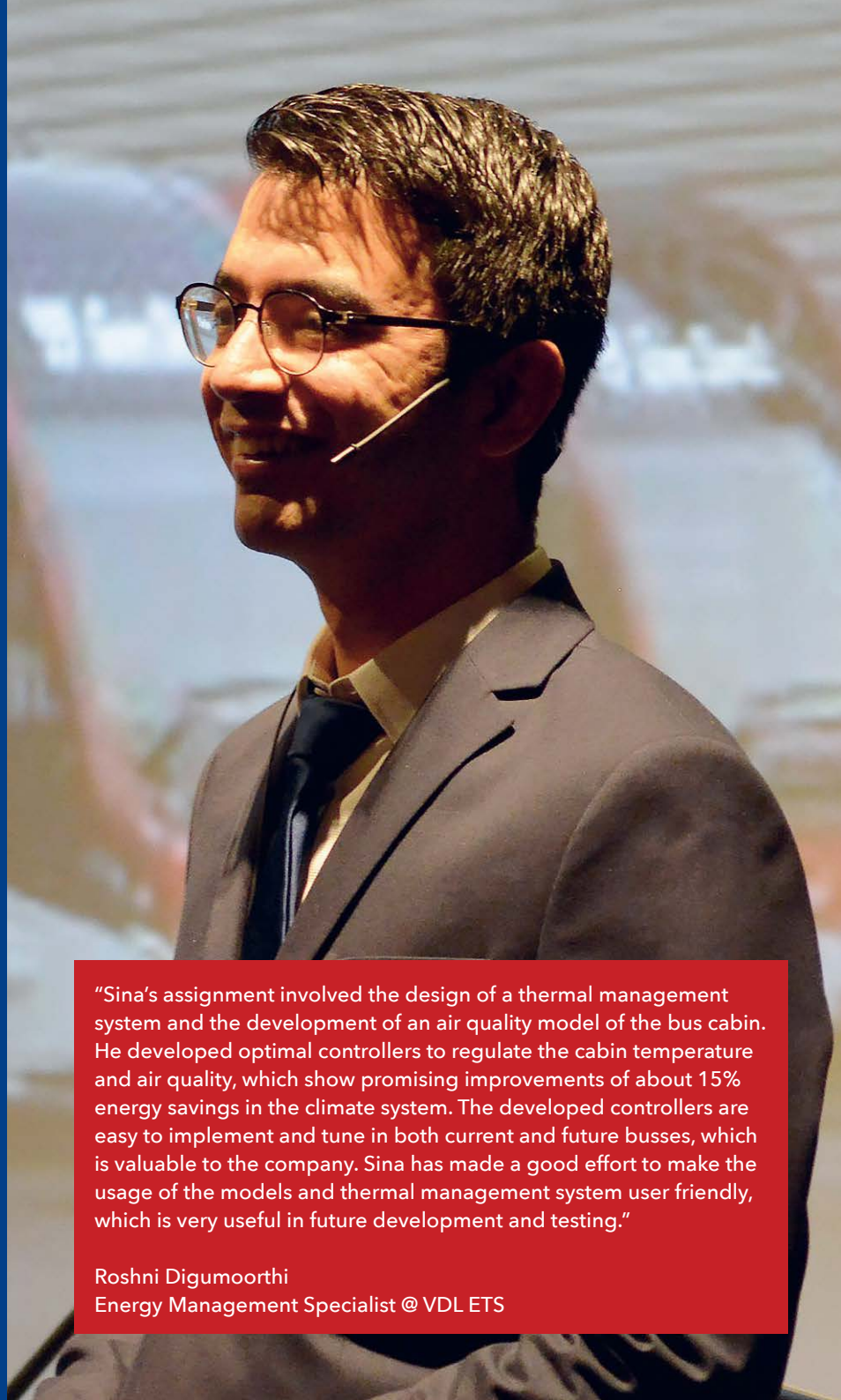
One of the greatest challenges in optimizing the energy consumed by the HVAC system in an e-bus is accuracy in modeling the dynamics of thermal behavior and comfort criteria behavior. First of all, there is only a limited number of studies in this domain for automotive applications and they are not sufficiently accurate. Thus, considerable effort goes to the improvement of available models in the thermal domain and the modeling and validation of CO₂ concentration dynamics.

RESULTS

The outcome of this work based on mutual control of CO₂ concentration and air temperature in specified zones, is showing up to 15% energy savings in the HVAC system. Extended passenger comfort in terms of controlled CO₂ concentration while using public transport vehicle is another achievement of this work.

BENEFITS

The achieved energy savings can be used to extend the vehicle range. VDL is producing a variety of e-buses which are used in various weather conditions in European countries. In this regard, each product type comes with an HVAC system, and thus, improving the energy consumption by this system in every product can lead to an extension in the range of the total fleet of public transport in target countries.



"Sina's assignment involved the design of a thermal management system and the development of an air quality model of the bus cabin. He developed optimal controllers to regulate the cabin temperature and air quality, which show promising improvements of about 15% energy savings in the climate system. The developed controllers are easy to implement and tune in both current and future busses, which is valuable to the company. Sina has made a good effort to make the usage of the models and thermal management system user friendly, which is very useful in future development and testing."

Roshni Digumoorthi
Energy Management Specialist @ VDL ETS

SINA SARNEIZEHDOOST, MSc PDEng

Data Driven Modeling & Control System Design for HVAC System of an Electric City Bus

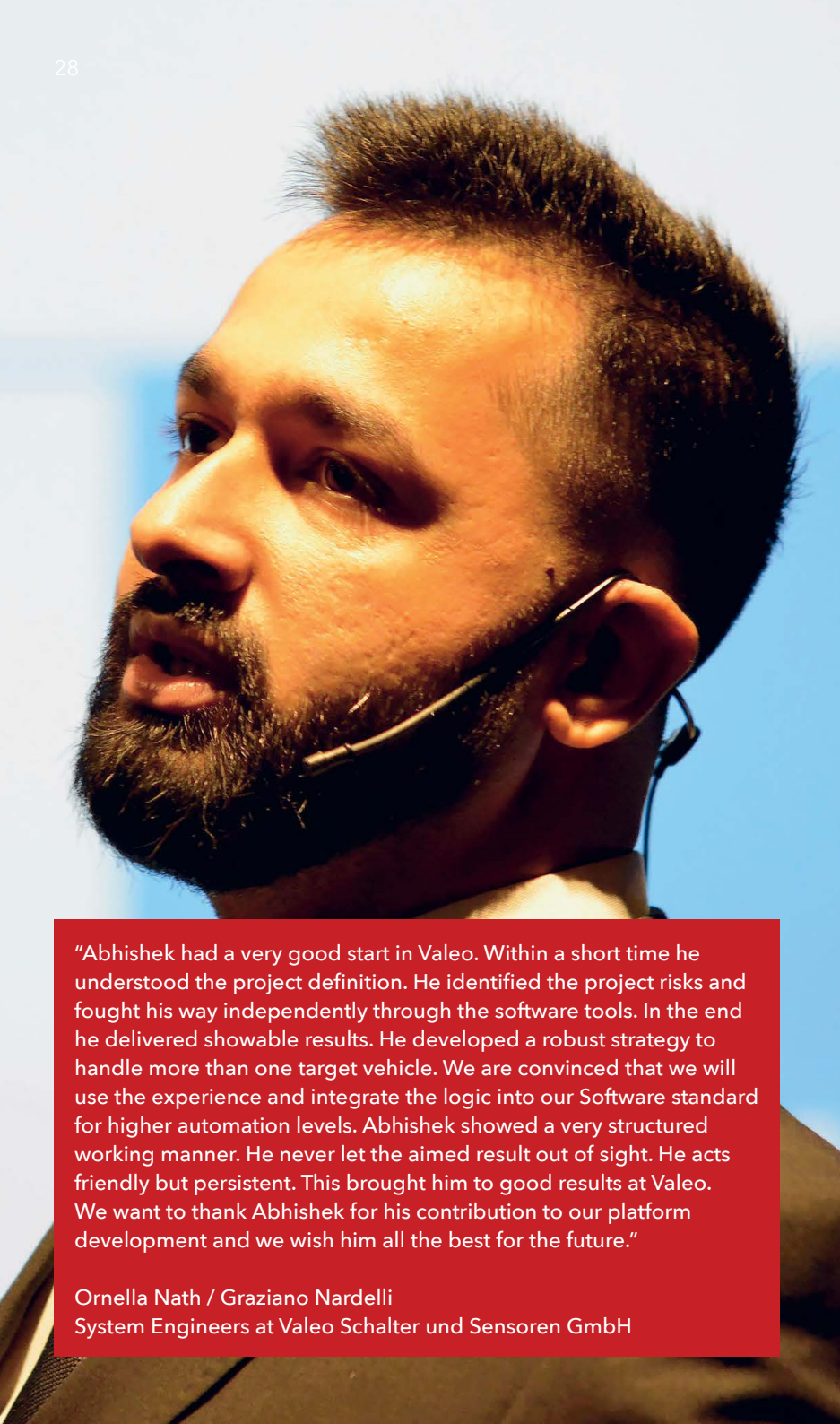
IMPROVING DRIVING RANGE & COMFORT

Aiming at zero emissions and increasing demands for higher efficiency without sacrifice in performance has pushed the industry towards electrification. The automotive industry is not an exception to this transition. However, this transition is not similarly simple in every industry. One of the most important challenges in the automotive industry and specifically in public transport is the range anxiety which delays the integration of e-mobility in public transport fleets. The challenge arises when e-buses experience severe weather conditions specifically in northern and central Europe, where the range of these buses is reduced up to 60% every winter due to heating and comfort requirements, a situation which introduces scheduling complexities for the bus fleet owners and increases the total cost of ownership for fleet operators and municipalities. Currently HVAC systems of electric buses are working



independent of the number of passengers on board. In addition, comfort criteria such as CO₂ concentration have not been taken into consideration as controllable variables. Therefore, the potential for energy saving and consequently range extension is considerably high.

Additionally, a definition of a multi-zone thermal management strategy in the e-bus passenger cabin is proposed. This strategy is fitted to a conceptual thermal management and control system design in order to reduce energy consumption and follow the required trajectory dictated by comfort indicators.



"Abhishek had a very good start in Valeo. Within a short time he understood the project definition. He identified the project risks and fought his way independently through the software tools. In the end he delivered showable results. He developed a robust strategy to handle more than one target vehicle. We are convinced that we will use the experience and integrate the logic into our Software standard for higher automation levels. Abhishek showed a very structured working manner. He never let the aimed result out of sight. He acts friendly but persistent. This brought him to good results at Valeo. We want to thank Abhishek for his contribution to our platform development and we wish him all the best for the future."

Ornella Nath / Graziano Nardelli
System Engineers at Valeo Schalter und Sensoren GmbH

CHALLENGES

The main challenge of the project was to use the existing architecture at Valeo and modify the pre-defined modules for advanced target analysis and vehicle control. This required understanding of the architecture and working of different functionalities. Another challenge was the development of the Model-in-the-loop (MIL) setup, for performing simulations, from an older version and integration of the updated ACC system into it.

RESULTS

The proof-of-concept implementation of the extended ACC system using a V-cycle system engineering approach was successful. The implementation and integration of the developed functions into the Valeo's platform was performed in a modular way and the validation was provided by performing MIL simulations for various test cases.

BENEFITS

The extended ACC system with advanced target analysis laid groundwork for Valeo for considering multiple targets in front of the ego vehicle, which in turn will extend the working range of the system in real life situations.

ABHISHEK SHARMA, MSc PDEng

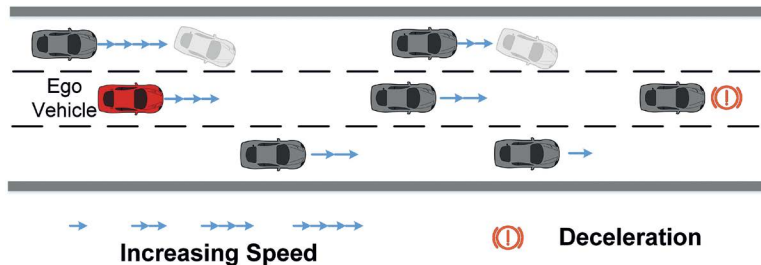
Development and Validation of Advanced Target Analysis for a Longitudinal Controller

EXTENDED ADAPTIVE CRUISE CONTROL SYSTEM

Since some decades Advanced Driver Assistance Systems (ADAS) has been a major area of research for the automotive industry. These systems aim at improving the safety not only for the occupants of the vehicle but also for the people in the immediate surrounding and also improve driver comfort and fuel efficiency. These systems are expected to grow more as the technology develops and will be shaping the future of the industry.

Valeo is one of the world's largest global automotive suppliers with a business group focusing on Comfort and Driving Assistance Systems. In high speed functionalities, Valeo offers longitudinal control functions such as the Adaptive Cruise Control (ACC) system whose primary function is to control the longitudinal acceleration of the vehicle in order to maintain a set speed and/or drive behind a preceding vehicle at a safe distance.

The current ACC system controls the vehicle acceleration based on one or two target vehicles. However, just using one or two targets for analysis limits the number of use cases that occur in real world scenarios. Other vehicles in the surrounding can also influence the ego vehicle in some specific situations. The goal of this project was to extend the current ACC system by improving the analysis of the vehicles ahead and consider how they should influence the acceleration of the ego vehicle.



CREDITS

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