AN energyengineering MAGAZINE PUBLICATION AUTUMN 2016

LOW CARBON VEHICLE

special edition

LCV2016

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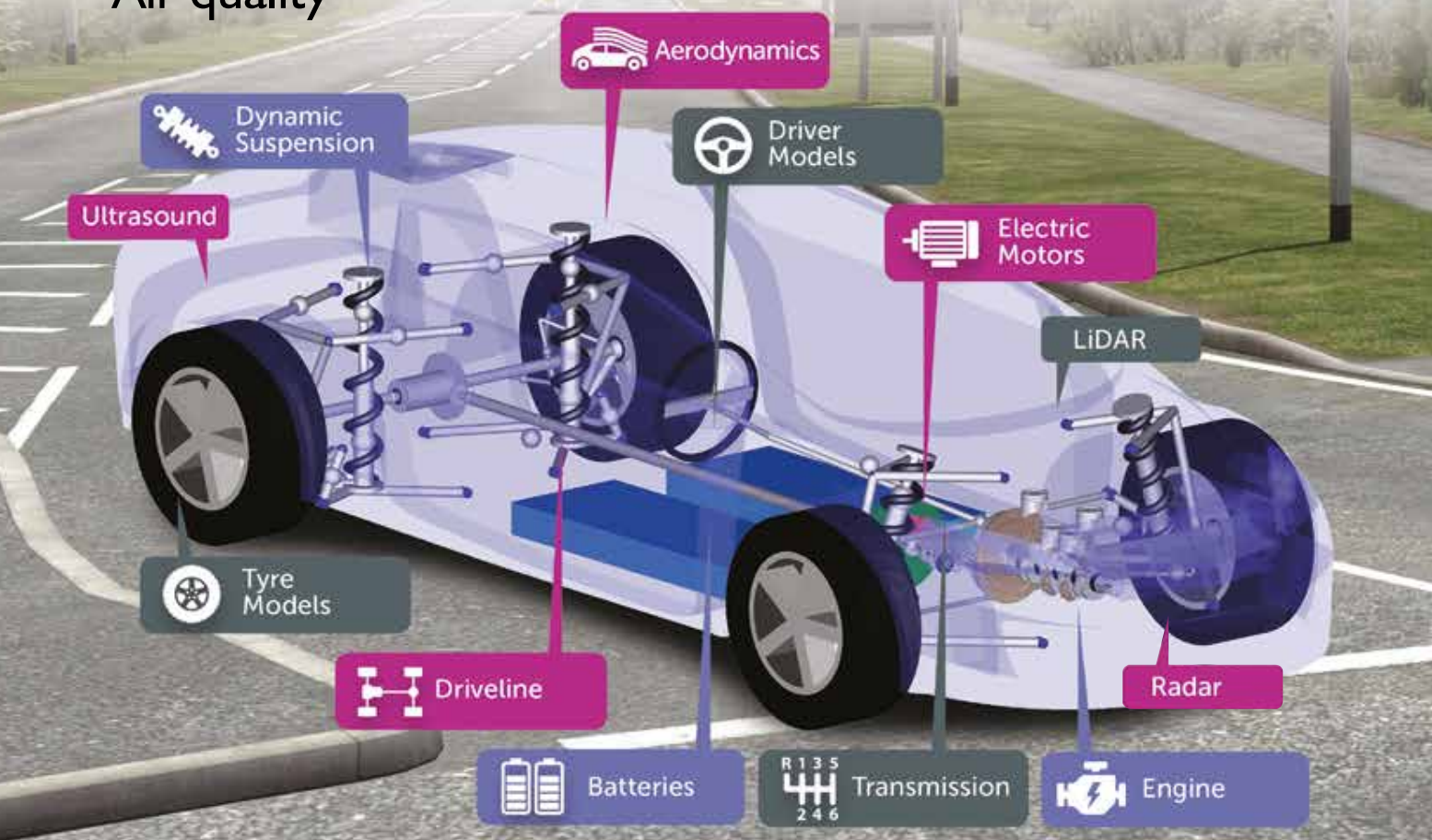


Complete vehicle system simulation

Using physical modelling tools to simulate the complete vehicle leads to a better understanding of the system behaviour and interactions enabling system level optimisation.

As the complexity of today's vehicles increases due to hybridisation, more advanced driver assistance systems and many other active systems it becomes increasingly important to be able to simulate how the complete vehicle system behaves and interacts. Using simulation from the start of the project enables design decisions to be influenced and optimal system solutions to be found.

As the complete vehicle system covers many different domains including mechanics, electrical, thermal, fluid and control we need to use system level modelling and simulation tools that can create predictive models covering all of these domains.

Dymola is a multi-domain modelling and simulation tool that uses the Modelica modelling language to describe the behaviour of components, devices and systems. This capability is encapsulated into a wide range of application libraries covering engines, powertrains, batteries, electric drives, vehicle dynamics, thermal management and human comfort.

Using Dymola, Claytex has produced complete vehicle system models for studying engines, drivelines, vehicle dynamics, thermal management, hybrid technologies and body systems. These have been applied extensively in Formula 1, NASCAR and IndyCar enabling the teams to evaluate and optimise new technologies and ideas before arriving at the track. In motorsport these models are deployed in the design office, integrated into the trackside tools and telemetry systems and used for HiL and DiL testing.

Role model

Alistair Welch learns how **Claytex** is helping its clients to make the most of complex simulation tools

Mike Dempsey

Claytex are specialists in helping clients to get the most out of Dymola – the Dassault Systèmes physical modeling and simulation tool for the design of complex engineering systems. Dymola, based around the Modelica modeling language, is used across transport sectors in the optimization of multi-domain systems in cars, aircraft, and fuel cells amongst other applications.

Given the tool's complexity and intricacy, automotive developers will often turn to a specialist consultancy, such as Claytex, when it comes to the use of Dymola. "We will get involved with clients when they start to introduce Dymola and we will spend time working with them, training people, and setting up the initial models," says Claytex founder and managing director Mike Dempsey. "That might be helping someone to figure out a concept: what should the cooling system look like? Will this system work or do you need a different one? Or [our involvement] can be much later on, looking in detail at getting a good correlation into the suspension system for example."

He explains that Dymola's real power is in the tool's ability to conduct multi-domain simulation. "It can model mechanical systems, which could be simple one dimensional systems, or full multi-body representations," continues Dempsey. "It can include fluid systems, electrical systems, other thermal systems, hydraulics, pneumatics, control: all combined into one simulation. You are able to look at how all these things are interacting."

Dymola is used extensively in motorsport (including Formula One, Nascar and IndyCar) as it offers teams a powerful trackside tool to have one consistent model covering everything that they are doing. There has been significant crossover from motorsport into the passenger vehicle sector across conventional, hybrid, and electric powertrains.

Claytex is currently working alongside Oxford Brookes University and major racing car manufacturer Dallara Automobili on the development of an electric racecar. The project, now approaching the third of its four scheduled years, has allowed students to use a full-vehicle model in Dymola, enabling them to gain a fuller understanding of individual system behaviour. Powertrain models are being tested in Dallara's driver-in-loop simulator.

"Everything now is electrified to some extent," comments Dempsey. "Now we will start to see more of the transfer on the hybrid electric side as we will be able to learn quickly through motorsport how we will have to adapt

Dr Raja Mazuir Bin Raja Ahsan Shah

Keep on trucking

Oxford-based Charge are a groundbreaking company aiming to transform cities through elegant, efficient, environmentally friendly electric trucks. Charge works alongside Claytex in using Dymola to cover a range of simulation tasks across multiple domains – including development of the powertrain, vehicle dynamics, cooling system, and HVAC aspects of these trucks.

"The electrification of trucks involves efficient energy management and also needs to maintain the vehicle attributes at the same level as a conventional powertrain

system," explains Dr Raja Mazuir Bin Raja Ahsan Shah, a research engineering specialist at Charge. "Hence, it requires detailed studies of vehicle system interactions in order to understand the vehicle system that dominates these attributes. The upfront modeling approach is vital to capture these attributes before developing the physical prototype. Dymola has a multi-physics modeling capability that is very useful in developing these complex interactions at both vehicle

rFpro delivers immersive test environments complete with traffic.

whatever solutions are in Dymola to really do what is necessary."

The company is involved in ongoing work with Jaguar Land Rover and Warwick Manufacturing Group around battery models. Additionally, Claytex is engaged on a project with Ford and AVL Powertrain running Dymola models in real time hardware-in-the-loop setups to support drivability calibration and validation. This is part of a drive towards 'Zero Prototyping' – developing technologies in such a way that does not necessitate the building of a prototype. "You can check your drivability is where you want it to be without having to go to the car," explains Dempsey. "We are 18 months into that two year project. We have engine models built, that are going through the process of getting them all to run in real time with the objective of having everything integrated."

Such reduction in prototyping would decrease the cost and time involved in bringing a new vehicle to market. Industry experts estimate that it could knock around three months off a typical development time. "All of the simulation companies are looking at how they can support these developments," says Dempsey. "There's a lot of interest in this project and several other potential customers are interested."

Tying into the trend towards reduced prototyping, Claytex are able to offer expertise in the use of rFpro to provide a complete virtual test environment. Claytex are distributors of rFpro which has been developed in motorsport to deliver Driver-in-the-Loop simulators that are physically accurate, and visually and aurally realistic. rFpro uses high fidelity track models created from LiDAR scans and can integrate Dymola models to provide the vehicle model. Claytex has developed the tool chain to easily export models from Dymola for use in rFpro. The system has an extensive library of digital circuit models including race tracks, public roads and automotive proving grounds as well as many road models that are built specifically for an individual customer.

system level and sub-system level, and for pin-pointing the dominant systems or components."

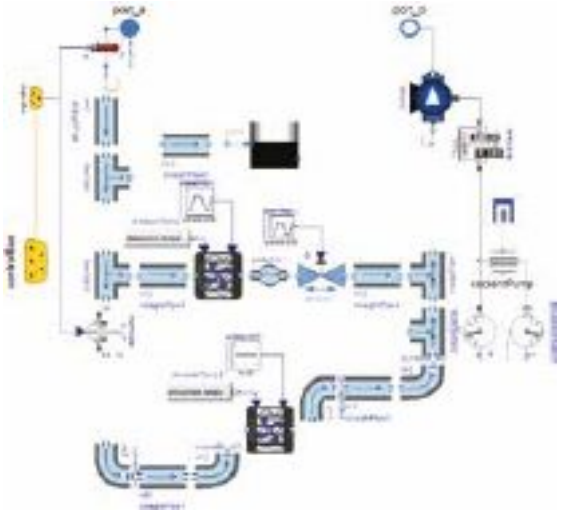
Mazuir continues: "All of these vehicle systems/sub-systems can be modeled within the same modeling workspace at the top level and then cascaded to a lower level in order to create a series of libraries that can be repeatedly used for different vehicle plant model architectures. This process is important for system modeling, particularly during development phase, giving engineers access to different options to optimise the system architecture for energy management and the improvement of other vehicle attributes."

Simulation enables Charge's engineers to specify vehicle system requirements at an early phase of vehicle development. "The process minimises the design and product risks by not committing tooling costs for the prototype build, as the majority of the validation activities can be simulated to produce results that are a close representation of the physical system/sub-system components, which also reduces the development lead-time," adds Mazuir. "Another advantage of system modeling is being able to perform component sizing optimisation for energy management in order to improve the vehicle range."

Dymola animation of vehicle suspension

Over 80 percent of the rFpro customer base is now within automotive OEM's and Tier 1 suppliers and we anticipate further growth with the introduction of new features to support the development of autonomous cars. Furthermore, rFpro has introduced a new product: Sensor IG. This enables rFpro to provide data feeds to cameras, LiDAR, Radar and ultrasound sensors. The rFpro Traffic module also allows integration with tools that can be used to define traffic in the virtual environment. Together these modules will enable the virtual test environment to be used to further develop ADAS and autonomous vehicles.

Schematic of a cooling system in Dymola



At the 2016 Cenex event, Claytex's expert engineers will be on the company's stand to explain the advantages of the Dymola modeling environment to potential clients in the low carbon vehicle sector. "We often see with big companies that they are very siloed in terms of how they work. They stay within their own department, build models for their own use and don't reuse them across the company," he argues. "We think there is a massive benefit to be gained by sharing models because you gain consistency. We can make that easier to do. You don't have someone over here building a battery model and testing one way, and then maybe at another next desk they are building a slightly different battery model of the same product and testing it in a different way."

In addition to collaboration within companies, Dempsey believes there is a case for increased dialogue and standardization within, and even across, industries. "There could be standardization at a low level as to what the interfaces should look like," he says. "Take a gearbox, for example, if you have a gearbox in a car or a truck, or a ship or a wind turbine, you may have slightly different things you are interested in but the gearbox generally has one input, one output, something that supports it on a mount and some actuation. If you could standardize even at that sort of level you start to promote more reuse of models to simulate gearboxes and that could be cross-industry."

Looking further ahead, Claytex is keeping a close eye on the autonomous vehicles market. "It's something everyone is working on, admits Dempsey. "I think over the next few years they are going to filter through more and more. However, there are a lot of questions to be answered about how, legally, you are allowed to use these vehicles before they become mainstream."

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