THE HOLISTIC APPROACH

Systems engineering has become a vital tool in modern motorsport. **Chris Pickering** speaks to one of the leading companies in the field

SIMULATION. It's a word that conjures up images of finite element analysis and computational fluid dynamics; long hours spent delving into the minutiae of specific, isolated problems. But in the real-world, of course, things rarely work in this secluded manner. Actions have consequences, sub-systems interact with one another and nothing truly exists in isolation.

The term that's applied to this holistic view is systems engineering and it's becoming increasingly important as the level of complexity and integration continues to ramp up in motorsport. Energy recovery systems, movable aerodynamics, and in some cases four-wheel drive, are leading to numerous overlapping influences and understanding them is becoming ever more vital.

Leamington Spa-based Claytex is an engineering consultancy that specialises in modelling and simulating such problems. From aircraft to air conditioning systems, it can provide expertise on simulating virtually anything, but the company's speciality is motorsport.

For the past few years much of its work has focused on vehicle dynamics: integrating driver simulators and genuine multi-body dynamics into engineering models.

Much of this is done using Dymola, a multi-domain simulation package from the makers of CATIA. It's a blank canvas for engineering simulation, based around the open-source Modelica language. Claytex acts as a retailer for the package; it also develops commercially-available model libraries as well as providing bespoke simulations for individual clients.

Claytex managing director Mike Dempsey says that one of Dymola's main strengths is its breadth of capabilities. "Dymola is all about multi-domain simulation. You can build a model that includes mechanics, hydraulics, dynamics, electrical systems and control all in one."

The software also boasts excellent integration with other packages and a strong real-time capability: "If you take vehicle dynamics as an example, the same model that the designers are using to determine the geometry of the car can be fed straight into a driving simulator. One model goes into everything. There are a lot of other tools that will do vehicle dynamics, but it's very rare to find something that will allow you to run a full multi-body model in real-time. Most of them – if they even give you the option of a multi-body model – will force you to reduce it down to a table.

It took a couple of years to get to the point where the multi-body model was running fast enough to power the simulators, but Claytex has now successfully rolled it out across Formula 1, NASCAR and other areas.

The same philosophy is currently being applied to powertrain problems. "Most driving simulators still use a simple map-based model for their engine parameters with no airflow modelling," says Dempsey. "That was fine until the industry started bringing in all these downsized turbo engines, but it's becoming more and more important to have those airflow characteristics. The transient response of these engines is massively different to a large-displacement naturally aspirated unit, so we have to get it right."

Dymola already allows an impressive amount of detail to be included in real-time simulations, but some models do still need to be simplified. Claytex, however, is planning to address that with a joint project backed by Innovate UK with Ford and AVL. "The aim is to get a full engine model with fluid dynamics and the combustion events that's able to run in real-time," comments Dempsey.

The idea is to bring the functionality that's already available offline into a real-time environment, and that requires a fundamentally different approach to the processing: "Sometimes you solve certain parts of the system by iterating around the equations multiple times at a particular calculation step. In order to run in real-time you need to know exactly how long it's going to take and that processing time has to be consistent and stable."

Ultimately, standalone packages will continue to play a role for specialist techniques like CFD combustion modelling. But the potential benefits of systems-level simulations are only going to increase. RT

RIGHT & BELOW
From F1 to a road car (below), spiralling complexity makes it vital to model all the systems on the car