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Developing advanced driver assistant systems

Balancing safety, comfort and fuel efficiency with a simulation-based testing and validation framework

This paper presents a virtual validation and testing framework for advanced driver assistant system (ADAS) development by Simcenter™ Engineering experts, and is based on a co-simulation platform of vehicle dynamics and world modeling tools. This work focuses on simulation-based approaches to frontload control design verification during the early phases of ADAS development using Simcenter Amesim™ software and Simcenter Prescan™ software. The approach is demonstrated with three use cases: adaptive cruise control, green wave technology and autonomous parking.

Contents

Executive summary

The demand for ADAS and autonomous vehicle (AV) technologies, which provide safety, comfort and environmentally friendly vehicles, has been growing rapidly in the automotive industry recently. These systems go beyond vehicle-centric assistant applications, such as automatic emergency braking (AEB) and traction control, by integrating traffic and environmental information. Simcenter Engineering services develop model-predictive control (MPC) algorithms for these advanced applications. This involves collaborative research and development activities from fields such as mechanical, electrical engineering, control, communications and computer science.

In this white paper, we present a co-simulation-based framework and technologies for frontload testing, verification and validation of these MPC-based ADAS/AV control systems during the early phases of development. The simulation toolset takes into account vehicle dynamics, traffic environment, vehicle-to-vehicle (V2V), vehicle-to-everything (V2X), sensor models, planning and control algorithms, and will be demonstrated via three ADAS applications: adaptive cruise control, green wave technology and autonomous parking.

The autonomous driving industry recognizes that simulation-based testing is an efficient method to validate ADAS/AV functionalities. The traffic environment has a wide variety of road types and conditions, vehicles, pedestrians, cyclists, obstacles and weather, and each scenario has multiple combinations of parameters. The number of scenarios increases exponentially with the number of parameters and can grow to millions. Typically, in order to achieve a reliable validation using real car testing, the car needs to drive millions to billions of kilometers, which is extremely time consuming and expensive [Kalra and Paddock (2016)][1]. Furthermore, not all scenarios can be produced and reproduced easily in real life. It is worth noting real road testing is valid for a specific mechanical, electrical and software configuration. If there is a need to adapt to a new configuration or software update, the test has to be conducted again. This is why the majority of ADAS performances should be validated with massive simulation, and hence model-in-the-loop (MiL) and software-in-the-loop (SiL) verifications will have to play a bigger role in the development process.

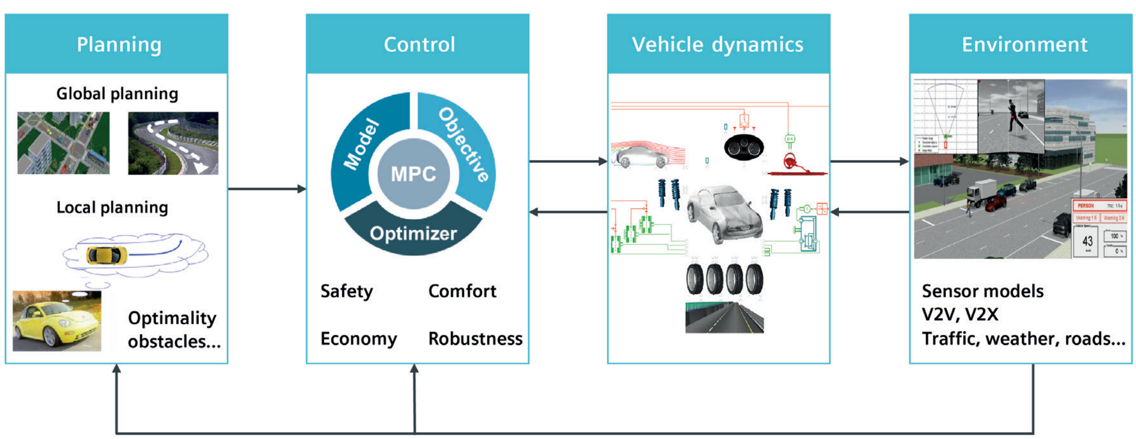

Figure 1: ADAS/AV co-simulation structure.

In this paper, we focus on the development of the planning and control components of the ADAS/AV systems using the proposed co-simulation framework. The planning algorithm dictates the desired trajectory the vehicle needs to follow, and the controller steers the vehicle to that trajectory. Developing and verifying these algorithms are challenging tasks due to four reasons:

- They need to guarantee safety in a wide variety of traffic scenarios, while taking into account vehicle dynamics constraints such as nonholonomic properties, and acceleration and steering constraints
- The car should drive in a similar manner to human driving; that is, not only in a safe and legal fashion, but in a smooth and comfortable manner. This is challenging, especially when driving in urban areas or at high speed on highways
- As one of the main drivers of autonomous driving technology, customers require that autonomous vehicles have to be more environmentally friendly and fuel efficient than conventional automobiles. The increasing governmental requirements on fuel economy and pollution are also impacting control specifications
- It is essential to consider robustness in the planning and control algorithms due to various uncertain sources, from both the vehicle modeling and environmental sides. Models for physical systems always have inaccuracies (due to flawed measurements, production errors and aging problems) and missed dynamics are inevitable because they are too complex to be taken into account. From the environmental side, sensing, mapping and localization algorithms are inherently nondeterministic due to measurement noise and uncertain environmental conditions

Considering all these challenging aspects, it is desirable to verify the planning and control developments in a simulation-based framework, in which all the physical and environmental factors are included.

As discussed, ADAS/AV system development incorporates multidisciplinary knowledge from different components. A co-simulation framework that can combine these components and frontload the design development in the early stage of functional development is crucial. This framework should be sufficiently flexible in order to adapt shared learning from industry and academic collaborators, and at the same time protect their key intellectual property rights. On the other side,

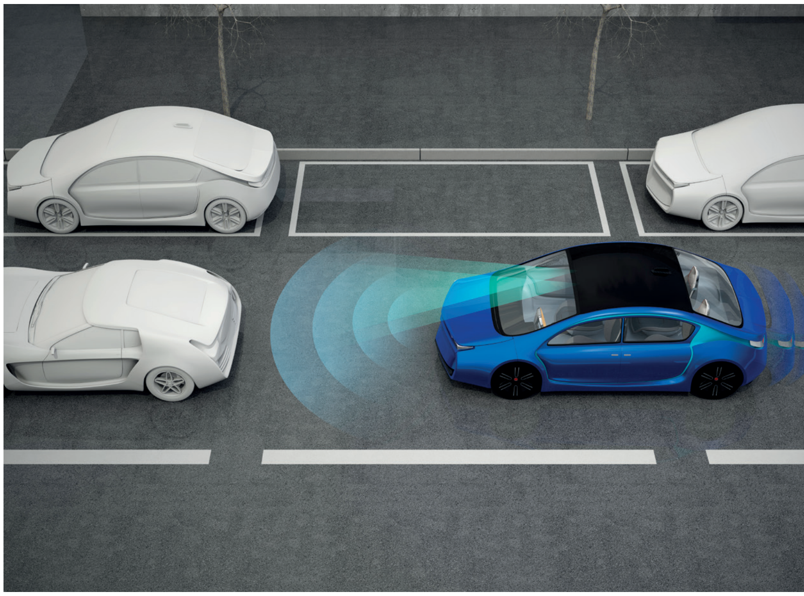

Figure 2: Automatic braking system concept.

researchers and engineers working on one component usually have some general assumptions about the other components. For instance, although the planner designs a reference trajectory that satisfies a certain set of constraints, it typically assumes accurate sensing, a simple vehicle model and a tracking controller that will be able to follow this trajectory accurately. However, vehicle dynamics and sensing configurations can have a substantial impact on the results. A co-simulation toolset that brings fidelity to chassis and sensor models helps to verify and improve the design development in a deterministic and structured manner.

The proposed ADAS/AV testing framework is part of Siemens' validation and verification framework for autonomous driving that supports the development of level 4 and 5 autonomous driving vehicles. It brings continuity to the development process with design and performance verification solutions for integrated circuits, systems and full vehicles. This proposed framework is based on the co-simulation of two software products: Simcenter Amesim and Simcenter Prescan. Simcenter Amesim provides an integrated simulation platform to accurately predict the multidisciplinary performance of intelligent systems in general and vehicle dynamics specifically. It offers plant modeling and simulation capabilities to connect to controls design, helping to assess and validate control strategies. Simcenter Prescan is a physics-based simulation platform that can be used to simulate complex traffic scenarios and ADAS/AV sensor technologies such as radar, LIDAR, ultrasound and camera. Simcenter Prescan can also be used to design and evaluate V2V and vehicle-to-infrastructure (V2I) communication applications. The combination of these two simulation frameworks, one focused on the vehicle dynamics and one focused on the external environment, yields a basis for the virtual validation and verification of autonomous driving functionalities.

The co-simulation structure is demonstrated in figure 1. This toolset provides an open, powerful and user-friendly platform for system modeling and analysis, and especially scripting capabilities to support application programming in higher abstraction level languages (the Matlab® environment, Python, etc.). Hence, it can easily be integrated with planning and control algorithms for frontloading tests. In this work, the ADAS development using the proposed framework is divided into three main steps. First, the algorithms are developed with ground truth data from the ADAS application and Simcenter Amesim vehicle dynamics. Further work on modeling, design of experiment (DOE) and optimization of vehicle-centric configurations (chassis, powertrain, braking models, etc.) can be conducted at this stage. Second, the designed algorithms are validated with Simcenter Prescan traffic and sensor simulation models. The scenarios and performance requirements mainly follow industrial standards, realistic or corner cases. The study of how to build the co-simulation configuration and the exchange of variables (vehicle, sensor, environmental and controller model variables) are investigated for each ADAS application. Third, the results are evaluated with respect to the system requirements; for example, safety, comfort, natural driving and ecology. The co-simulation setup enables the user to test all model aspects, validate sensor precision and improve visualization. Compared to physical prototype testing, the major benefits of using simulations are high repeatability, low marginal cost and ease of changing model parameters.

It is worth stressing multiphysics modeling software Simcenter Amesim has been investigated extensively by industry and academia for model-based systems engineering (MBSE) development. For example, Wissel et al. (2016)[2] applied Simcenter Amesim for developing powertrain systems together with the MPC technique, and Vanhuyse et al. (2016)[3] designed nonlinear MPC for hybrid vehicles developed with Simcenter Amesim. Although the authors didn’t consider the benefits of Simcenter Amesim for ADAS applications, they did integrate environmental and sensor modeling software like Simcenter Prescan.

The paper is organized as follows: Section 1 explains the main technologies used in the co-simulation. It provides more details on the technologies of the software and algorithms used in the co-simulation framework: Simcenter Amesim, Simcenter Prescan, planning and control designs and the co-simulation setup. In section 2, adaptive cruise control (ACC), green wave technology and autonomous parking are demonstrated. Finally, section 3 provides our conclusions.

Technology

In this section, the main technologies that are used in the co-simulation are presented.

1.1 Vehicle dynamics

Simcenter Amesim is a multi-physics simulation platform that provides libraries of physical domains such as fluid, thermal, mechanical, electromechanical and powertrain. In this work, it will be used to simulate a vehicle and its dynamics for the purposes of testing ADAS/AV planning and control algorithms. The fact this software can be used to handle various physical domains makes it a practical integrated solution for the automotive industry. The extensive libraries can substantially speed up modeling work. For example, when designing a headlight-angle controller, engine dynamics are not important. In that case, a simple premade engine block can be used. This approach enables the user to make sure no time is lost on modeling noncrucial components and little computing time is consumed. By connecting blocks, a complex and realistic model can easily be constructed for system level simulations. On the other hand, detailed simulations of single components can be made as well. Figure 3 shows the model of a complete vehicle chassis that is used in our use cases, including powertrain, braking, suspension and steering components.

1.2 Environment

Simcenter Prescan is used in the automotive industry for developing ADAS and autonomous driving systems. It has an intuitive graphical user interface (GUI) with extensive environmental modeling capabilities, allowing users to build and modify traffic scenarios, including road sections, infrastructure components (buildings, traffic signs), actors (cars, trucks, cyclists, pedestrians), weather conditions (rain, snow, fog) and light sources (the sun, headlights, lamp posts). The vehicle models can also be equipped with physics-based ADAS sensors that sense the virtual environment such as radar, LIDAR, camera, ultrasonic, Global Positioning System (GPS) and

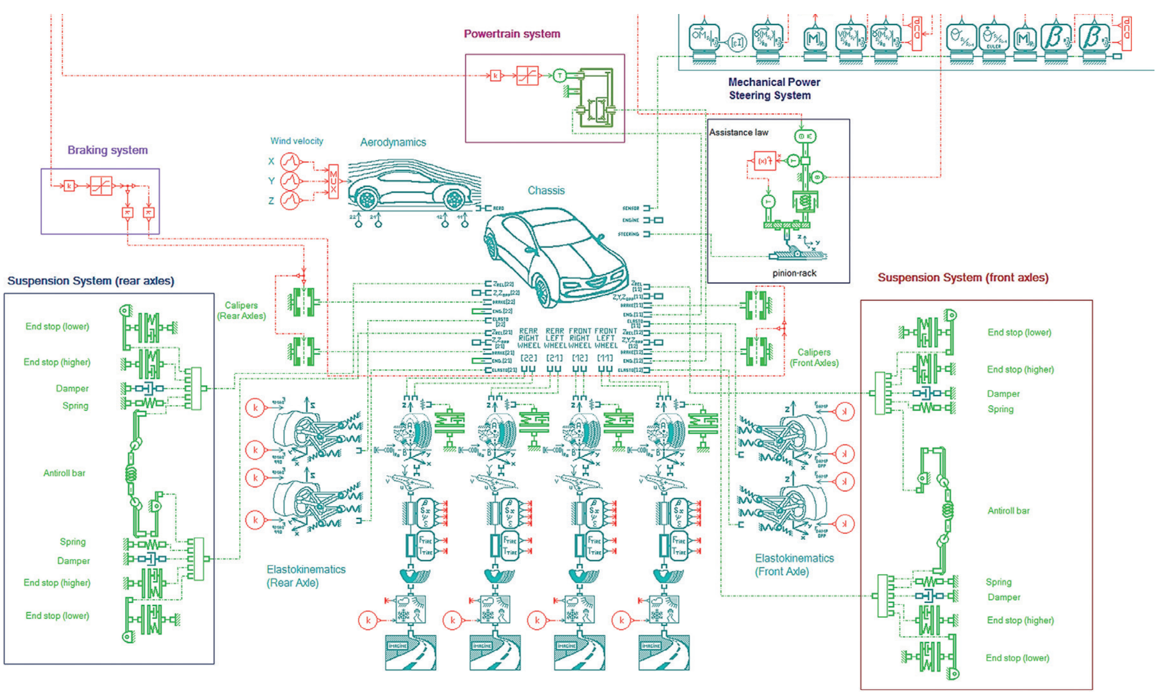

Figure 3: Simcenter Amesim vehicle dynamics simulation of the vehicle chassis.

antennas. ADAS systems are designed to reduce the driver workload by interpreting the environment and acting accordingly. The key for such a system is how realistically the environment and sensors can be simulated. That is when Simcenter Prescan is powerful as it has advanced visualization capabilities. The benefit of good visualization is twofold. First, it helps the engineer develop new ADAS system functionality. Second, good visualizations are useful to communicate work progress to management and customers. A screen shot from a Simcenter Prescan visualization video is given in the environmental block in figure 1.

1.3 Planning

The planning designs depend on specific ADAS applications. For example, in ACC, the planner generates reference velocity and steering profiles in order to maintain a safe distance with the car driving in front. This function is often used on highways at high speeds, thus the computation must be sufficiently fast, and vehicle dynamics analyses must be factored in since vehicle-specific behavior significantly influences the resulting trajectory. Green wave technology usually happens on a straight road/lane, where the car receives a reference velocity from the traffic light infrastructure via V2X communication. The planning algorithm is mainly implemented from the infrastructure side and is less important from the vehicle side. In autonomous parking, the car drives at low speed; consequently, the planning computation time is less critical than driving on the highway. However, the parking area often has limited space and there are more types of obstacles (other cars, pedestrians, objects, etc.) coming from different directions. In some cases, when changing gears (forward/backward) and directions are needed, the task becomes harder. The planner needs to factor all these considerations into the design. Generally, the planning stage in our use cases is divided into two main steps:

- Global planning: Planning the route (or waypoints) at a high level. This is applied in the parking use case when the global planner roughly generates the path to follow from the initial point to the goal parking lot, for example, based on the shortest route
- Local planning: Given a reference path (or waypoints) from the global planner, the vehicle will plan its own detailed trajectory, including timing profile. But it is not necessary for the vehicle to follow the path precisely as the following requirements are more critical:

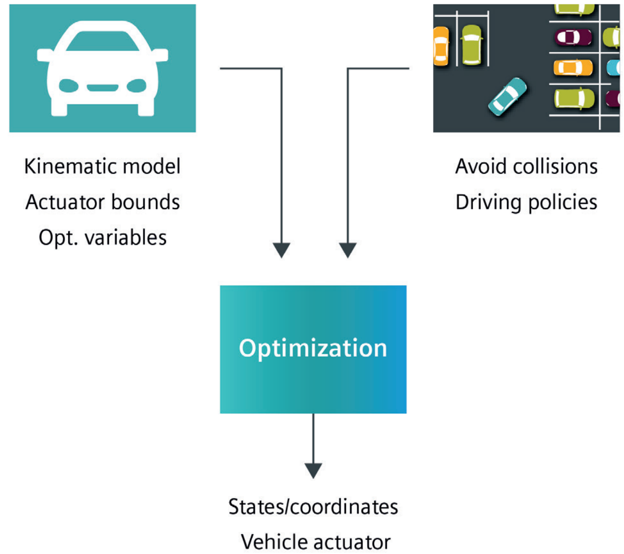

Figure 4: Local planning structure.

1. Vehicle constraints such as nonholonomic constraints (for example, the vehicle cannot move to any configuration), steering, velocity and acceleration constraints
2. Avoiding obstacles: An unexpected obstacle (for example, pedestrian, other moving cars, etc.) was encountered during the execution of the precomputed path. Local planning is thus an online planning stage
3. Optimality with respect to a given criteria such as timing or fuel consumption

Figure 4 presents the local planning structure that is used in the autonomous parking application. Note there could have been another layer of planning in other ADAS systems; for example, the traffic planner decides to change lanes, or overtake another car, but it is not the focus of our use cases.

1.4. Tracking control

The controller is designed to control the vehicle along the computed trajectory. The controller is crucial because of uncertainty reasons, typically plant model mismatch and disturbances to the vehicle. A proportional–integral–derivative (PID) control is developed as a comparison baseline. The PID controller is simple to implement and has well understood characteristics. The fact the PID is mathematically simple and a black box type control (no modeling required) makes it a practical tool that is widely used in industrial applications.

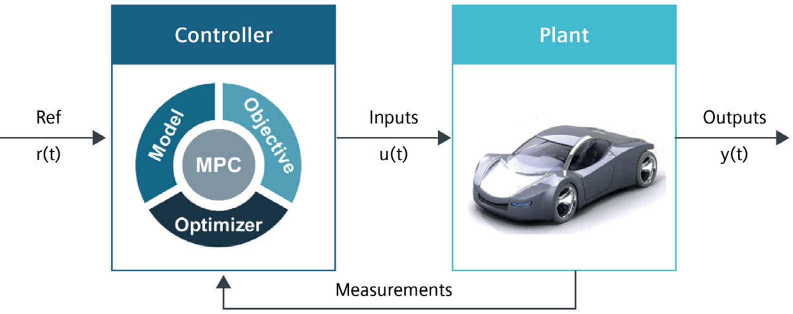

Figure 5: Model predictive control structure.

Our main focus on control design is model predictive control development that can deliver optimal control over a wide range of operation conditions. MPC design relies on solving a model-based optimization problem, and has two main advantages over PID control: it can deal efficiently with multi-input multi-output (MIMO) systems and vehicle system constraints. MPC is being actively investigated in the automotive industry because the algorithm, implementation and tuning are quite efficient and there is a large potential for MPC-based virtual sensors.

1.5 Co-simulation structure

In this subsection, the presented technologies are combined in the co-simulation structure.

1.5.1 Ground truth design

The first tuning step is performed in the ground truth simulation environment of Simcenter Amesim. In order to be able to tune the controllers for optimal performance, objective performance measures are needed based on which tuning process can take place. At this stage, incorporating sensor dynamics and environmental influences on the measurement signals are not yet of concern. The Simcenter Amesim solver runs the vehicle model, in which all Simcenter Amesim related functionalities can be used and the model variables are readily accessible. The main goal is to get the controller dynamics set up correctly so the controller performs well in ideal circumstances. The controller can be developed using Simcenter Amesim or from other environments (for example, Matlab® enviroment, Python).

1.5.2 Co-simulation setup

Simcenter Prescan is then incorporated in order to simulate environment and sensors. This allows testing and validating planning and control with more relevant scenarios, steering away from ground truth assumptions. The decomposition of the co-simulation setup is not straightforward as some parts can be moved from one software package to another and vice versa. This should be taken into account for the specific ADAS application and the purpose of testing. Clearly, different possible configurations can cause confusion when collaborating as a team. To facilitate the workflow, an interface that connects different models has to be agreed upon before starting the project. This interface defines what and how variables are exchanged between the models.

As an example, we present the model decompositions and variable exchange interface of the ACC use case. An environment is simulated in Simcenter Prescan, and the sensors are mounted on the ego vehicle, which sense the environment. The output signals of those sensors are led from Simcenter Prescan to the ACC controller in the Simulink® environment. The current acceleration and yaw rate are also used by the controller, with those signals coming from the Simcenter Amesim model. The controller calculates throttle and brake signals. Those signals are then fed into the Simcenter Amesim vehicle model. A path follower in Simcenter Prescan also calculates a suitable steering signal that keeps the vehicle on a predefined path. To be able to do this, the path follower needs the yaw angle from the vehicle model. The steering signal is fed through Simulink into the Simcenter Amesim model. Moreover, for each of the four tires, a road friction coefficient value (based on the position of the car and the ground material) is sent through Simulink to the Simcenter Amesim model. Given those inputs (tire friction, steering angle and throttle/brake signal), the states (position and velocity) of the vehicle can be calculated using the Simcenter Amesim solver. The new vehicle states are then used to update the states of the vehicle model in Simcenter Prescan. Accordingly, environment sensing is updated, and the circle continues.

Use cases

Three use cases follow: ACC, green wave technology and autonomous parking, which are typically at high speed, middle range speed and low speed, respectively. They use three different co-simulation decomposition/interface setups and planning/control design developments. The V2V and V2X technologies are also included. The development of an ACC system is first discussed in detail to provide insights into the proposed framework, and then the other two use cases will be presented.

2.1 Adaptive cruise control

The ACC development relies on a key performance indicator (KPI). This is a number or set of numbers that describes the performance of a system, and can also be used to compare the performance of different ACC systems in an efficient and practical way. The basis of the KPI calculation is often a benchmark that is set by industry standards. In our research, we consider the following four characteristics to describe an ACC controller performance.

- Safety: Describes how the ACC controller avoids and handles dangerous situations. Collisions should be avoided at all times. A quantifiable parameter that describes how a controller avoids getting into collision-prone situations is the time-to-collision (TTC) measured in seconds
- Comfort: Describes how gentle the controller is to ensure a comfortable ride for passengers. To achieve desirable comfort levels, the International Organization for Standardization (ISO) standard sets limits on the tolerated acceleration and deceleration levels. The result of this integration is a KPI number that represents the comfort performance of the controller
- Natural driving: Considers how human the controller is behaving in traffic situations. The maintained following distance is counted in this case. This is for determining the mental comfort of the passengers. If an ACC system behaves differently from how an average person would act, it would make the passengers feel uneasy and the driver would feel a constant urge to retake control of the car. Naturally, drivers keep a velocity-dependent following distance that can be expressed in seconds, which is called head time
- Ecology: Describes how fuel economy and pollution are affected by the controller, and relates to the torque demand. High torque demands result in higher engine emissions. Diesel engines produce an increase in particulate matter emissions and gasoline engines deliver increased hydrocarbon and nitrogen oxide (NOx) emissions

Ground truth testing

The above mentioned methods allow you to calculate four different KPIs: safety, comfort, natural behavior and ecology. The next step is to create scenarios in which the controller can be tested. The scenarios are simulated in a ground truth environment. That means, for example, the controller disposes of input variables that are always accessible and fully accurate. It can be comparable to the situation of perfect sensors that have infinite resolution, infinite sample rate and zero noise. This ground truth environment is created in a co-simulation with Simcenter Amesim and Simulink. The vehicle model runs in Simcenter Amesim, and the controller model runs in Simulink. The exact signals, such as relative velocity, following distance, velocity and acceleration, can be extracted from the Simcenter Amesim model during simulation and fed into the controller. To make the decision, one has to take into account the importance attached to different driving characteristics like safety, comfort, natural driving behavior and fuel economy. Based on the relative importance, a weight can be assigned to each of the four KPI numbers for each controller. The controller tuning relies on two steps. The first step involves finding out what parameters can be configured in order to tune the controller for optimal performance. For example, in the PID controller it is straightforward the configurable parameters are P, I and D gains. In the MPC controller, it is characterized by the set of weights used in the objective function. The second step finds the optimal parameter configuration that delivers better results than other configurations. This can be done by testing stochastically or exhaustively with different parameter sets; there are also some design of experiments tools that can help with that.

Co-simulation in Simcenter Amesim and Simcenter Prescan testing

It is clear the controller developed in the ground truth environment cannot be used to process realistic sensor signals. It doesn't need to distinguish between several possible targets. Only the data of one vehicle just in front of the ego vehicle was fed into the controller. On the other hand, realistic sensors sense multiple targets at the same time and the controller has to decide first what target is in the lane in front of the ego vehicle. In order to create a working controller, the ground truth controller has to be expanded with an extra module: the target selection module. The controller is then adapted and ready to function with realistic sensor output. The remaining works are modeling the sensors and the environment on Simcenter Prescan.

Three scenarios will be built in the Simcenter Prescan software, according to the tests prescribed in the ISO standards. The first scenario will test the discrimination capabilities of the developed ACC systems. The second scenario will test the retargeting capabilities. Retargeting means the controller can autonomously judge what vehicle drives in front of it, and adapt its judgment based on sensor output when the current

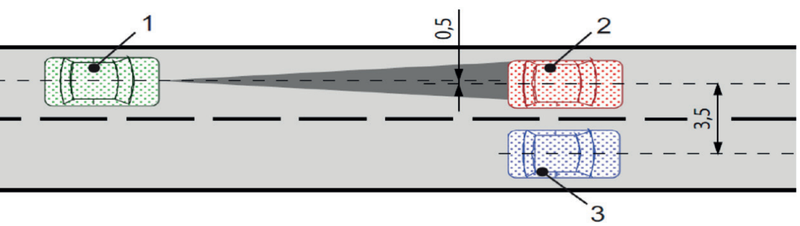

Figure 6: Discrimination capabilities test [ISO15622].

traffic situation changes due to, for example, a cut-in or cut-out event. The third scenario will test the curve capabilities of the controller. All those tests are performed on dry asphalt in clear weather conditions with a visibility of 1,000 meters (m) and a temperature between –20 to 40 degrees Celsius.

- Discrimination capabilities: This test measures the capability of the ACC controller to discriminate between two adjacent vehicles and to decide which one is in the same lane as the ego vehicle. The test is performed on a straight road, prescribed by ISO 15622. Vehicle 1 (ego vehicle) and vehicle 2 drive in the same lane. The ego vehicle follows in steady state following mode with the maximum allowable time gap. Vehicle 2 then accelerates while vehicle 3 stays at a constant velocity. The ACC controller interprets the situation and controls the longitudinal behavior of the ego vehicle. The test is successful if the ego vehicle correctly accelerates to follow vehicle 2 and passes vehicle 3

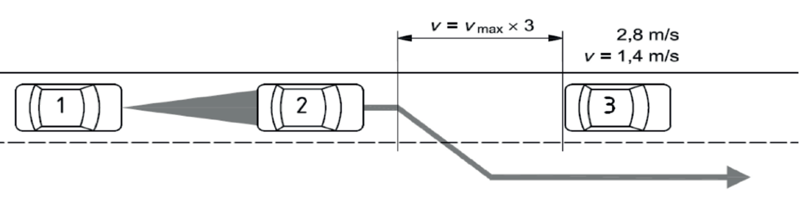

Figure 7: Retargeting test [ISO22178].

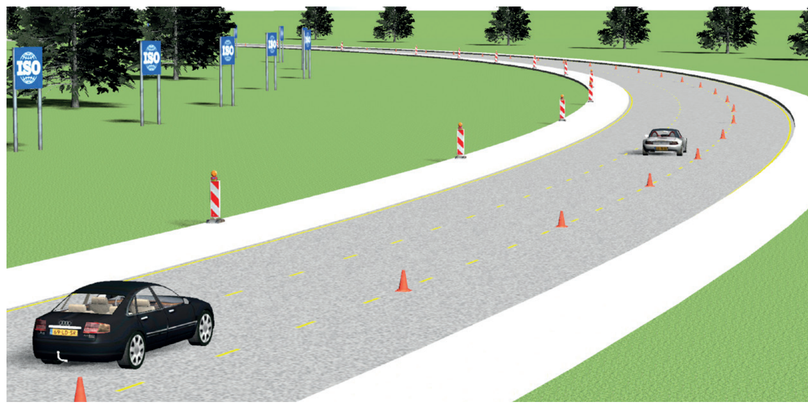

Figure 8: ACC use case: object selection in a curve [ISO 15622].

- Retargeting capabilities: This test measures the capability of the ACC controller to react to a cut-out of the preceding vehicle and to retarget accordingly. As prescribed by ISO 22178, this test is performed on a straight road. The ego vehicle is controlled by the ACC controller and follows the preceding vehicle in steady state. The preceding vehicle changes to the right lane

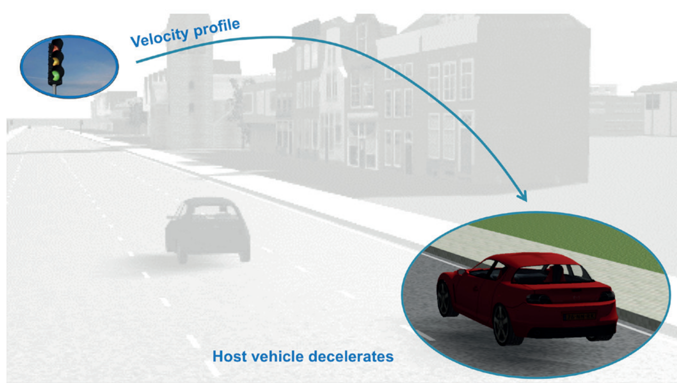

Figure 9: Green wave technology.

because there is a much slower vehicle in front of it. The test is successful if the ego vehicle decelerates and starts driving behind the slow vehicle

- Curve capabilities: This test measures the capability of the ACC controller to perform steady longitudinal control while driving through curves. As specified in the ISO 15622 standard, in this case, a curve of radius 125 m has to be selected. The preceding vehicle and the ego vehicle drive in steady state in the same lane. After 10 seconds, the preceding vehicle slows down. The test is successful if the ego vehicle starts to decelerate before the time gap becomes smaller than two-thirds of the selected time gap

2.2 Green wave technology

The main idea of green wave technology is that a car informs the driver when the traffic light will turn green and what speed to maintain to get through a series of green lights at constant speed by transmitting the information between the vehicle and the infrastructure. The advantages include reducing traffic jams, less fuel consumption and less stress for drivers. Figure 9 shows the Simcenter Prescan demonstration of this ADAS application. The co-simulation setup and control development is similar to the ACC case.

2.3 Autonomous valet parking

Valet parking is a functional extension of parking assistance and is estimated to be one of the first commercially available, fully automated driving functions since driving occurs at low speed and the traffic environment can be supervised. When activated by the user, the function together with a parking area management (PAM) system will take over full control of the vehicle and the vehicle is driven through the parking area until it comes to a designated parking position. In this application, different planning and control levels are required:

- Global planning: Planning the path (or waypoints) from the initial handover zone to the goal parking bay. This task is generated from the PAM with a parking map
- Local planning and control: Given the reference path from the global planning, the vehicle will plan its own trajectory to follow the defined path or waypoints using its sensors and perceptions. The planner should deal with uncertainties in the parking area (pedestrians, other cars entering or leaving, etc.)
- Maneuvering planning and control: This component considers vehicle maneuvering to the parking bay. The approaches and requirements are mostly similar to the local planning stage, but require more attention due to tight space and more obstacles (parked cars). In addition, in some cases, multiple movements with change of direction (or gear shift) of forward/backward is required. Figure 10 shows our valet parking scenario in Simcenter Prescan

Unlike ACC and green wave technology use cases, the planning and control algorithms for valet parking are mainly developed in Matlab and Python, both for velocity and steering planning and control.

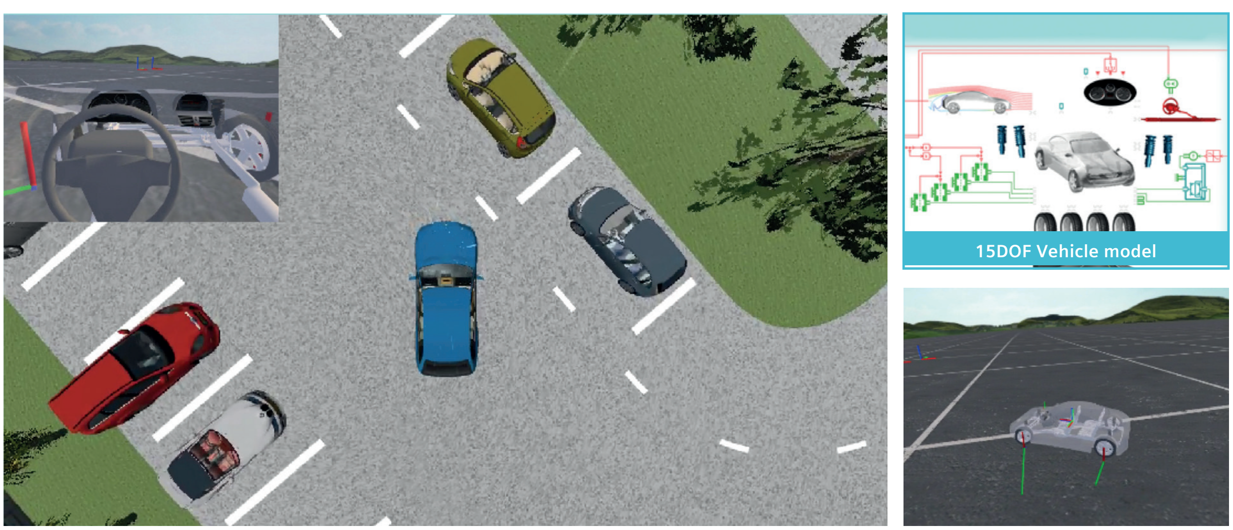

Figure 10: Valet parking scenario demonstrating co-simulation of Simcenter Amesim and Simcenter Prescan.

Conclusion

The co-simulation testing framework of Simcenter Amesim and Simcenter Prescan delivers benefits in multiple ways. First, the complete planning and controller developments can be tested and validated with high fidelity vehicle dynamics and real-world environments using physics-based sensors. The second benefit is the standard test scenarios, or any other corner case scenarios, with more focus on interactions with the environment, which can be used for testing. This is valuable since it drastically reduces the number of physical prototype tests that have to be performed. In addition, the repeatability of those tests is much higher than the tests performed in a real prototype: other traffic and weather conditions are under full control of the control engineer. Finally, the great visualization quality that Simcenter Prescan offers enables engineers and customers to get a clear picture of key issues.

References

1. Kalra, N., Paddock, S., 2016. "Driving to Safety: How Many Miles of Driving Would It Take to Demonstrate Autonomous Vehicle Reliability?" Santa Monica, California: RAND Corporation
2. Wissel, D., Thomas, V., Lansky, L., 2016. "Linking model predictive control (MPC) and system simulation tools to support automotive system architecture choices," 8th European Congress on Embedded Real Time Software and Systems
3. Vanhuyse, J., De Bruyne, S., Nicolai, M., Atarashi, D., Van Der Auweraer, H., Desmet, W., 2016. "Nonlinear MPC design using Amesim models." TMCE 2016 Symposium. Aix-en-Provence, France
4. Simcenter Amesim: https://www.plm.automation.siemens.com/en/products/lms/imagine-lab/amesim/
5. Simcenter PreScan: https://www.tassinternational.com/prescan

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