

ASM Traffic: New Model for Simulating

Traffic Jam on Virtual





Road Traffic

Roads

Imagine you are developing a driver assistance system that has to detect traffic situations and react to them correctly. This is a unique challenge – as is testing function algorithms that have just been developed. Who wants to be driving along in a vehicle, waiting to see how a brand new, untested automated braking maneuver will perform? A simulated test drive is so much more relaxed.

To have a lot happening on the roads during the virtual test drive, a whole bunch of other vehicles need to be driving around in such a manner that the driver assistance system has plenty to do. This is exactly where dSPACE's new simulation model comes in: ASM Traffic puts virtual road traffic into the simulation. In addition to includ-

ing fellow vehicles, it also provides a further indispensable component for this type of assistance system: models for object detection sensors with a 3-D scanning beam, such as radar. Several of these can be "fitted" to the test vehicle. With equipment like this, nothing stands in the way of the virtual testing of new algorithms.

Real-World Experience

DENSO CORPORATION in Japan has been using ASM Traffic in a pilot project since November 2007. The new model is used for function development and testing for ACC systems. Mr. Nishimura from DENSO sums up his experience with the model as follows:

“In DENSO’s previous method, HIL users first had to create Simulink models for fellow vehicles’ behaviors and the radar themselves. Then they had to make timing adjustments to synchronize the traffic with the HIL test case. Now ASM Traffic provides all the models that are required, and also a convenient editor for creating traffic behavior. Events can be used to synchronize the traffic with the HIL test case. The result is a significant improvement in HIL efficiency.”

Takao Nishimura, DENSO CORPORATION

Setting up Road Traffic

At this point, developers will be asking how they can set up the traffic situations their assistance systems will have to face. There has to be a simple, flexible way of creating at least the virtual traffic situations defined in the specifications.

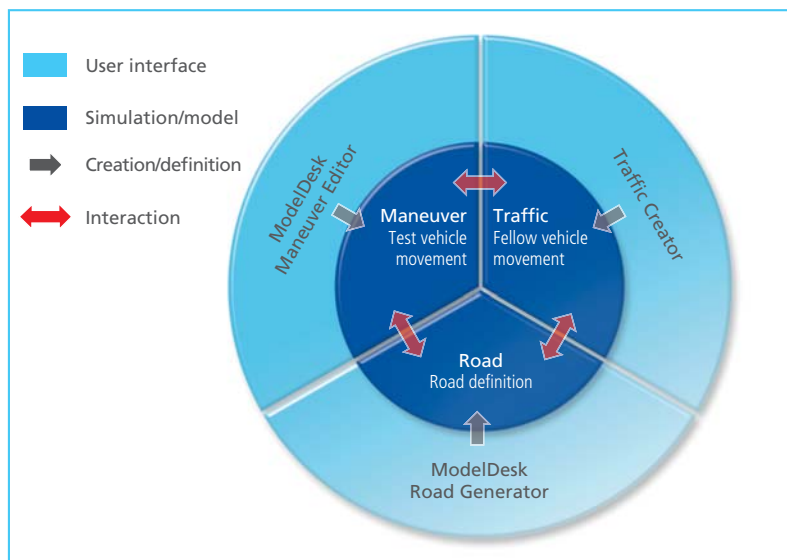
This is why ASM Traffic has a special editor called the Traffic Creator, which can be used to create almost any traffic scenario. In fact, the

enormous flexibility in scenario creation that Traffic Creator offers is ASM Traffic’s particular strength. Each of the 15 fellow vehicles is given its own individual trajectory, which can even change in response to events.

Workflow

To understand the way the Traffic Creator works, you need to know the overall workflow. First a road

consisting of segments is defined, then the driving maneuver for the test vehicle that will run on the road. The simplest case is a straight stretch of road with a test vehicle traveling along it at a predefined speed. The road and the maneuver are both created in ModelDesk. ModelDesk is the parameterization software for the ASM Vehicle Dynamics Simulation Package, which is the basis for the driving simulation and therefore also needed for running ASM Traffic. Traffic definitions in the Traffic Creator are also based on segments and are therefore fully consistent with road and maneuver definitions. With the Traffic Creator’s options you can define the movements of each fellow vehicle in relation to the road or to other vehicles.



Test scenarios are a combination of road, test vehicle movements, and fellow vehicle movements.

Driver assistance systems such as ACC and precrash are equipped with radar sensors for object detection.



Every Which Way

The trajectories of the fellow vehicles are calculated from distances or speeds, which can be defined either as absolute values or in relation to other vehicles or the road. Basic movement profiles such as constants and ramps are available for segment definition. The transition from one movement segment to the next can be defined freely. The transition criteria can be any event such as approaching a certain speed limit, reaching a predefined distance to other vehicles, or any external trigger signal such as CAN signals or user inputs.

Sensor Model

The sensor model in ASM Traffic simulates a 3-D detection range consisting of three layered triangles. The fellow vehicles are treated as cuboids. The sensor model uses a purely geometric approach, so it can also be used for sensor types other than just radar sensors, such as lidar and camera. The sensor model calculates the nearest point of each of the fellow vehicles detected in the sensor's range and returns the distance, the relative speed, the relative acceleration, and the relative horizontal angle for each one.

Visualization and Examples

Visualization of the simulated traffic scenarios is performed by Motion-Desk, the 3-D animation software from dSPACE. ASM Traffic provides seven traffic scenario examples, including special ones such as for oncoming traffic and pedestrians. Thus equipped, the new model can be put into operation quickly.

Applications

ASM Traffic is ideal for hardware-in-the-loop (HIL) testing of adaptive cruise control (ACC) and precrash systems. Function development is supported by Simulink® simulation on a host PC. ASM Traffic can mimic traffic scenarios of all kinds, from simple lane changes to complex scenarios with 15 fellow vehicles. The tests can cover how the ECUs function, and how they behave at the limits of the sensor range. ■



3-D animation of a traffic scenario simulated with ASM Traffic.

Example Application

The following example test case shows how the function of an ACC ECU is tested on a HIL simulator. First the scenario is defined, and then automated testing is performed. Finally, the example explains the results that are obtained. The objective of this example is to show how certain properties of an ACC system can be evaluated.

Defining the Traffic Scenario

The scenario comprises the test vehicle and three fellow vehicles, one of which cuts into the test vehicle's lane. This lane change is triggered when the distance between the test vehicle and the fellow vehicle drops below a certain value. In addition to showing the basic definition options, this example scenario also explains the method of segment-based definition and event-based segment transition.

Segment 1:

The starting point is a maneuver in which the test vehicle T travels along the left lane of a straight road at a speed of 120 km/h. The first fellow vehicle is initialized at a distance of 200 meters ahead of the test vehicle. The longitudinal positions of the two other fellow vehicles are each defined in terms of the distance to the vehicle behind. All the fellow vehicles have a speed of 100 km/h.

The test vehicle T approaches the fellow vehicles in the passing lane at the ACC-regulated speed of 120 km/h. When the distance between the test vehicle and fellow

vehicle F2 drops below 30 meters, a segment end condition is reached. This event triggers the transition to the next segment, the cut-in maneuver.

Segment 2:

Fellow vehicle F2 now performs a lane change into the passing lane (cut in). This brings it into the detection range of the test vehicle's distance sensor. The ACC system now has to adjust the distance between the test vehicle and the fellow vehicle to the desired distance setting.

Test Sequence

Using the defined test scenario the following steps are performed at the HIL testing station to test the ACC ECU:

1. The ACC is switched on and its settings are specified.
2. The test scenario is run.
3. Measurement begins with the fellow vehicle's first steering action.
4. Measurement data is captured until a constant driving state has been reached.
5. The measured data is evaluated.

To vary the simulation, steps 1 to 5 can be repeated with the same scenarios but with different parameters.

Variations

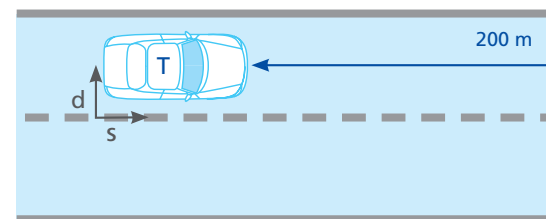
Variations of the scenario can be run automatically in batch mode by using Python scripts in ModelDesk. The variations let the user apply different distance settings in the ACC and different fellow vehicle F2 speeds.

Measurement and Evaluation

For evaluating this use case the following variables will be captured:

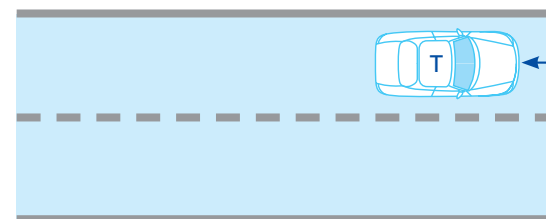
- Speed of the test vehicle
- Deceleration of the test vehicle
- Speed of the fellow vehicle
- Distance between the test vehicle and fellow vehicle F2

Segment 1 (Initial)

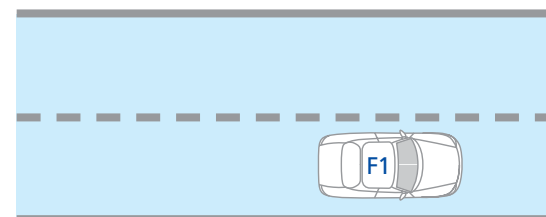


$$\begin{aligned}d_r &= +2 \text{ m} \\v_r &= 120 \text{ km/h} \\s_r &= f \text{ (maneuver)}\end{aligned}$$

Segment 1 (End)



Segment 2

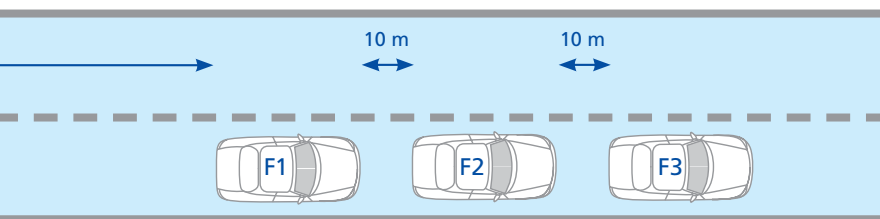


$$\begin{aligned}d_{f1} &= -2 \text{ m} \\v_{f1} &= 100 \text{ km/h}\end{aligned}$$

The measured signals are evaluated according to the following criteria:

- Response time and control time of the ACC system
- Distance to target object (as specified; as defined by law)
- Controller behavior with regard to comfort (e. g., evaluation of test vehicle deceleration)

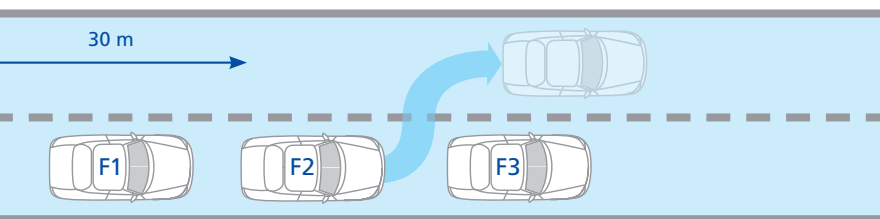
d = lateral position on road
 s = longitudinal position on road
 v = vehicle speed



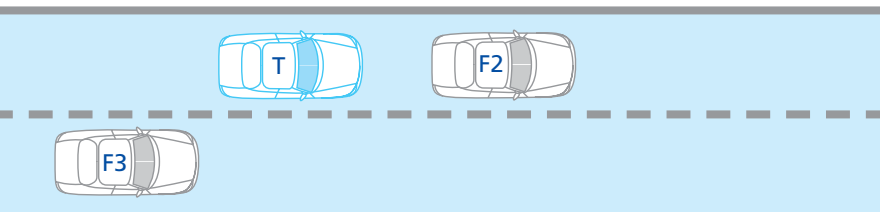
$$\begin{aligned} d_{F1} &= -2 \text{ m} \\ v_{F1} &= 100 \text{ km/h} \\ s_{F1} &= s_T + 200 \text{ m} \end{aligned}$$

$$\begin{aligned} d_{F2} &= -2 \text{ m} \\ v_{F2} &= 100 \text{ km/h} \\ s_{F2} &= s_{F1} + 10 \text{ m} \end{aligned}$$

$$\begin{aligned} d_{F3} &= -2 \text{ m} \\ v_{F3} &= 100 \text{ km/h} \\ s_{F3} &= s_{F2} + 10 \text{ m} \end{aligned}$$



Segment end condition $\text{dist}(F2, T) < 30 \text{ m}$ triggers a lane change that will be performed in the next segment.



$$\begin{aligned} d_{F3} &= -2 \text{ m} \\ v_{F3} &= 100 \text{ km/h} \end{aligned}$$

$$\begin{aligned} d_T &= +2 \text{ m} \\ v_T &= f(\text{ACC}) \end{aligned}$$

$$\begin{aligned} d_{F2} &= -2 \dots +2 \text{ m} \\ v_{F2} &= 100 \text{ km/h} \end{aligned}$$

ASM Traffic's Profile

Product Class:

- Simulation of road traffic surrounding a test vehicle
- Extension for the ASM Vehicle Dynamics Simulation Package

Key functions:

- Simulation of 15 independent fellow vehicles
- Radar sensor model with a 3-D beam
- Multiple sensors
- Flexible definition of traffic scenarios
- Online and offline simulation in real time

Applications:

- HIL testing of ACC and precrash ECUs
- Function development for ACC and precrash systems

