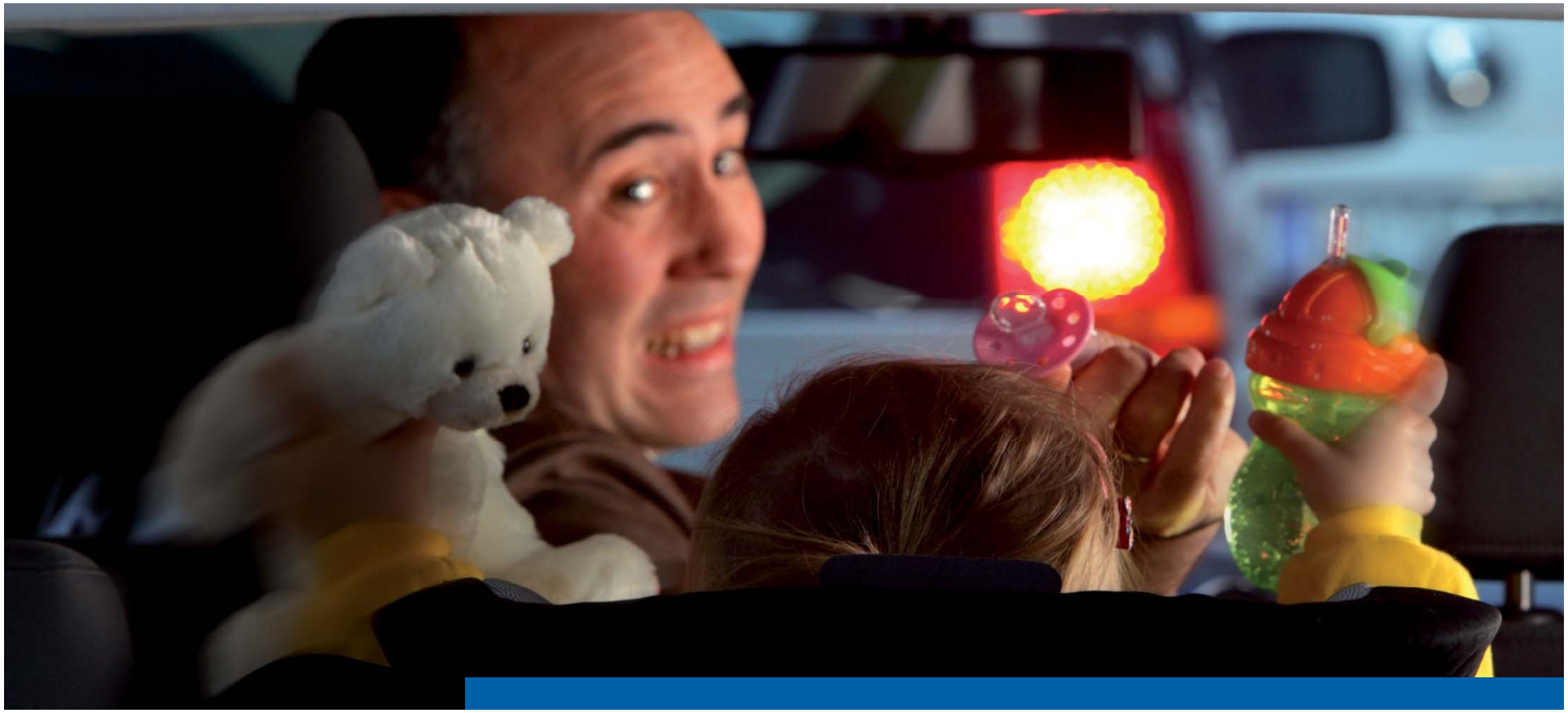

Virtual driving as an important component for functional tests of ContiGuard® Functions

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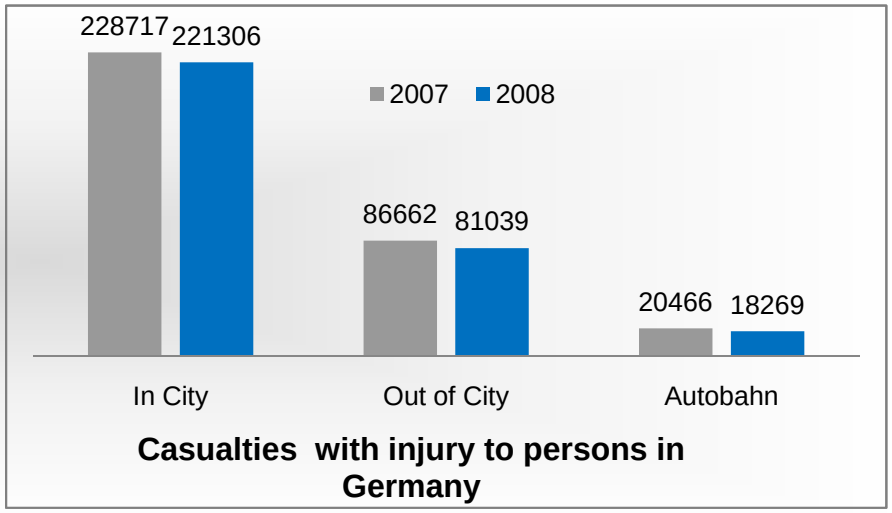
Agenda

1. Introduction and Motivation
2. Emergency Brake Assist “EBA City” from Continental
3. Simulation environment for “EBA City”
4. Customer use cases and test challenges
5. Maneuver and evaluation catalogue
6. Benefits and Conclusion

Introduction and Motivation

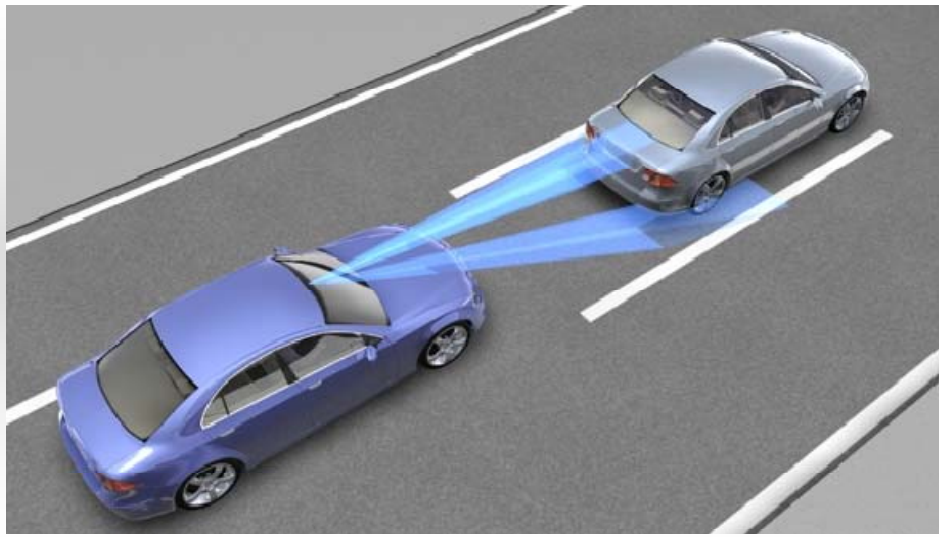
69% of accidents with injuries to persons are in city areas up to 30 kph



- Rear collision is the most frequent collusion type
- Main reason is the lack of attention of the driver

"Emergency Brake Assist" from Continental was developed to support drivers in these situations

Introduction and Motivation



Challenge

- Development of a distributed system
- Assistant function influencing the vehicle dynamics
- Quality Assurance

Motivation

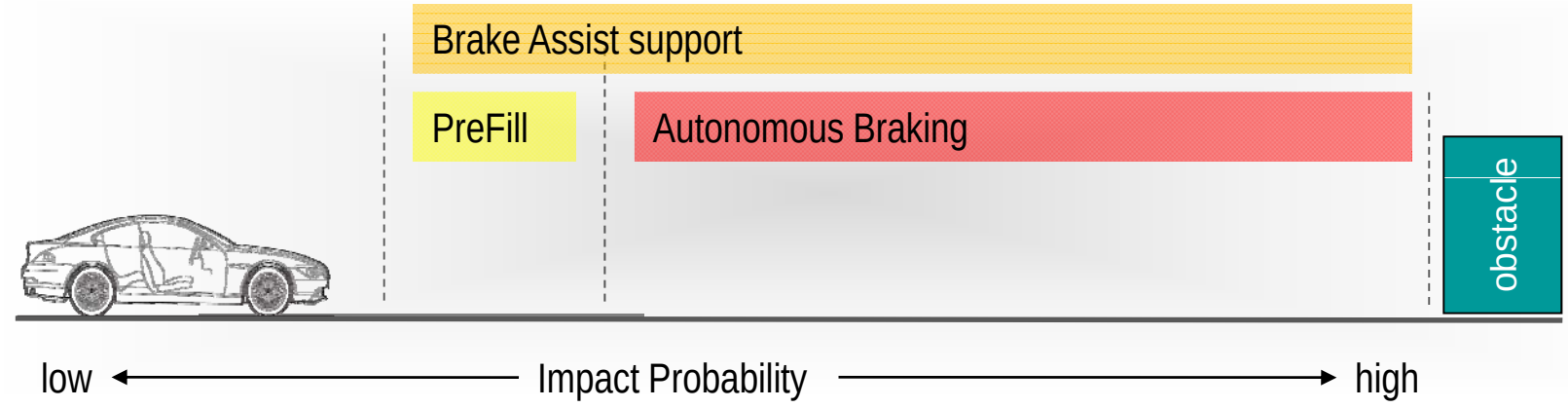
- Closed Loop simulation
- Robust simulations in early development phase
- Optimizing test efforts and test coverage esp. for difficult use cases

"EBA City" from Continental

EBA City consists three sub-functionalities and is active below 30 kph

How probable is the collision situation?
How easy is the avoidance by steer?

- Situation Analysis based on ego vehicle dynamics and distance information from Sensor
- Objects are interpret within 10 m
- Calculation of probability index

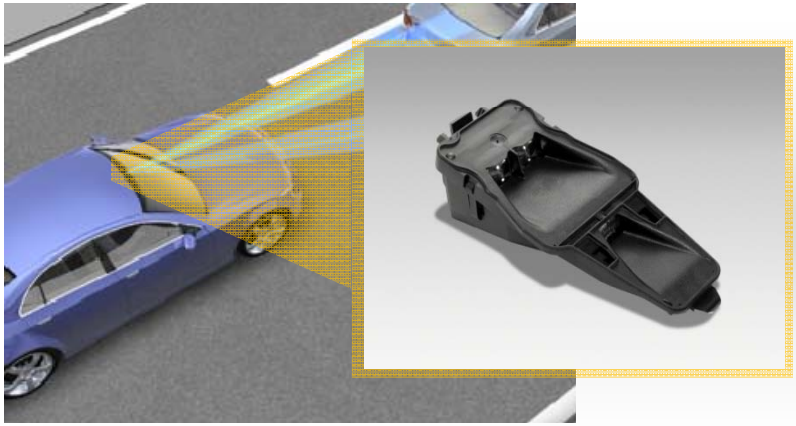


“EBA City” from Continental

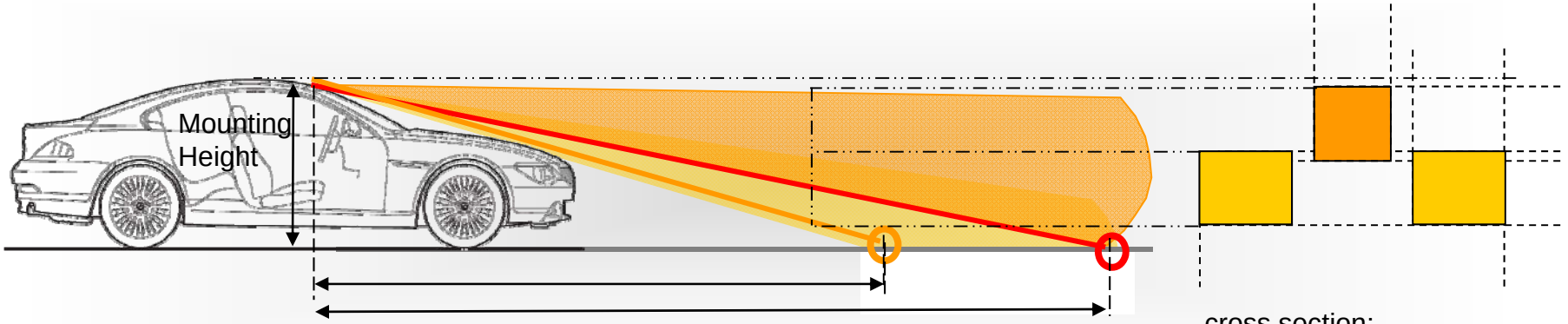
EBA City consists three sub-functionalities and is active below 30 kph

PreFill	Brake Assist Support	Autonomous Braking
Preconditioning of the Brake System Activation of Brake System but without noticeable vehicle deceleration)	Request of Sensitivity Change EBA City sends information to the Brake Assist, which are used to set the activation thresholds of the BA	EBA City sends a graded deceleration request to the brake

Principle of CV - Closing Velocity Sensor for environment identification



Sensor Principle:	Time of Flight of Light Pulses
Wave length:	IR
Mounting Position:	behind Windscreen at interior rear view mirror



Simulation environment for “EBA City”

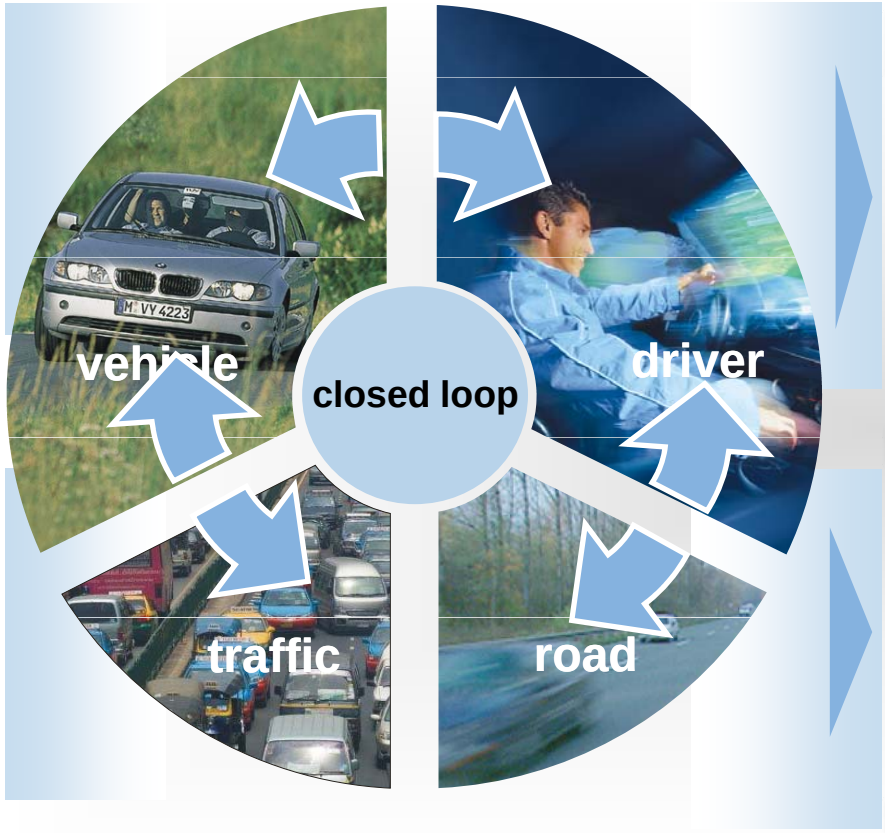
virtual test driving

Requirements on Simulation Environment derived from Use Cases …

- Realistic and adaptable model of vehicle dynamics
- Possibility to simulate complex scenarios → Driver model + maneuver control
- Maneuver and event based traffic simulation for complex scenarios
- Reusability of test cases → easy application without model change
- Interface between simulated environment and sensor model
- Matlab Simulink Interface
- realistic brake hydraulic model and deceleration interface
- Test management tool
- Signal manipulation (e.g. CAN) for failure test
- Online 3D animation
- Real-time capability

Simulation environment for “EBA City”

CarMaker simulation platform was used for vehicle – driver – road – traffic



Field of applications for ADAS (samples)


Adaptive Cruise Control


Parking Assistance


Collision Avoidance


Lane Keeping Assistance

Simulation environment for “EBA City”

Real system

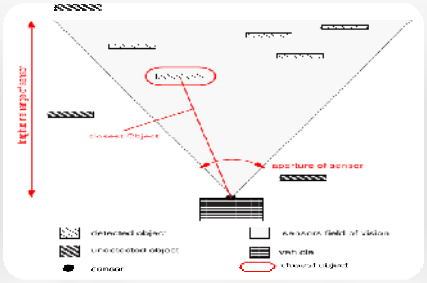
Test vehicle

CV-Sensor

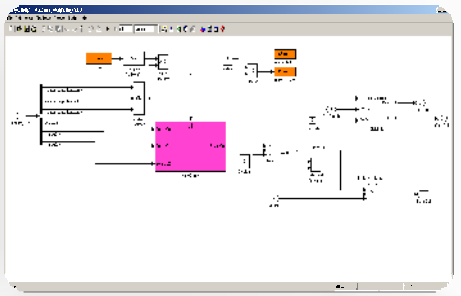
CV Sensor with EBA City

Virtual environment

Vehicle Dynamics Model



DA Sensor Model

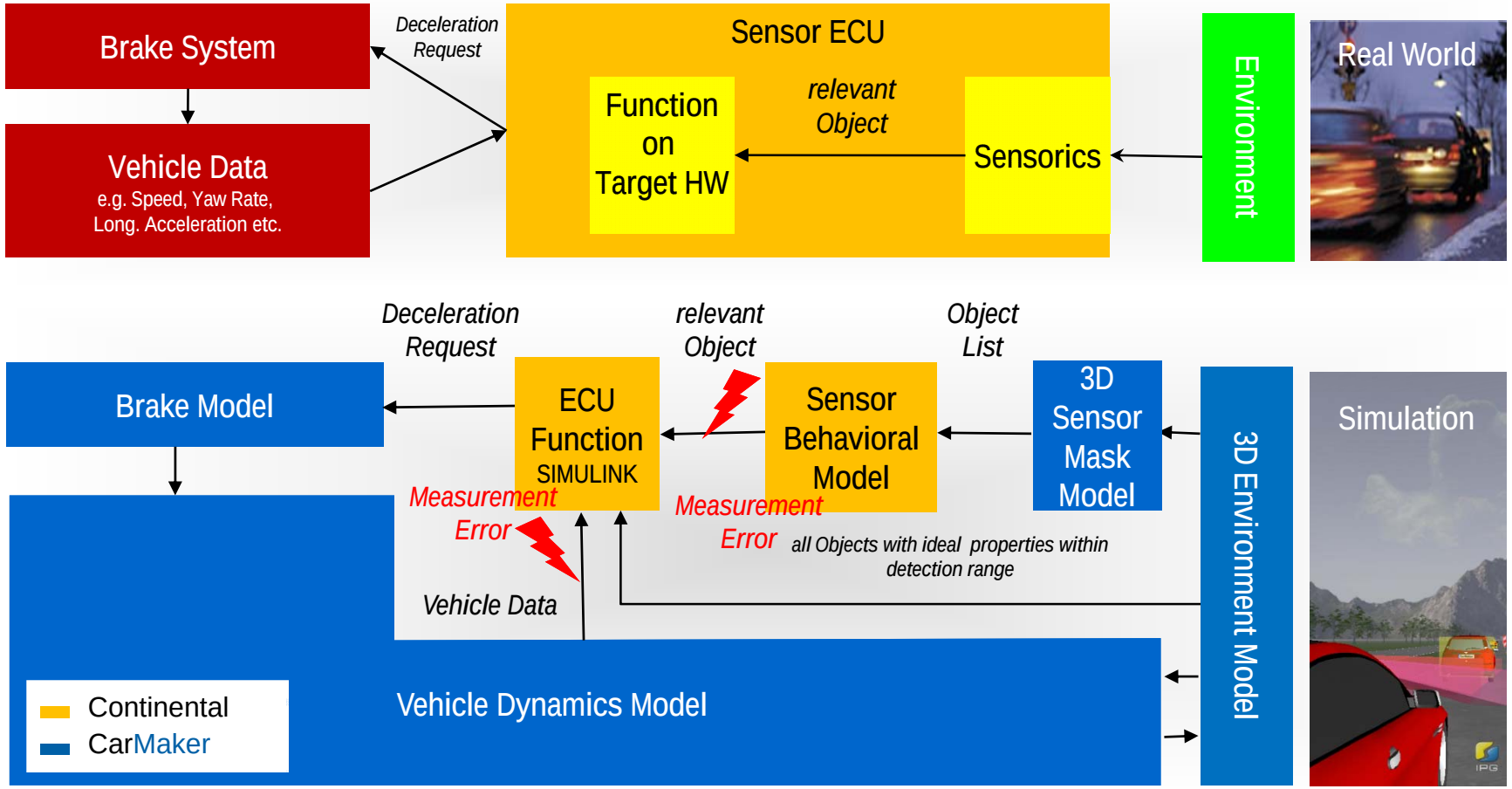


SIMULINK Model

Simulation environment for “EBA City”

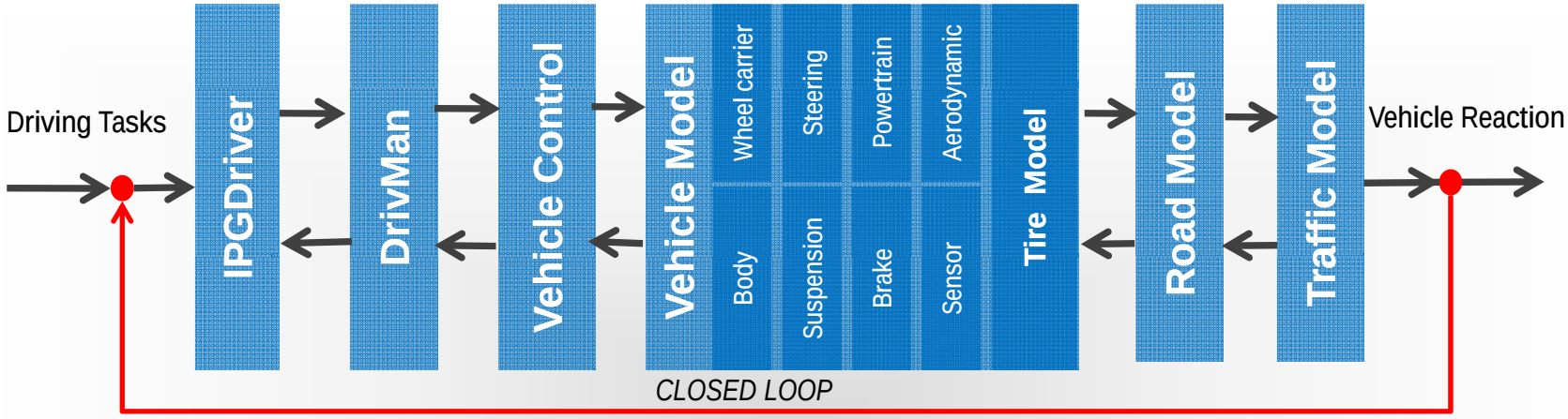
Continental

Key models have been integrated into CarMaker model platform



Simulation environment for “EBA City”

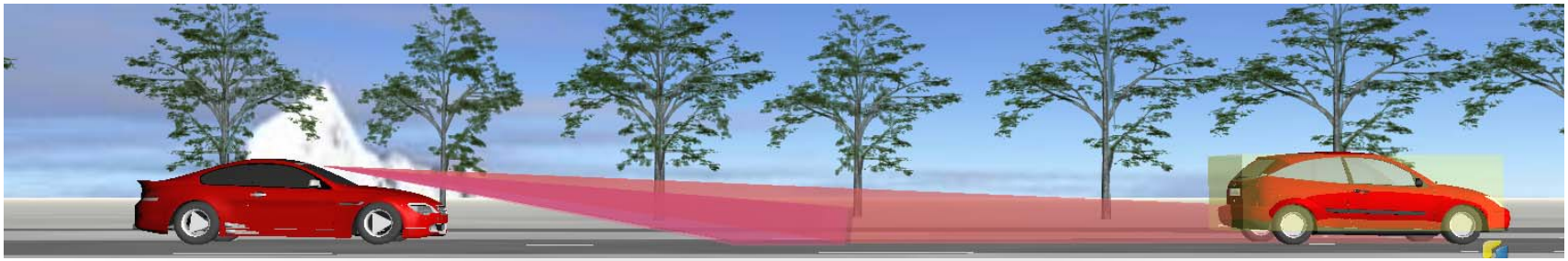
A vehicle control module allow the interaction of driver and ADAS systems



- **Driver model is embedded in a drive maneuver control module**
  - Driving tasks management (automatic and event driven maneuver stages)
  - Monitoring and analysis of all quantities with realtime expressions (parameterizeable)
  - dynamic switch between open and closed loop (lateral and longitudinal tasks)
  - Event driven operation commands (e.g. failures imprint, system activation etc.)
- **HMI for drivers wish and vehicle control interface for cooperative functions**
  - HMI: Steering wheel (deg or M), pedal (brake, accel., clutch), shift, cockpit switches etc.
  - Acc/Dec interface (longitudinal) and steer angle /torque interface for system requests
  - Interface for control systems (e.g. assist systems) to manage co-operation driver/controller

Simulation environment for “EBA City”

Following approaches and boundary conditions have been considered

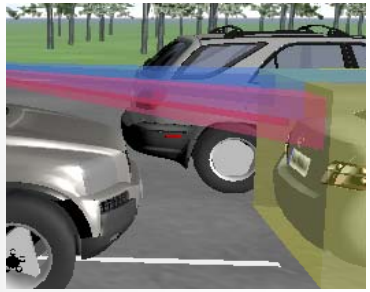


- Simulation provide first of all ideal object information
  e.g. position, size, speed, acceleration are exactly known
- For comparability with real test scenarios - at least partial sensor properties (measurement errors) must be modeled
- Quality of vehicle information on CAN (e.g. speed) suffers from measurement errors (absolute, temporary, delay’s, noise etc.). This could lead to difference to real testing.
- A systematic signal manipulation within the test maneuver must be possible to investigate the failure robustness

Customer use cases and test challenges

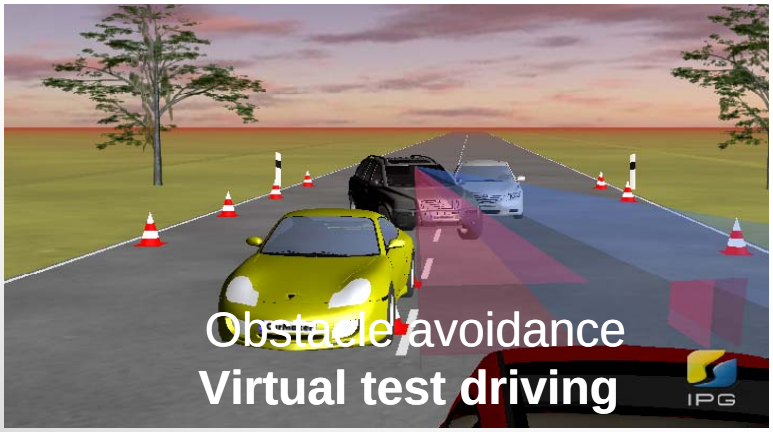
Simulation shall reconstruct real use cases by event triggered maneuvers



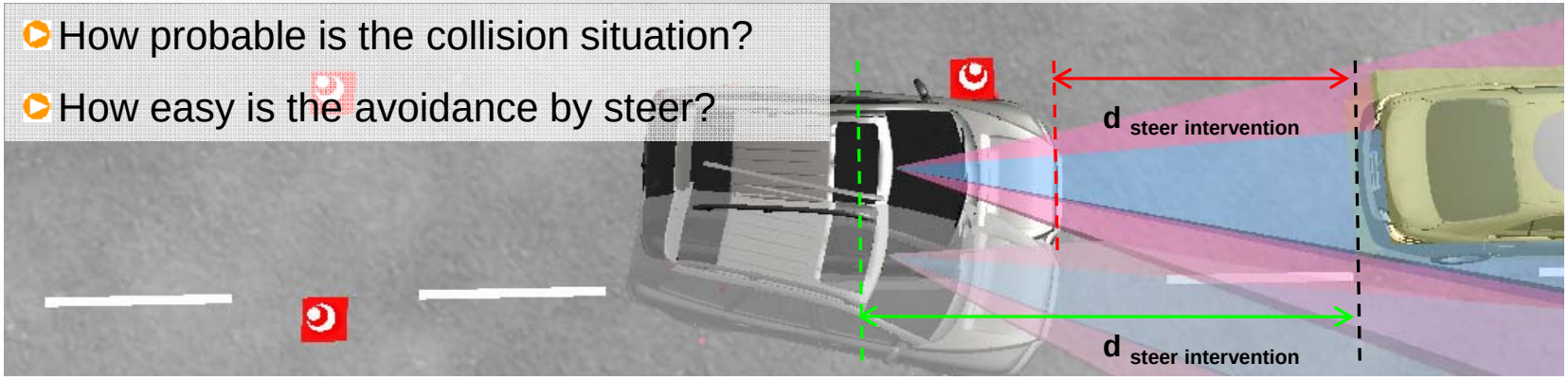



- **Pure longitudinal mission**
  - speed difference to moving or stationary objects (e.g. drive against obstacle)
- **Pure lateral mission**
  - lateral moving object (e.g. vehicle sheer in)
  - avoiding obstacle (e.g. speed breaks and chicanes in play streets)
- **Combined longitudinal and lateral mission**
  - lateral moving object with speed difference (e.g. vehicle sheer in)
  - avoiding moving obstacle with speed difference (e.g. entrance at parking area)

Event triggered maneuvers guarantee reproducibility and reusability

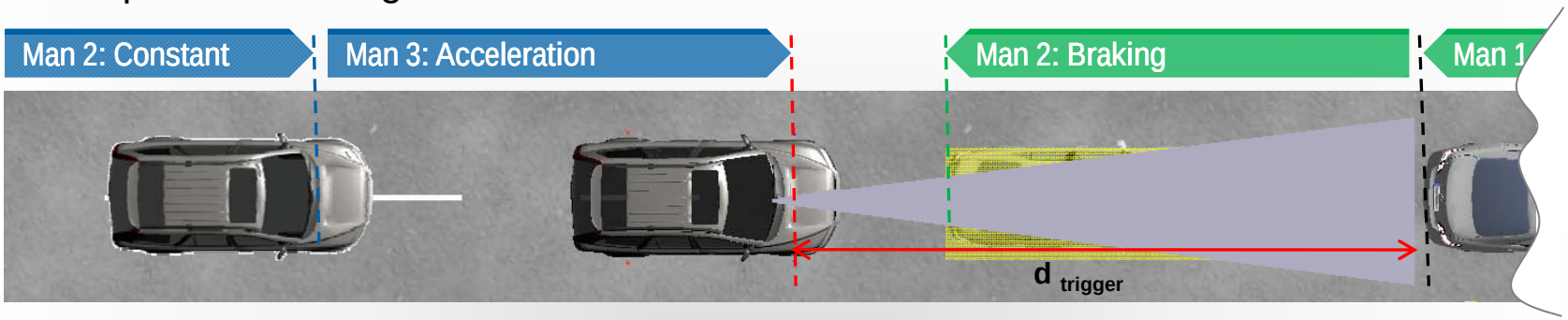


- How probable is the collision situation?
- How easy is the avoidance by steer?

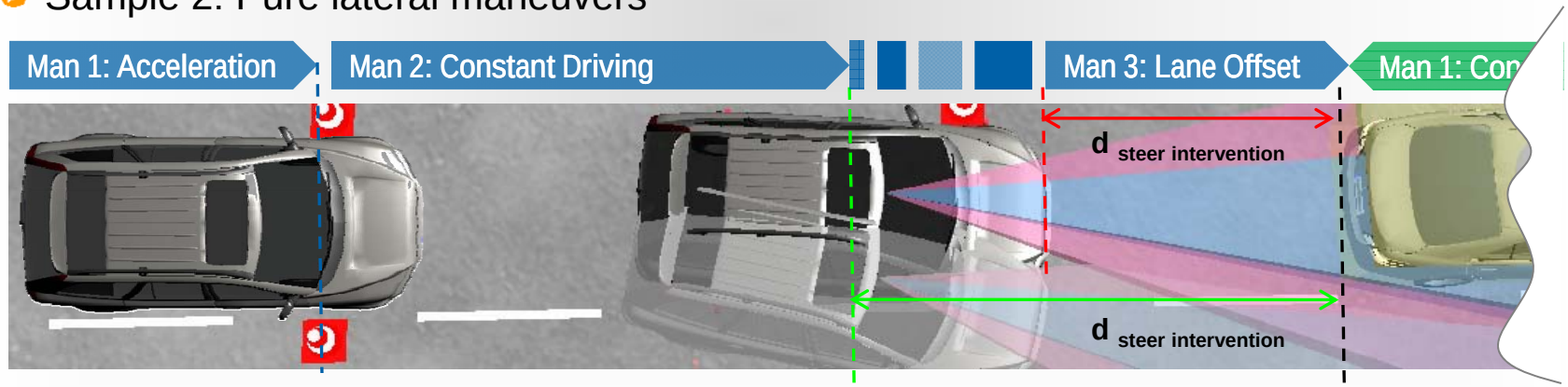


Event triggered maneuvers by monitor and analyze of related quantities

- Sample 1: Pure longitudinal maneuvers



- Sample 2: Pure lateral maneuvers

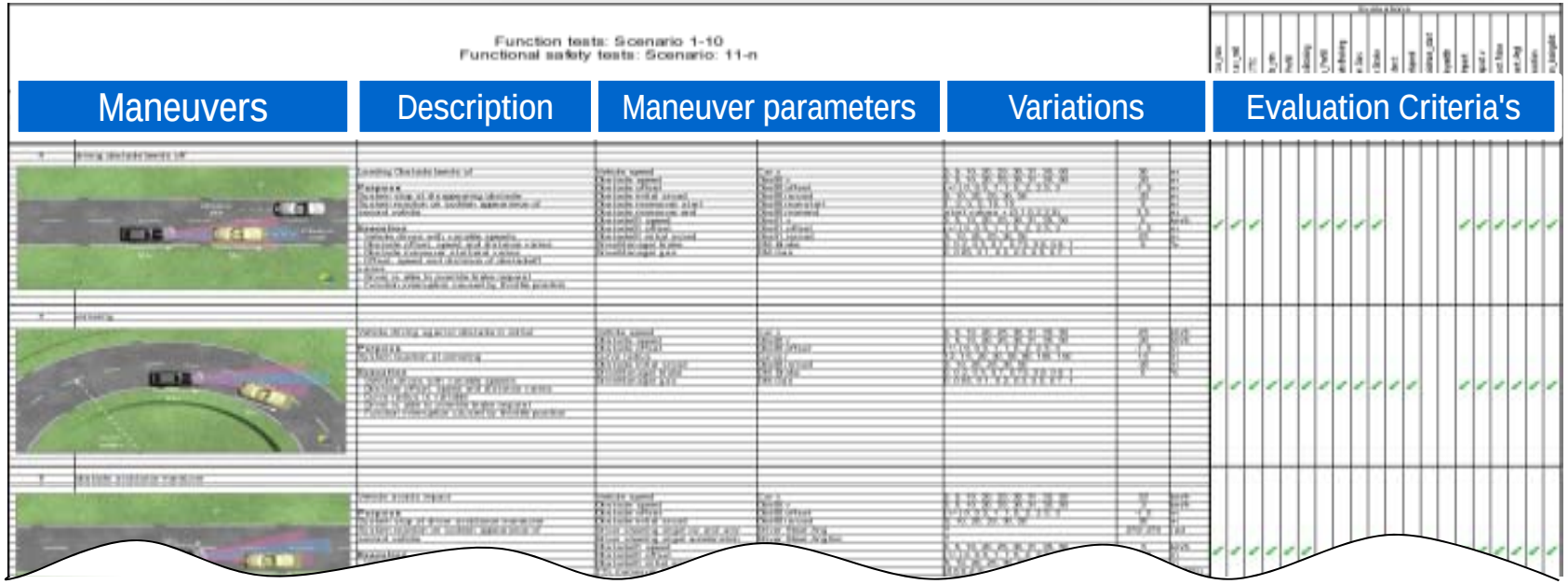


- Sample 3: Combined longitudinal and lateral maneuvers

Maneuver and evaluation catalogue

A detail maneuver test catalogue have been developed based on …

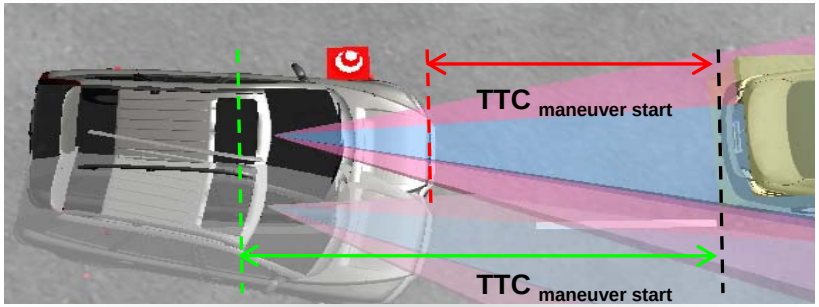
- Functional Safety Assessment
- Event Tree Analysis
- Real Test Procedures
- Field Experience



Maneuver and evaluation catalogue

For each maneuver test variations and default values have been defined

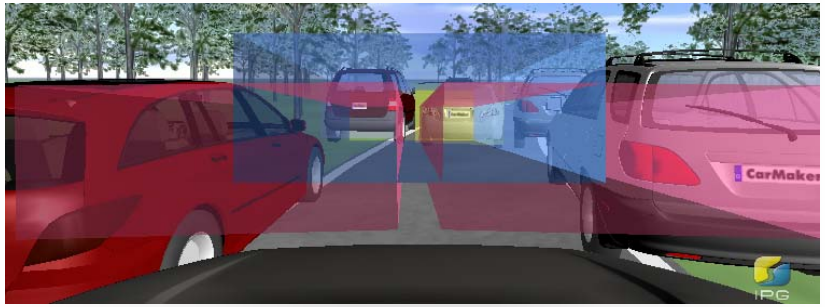
Maneuver 6: Obstacle Avoidance



Test Variation

- Vehicle speed
- Obstacles speed
- Obstacles offset
- Obstacles initial s-road
- Driver steer angel / speed
- Driver gas
- TTC maneuver start

Maneuver 9: Alleyway driving



Test Variation

- Vehicle velocity
- Obstacle velocity
- Alleyway width
- curvature / curve radius
- Accelerator position
- Decelerator position

Maneuver and evaluation catalogue

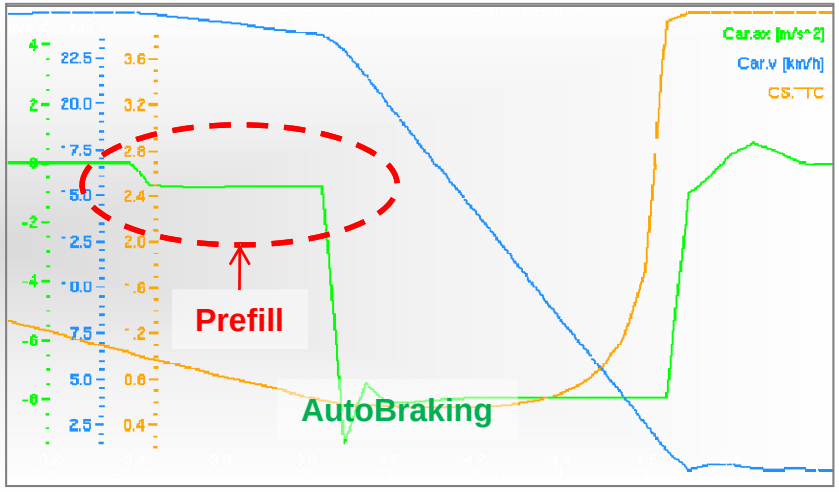
For each maneuver evaluation criteria's have been created and allocated

Maneuver 6: Obstacle Avoidance

Maneuver 9: Alleyway driving

Characteristic Values

- ds_min [m]
- Car.ax_max [m/s²]
- Prefill [0,1]
- AutoBraking [0,1]
- TTC [s]
- Impact [0,1]
- Driver.Brake [%]
- Driver.Gas [%]
- ds_Prefill [m]
- ds_AutoBraking [m]
- dec.t [s]
- relspeed [m/s]
- TTC.avoid_manstart [s]
- Alley_width [m]
- Reaction [s]
- Reaction_losingdist [m]
- Impact.v [m/s]
- Impact.Angl [°]



Maneuver and evaluation catalogue

A test management tool was applied with maneuver and evaluation catalogue

Vehicle Configuration
- Handover key values e.g. engine, tire …

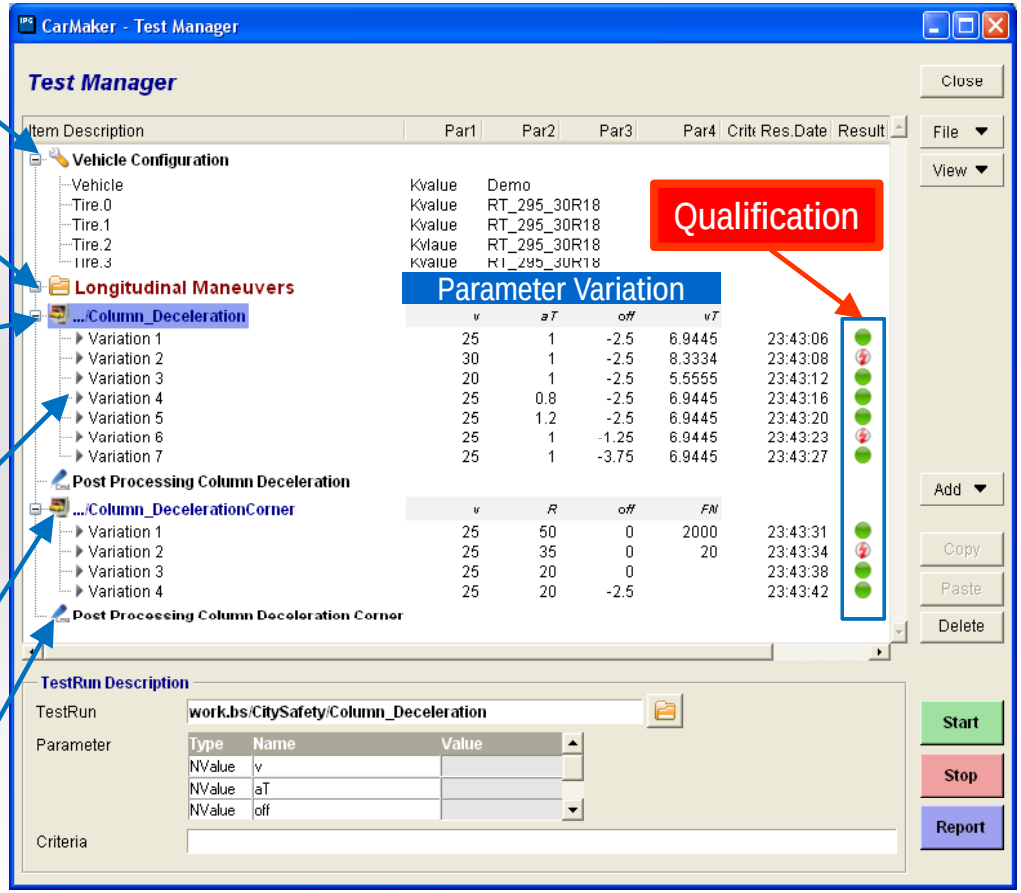
Test Group Definition
- e.g. longitudinal, lateral maneuvers …

Test Case 1
- Test Case selection e.g. TestRun

Parameter Variations
- Variation list of any system parameter
- vehicle, road, controller, test execution etc of all InfoFiles!

Test Case 2
- Test Case selection e.g. TestRun

CONCERTO Application
- Automatic start of post-processing

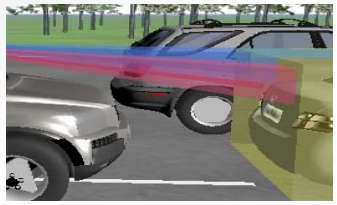


Benefits and Conclusion

- Successful Closed Loop simulation of ADAS function with environment sensor
- Implementation of a TestManager with respects to the demands from ADAS functions

<u>Benefits utilizing simulation for the development of ADAS functions:</u>

- Simulation studies for “Functional Safety Assessment”
- In the Loop Algorithm tests in the development phase
- Parameter studies for integrated functions and related valid ranges
- Virtual testing of functional system behavior
- Test of “Failure Resistance” by failure imprint (maneuver driven)
- Virtual pre-tests for test matrix reduction of road tests



Thank You

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