Verification of Variants in the Development of Vehicle Dynamics Control Systems using CarMaker for Simulink
Development of Porsche Stability Management (PSM)
Contents of Presentation

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Motivation

Relationship between Requirements, Test Cases and Evaluation

Aim: No Requirement without Verification
**Motivation**

### Rising Effort regarding Verification

Legend:
- ○ existing variants
- ○ new variants
- ● verified using driving tests
- ● verified using simulation

Verification by simulation in addition to driving tests

- ⇒ control of rising complexity
- ⇒ cost reduction

Verification of Variants using CarMaker
Verification of Variants in the Past & the Future

Schematic Process

**Past**
- Revision PSM Software
- Definition of variants
- Driving Test Verification
- Result?
  - Positive: PSM Software Verified
  - Negative

**Future**
- PSM Software
- Definition of variants for driving tests
- Additional variants for simulation
- Driving Test Verification
- Revision PSM Software
- Simulation Verification
- Result?
  - Positive: PSM Software Verified
  - Negative
Verification of Variants in the Past & the Future

Implementation

Functional Requirements

1) Driving Behavior ...
2) Brake Travel ...
3) Handling ...
   ...
n) Requirements

Test Cases Driving Test

1.1) handling, v = ...
1.2) lane change ...
1.3) step steer input ...
2.1) dry asphalt, v = ...
2.2) wet asphalt, v = ...
2.3) μ-Split ...
   ...
n.1) ...

Test Cases Simulation

1.a) sinusoidal steering ...
1.b) FMVSS no. 126 ...
1.c) load change ...
2.a) dry asphalt, v = ...
2.b) wet asphalt, v = ...
2.c) μ-Split ...
   ...
n.a) ...

Verification by Driving Test

Filter

Test Cases

Verification by Simulation

Filter

Test Cases

Verification of Variants using CarMaker
Developed Tool Chain in Cooperation with IPG

Overview

Data Bases

Test Setup

Simulation

Evaluation

Report

Verification of Variants using CarMaker

Data flow between the tools is managed by TestManager extensions developed by IPG for Porsche
Developed Tool Chain in Cooperation with IPG
Data Bases in Requirements Management Software DOORS

**e.g. Vehicle Configuration:**
- Definition drivetrain & chassis systems
- Definition of tire models
- Switches chassis systems
- Definition of additional mass
- Optional Matlab expression

**e.g. Maneuver Parameters:**
- Parameter description used in CarMaker TestRun
- Optional Matlab expression
- Parameter values
- Linked criteria to evaluate this maneuver

Export of data base contents in xml-format based on Requirements Interchange Format (RIF)
Developed Tool Chain in Cooperation with IPG
Test Setup and Simulation

- Composition of a user defined test-series using TestManager with Porsche-specific features
- Import of vehicle-, maneuver- and criteria-parameters from data bases
- Further restriction of selection possible

Automated simulation of test-series in CarMaker; selection between the following modes:
- Simulation and evaluation
- Simulation only
- Evaluation only (previous simulation results necessary)
Developed Tool Chain in Cooperation with IPG

Evaluation and Test Report

• Evaluation in Matlab using parameters from data base import
• Graphical display of evaluation results for every criterion

- Automatic generation of test report in HTML-format
- Clear visualization of evaluation results:
  - Green: criterion passed
  - Yellow: evaluation error (e.g. end condition not found)
  - Red: criterion not passed

All simulation- and evaluation results are automatically saved.
Further Application of Tool Chain

Milestones
- Kick-Off
- SW 1
- SW 2
- SW 3
- SW n

SOP

Use of Simulation Tool Chain
- Overall Verification
- Legislative Requirements
- Quick-Check SW Release
- Development Support

Development Time

Verification of Variants using CarMaker
Summary

- Porsche developed a simulation tool chain for the verification of vehicle variants in cooperation with IPG
- The developed tool chain is applied in addition to driving tests in order to handle the increasing diversity of vehicle variants and PSM functions
- The introduced simulation procedure depicts an efficient tool for a functional verification of a large number of PSM variants
- The tool chain can be used for further applications in the PSM development process such as quick-checks of new software releases, conduction of a functional parameter study, etc.
- The use of the developed tool chain can be transferred to other vehicle dynamics control systems