Automated Testing in Automotive Software Development using Vehicle System Simulation

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Motivation: Frontloading in ECU Development

![Diagram showing V-model with MiL, SiL, HiL, and In-Vehicle Test stages, and defect occurrence and repair cost over time.](image-url)
Motivation: Extend Testing Capabilities in the Lab

Example ADAS application: LDW/LKA/autonomous steering

- Stimulating a camera-based ADAS can be a lot of work!
- Examination of steering controller (LKA, autonomous steering) requires closed-loop testing
Motivation: Extend Testing Capabilities in the Lab

Example application vehicle dynamics: 4WD control
Vehicle Simulation offers:
- Consistent stimulus for ECU
- Closed loop operation:
  - Test controller influence and behaviour
  - Assessment of control quality
  - Pre-Calibration
  - Prepare on-road tests
  - Examine controller changes during on-road-tests
HiL Closed Loop Test Environment for 4WD ECU

Test Automation

- Windows PC
- XCP calibration & measurement
- RBS & maneuver manipulation
- maneuver & vehicle states
- maneuver selection
- DYNA4 Task
- Maneuver & road parameter datasets
- CANoe
- Restbus (CAPL)
- DYNA4 Vehicle simulation model

CANape

- Vector VN 7600
- CAN/FR
- Feedback values
- Wheel speeds, ...
- Integrated SW on ECU
Test Automation

Automation project execution

Load vehicle data & maneuver | Run test | Report generation | Sync test spec and results with requirements
DYNA4 Vehicle Dynamics Simulation

- Driver
- Steering
- Suspension
- Tire

μ low
μ high

CANoe
DYNA4 Vehicle Simulation Model
Code Generation & Build
def node layer dll
DYNA4 Vehicle and Maneuver Data Management

Vehicle Model & Parameters

Tasks

Dataset Export

Slalom
Double Lane Change
Circle
Race Track
HiL Closed Loop Test Environment for 4WD ECU

Windows PC

Test Automation

XCP calibration & measurement

RBS & maneuver manipulation

maneuver & vehicle states

maneuver selection

DYNA4 Framework

Export

DYNA4 Task

Maneuver & road parameter datasets

DYNA4 Vehicle simulation model

Restbus (CAPL)

CANoe

CANape

Integrated SW on ECU

Vector VN 7600

DYNA4 Task

Maneuver & road parameter datasets

Feedback values

Wheel speeds, …

CAN/FR

Pushing Innovation
SiL Closed Loop Test Environment for Virtual ECU

Windows PC

Test Automation

DYNA4 Framework
Test definition, execution & evaluation

Parameterization
Internal Signals
Output Signals

Road Data
Vehicle Data
Virtual Test Driver

DYNA4 Vehicle
Simulation Model

Rest-bus

Feedback to Model

Virtual ECU

SWC 1
Model

SWC 2
(VDC)
S-Function: Generated C-Code

SWC 3
Model

SWC 4 (BSW)
Simplified Model

Test Automation
MiL Closed Loop Test Environment for ECU Model

Windows PC

Test Automation

DYNA4 Framework
Test definition, execution & evaluation

Parameterization
Internal Signals
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Road Data
Vehicle Data
Virtual Test Driver

DYNA4 Vehicle Simulation Model

Rest-bus

Feedback to Model

ECU Model

Pushing Innovation
DYNA4 Task Flow Diagram

- **Test Tasks:** Run Maneuvers
- **Postprocessing Tasks:**
  - Generate reports
  - Summarize results of multiple tests
Software Development Process with Vehicle Simulation

DYNA4 Task
Maneuver & road parameter datasets

SW development → SiL Test → HiL Test → Vehicle verification

Bug report

SW code generation → SW integration
Conclusions

- **Advantages of vehicle system simulation**
  - Quick validation of SW features with different vehicle variants
  - More Bugs can be found & fixed earlier (Front-Loading)
  - High SW quality & maturity

- **Advantages of the presented test environments (MiL, SiL, HiL)**
  - Reuse of models, maneuvers & tests throughout development process
  - Engineers keep the tools they are used to:
    - Tight integration DYNA4 – CANoe
  - Portability, always available
  - Highly automated and reproducible test execution