Automated test of the AMG Speedshift DCT control software

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Outline

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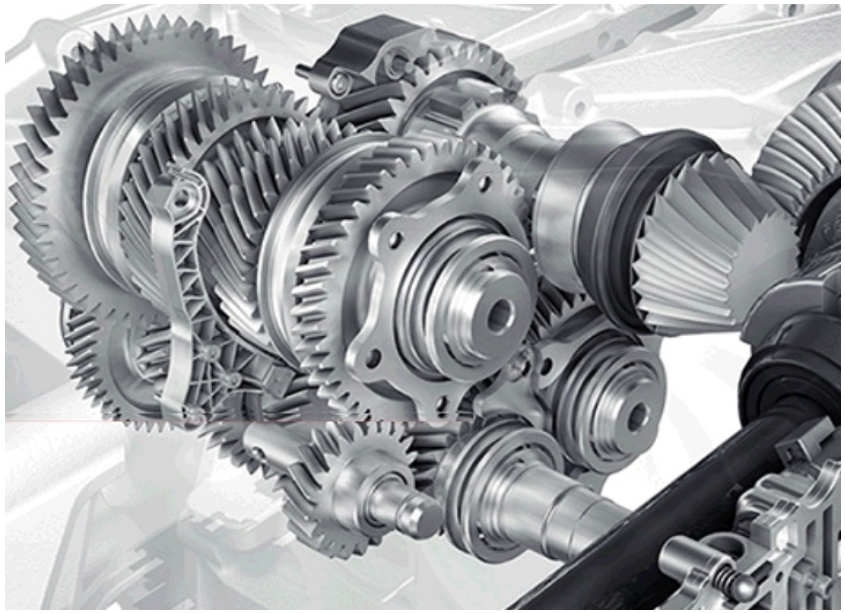
- Motivation
- Principle of the scenario generator
- Test of AMG Speedshift DCT control software

  - the AMG Speedshift DCT
  - the software test setup
- Results and conclusion



Motivation

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Ever growing complexity
of automotive controllers

How to validate and test?

- do more road tests ?
- write more test scripts ?

This does not scale well
Code size grows faster
New processes needed

- After initial coding you can expect one bug per 20 lines of code
- After thorough unit testing you can expect 1 bug per 1000 lines of code in the final release
  - 1 line ~5 bytes, so 1 bug per ~5KB

Application	Code Size	Statistics
Steering Angle Sensor	32KB	7 Bugs
Low-end Sensor Cluster	128KB	26 Bugs
Airbag Controller	256KB	52 Bugs
EPS Controller	512KB	104 Bugs
Central Chassis Controller	1.5MB	308 Bugs

source: presentation by Hans Adlkofer, Infineon, 2009

Idea

- increase degree of automation
- generate and evaluate useful test scenarios automatically

TestWeaver – scenario generator

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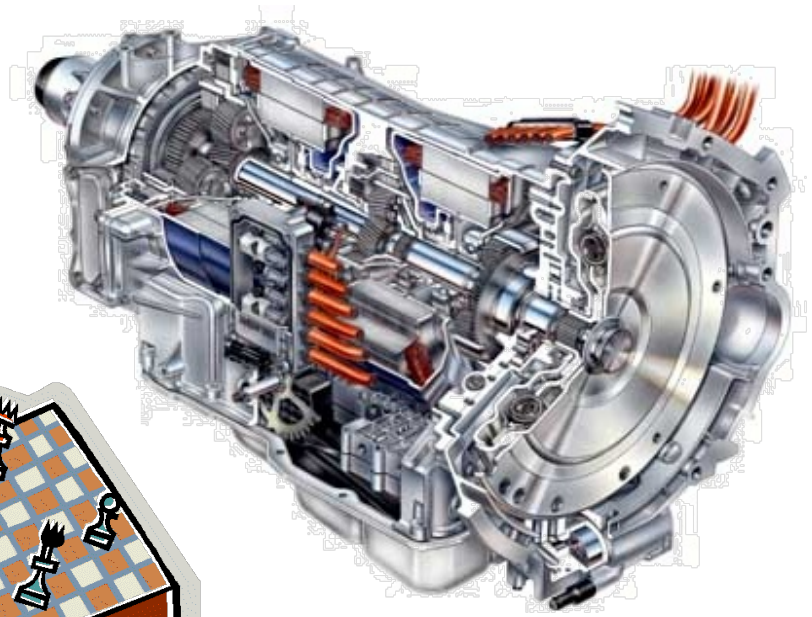
Idea

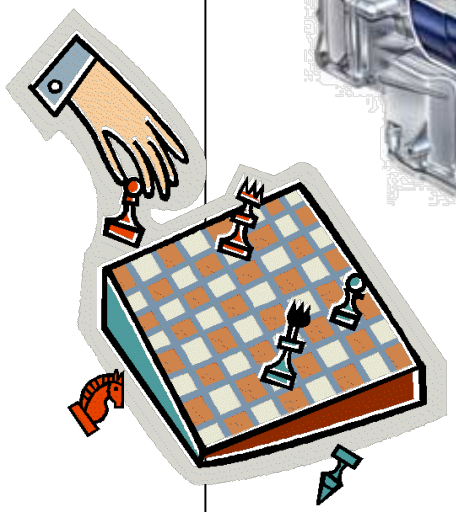
- intelligent generation of 1000s of differing test scenarios
- active attempt to:
  - maximize state coverage
  - drive the system in “difficult” situations

Benefit

- high coverage
- low efforts for test specification

Testing =
playing against (simulated) system





Strategy for Test Generation

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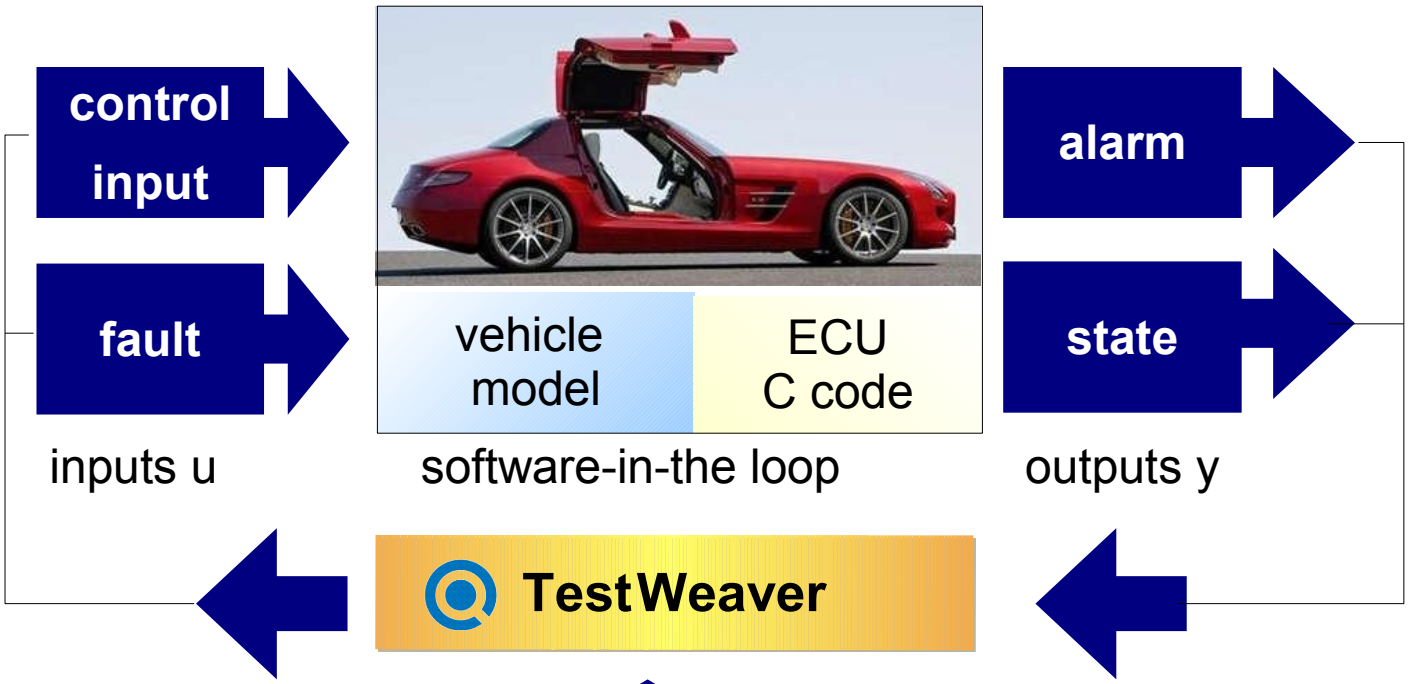
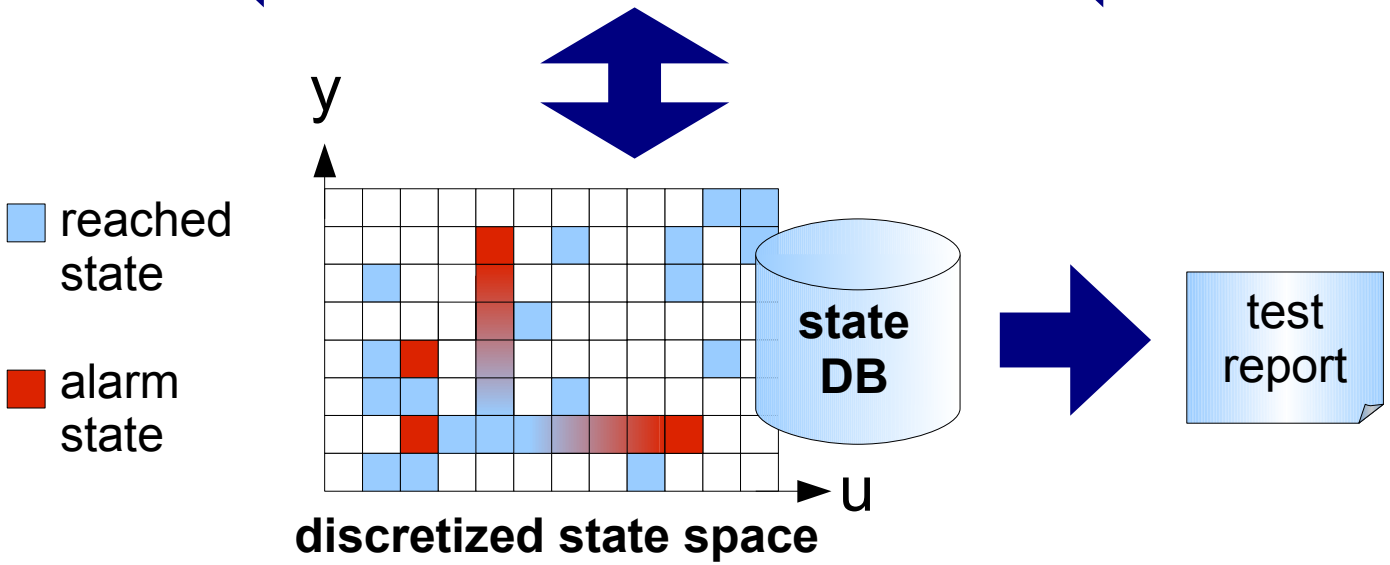


GOALS

find bugs:
Change sub-optimal scenarios to generate worst-cases

coverage:
Drive the system in states that have not been reached before



TestWeaver - Test Generation Strategy

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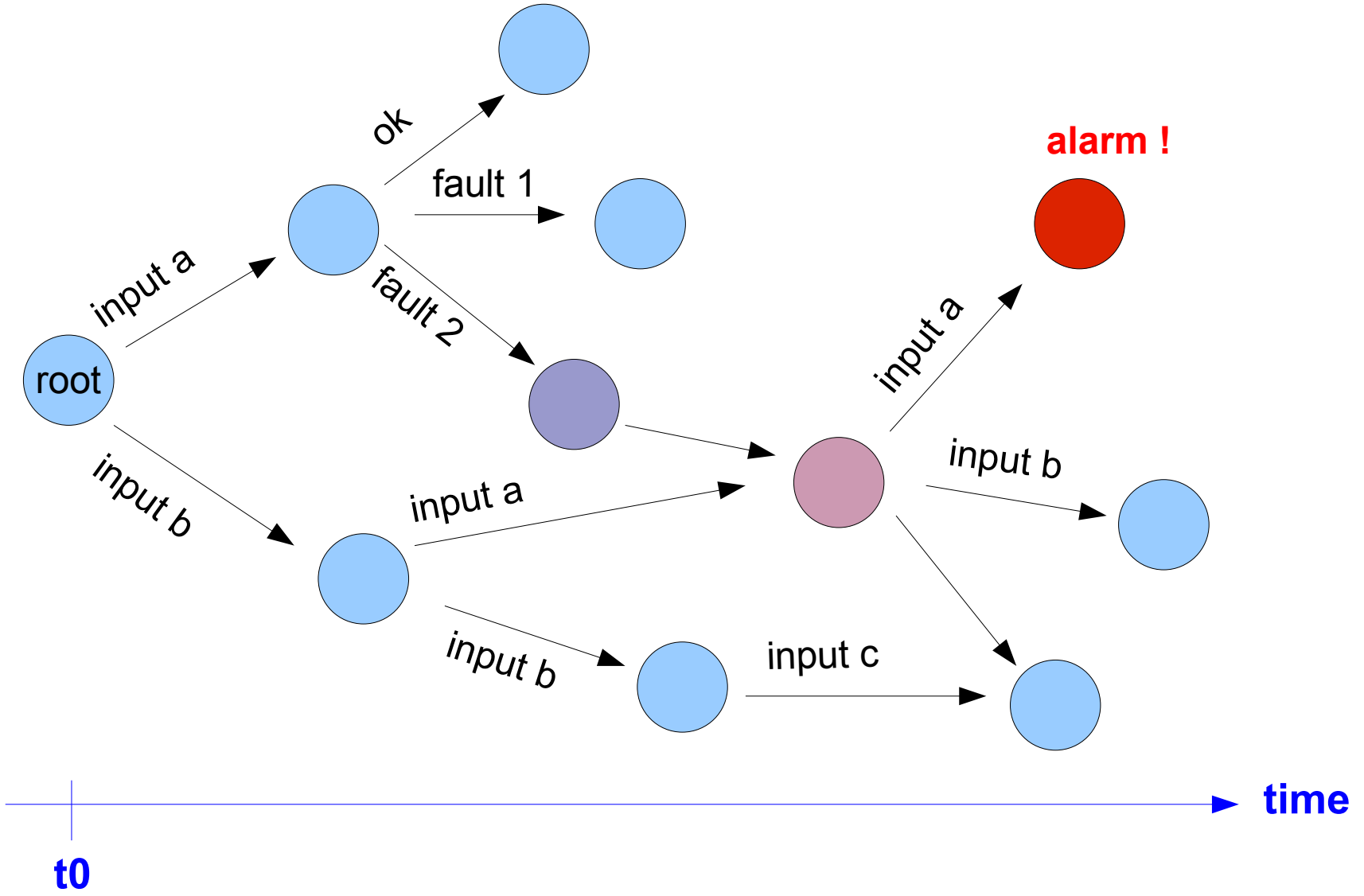

Virtual Integration – Software in the Loop

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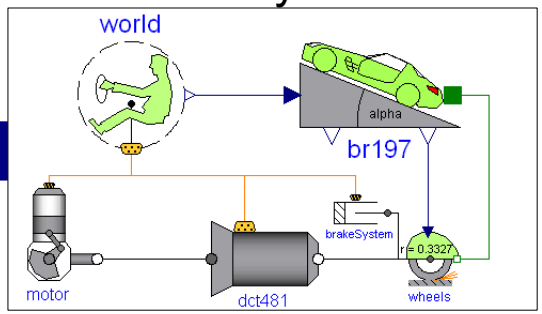
Simulink / TargetLink

module .mdl

object .obj

.obj

Modelica / Dymola



developer

DCT control SW

A2L
PAR
DCM

vehicle model

Silver

Interactive drive of the virtual vehicle

SiL and debugging environment

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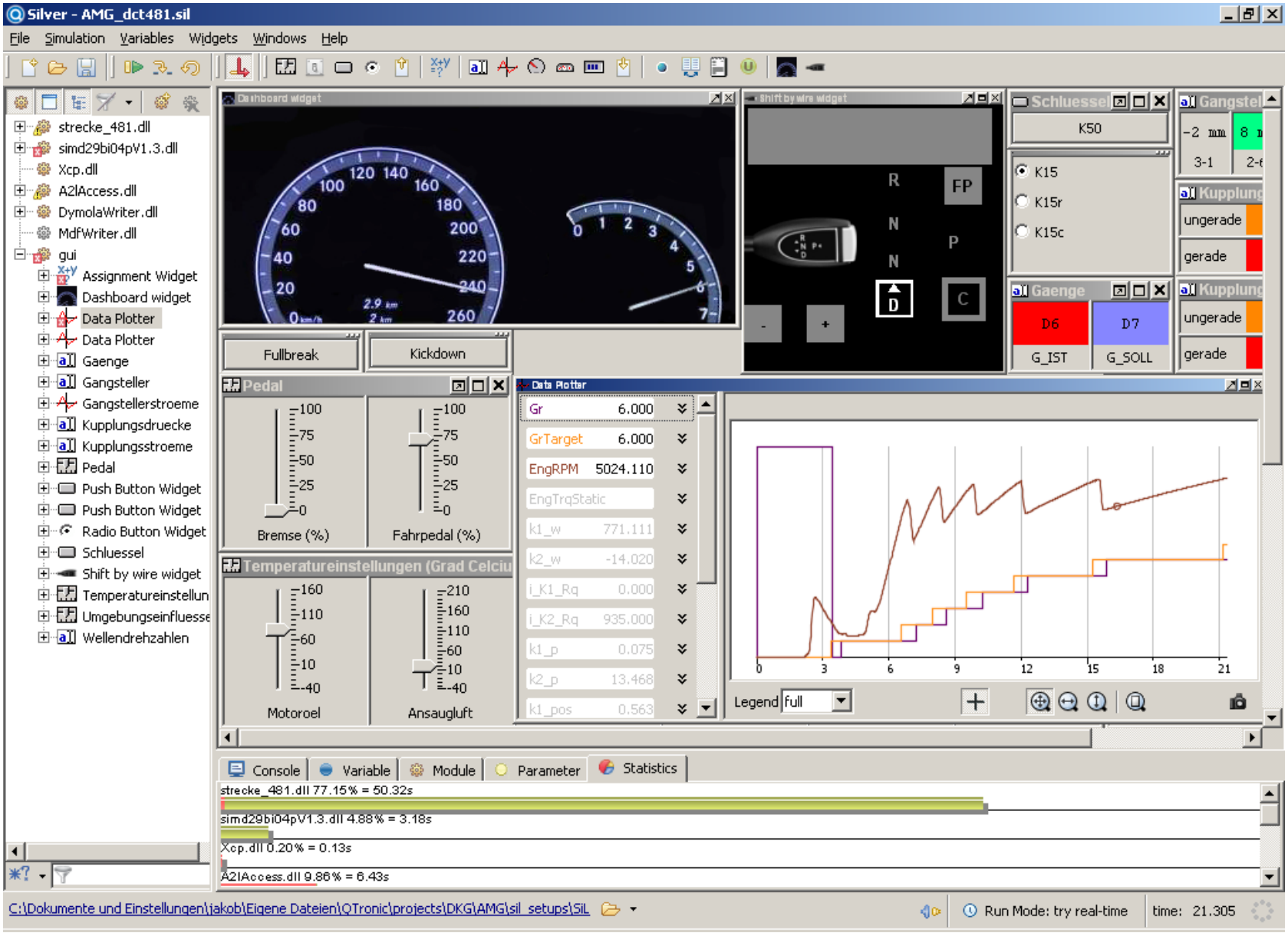

DCT with mechanical locking differential

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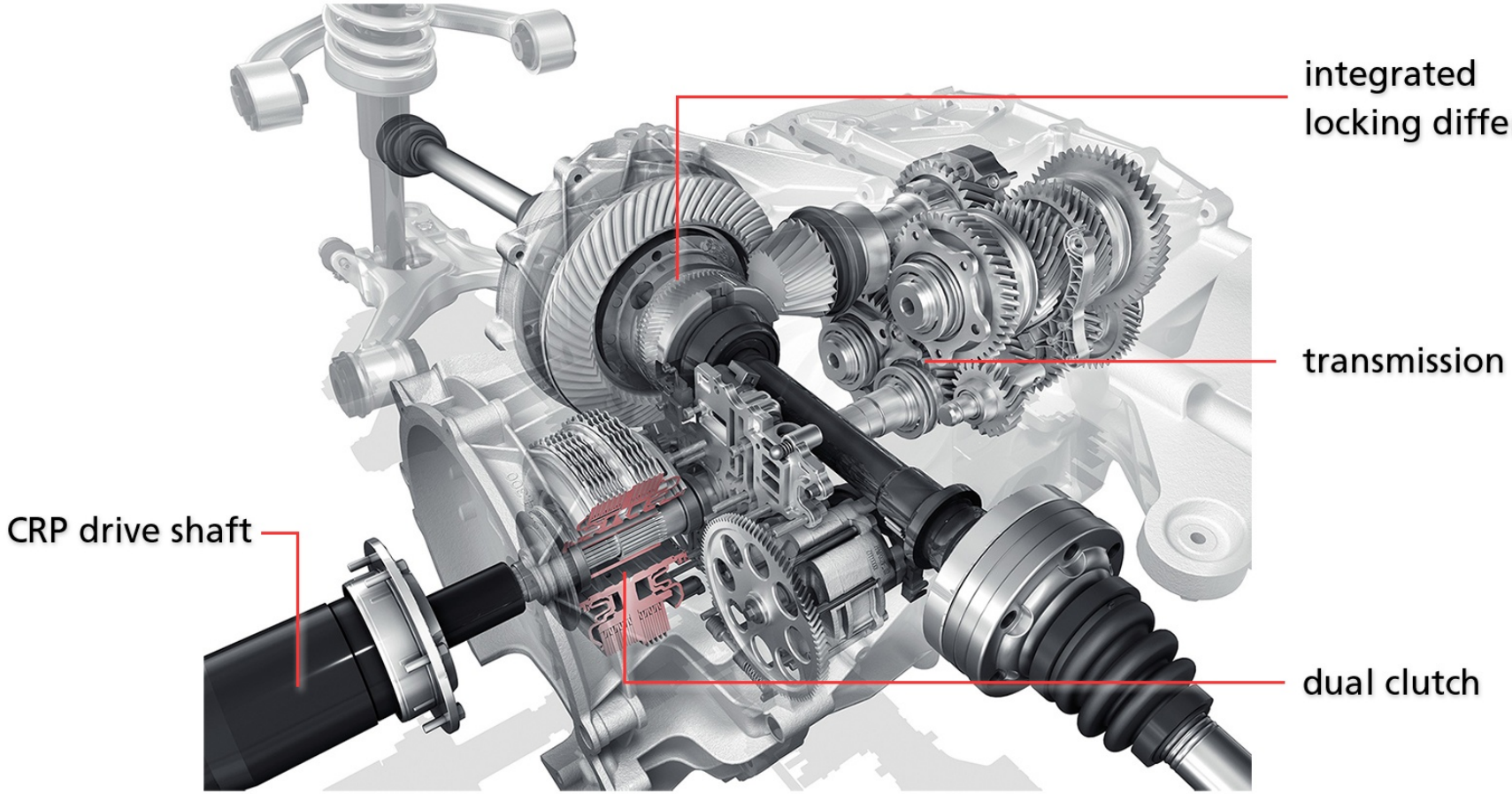
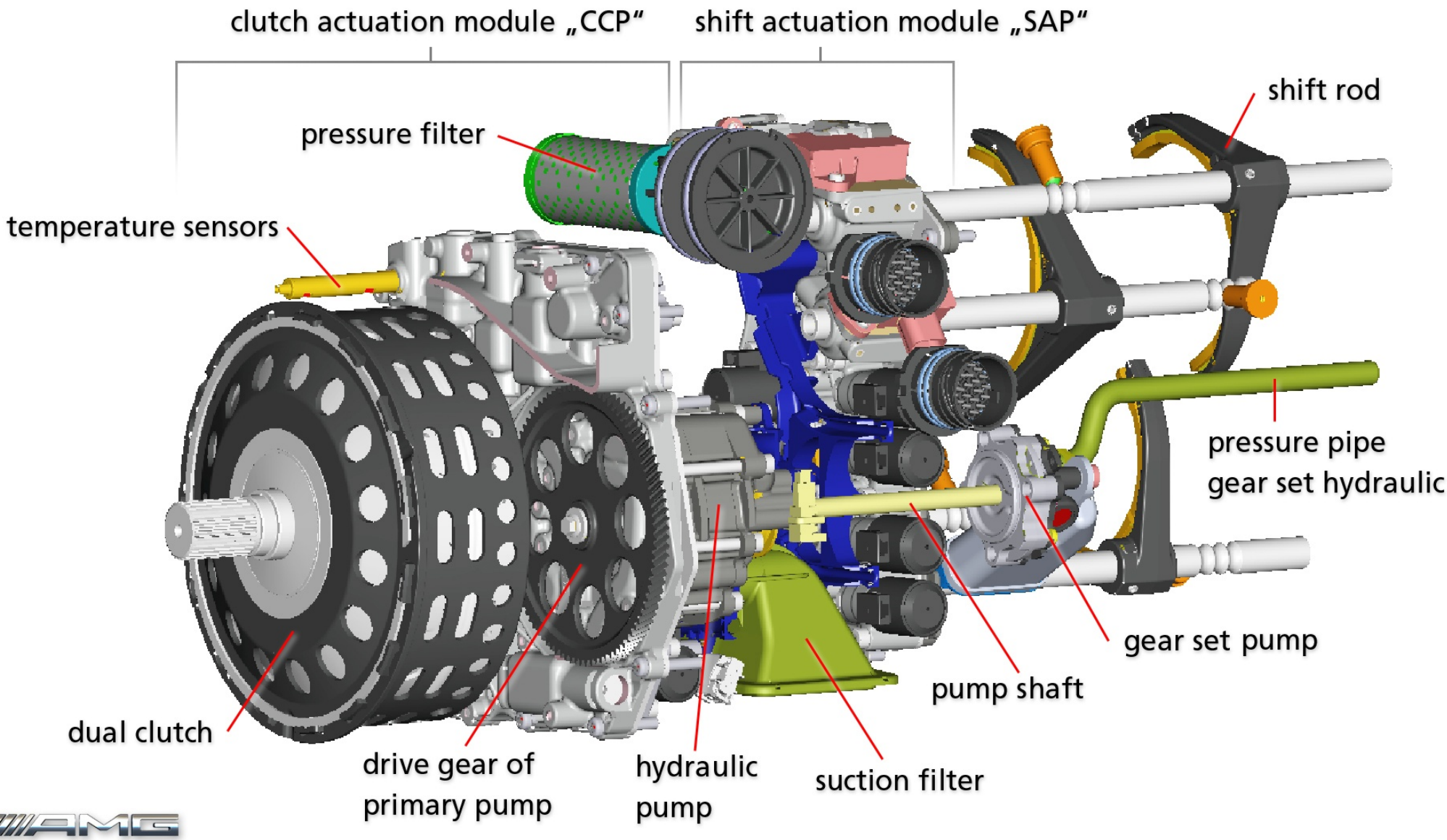


AMG

Hydraulic unit of the DCT



Source: Hart et.al., The function development and application of the DCT in the Mercedes-Benz SLS AMG. VDI-Berichte 2081: Getriebe in Fahrzeugen 2010, pp. 599-615

Drivetrain of the Mercedes-Benz SLS AMG

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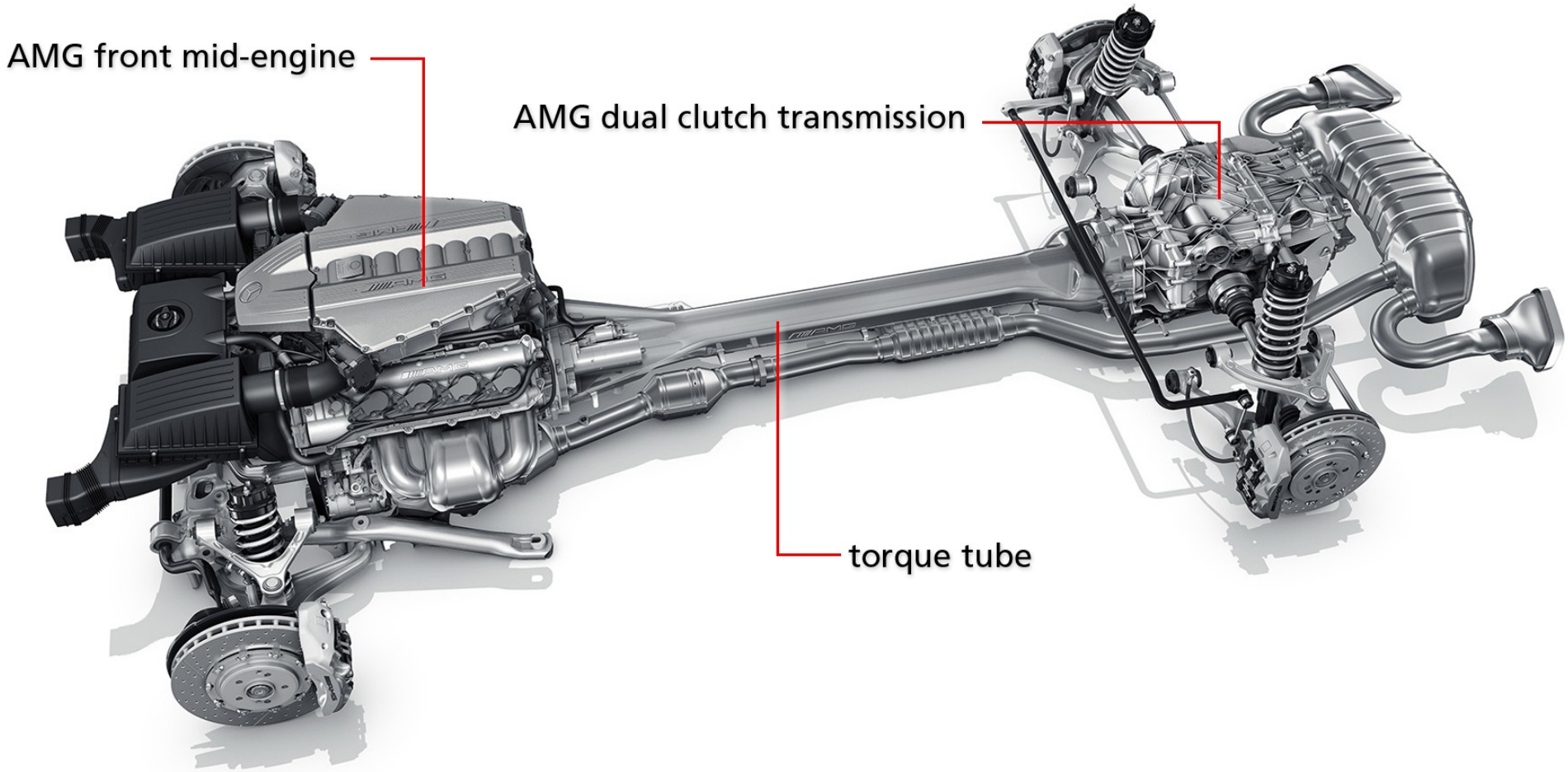

AMG

Drivetrain physical simulation model

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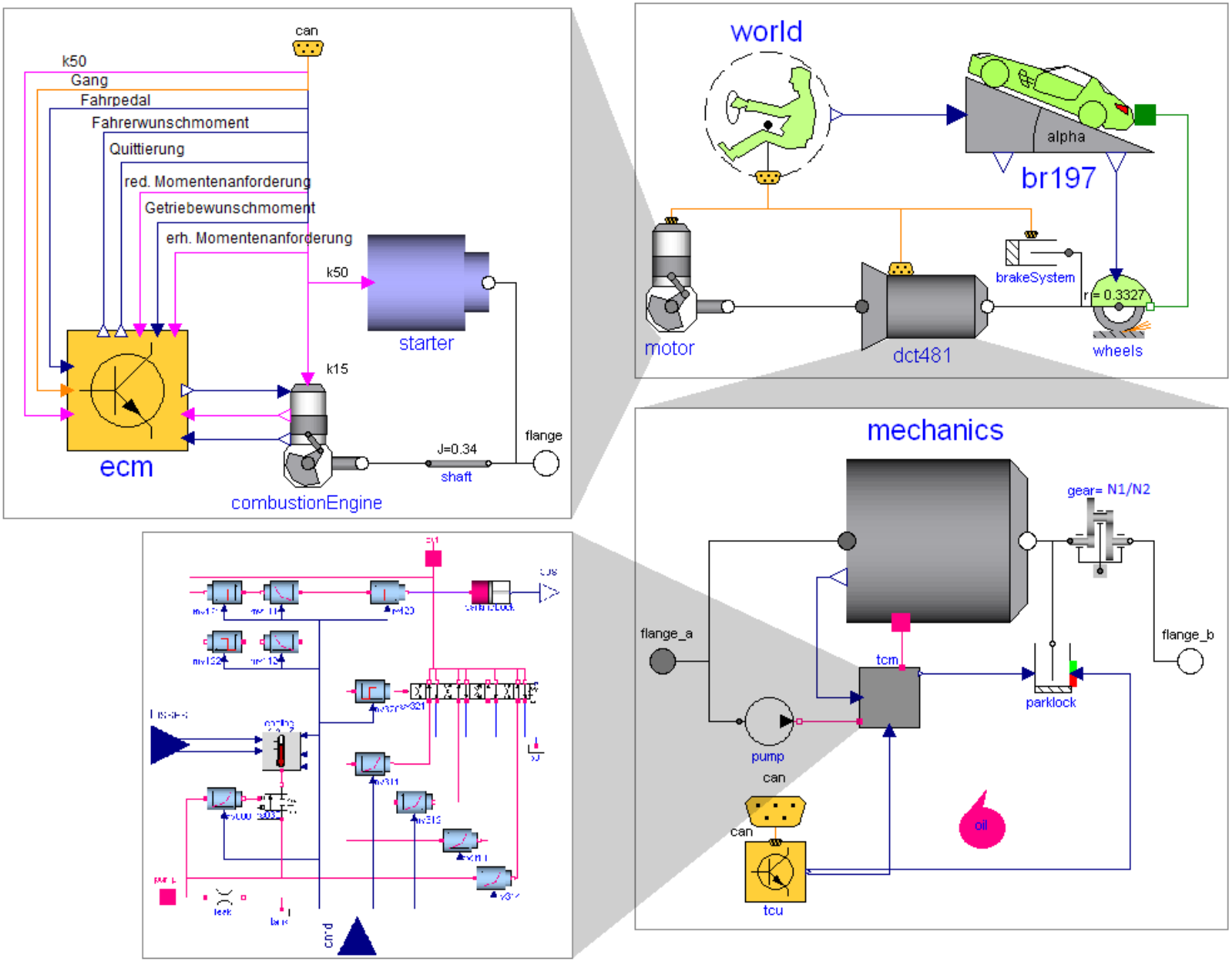

Drivetrain simulation model – gear actuators

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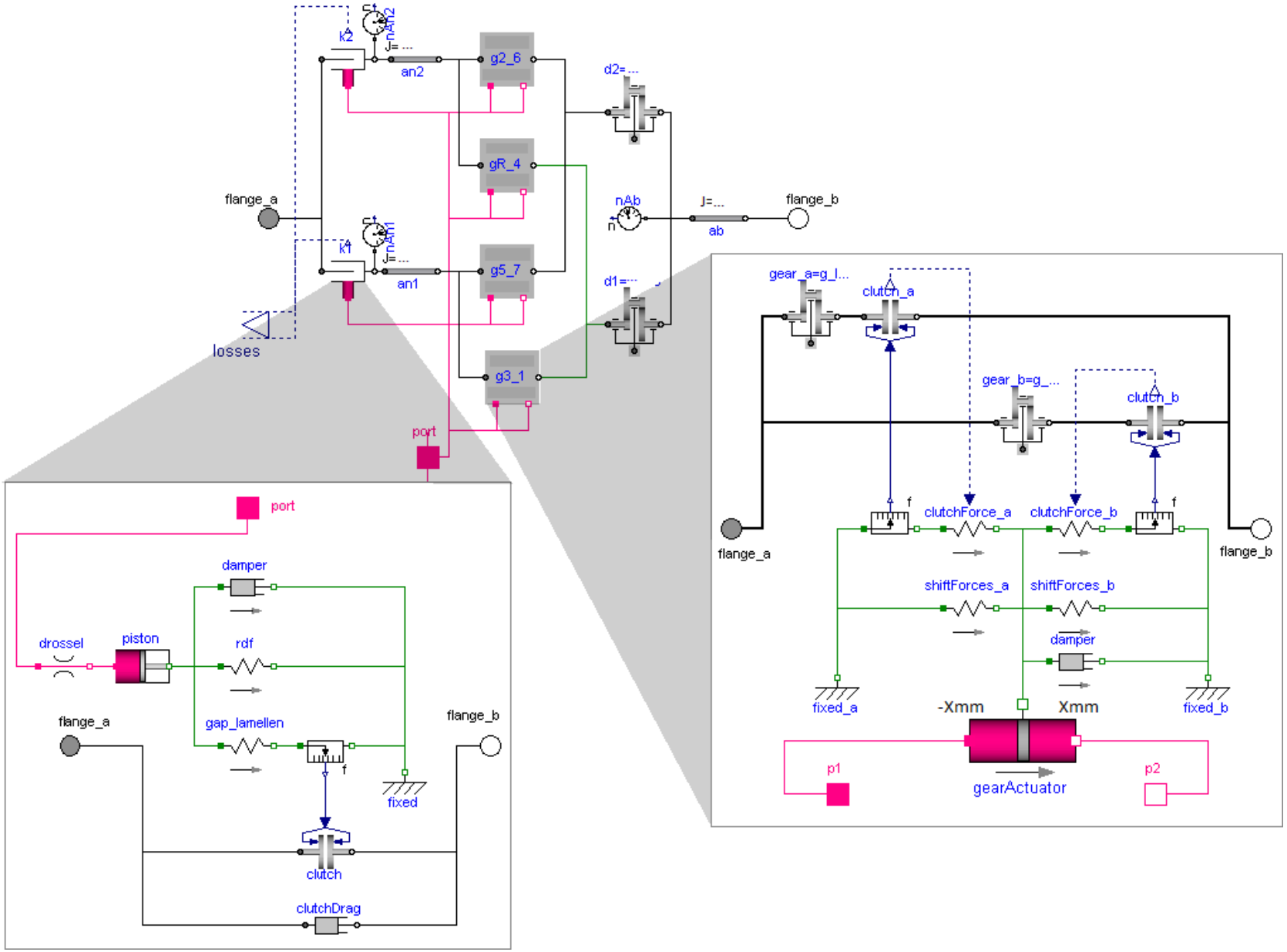

SiL and debugging environment

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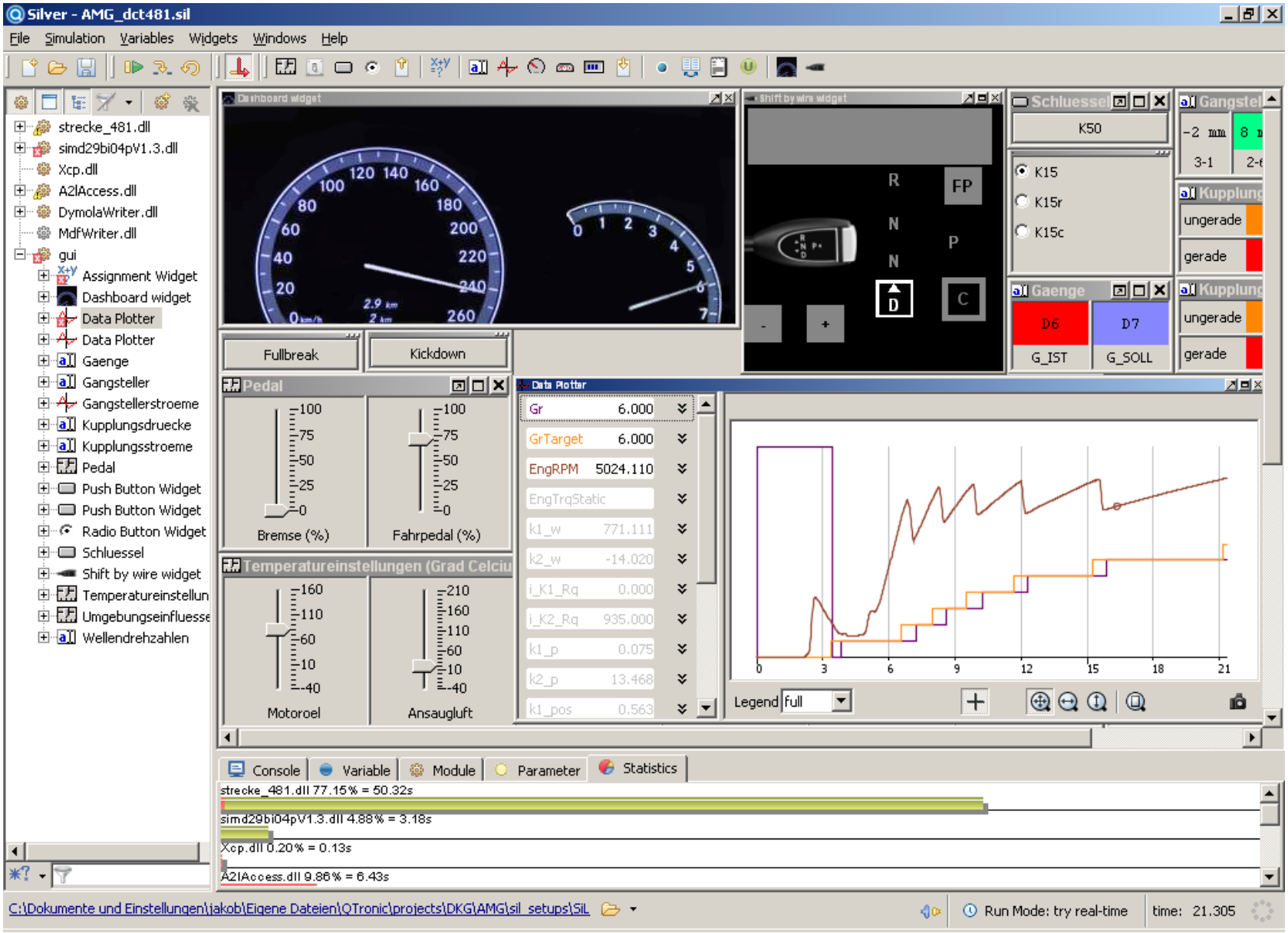

Setup of the software test

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developer

Simulink / TargetLink

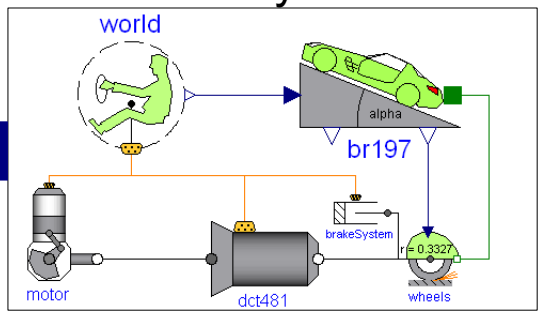
module .mdl

object .obj

test report

.obj

Modelica / Dymola



24 hours

TestWeaver

drive the virtual vehicle
generate worst-case scenarios

DCT control SW

A2L PAR DCM

vehicle model

Silver

TestWeaver instruments

TestWeaver Alarms: correctness / quality

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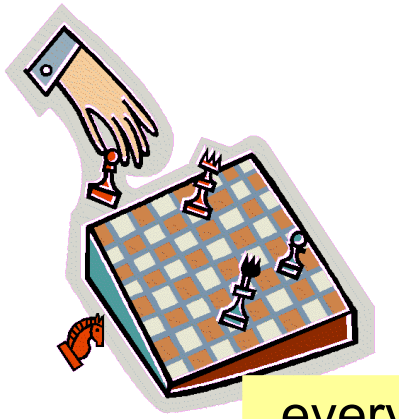
- **Runtime exceptions**:
  division by zero, stack overflow...
- **A2L range monitoring**:
  thousands of TCU signals...
- **Shift durations**:
  average and maximal durations
- **Clutch overheating, overspeeds:**
  engine overspeed or stalled...
- **DCT condition monitoring**:
  > 200 signals, fault codes
- **Oscillations and unexpected control sequences:**
  repeated up/down shifts, bad fault diagnosis, bad fault reaction

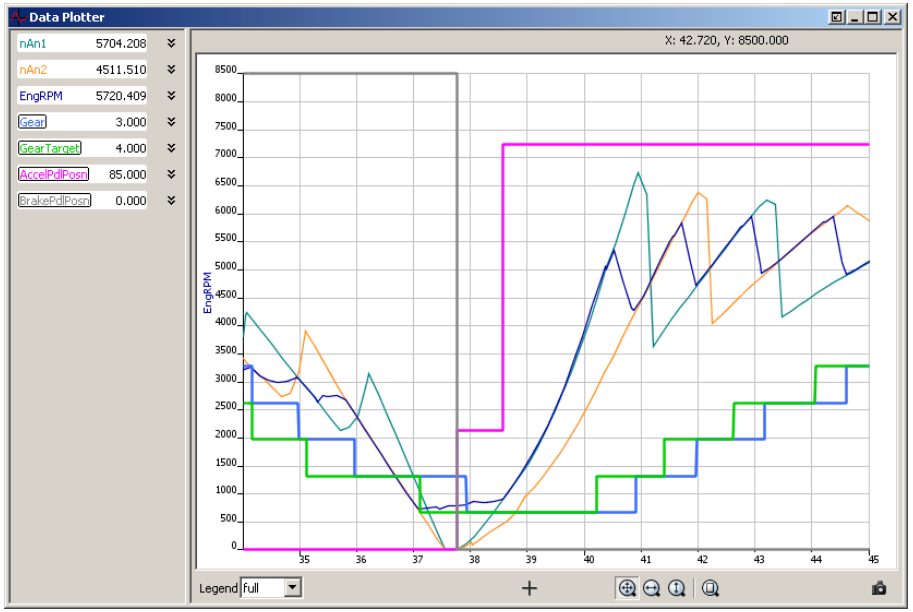


every problem reported by TestWeaver comes with one or more reproducible examples!

- **Code coverage** and system state coverage

Example: Problem found and corrected

oscillation of target gear
- found by TestWeaver
- replay in Silver



improved control software
- run regression test
- problem solved

Test Results and Conclusion

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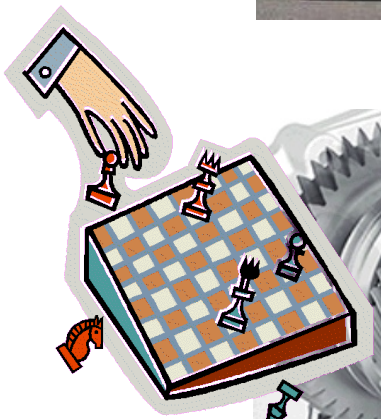
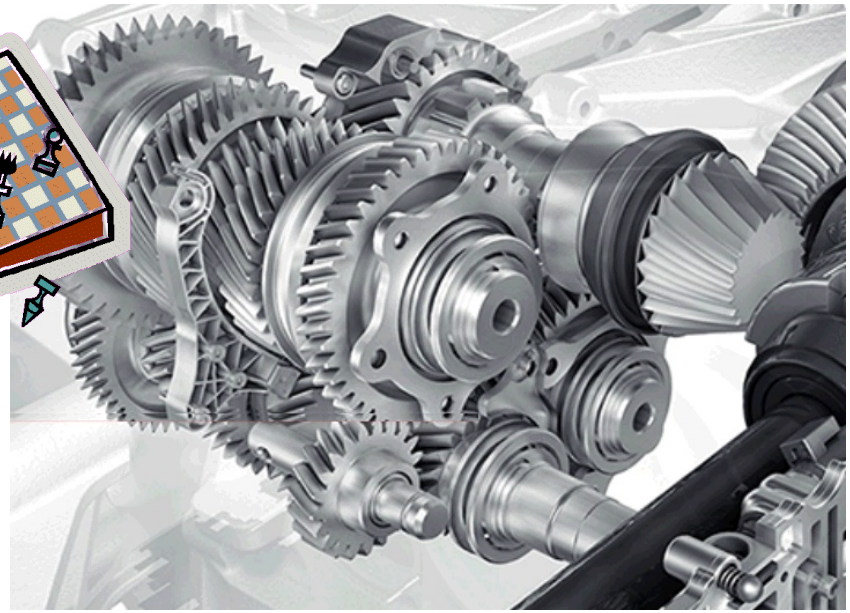
Test of DCT control software

- generated and analysed over 3000 different driving scenarios, each 45 sec. for every software release
- systematic test and validation with many usual and many unusual driving conditions





Conclusion

- The presented approach seems extremely well suited for the validation of automotive transmission controllers
- Necessary complement to other QA measures, test benches, prototype driving
- Main benefit:
  - much higher test coverage
  - feasible work effort