



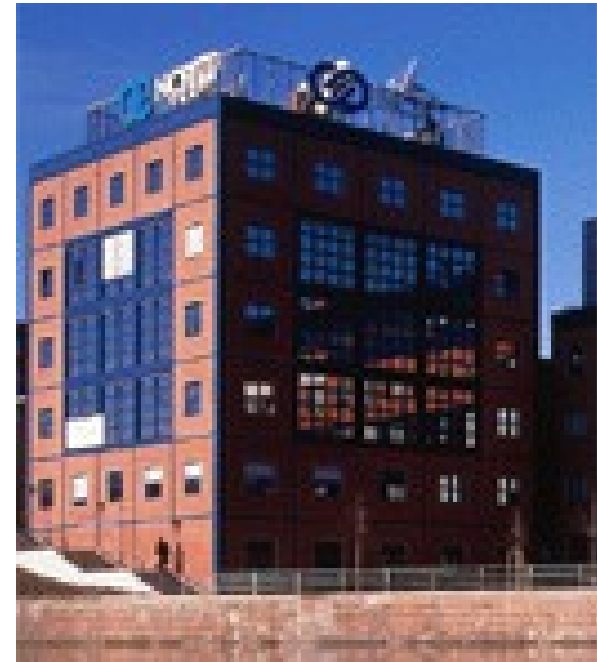
Silver + TestWeaver

Tools for Simulation-Based Design System Test and Validation

Mugur Tatar
QTronic GmbH, Berlin
SESP 2008, Noordwijk

QTronic: Tools & Engineering for Simulation-Based Development

- Started 2006
offspring of DaimlerChrysler Research
- Expertize
 - Modeling for simulation
 - Co-simulation
 - Automatic test and validation
- Tools
 - **Silver**: virtual system integration
 - **TestWeaver**: system test and validation



QTronic Headquarters
in Berlin

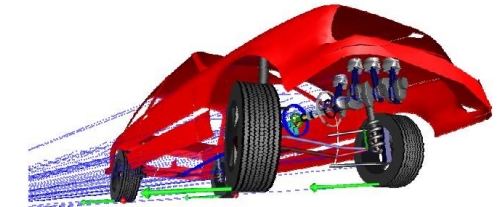
Development with

- C/C++, Simulink, ...



Control SW

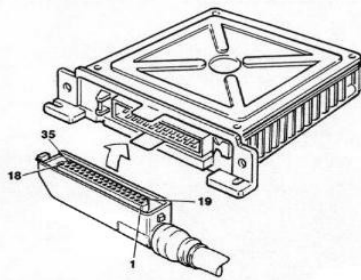
Low-Level



Simulation tools

- Modelica, Simulink, ...

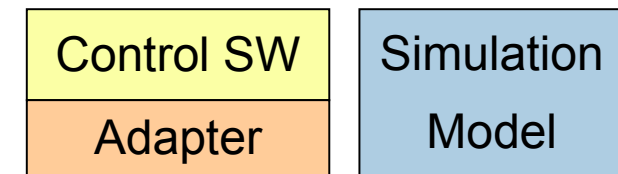
fast
feedback



**Prototype
Test**



HiL Test



SiL Test

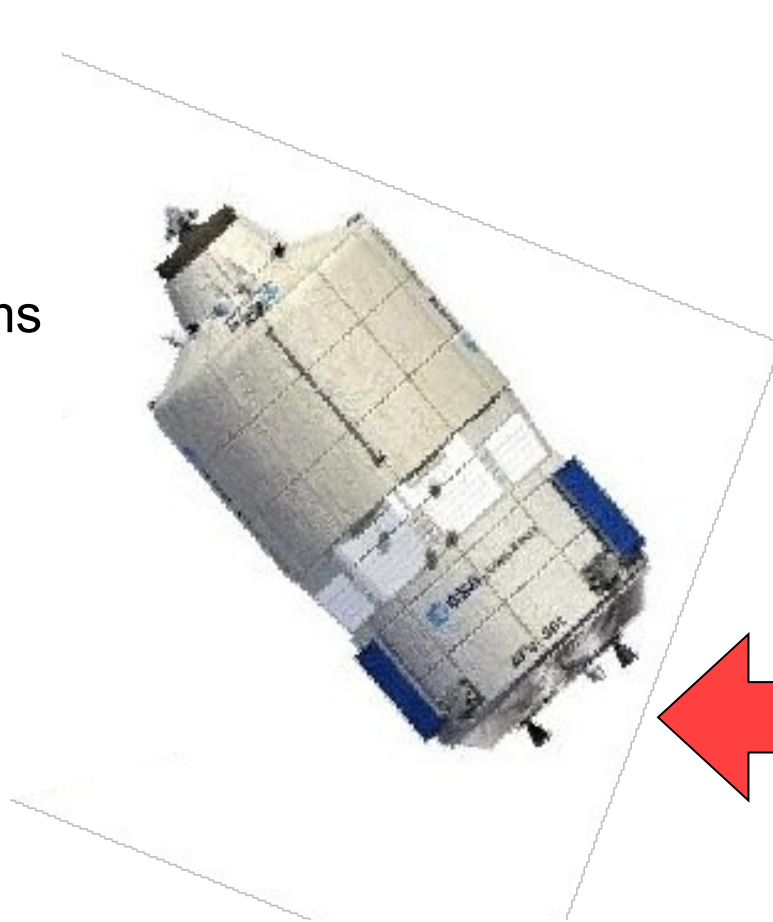


TestWeaver

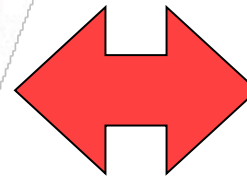
**Virtual
Integration**

Interaction of

- Software
- Physical Systems
- Control and Mission Actions
- Environment



Combinatorial interaction



- HW Faults
- Tolerances
- Aging

Unintended interactions and faults happen...

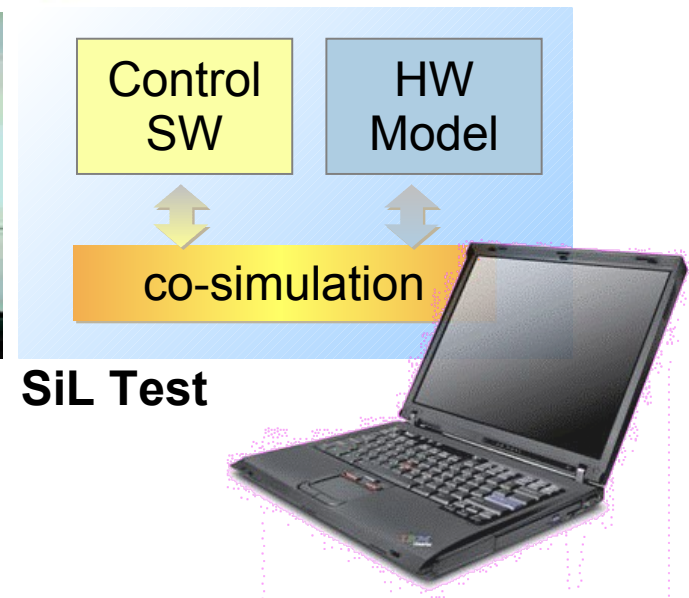
Important:

Find all faults and weaknesses before release

```
Test #31  
start_car();  
shift_lever = D;  
while(gear<2)  
  accelPedal = 20;  
if(time>2)  
  error("no shift")  
...
```



HiL Test



SiL Test

Limitations

- High costs of production and maintenance of test scripts
- Test coverage

Idea

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

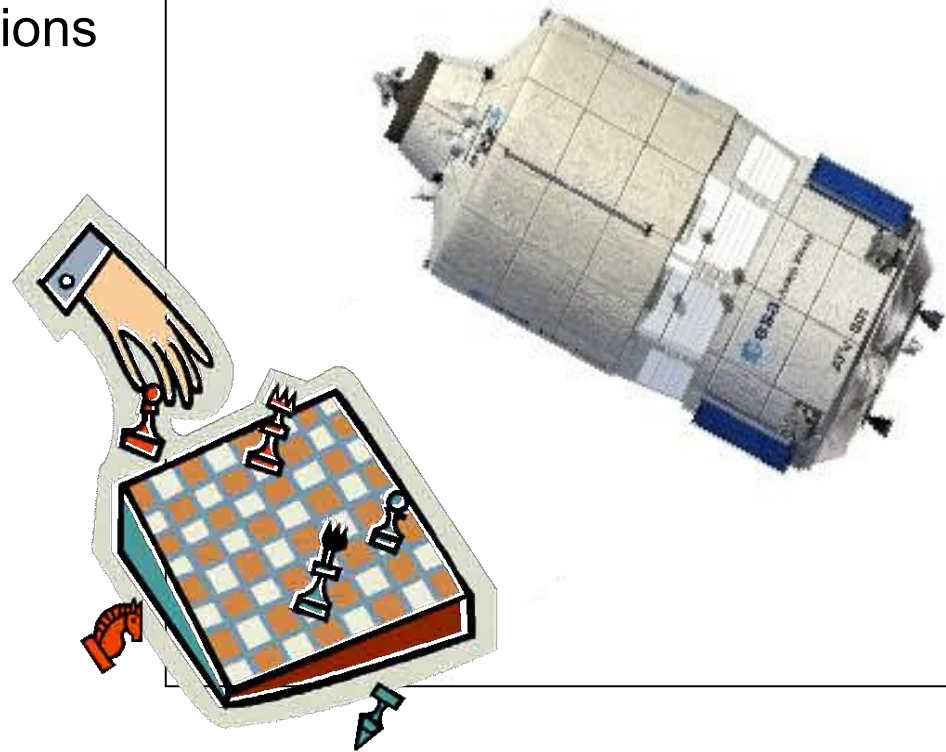
Benefit

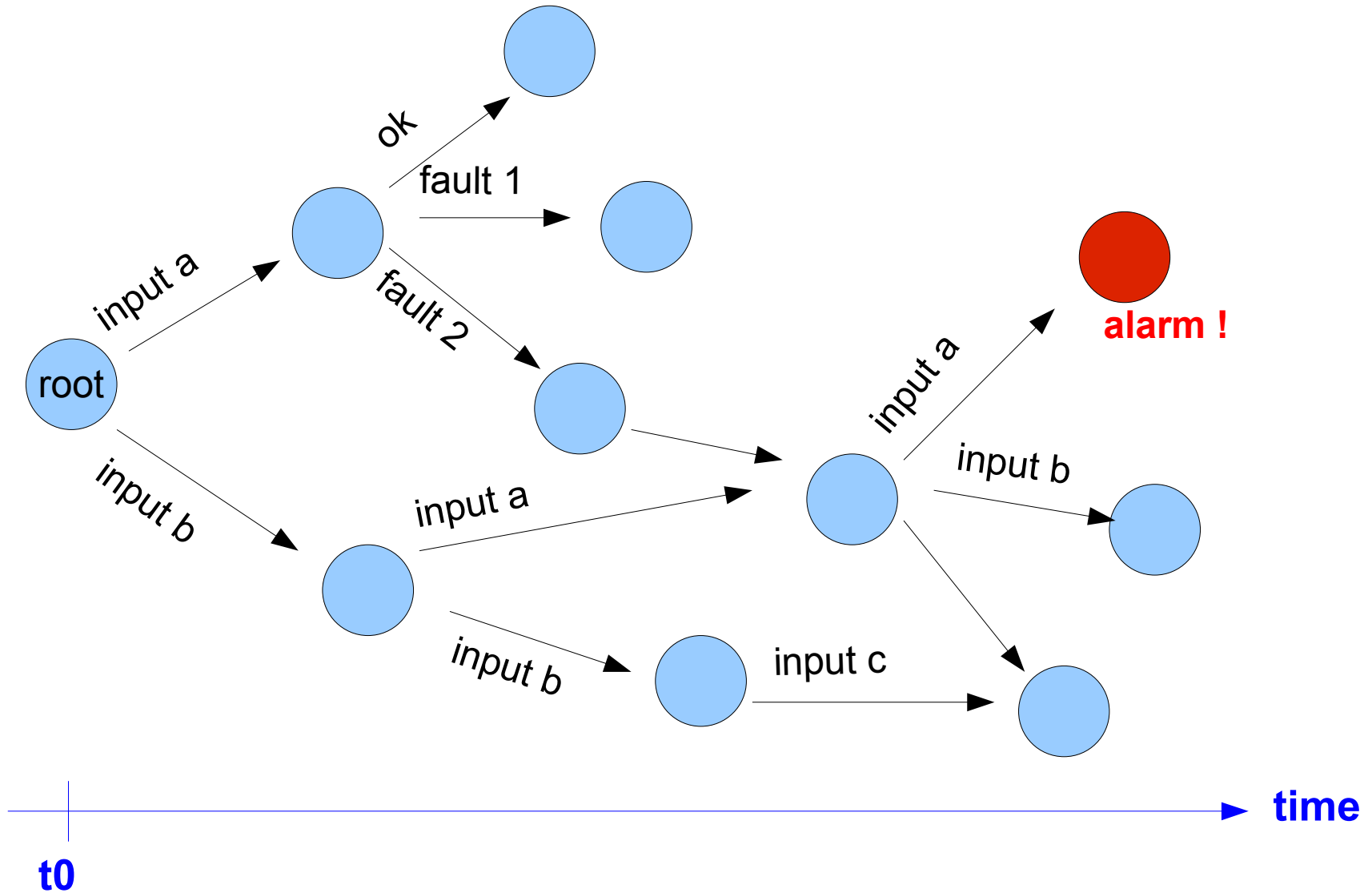
- high coverage
- lower efforts for test specification

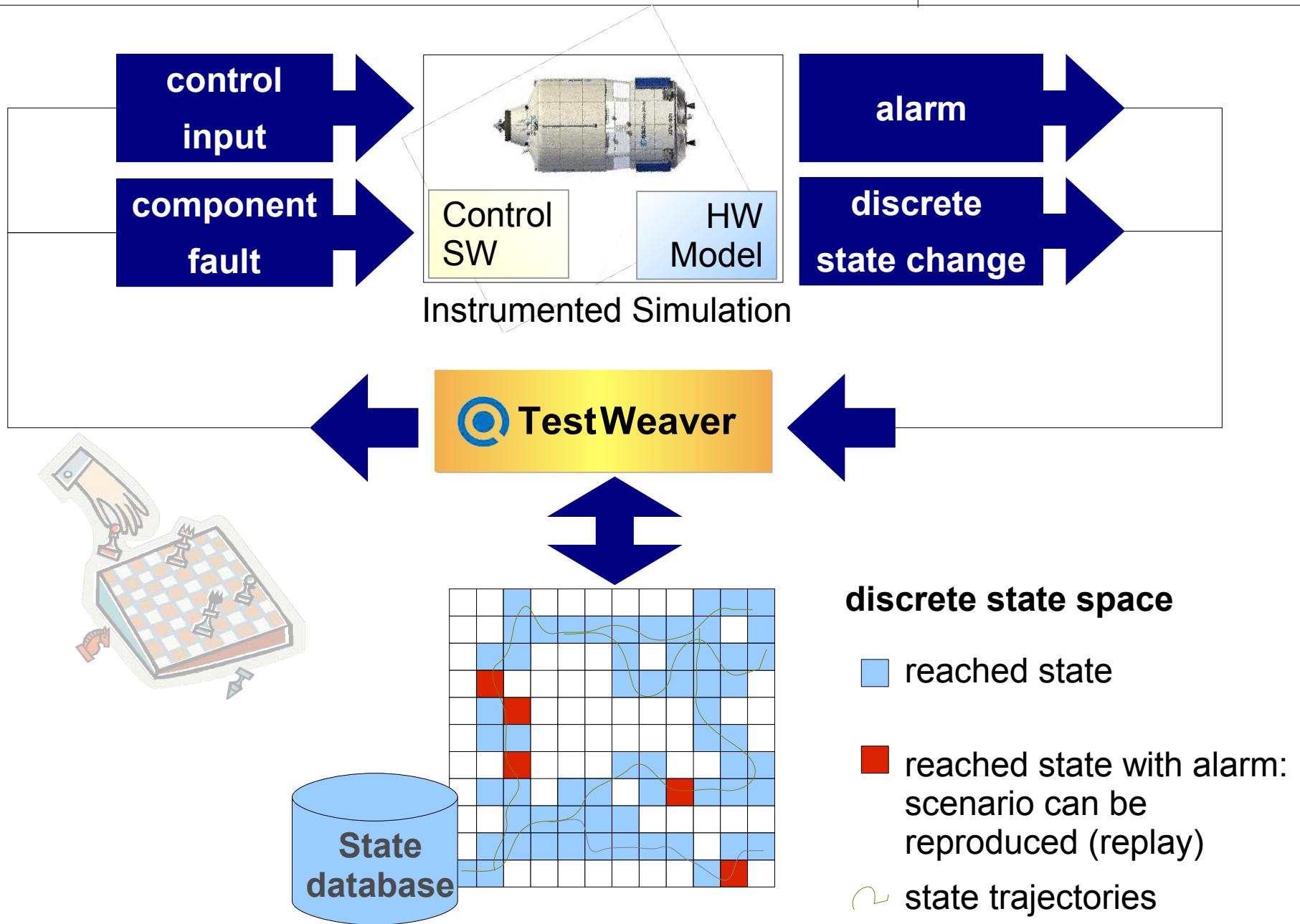
Technology

- analyze results of past simulations to plan the future “game moves”

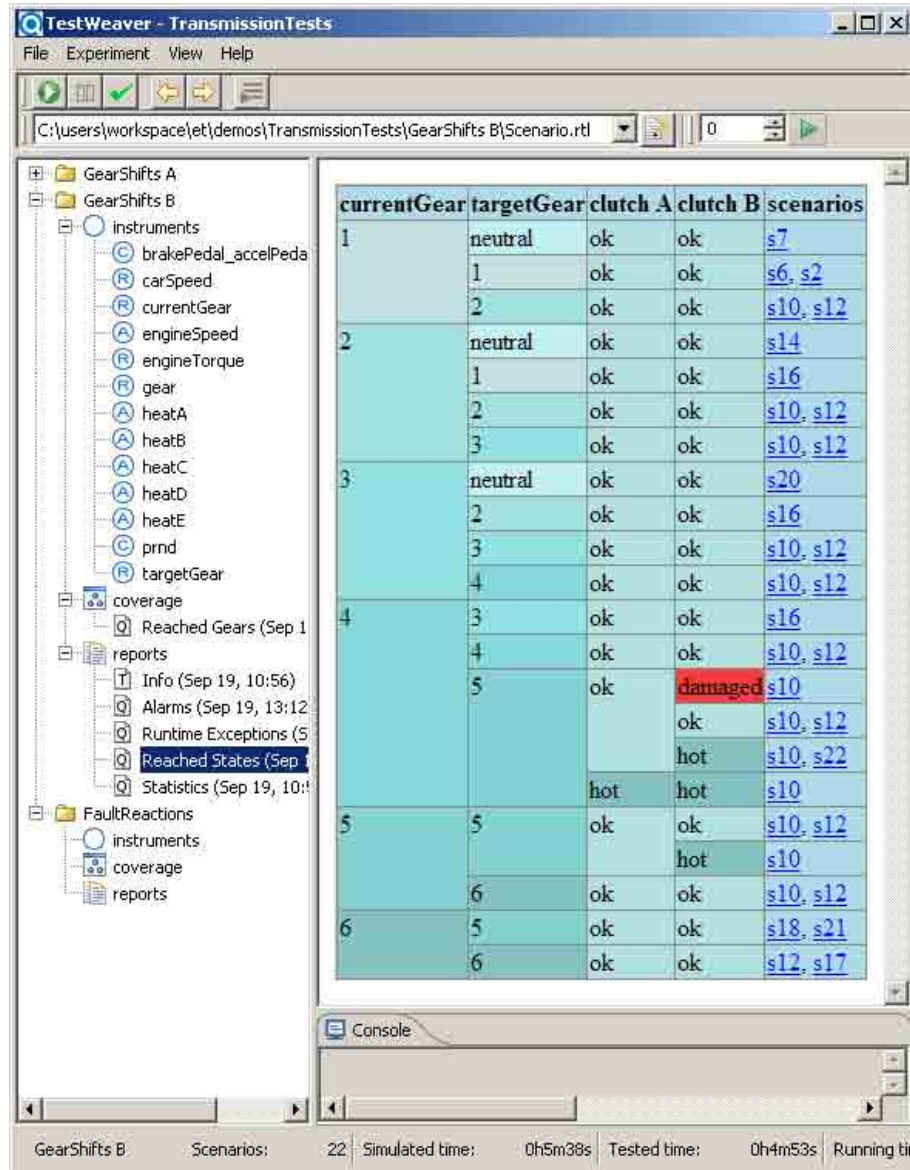
**Testing =
playing against (simulated) system**



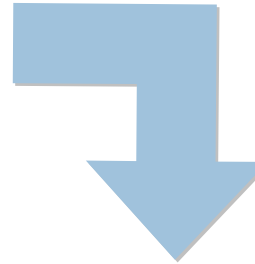




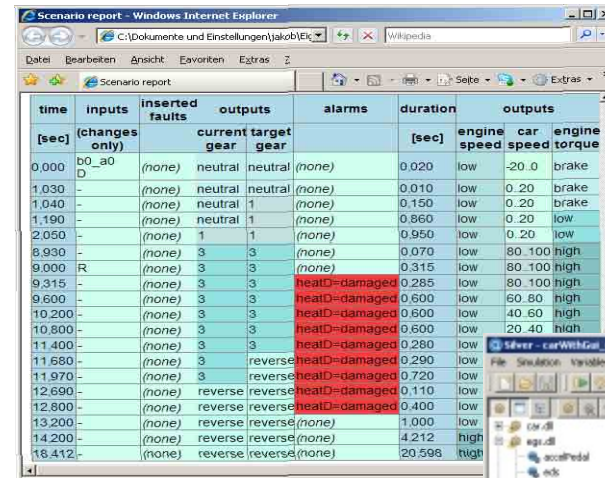
Overview report for all scenarios



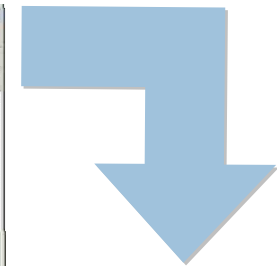
| currentGear | targetGear | clutch A | clutch B | scenarios |
|-------------|------------|----------|----------|-----------|
| 1 | neutral | ok | ok | s7 |
| | 1 | ok | ok | s6, s2 |
| | 2 | ok | ok | s10, s12 |
| 2 | neutral | ok | ok | s14 |
| | 1 | ok | ok | s16 |
| | 2 | ok | ok | s10, s12 |
| 3 | neutral | ok | ok | s20 |
| | 2 | ok | ok | s16 |
| | 3 | ok | ok | s10, s12 |
| 4 | 4 | ok | ok | s10, s12 |
| | 3 | ok | ok | s16 |
| | 4 | ok | ok | s10, s12 |
| 5 | 5 | ok | damaged | s10 |
| | 5 | ok | hot | s10, s22 |
| | 6 | ok | hot | s10 |
| 6 | 5 | ok | ok | s10, s12 |
| | 6 | ok | ok | s10 |
| | 6 | ok | ok | s18, s21 |
| 6 | 5 | ok | ok | s12, s17 |
| | 6 | ok | ok | s10, s12 |
| | 6 | ok | ok | s12, s17 |



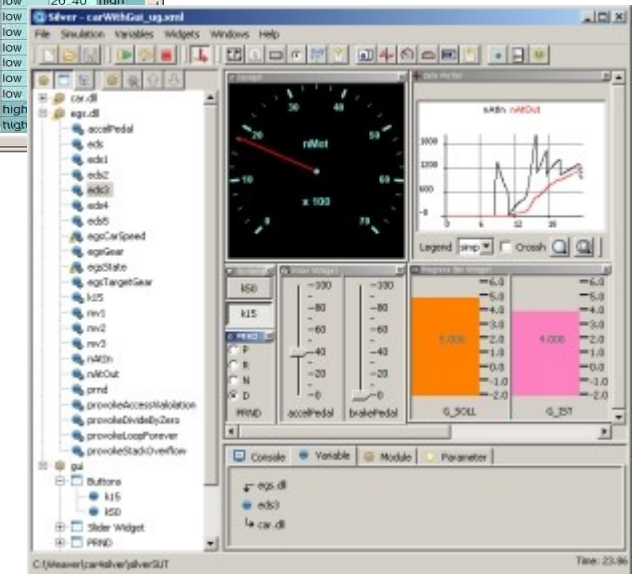
Detailed reports for individual scenarios



| time | inputs | inserted faults | outputs | alarms | duration | outputs | | | |
|--------|----------------|-----------------|--------------|-------------|---------------|--------------|-----------|---------------|-------|
| [sec] | (changes only) | | current gear | target gear | [sec] | engine speed | car speed | engine torque | |
| 0.000 | bo_a0 | (none) | neutral | neutral | (none) | 0.020 | low | -20.0 | brake |
| 1.030 | - | (none) | neutral | neutral | (none) | 0.010 | low | 0.20 | brake |
| 1.040 | - | (none) | neutral | 1 | (none) | 0.150 | low | 0.20 | brake |
| 1.190 | - | (none) | neutral | 1 | (none) | 0.860 | low | 0.20 | low |
| 2.050 | - | (none) | 1 | 1 | (none) | 0.950 | low | 0.20 | low |
| 8.930 | - | (none) | 3 | 3 | (none) | 0.070 | low | 80.100 | high |
| 9.000 | R | (none) | 3 | 3 | (none) | 0.315 | low | 80.100 | high |
| 9.315 | - | (none) | 3 | 3 | heatD-damaged | 0.285 | low | 80.100 | high |
| 9.600 | - | (none) | 3 | 3 | heatD-damaged | 0.600 | low | 60.80 | high |
| 10.200 | - | (none) | 3 | 3 | heatD-damaged | 0.600 | low | 40.60 | high |
| 10.800 | - | (none) | 3 | 3 | heatD-damaged | 0.600 | low | 20.40 | high |
| 11.400 | - | (none) | 3 | 3 | heatD-damaged | 0.280 | low | | |
| 11.680 | - | (none) | 3 | reverse | heatD-damaged | 0.290 | low | | |
| 11.970 | - | (none) | 3 | reverse | heatD-damaged | 0.720 | low | | |
| 12.690 | - | (none) | reverse | reverse | heatD-damaged | 0.110 | low | | |
| 12.800 | - | (none) | reverse | reverse | heatD-damaged | 0.400 | low | | |
| 13.200 | - | (none) | reverse | reverse | (none) | 1.000 | low | | |
| 14.200 | - | (none) | reverse | reverse | (none) | 4.212 | high | | |
| 18.412 | - | (none) | reverse | reverse | (none) | 20.598 | high | | |

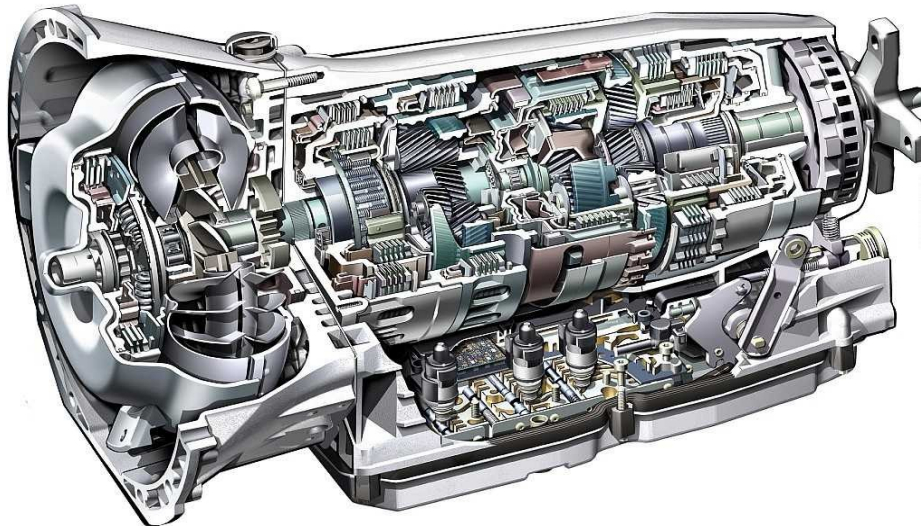


Replay, plot, debug



The screenshot shows the TestWeaver simulation environment. On the left is a control panel with various sliders and buttons for parameters like 'accPedal', 'brakePedal', 'clutchPedal', 'engineSpeed', 'engineTorque', 'gear', 'heatA', 'heatB', 'heatC', 'heatD', 'heatE', 'prnd', and 'targetGear'. In the center is a speedometer showing a needle pointing to approximately 20. On the right is a graph titled 's18/s21' showing a plot of engine torque over time. Below the graph are several numerical displays for variables like 'accPedal', 'brakePedal', 'clutchPedal', 'G_SOLL', and 'G_ZIT'.

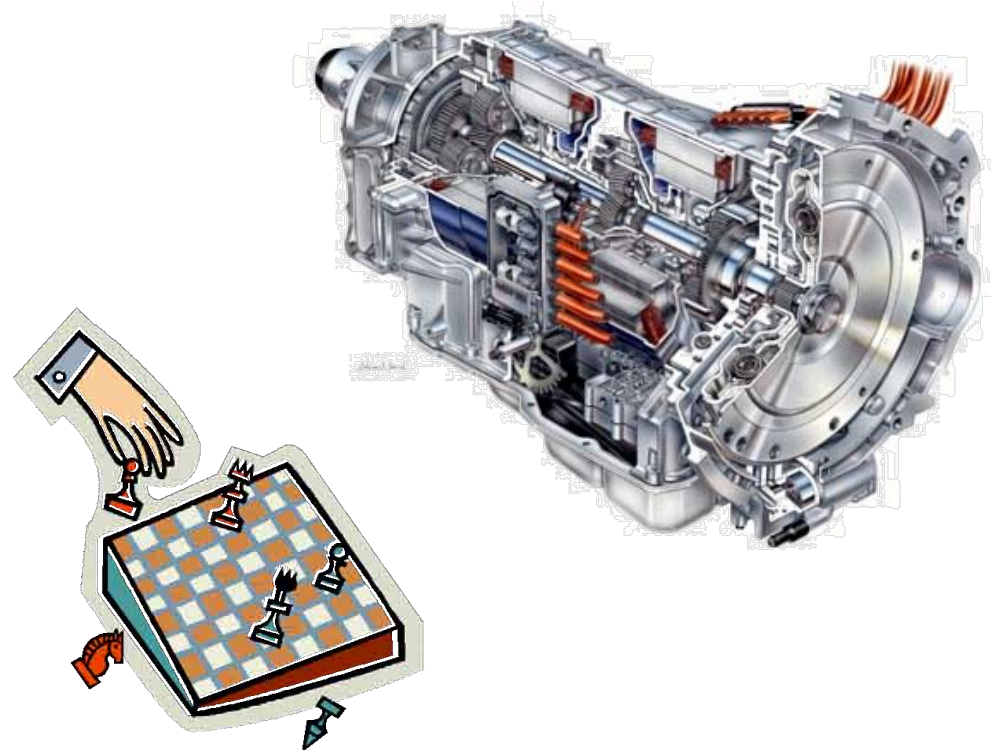
- Software test with **TestWeaver**
- Co-simulation with **Silver**
- Every software release:
24h test in parallel on several PCs
- Thousands of driving situations
generated and analyzed



AMG SPEEDSHIFT
MCT 7-speed sports transmission

Runs with:

- Modelica/Dymola
- Matlab/Simulink
- Silver (co-simulation)
- C/C++

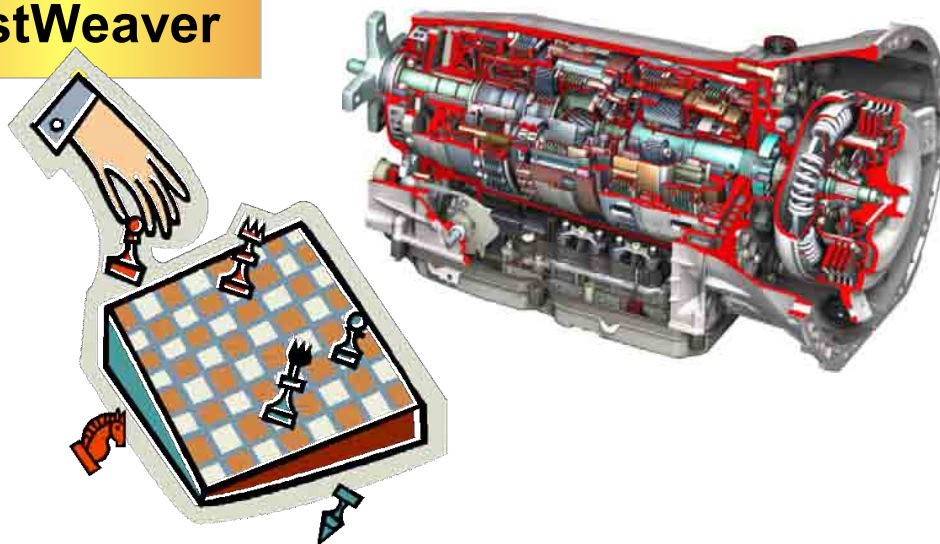


Easy integration with other simulation environments

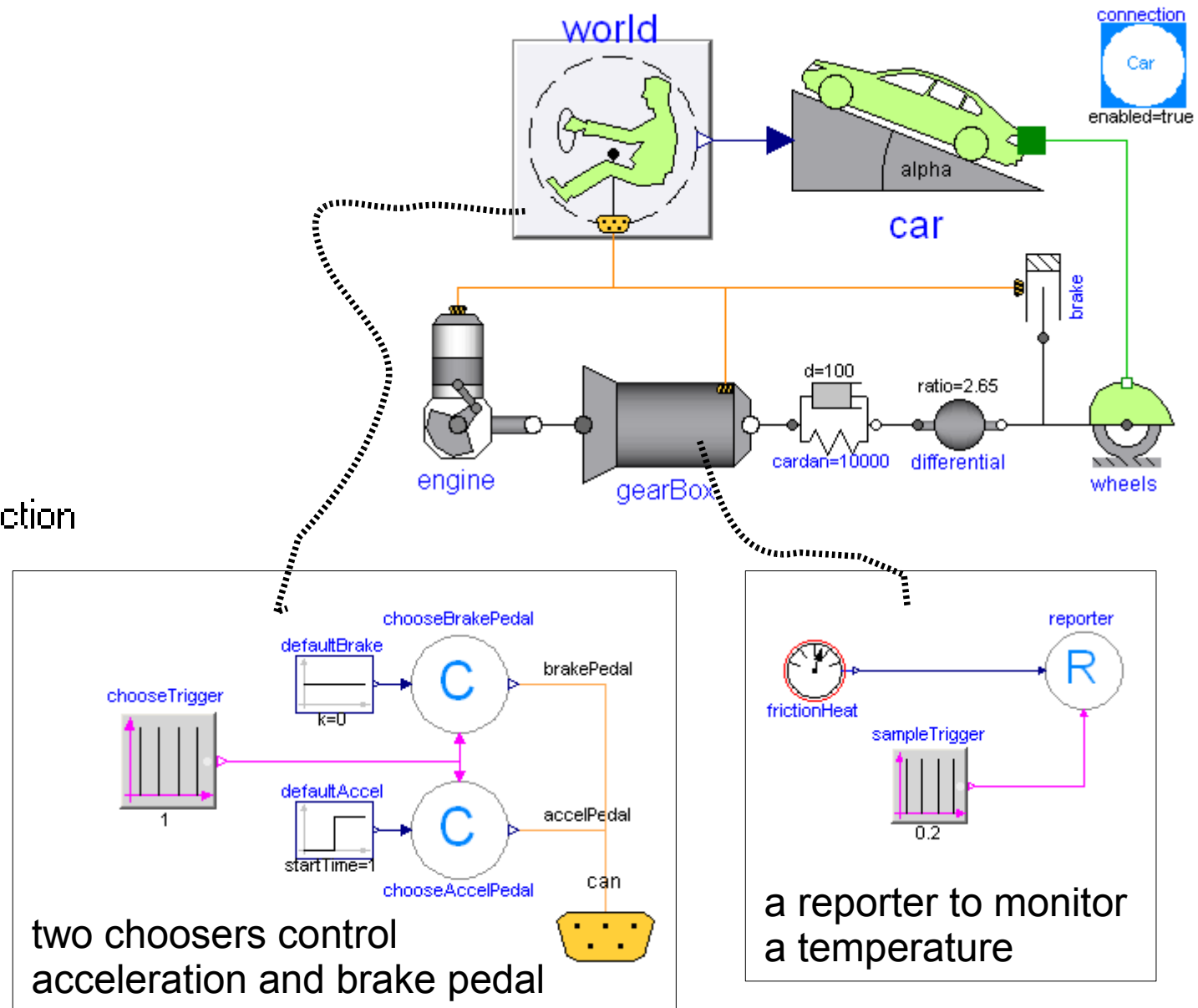
Test automation based on computer chess principles

- High test coverage
- Reduced specification overhead

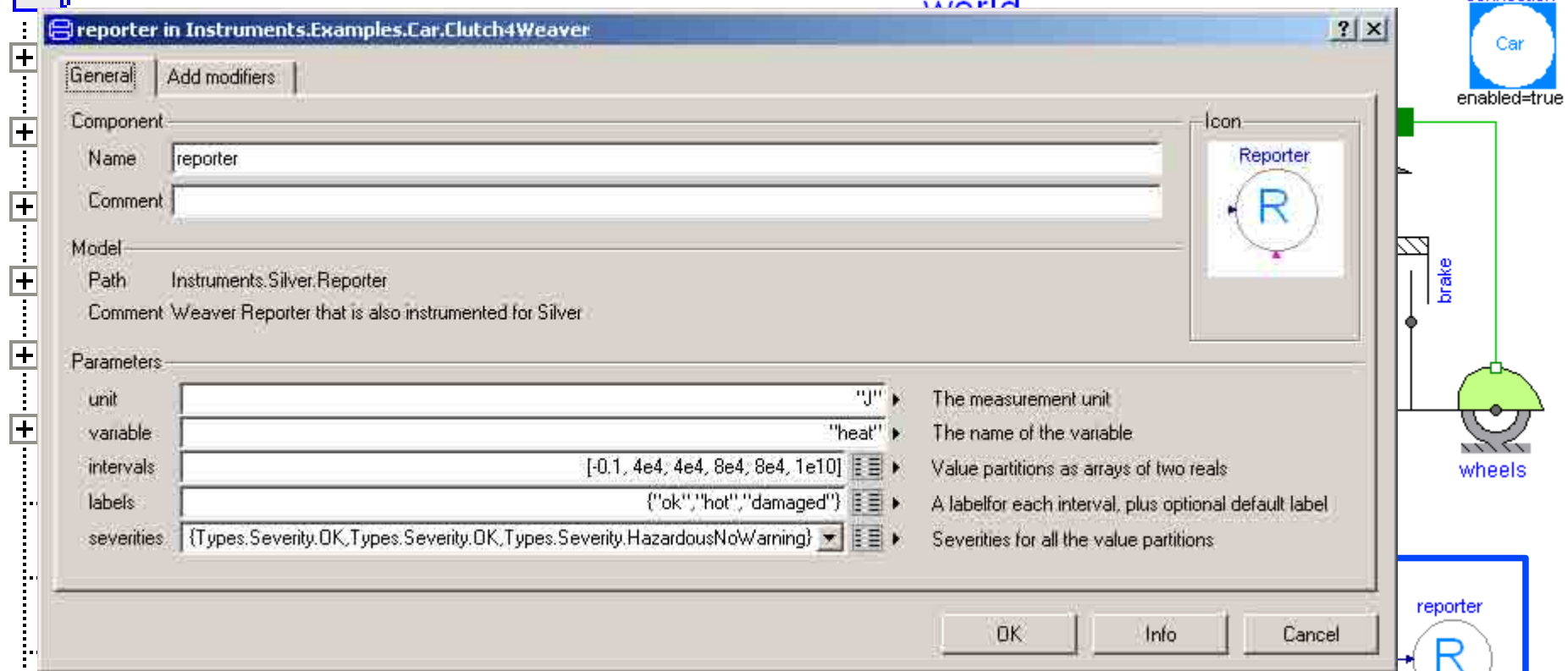
TestWeaver



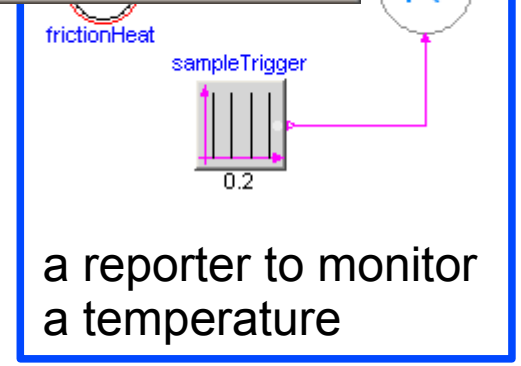
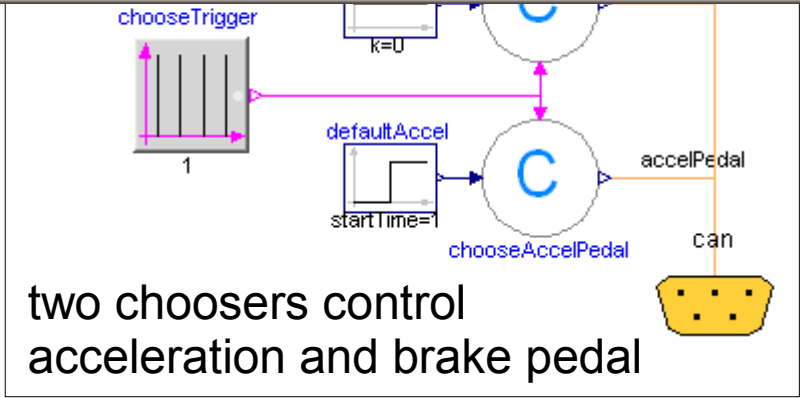
- Instruments
- + Types
- + Functions
- + Interfaces
- + Silver
- + Examples
- + Icons
- WeaverConnection
- Parameter
- Reporter
- Chooser

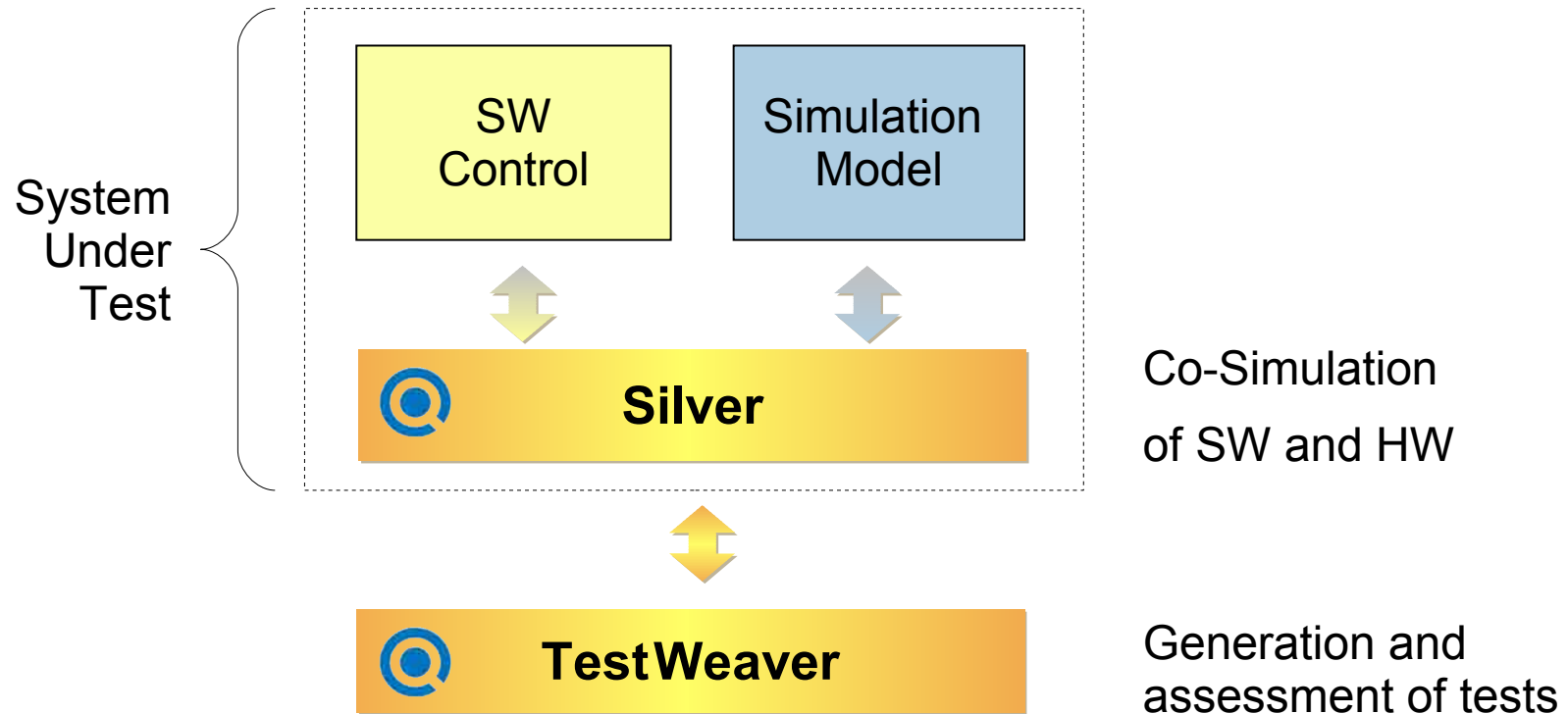
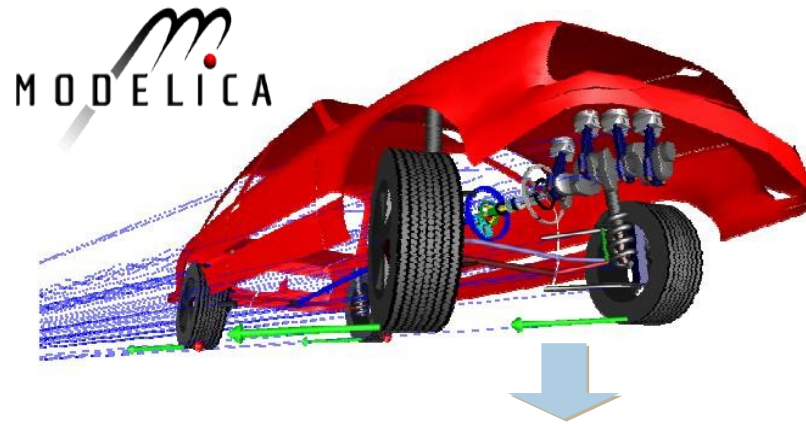


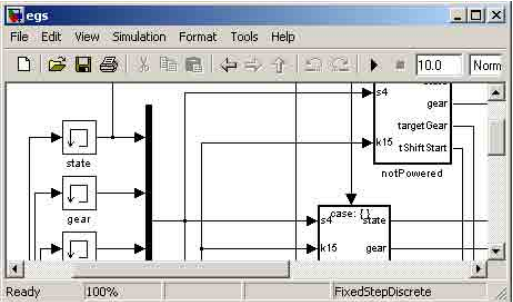
Instruments



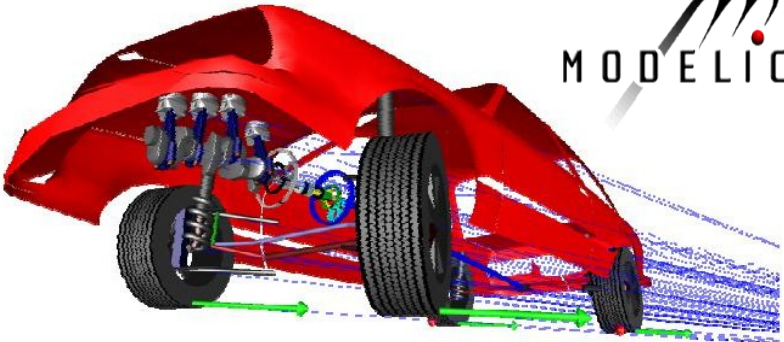
Chooser





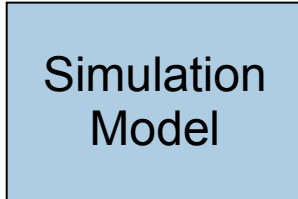


Matlab/Simulink,
C/C++, ...



MODELICA

**fast
feedback**



Executable modules
DLL – binary format



Developer

System
Co-simulation of
SW and HW model

- Errors in the SW module:
 - div. by zero
 - overflows ...
- Critical States:
 - overheating
 - loss of control
 - spec violations ...
- Coverage:
 - what states were tested

