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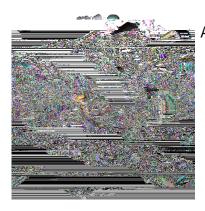
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## History and Motivation

Soft' are-in the-Loop simulation is used at Daimler transmission development since many years:



Autotronic since /22;

Rapid-prototyping via +-Muster Simulin"-SiL ' ith floating-point code Module- and system-tests in Simulin" Continuous operation simulations

- ' ith fi=-point code
- many different tools
- many of them developed in-house

7b>ective for ne' pro>ects:

- ? simplify tool chain
- ? use of @standard soft' areA
- ? minimiBe in-house customiBation of tools

first application of the ne' tool chain: dual clutch tranmission CDCTD development

7G-Tronic since /22;

Rapid-Prototyping via ac"bone

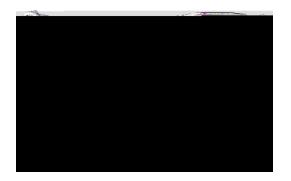
**History and Motivation** 

<i=-point code simulation

System tests

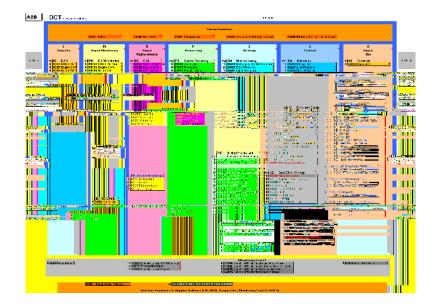
Continuous operation simulations

' ith fi=-point code



### <unction tool bo=

G soft' are functions ' ith ca%/E1 modules G developed using MatLab\*Simulin"\*Stateflo' G and dSpace TargetLin" ' ith DataDictionary G /11H autocode



**DCT** Development

7b>ective of SiL:

Gintegrated tool chain

G cover soft' are-in the-loop and rapid prototyping

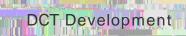
Gsupport soft' are validation and automated test



- or"flo' for soft' are development

dSpace code generator

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## Simulation environment

Tools:

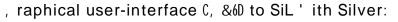
G Simulation: Silver C. TronicD

G Measurement: Canape C5ectorD

G Debugging: 5isual Studio (Microsoft)

G +utomated Test: Test- eaver C. TronicD

G Code Coverage: Test' ell CTC?? <code>C5erifysoftD</code>



 $G\,{\rm 6nteraction}$  of driver\*user ' ith simulated car

G +ccel pedal# bra"e padel# ignition# temperature# J

DCT Development

can be controlled

G +II inputs and outputs can be directly manipultated



"ilver Core

## Simulation environment

Tools:

G Simulation: Silver C. TronicD

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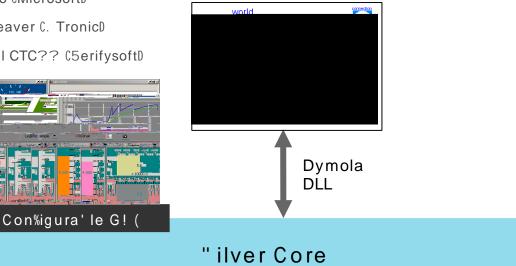
hard' are DLL:

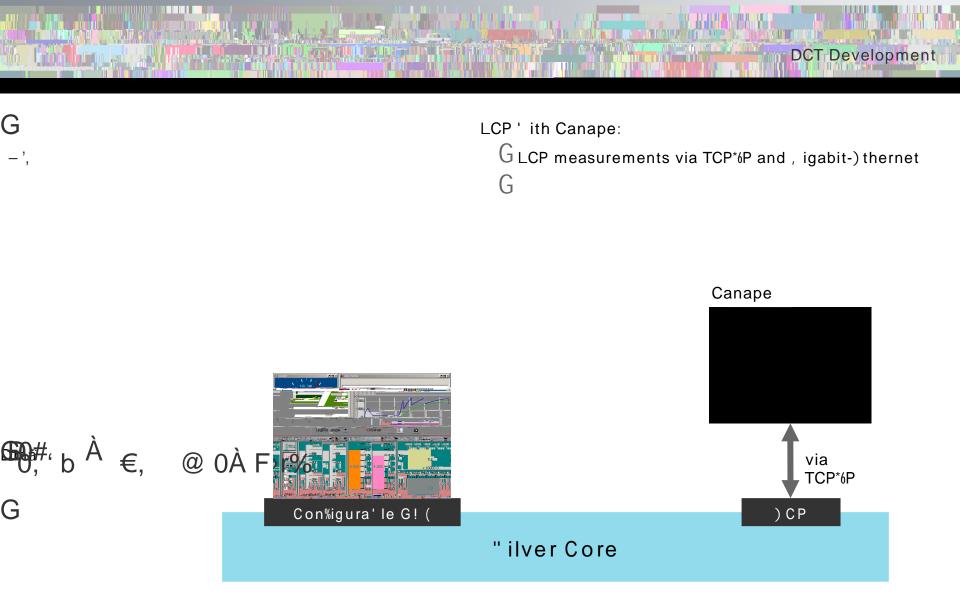
 $G\,\mbox{simulated vehicle}{\mbox{# engine and transmisssion}}$ 

**DCT** Development

G developend in-house using Dymola

#### hard' aremodel









DCT Development

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#### " ilver Core

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## Simulation environment

Tools:

G Simulation: Silver C. TronicD

G Measurement: Canape C5ectorD

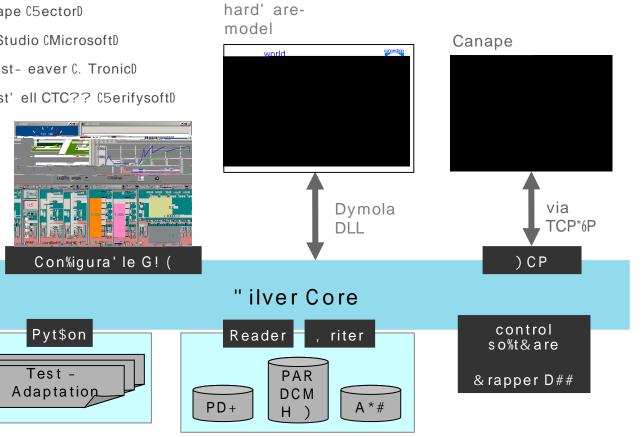
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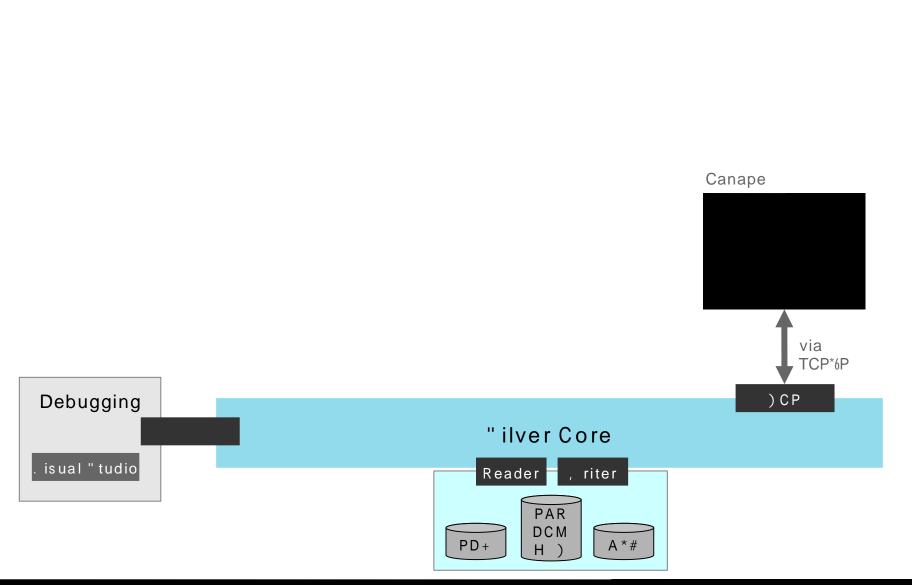
 $G\ \mbox{+utomated Test: Test- eaver C. TronicD}$ 

G Code Coverage: Test' ell CTC?? <code>C5erifysoftD</code>

Scripting ' ith Python: G frel uently used procedures can be automated using scripting Ce% g% engine start# adaptation procedureD

**DCT** Development





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DCT Development

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### +dvantages of SiL

G +ccelerated and early detection of errors because every developer can test his module in the conte=t of all /E1 modules

Summary

G

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/ Silver simulation runs on a standard laptop:

- ' ithout graphical user-interface
- ' ithout simulation of the hard' are CvehicleD

- ' ith Canape and LCP via TCP\*6P
- ' ith ' rapper DLL and entire control soft' are







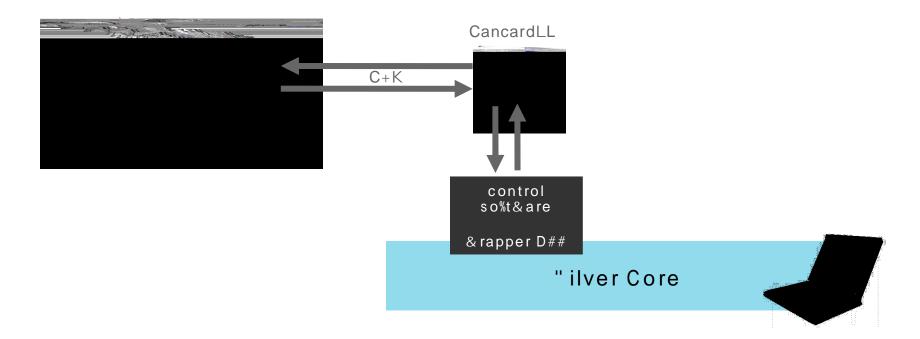
#### CancardLL



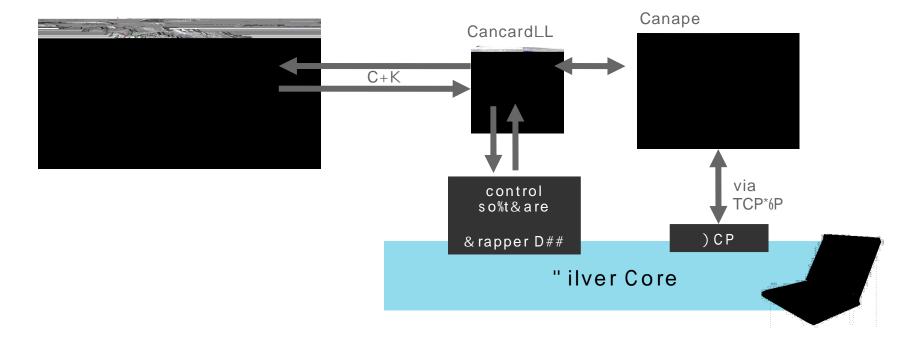


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E )C& in vehicle sends measured sensor values via C+K to Silver



F Canape measures both# the control soft' are internal signals via LCP# as ' ell as ) C& signals via CancardLL and C+K#







## 7b>ectives of automated testing

- higher I uality and better validation of soft' are before first use in a real car
- monitoring of application data# in addition to test using test rigs and continuous operation

#### This is achieved using

- many test scenarios# automatically generated in a controlled# intelligent ' ay
- regression tests ' ith simulation of continuous operation and scenario databases

- hich errors are ' e loo"ing forM

+utomated Testing

- runtime e=ceptions
- division by 1
- value out of bound ' %r%t +OL
- access violation
- infinite loop

#### Range violations

- user-defined criteria
- overheating of components
- duration of gear shifts

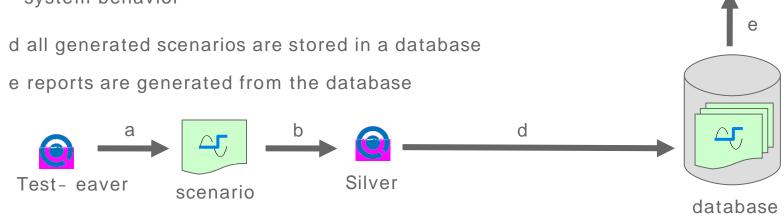
### +utomated testing using Test- eaver

8 TestN

- a Test- eaver generates a scenario
- b Silver runs the scenario# remote controlled by Test- eaver
- c if the scenario leads to suspicious or critical behavior# Test- eaver varies that scenario# in order to provo" e hard errors and local ' orst case system behavior

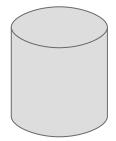
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+utomated Testing

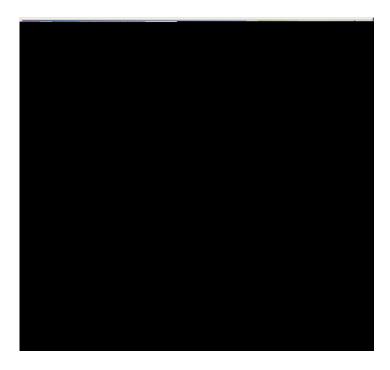








### +utomated testing using Test- eaver



5alidation of a soft' are release

G run at least /1%111 scenarios G analyBe reports and suspicious scenarios G e=port critical scenarios to regression test database

+utomated Testing

## 7utline of the tal"

#### History and Motivation

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#### Code Coverage +nalysis ' ith Test' ell CTC??

CTC++ Covera	ge Report - Files	s Summary
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G integrated ' ith Test- eaver G separate report in Test- eaver G coverage analysis for entire pro>ect C source file functions code path

**Code Coverage** 

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## 7utloo": ne=t steps

- G further increase soft' are I uality
- G increase code coverage
- G simulation of continuous operation as regression test
- G distributed simulation: soft' are is simulated on multiple computers in parallel
- G compare variants ' ith each other
- G build failure database ' ith critical scenarios

7 utloo



## Than" you for your attentionN