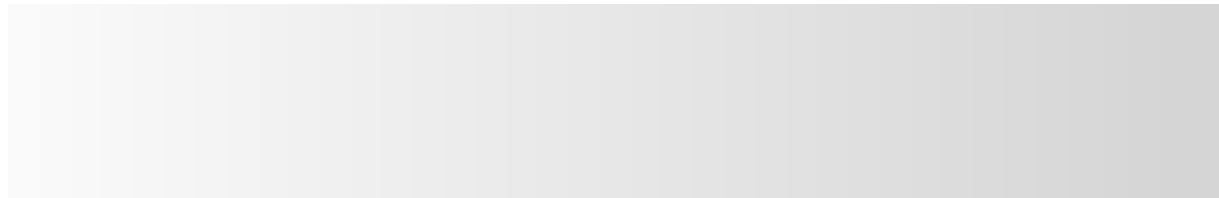


7 outline of the tal"



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
- Simulink-SIL with floating-point code
- Module- and system-tests in Simulink
- Continuous operation simulations
- with fixed-point code

- many different tools
- many of them developed in-house

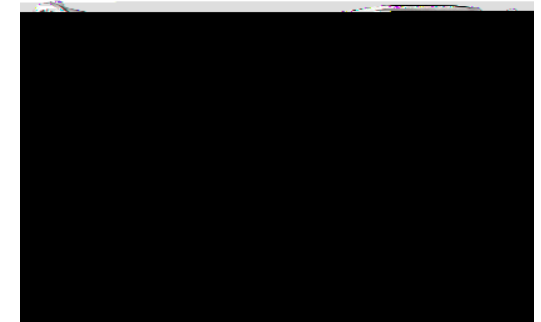
Effective for new projects:

- ? simplify tool chain
- ? use of standard software
- ? minimize in-house customization of tools

first application of the new tool chain:
dual clutch transmission (DCT) development

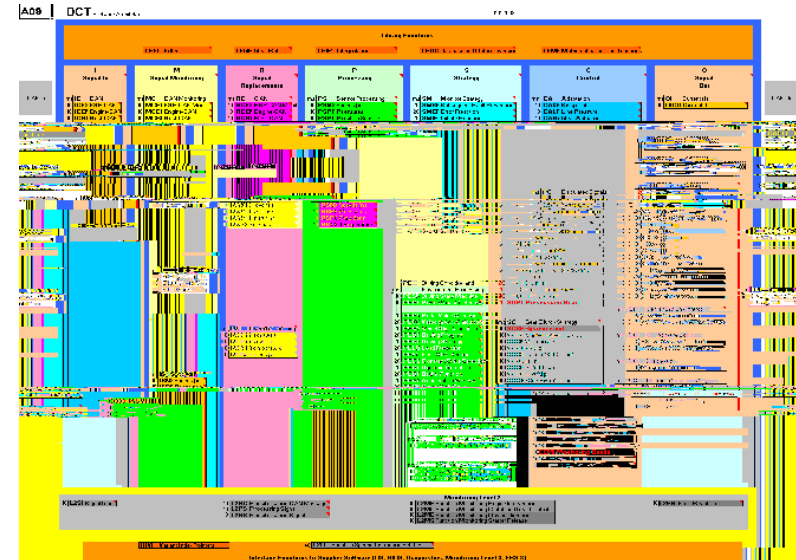
7G-Tronic since /22;

- Rapid-Prototyping via hardware-in-the-loop
- with floating-point code simulation
- System tests
- Continuous operation simulations
- with fixed-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



7b>ective of SiL:

Gintegrated tool chain

Gcover soft' are-in-the-loop and rapid prototyping

Gsupport soft' are validation and automated test

- or "flo" for soft are development

dSpace code
generator

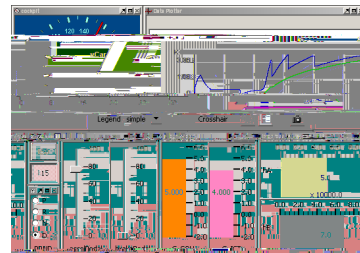




Simulation environment

Tools:

- G Simulation: Silver C. TronicD
- G Measurement: Canape C5ectorD
- G Debugging: Visual Studio CMicrosoftD
- G Automated Test: Test- eaver C. TronicD
- G Code Coverage: Test' ell CTC?? CVerifysoftD



Configurable G!

, graphical user-interface C, &6D to SiL ' ith Silver:

G Interaction of driver*user ' ith simulated car

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

can be controlled

G +II inputs and outputs can be directly manipulated

" ilver Core

Simulation environment

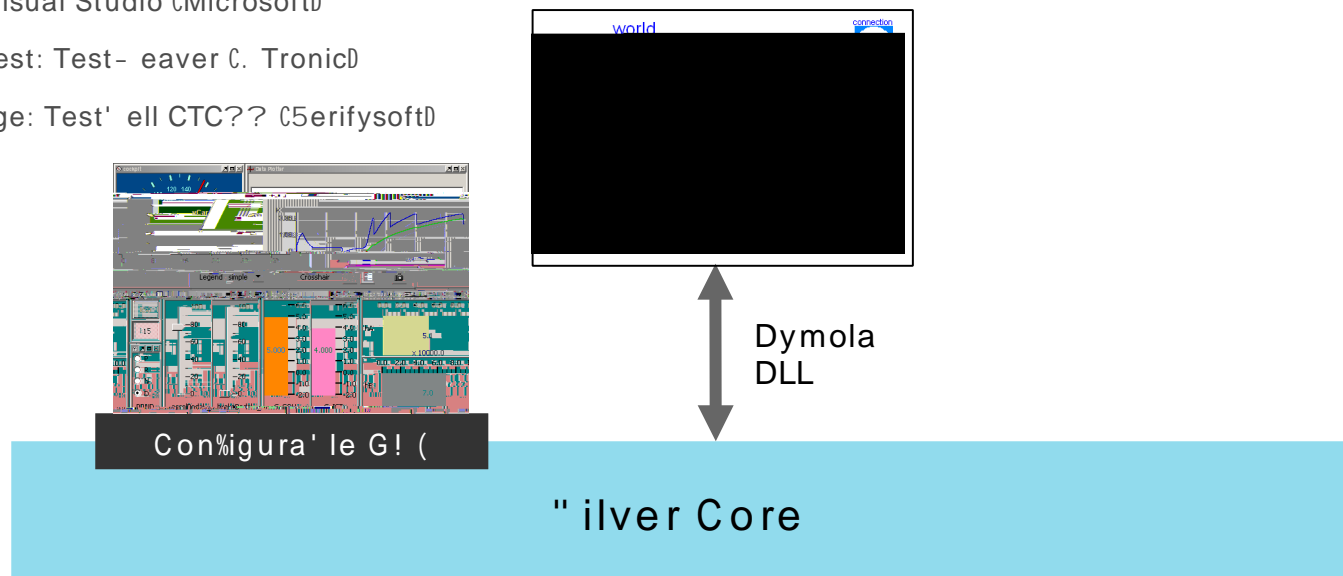
Tools:

- G Simulation: Silver C. TronicD
- G Measurement: Canape (SectorD)
- G Debugging: Visual Studio (MicrosoftD)
- G Automated Test: Test-eaver C. TronicD
- G Code Coverage: Test-eall CTC?? (VerifysoftD)

hard' are DLL:

- G simulated vehicle# engine and transmission
- G developend in-house using Dymola

hard' are-model

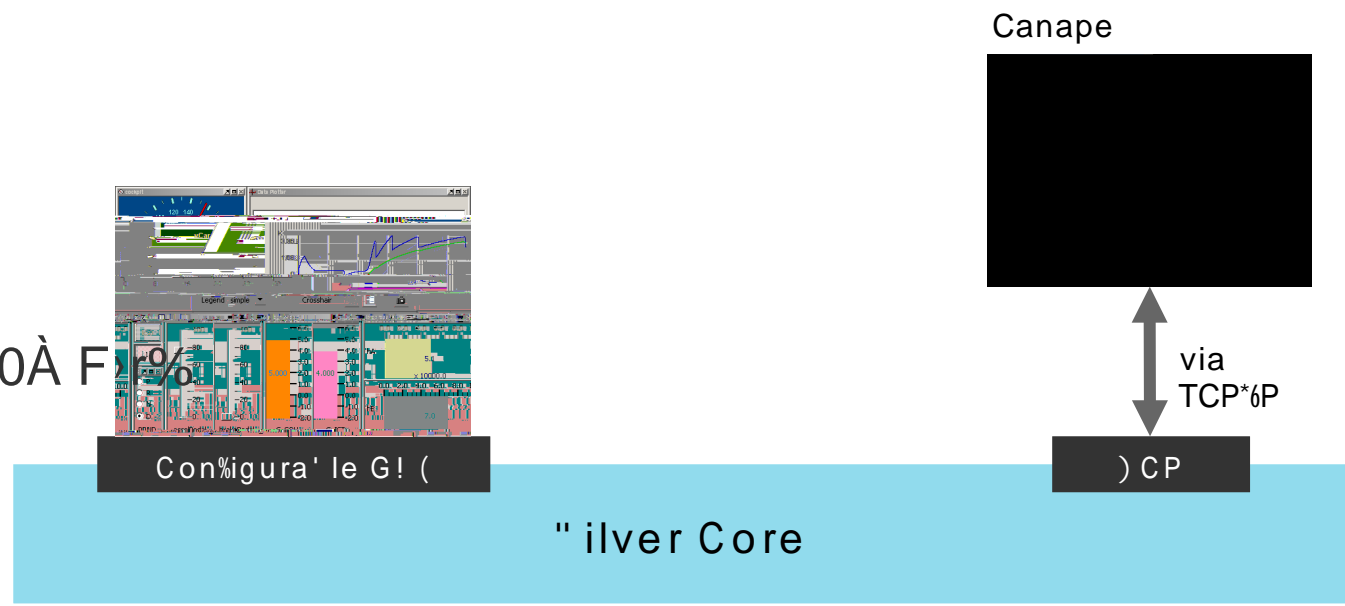


LCP with Canape:

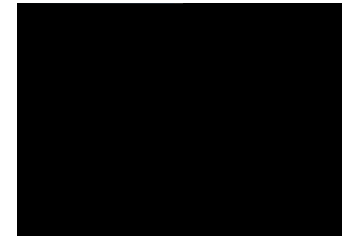
LCP measurements via TCP*6P and , igabit-) thernet
G

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#, b À € , @ 0À F r%
G







"ilver Core

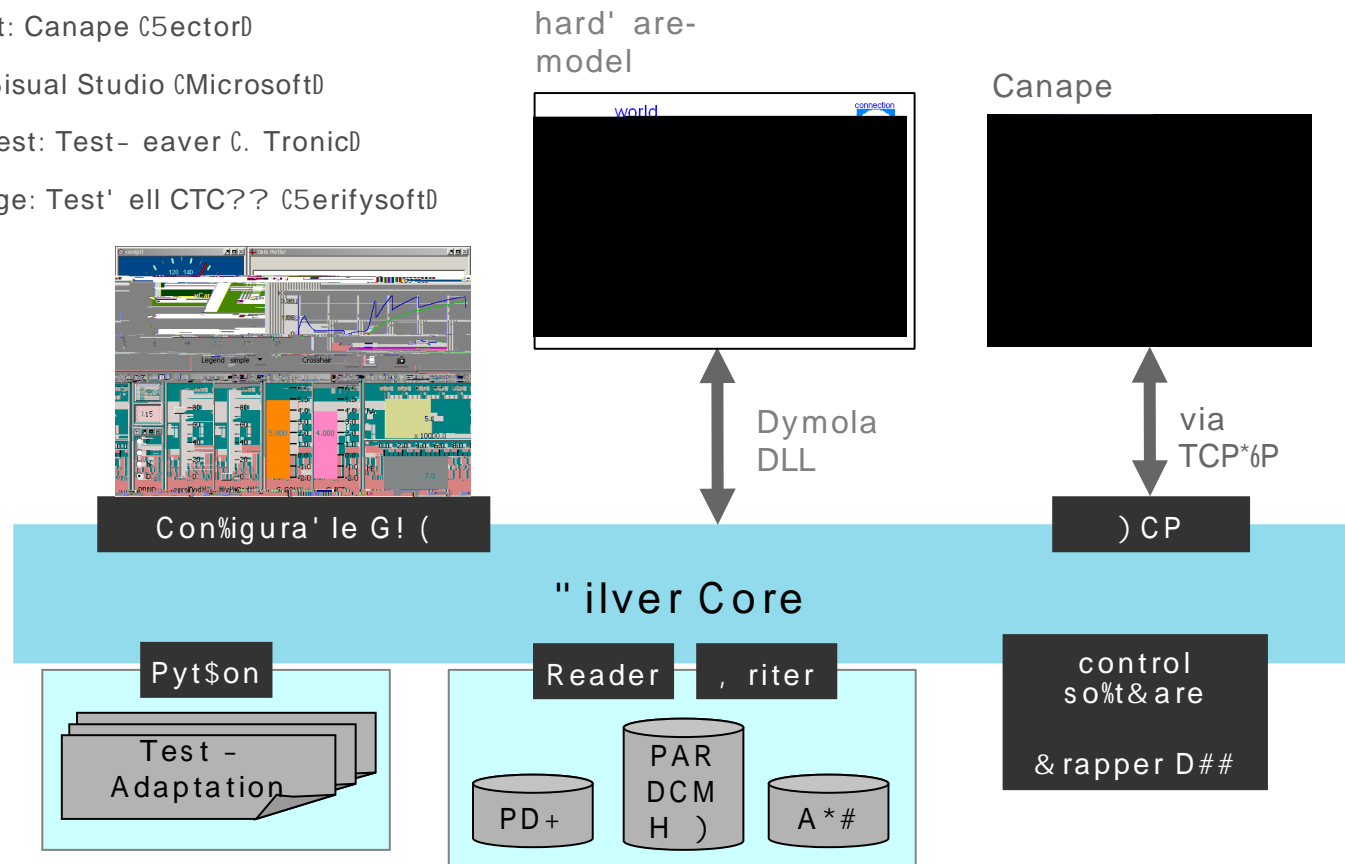
Simulation environment

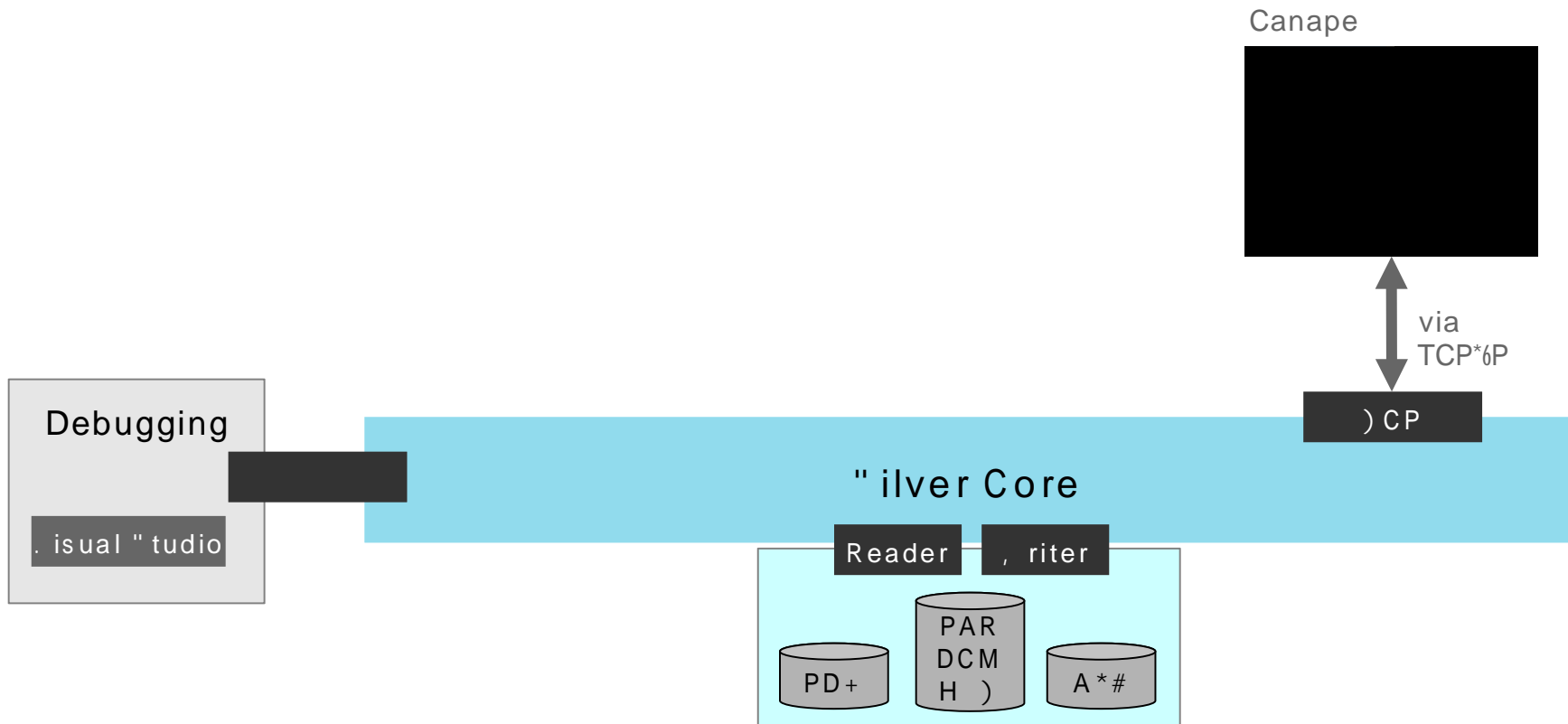
Tools:

- G Simulation: Silver C. TronicD
- G Measurement: Canape (SectorD)
- G Debugging: Visual Studio (Microsoft)
- G Automated Test: Test- eaver C. TronicD
- G Code Coverage: Test' ell CTC?? (erifysoftD)

Scripting with Python:

Generally used procedures can be automated using scripting engine start# adaptation procedureD





+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

G

Rapid Prototyping

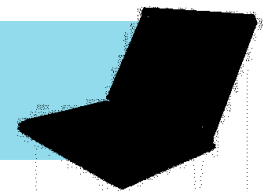
- / Silver simulation runs on a standard laptop:
 - without graphical user-interface
 - without simulation of the hardware (vehicle)
 - with Canape and LCP via TCP/IP
 - with rapper DLL and entire control software



control
software

& rapper DLL

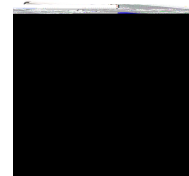
" Silver Core



Rapid Prototyping

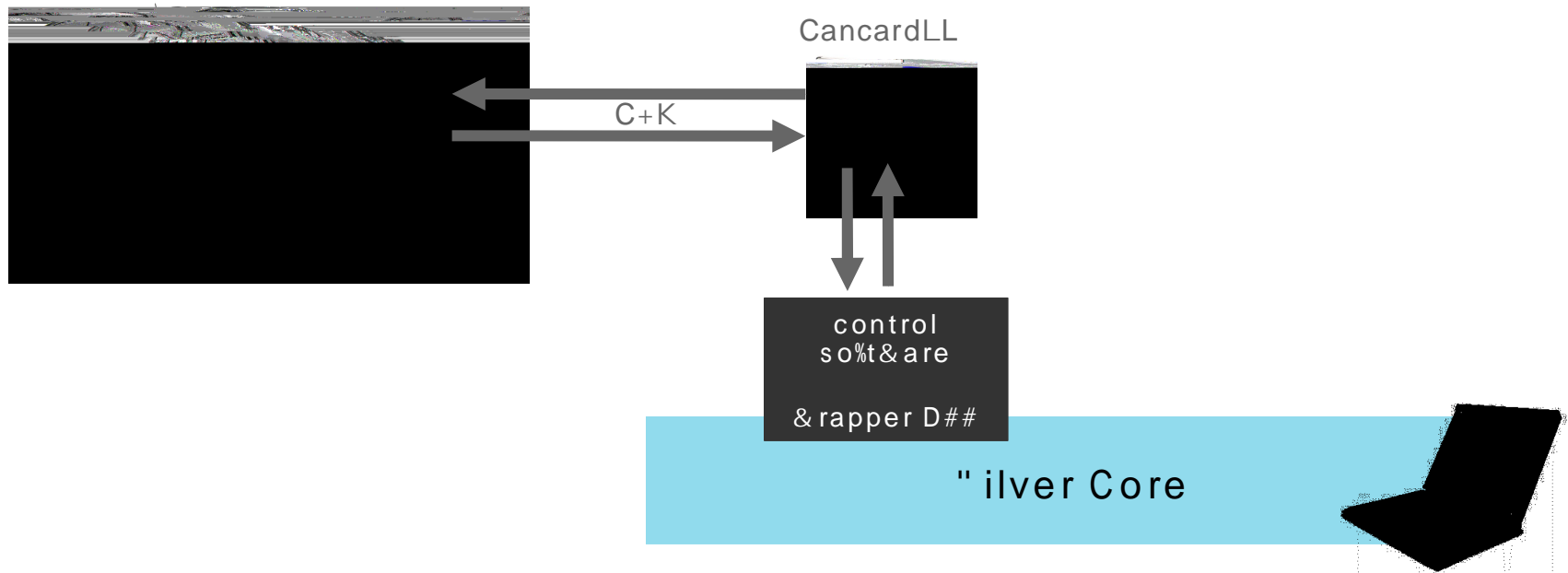


CancardLL



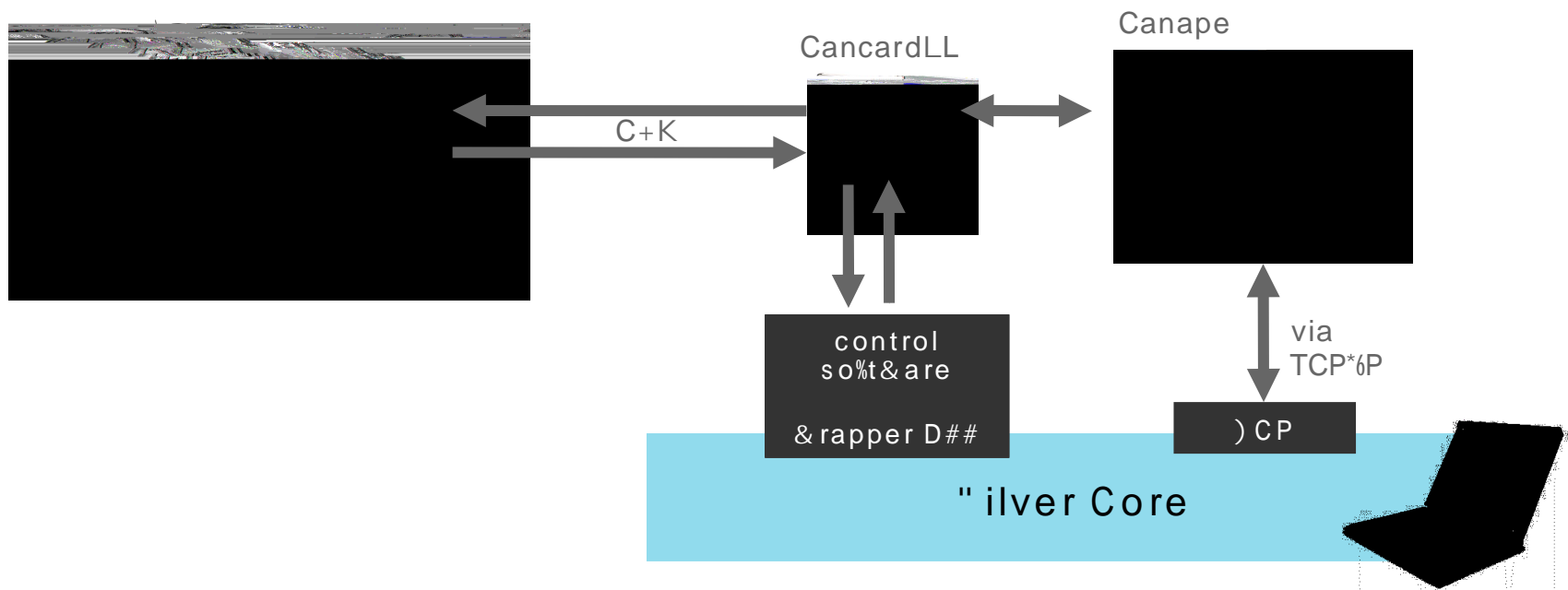
Rapid Prototyping

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

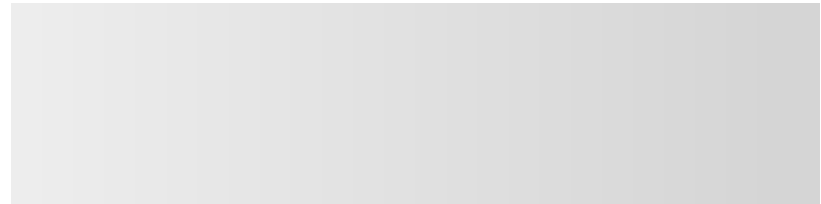


Rapid Prototyping

- F Canape measures both the control software internal signals via LCP as well as CAN signals via CancardLL and C+K



7 outline of the tal"



Benefits of automated testing

- higher quality and better validation of software 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

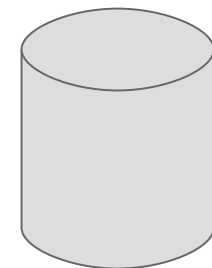
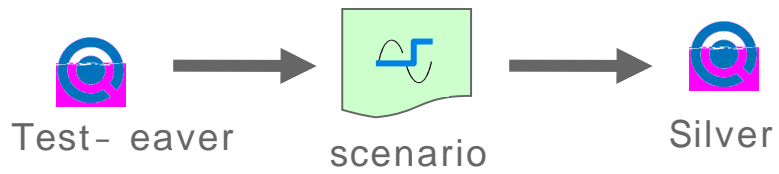
- many test scenarios automatically generated in a controlled intelligent way
- regression tests with simulation of continuous operation and scenario databases

- high errors are being looking for
- runtime exceptions
- division by 1
- value out of bound
- access violation
- infinite loop

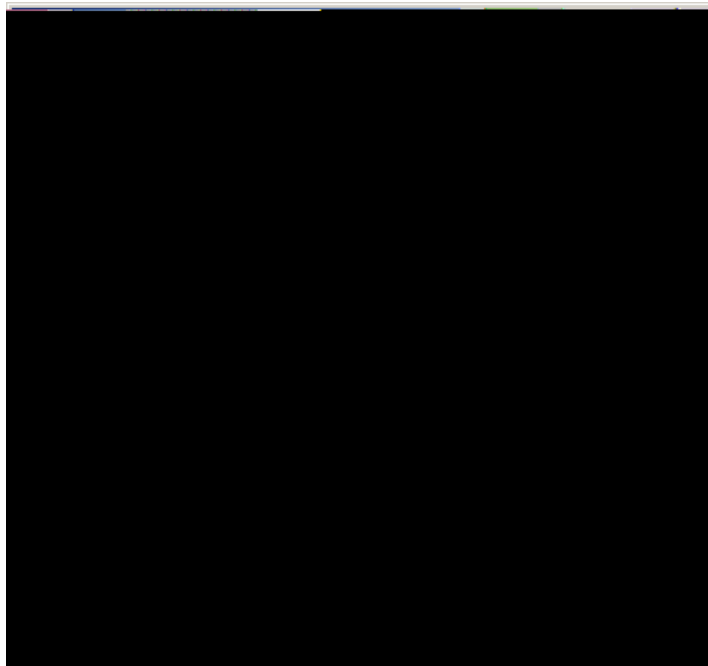
Range violations

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

+utomated testing using Test- eaver



+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

7 outline of the tal"

History and Motivation

7utloo" : ne=t steps

- G further increase soft' are l 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

Thank you for your attention