Test-Driven Scenario Specification of Automotive Software Components

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- **6 years job experience at Leopold Kostal GmbH & Co. KG as software engineer**
- **since 12/2018 research associate at IDiAL Institute - FH Dortmund**
- **phd student at Paderborn University & FH Dortmund**

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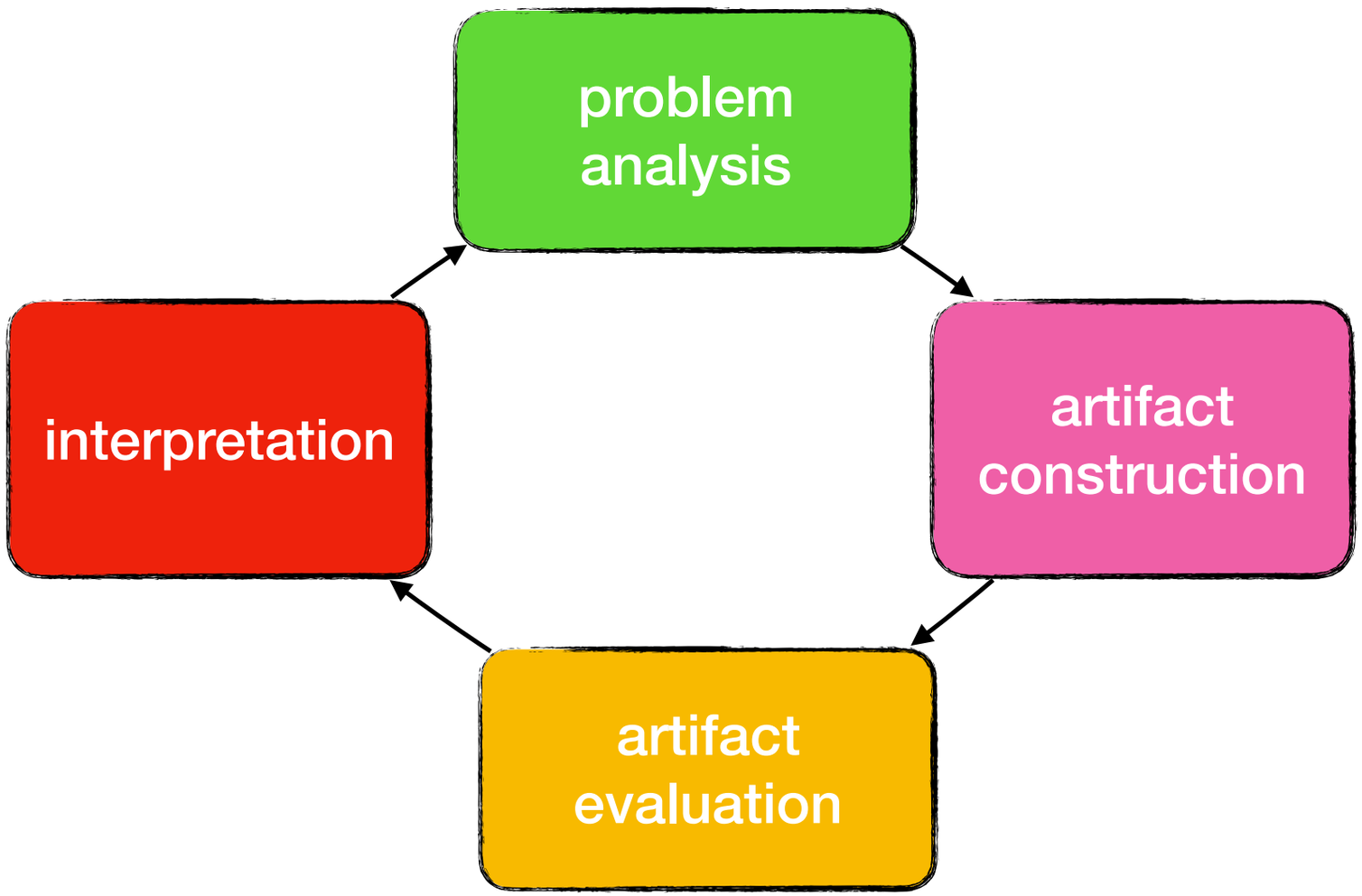
Research Context and Design

Design Science Research
-building and evaluating a solution-
-assessing its actual impact in reality-



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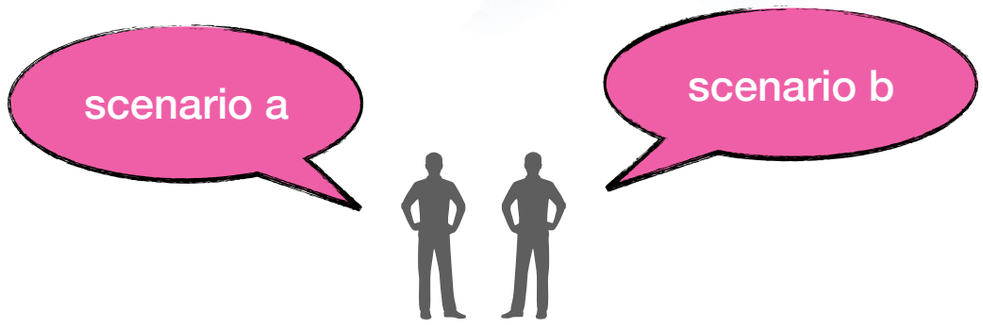
Problem Description and Motivation for TDSS

complex automotive software systems
A. high contextual complexity
B. high dynamics in projects

→ costly development iterations
→ high verification/validation effort

How to support a natural and intuitive formalization of requirements with the goal to:
A. automatically analyze these requirements?
B. systematically work out test cases based on these requirements?



→ reduce development costs by:
A. early detection of requirement inconsistencies and ambiguities
B. reusing test cases in later process steps

Example: Onboard Charger for electric vehicles

Req1: No temperature related derating of the available output power shall be commanded, if the coolant inlet temperature sensor reads values between -40°C and 65°C.

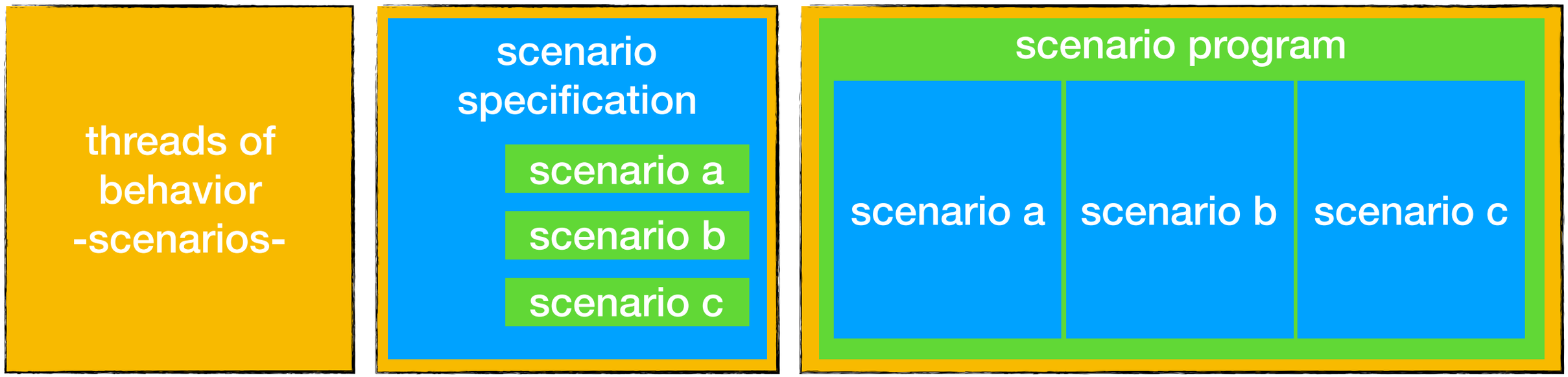
Req2: If the coolant inlet temperature sensor reads values between 65°C and 75°C, linear derating with 1/10 of maximal output power per 1°C shall be commanded.

Req3: Power-down above 75°C coolant inlet temperature.

Req4: Power-down if coolant inlet temperature increases more than 5°C within 5s.

Req5: Power-down if PCB temperature increases more than 20°C within 3s.

Background: Scenario Modeling Language for Kotlin (SMLK)



Req1: No temperature related derating of the available output power shall be commanded, if the coolant inlet temperature sensor reads values between -40°C and 65°C.

```
scenario(deratingComponent.startCycle){
    if (deratingComponent.coolantTemp in -40..65)
        request(deratingComponent.setDeratingFactor(1.0))}
```

Behavioral Programming: http://www.wisdom.weizmann.ac.il/~bprogram/
Live Sequence Charts: http://wiki.weizmann.ac.il/playgo/index.php/Live_sequence_charts
Scenario Modeling Language: http://scenariotools.org/scenario-modeling-language/

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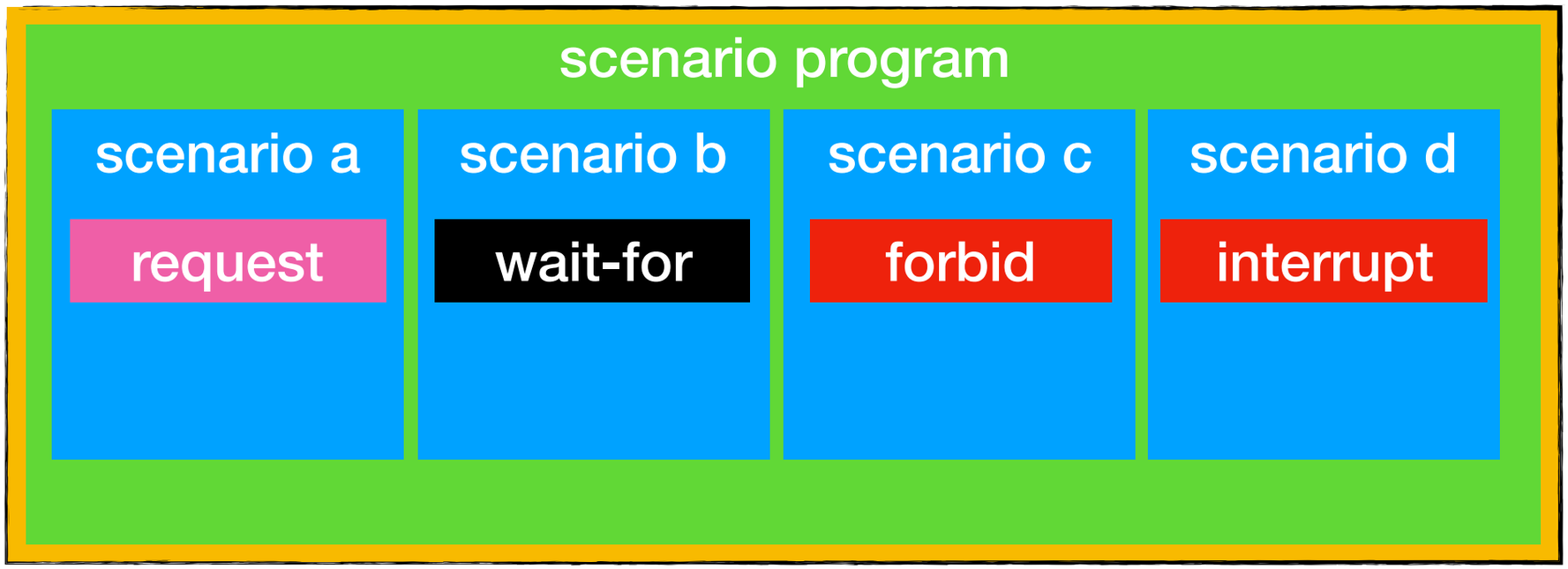
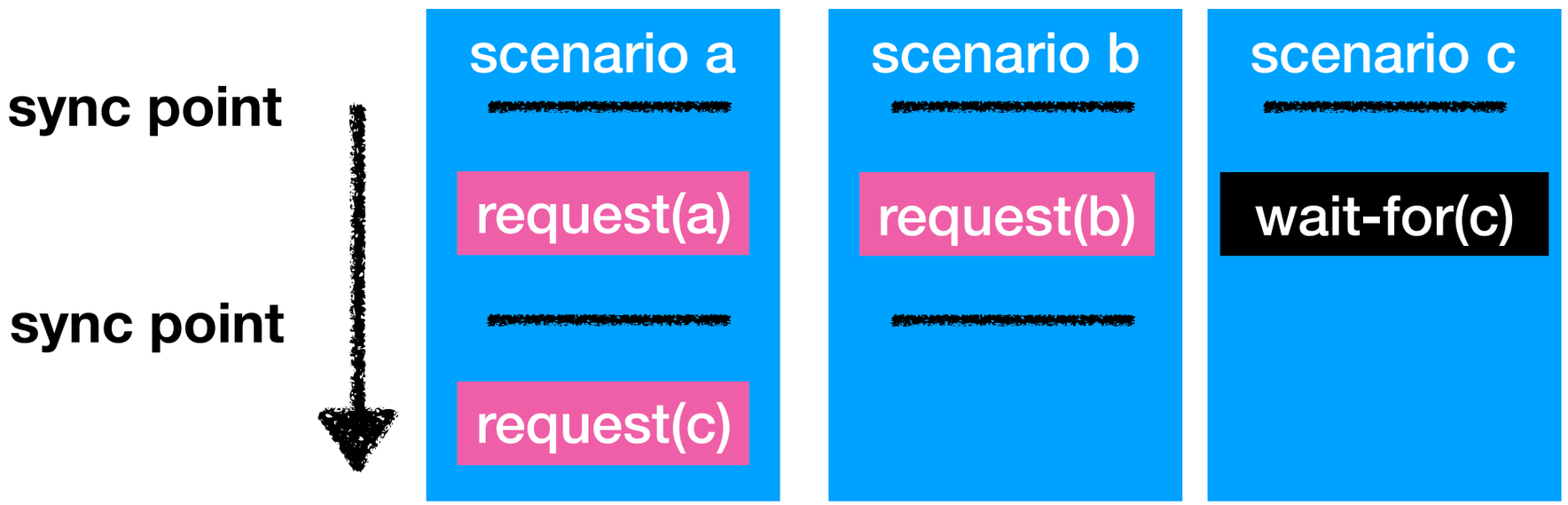
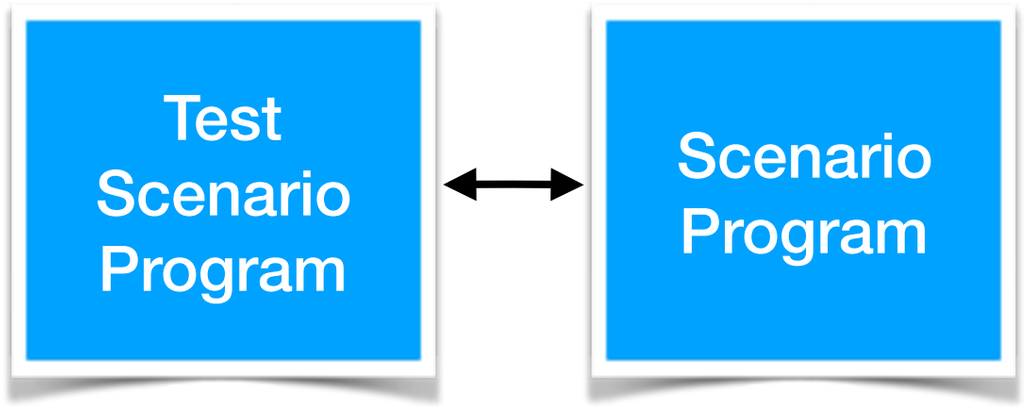




Test-Driven Scenario Specification of Automotive Software Components (TDSS)

request external events (e.g. temperature values)

wait for scenario program events (e.g. expected derating factor)



request, wait-for, forbid, interrupt specific events to model the behavior of the software component

Test-Driven Scenario Specification of Automotive Software Components (TDSS)

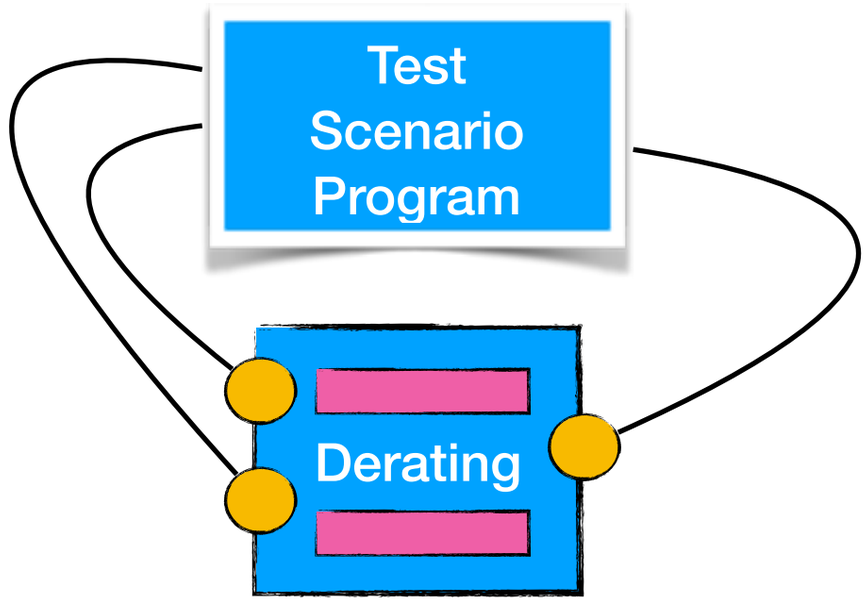
```
@Test
fun `At 66°C the DeratingFactor is 0-9`() =
    runTest(deratingScenarioProgram){
     deratingIOSequence(Triple(66, 66, 0.9))}
```

request(temperature values)

request(start cycle)

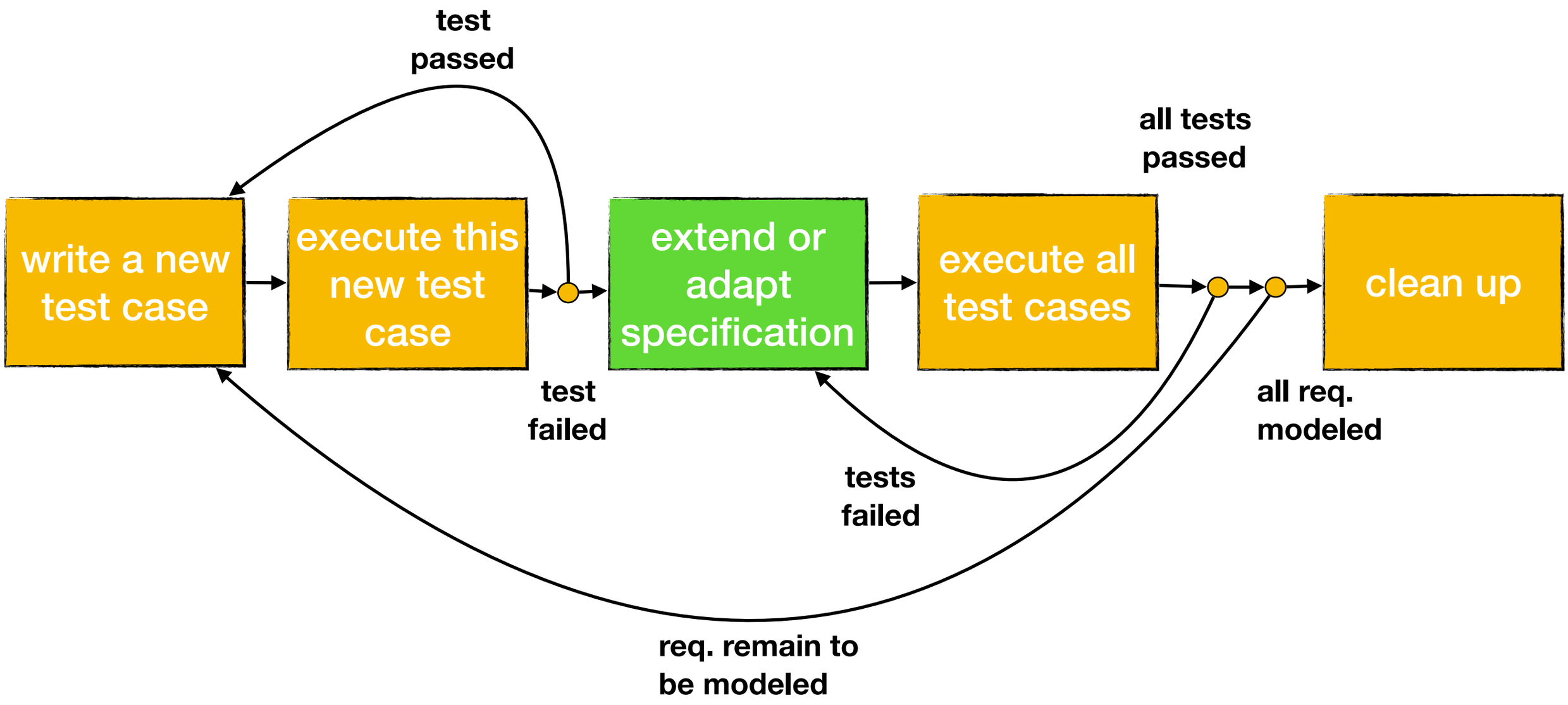
waitFor(derating value)

waitFor(end cycle)




```
cycleScenario(deratingComponent){
    if (deratingComponent.coolantTemp in 65..75)
        request(deratingComponent.setDeratingFactor(
   (75.0-deratingComponent.coolantTemp)/10))}
```

Test-Driven Scenario Specification of Automotive Software Components (TDSS)



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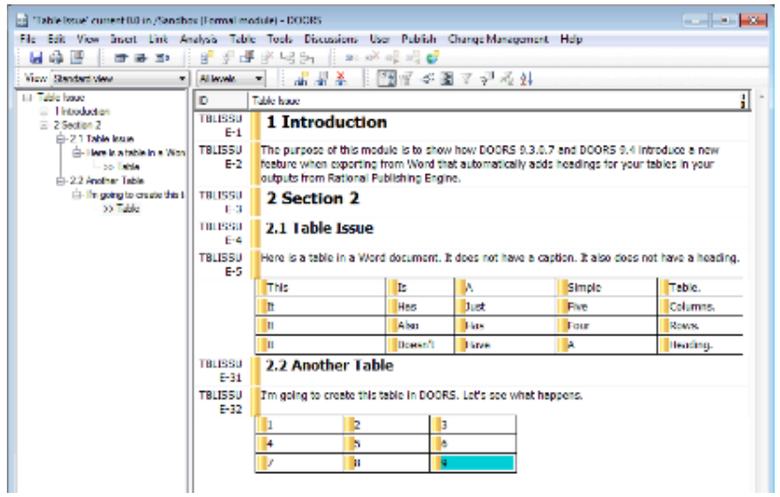

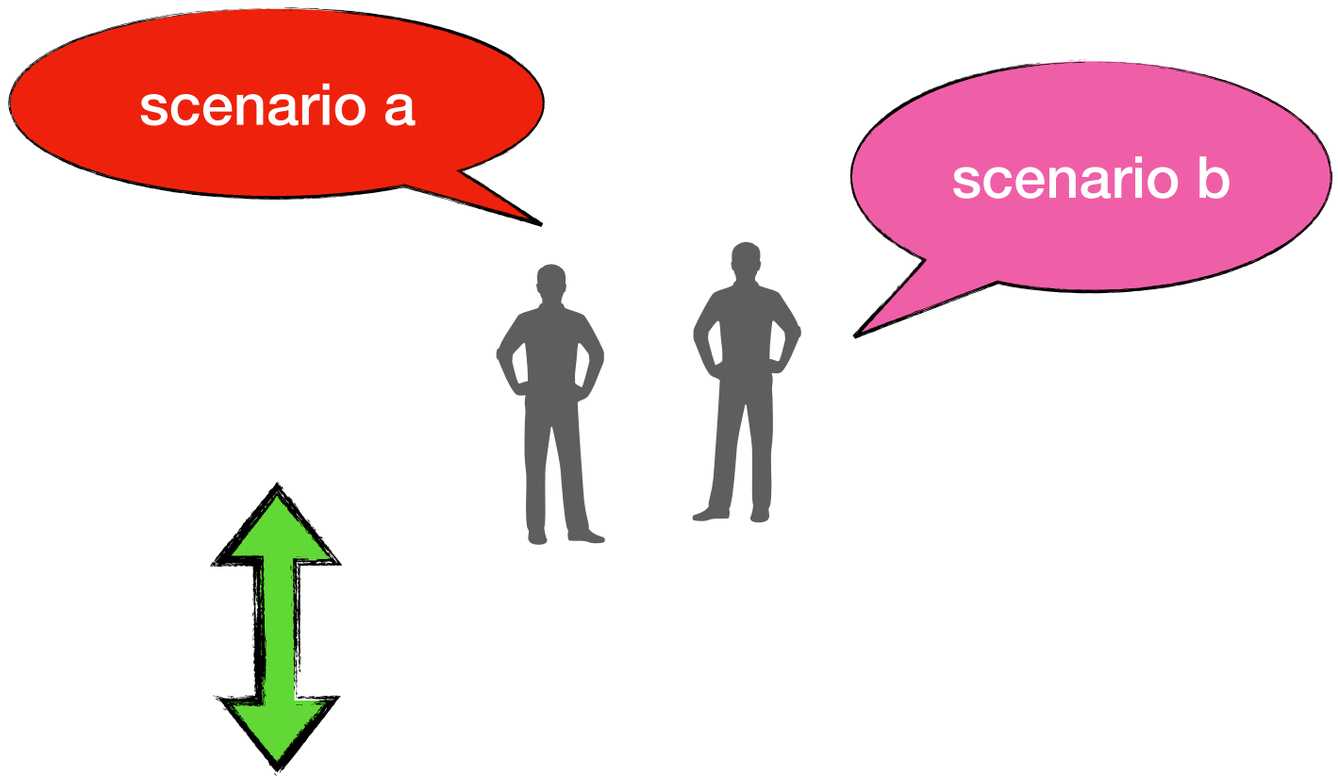


```
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    if (deratingComponent.coolantTemp in 65..75)
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    (75.0-deratingComponent.coolantTemp)/10))
}
```

TDSS - Evaluation

IBM DOORS

Software Requirements Analysis

Req1: No temperature related derating of the available output power shall be commanded, if the coolant inlet temperature sensor reads values between -40°C and 65°C.

Req4: Power-down if coolant inlet temperature increases more than 5°C within 5s.

Software Qualification Test

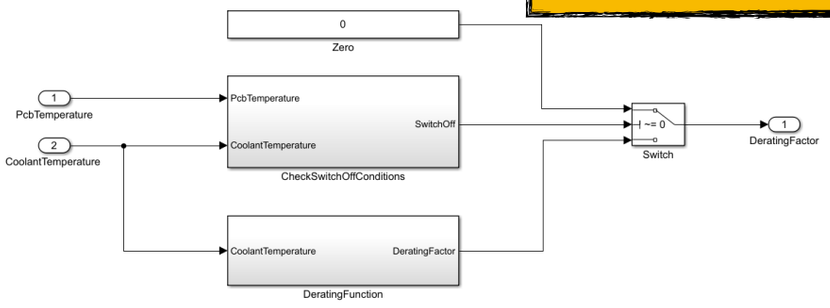
Software Architectural Design

Software Integration and Integration Test

MATLAB

Software Detailed Design and Unit Construction

Software Unit Verification



Assessment Result	Test001/TSeq001	Test001/TSeq002	Test001/TSeq003	Test001/TSeq004
mars_RS1 : Failed				
mars_RS2 : Failed				
mars_RS3 : Passed				
mars_RS4 : Passed				
mars_RS5 : Passed				

Assessment Result	Test001/TSeq001	Test001/TSeq002	Test001/TSeq003	Test001/TSeq004
mars_RS1 : Passed				
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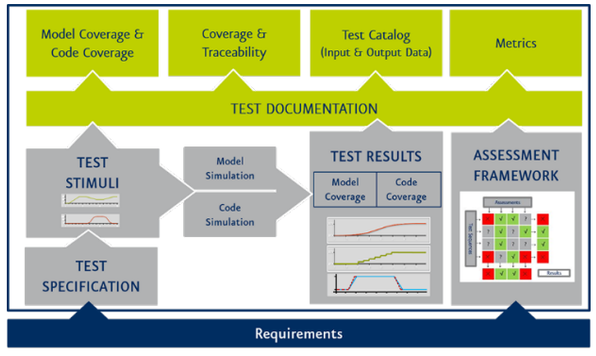
mars_RS3 : Passed				
mars_RS4 : Passed				
mars_RS5 : Passed				



TDSS - Summary

Test-Driven Scenario Specification of Automotive Software Components:

- **new approach for the test-driven, scenario-based requirements specification**
- **combines agile practices with formal specification and analysis**
- **SMLK is suited to formalize functional requirements in an intuitive way**
- **immediately testing of requirements:**
  - **feeling of control to the requirements specification and analysis phase**
  - **high confidence of correctness when the final implementation is tested: tests vs. requirements vs. implementation**

Outlook

1. Combinatorial Test Design
2. Transition to Design
3. Transition to Validation
4. Evaluation: based on DSR framework, systematically assessing the impact in reality