

Bordeaux, 22-24 October 2019



APPLYING KEYWORD DRIVEN TESTING TO VALIDATE VEHICLE SOFTWARE



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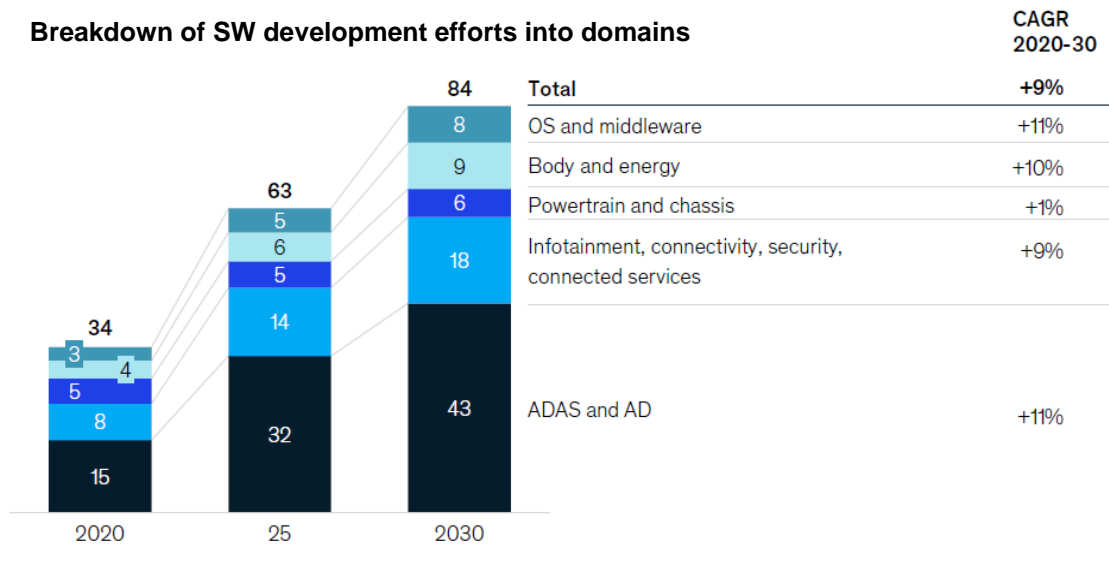
AUTOMOTIVE INDUSTRY CHALLENGE

The Changing Automotive Landscape

“In the next decade, the automotive industry will face a magnitude of change that has not been seen in a century. This change will be driven primarily by four mutually reinforcing trends, i.e., autonomous, connected, electric, and shared (ACES) vehicles...”

Source: Automotive software and electronics 2030, McKinsey & Company

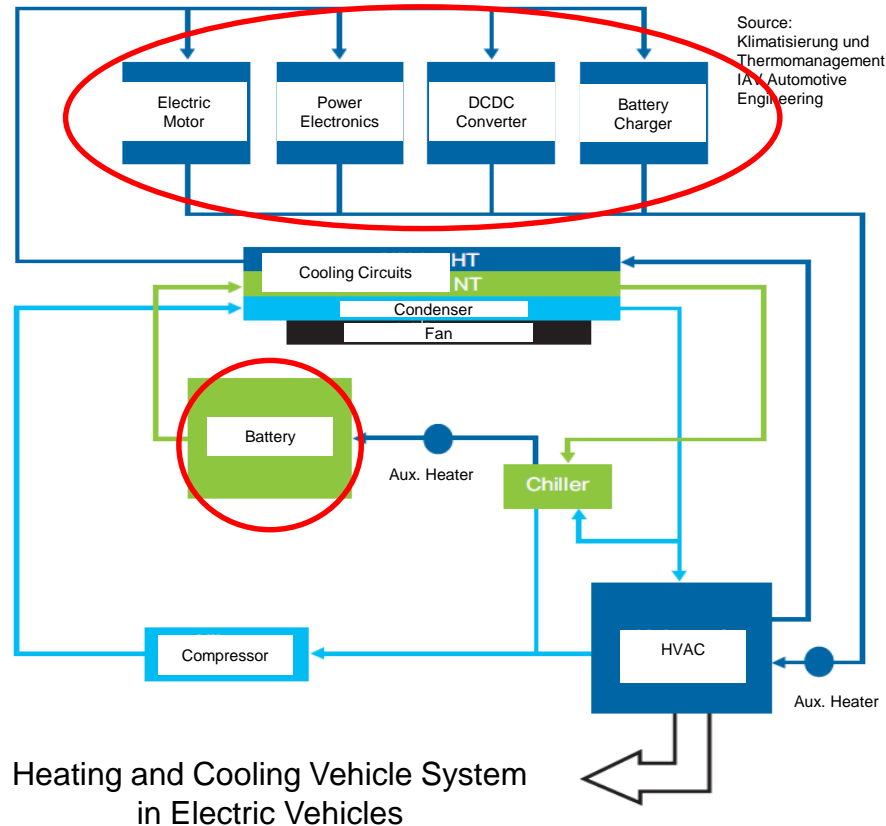
Breakdown of SW development efforts into domains



SOURCE: McKinsey analysis

- Software Standardization (e.g. Autosar) enables the separation from Hardware and Software. As result, Hardware is becoming a commodity i.e. **Software is the most important added value to the final product**
- Surge in Complexity of Software Functions (i.e. Energy Domain)
- Increasing Safety Criticality of Software Functions
- Higher demand for faster and cost effective Verification & Validation Processes

Thermal Management System Overview: Hybrid (PHEV), Electric (BEV) Vehicles



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AUTOMATED VIRTUAL DRIVING CYCLES: PROJECT GOAL AND OBJECTIVES

Project Goal and Objectives

- Shift In-Vehicle Tests to a Test Rig (reduction of the number of vehicle prototypes)
- Raise Productivity in terms of Test Cases
- Customer Focus on Specifying and not on Implementing Tests
- Provide an efficient Software Validation Process based on Customer Skill Set (good Knowledge on In-Vehicle Software Validation)
- Improve Communication within the Test Team
- Drive cross functional cooperation within the Organization

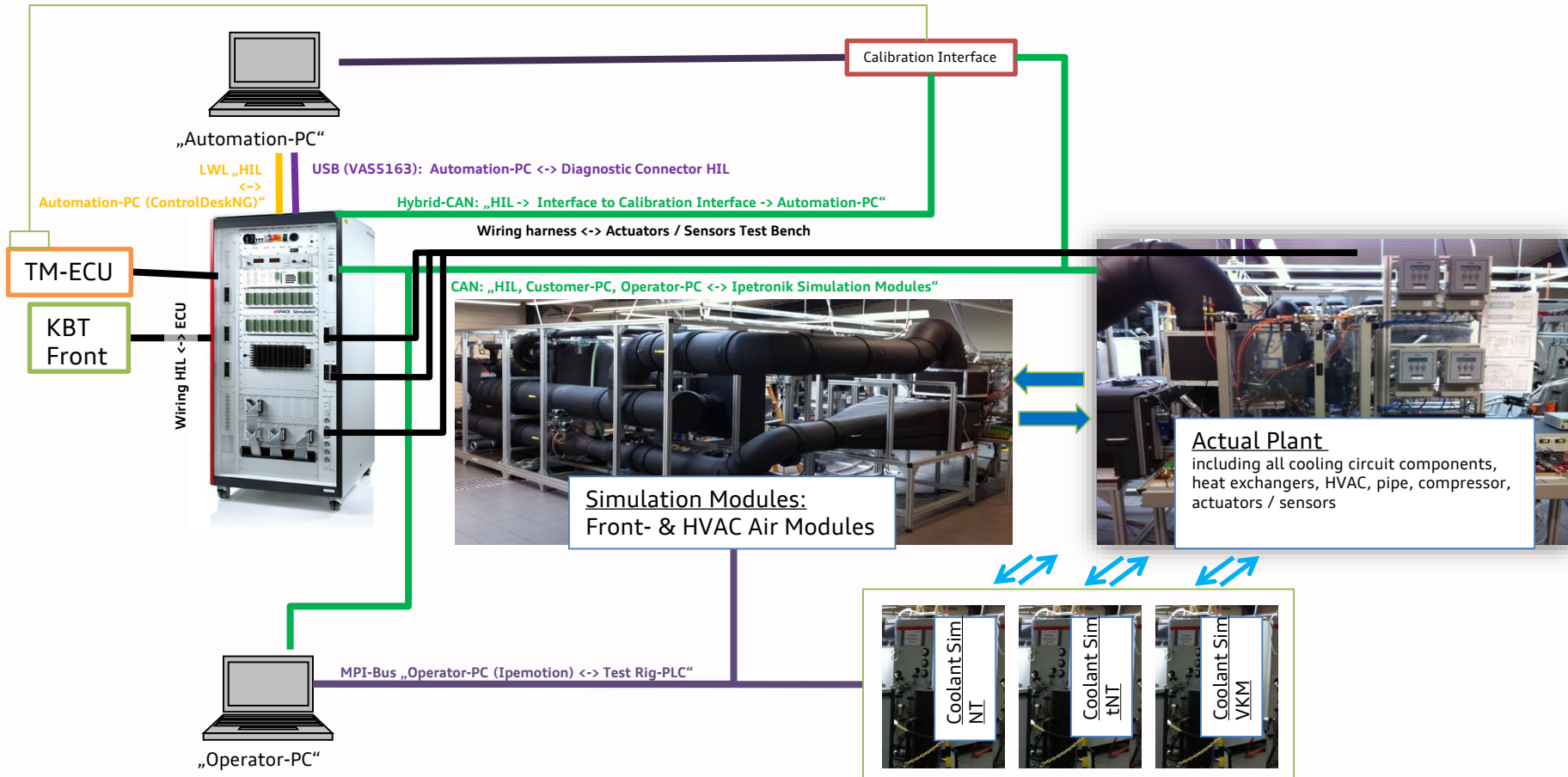
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THERMAL MANAGEMENT TEST RIG: OVERVIEW

Test Rig: System HiL

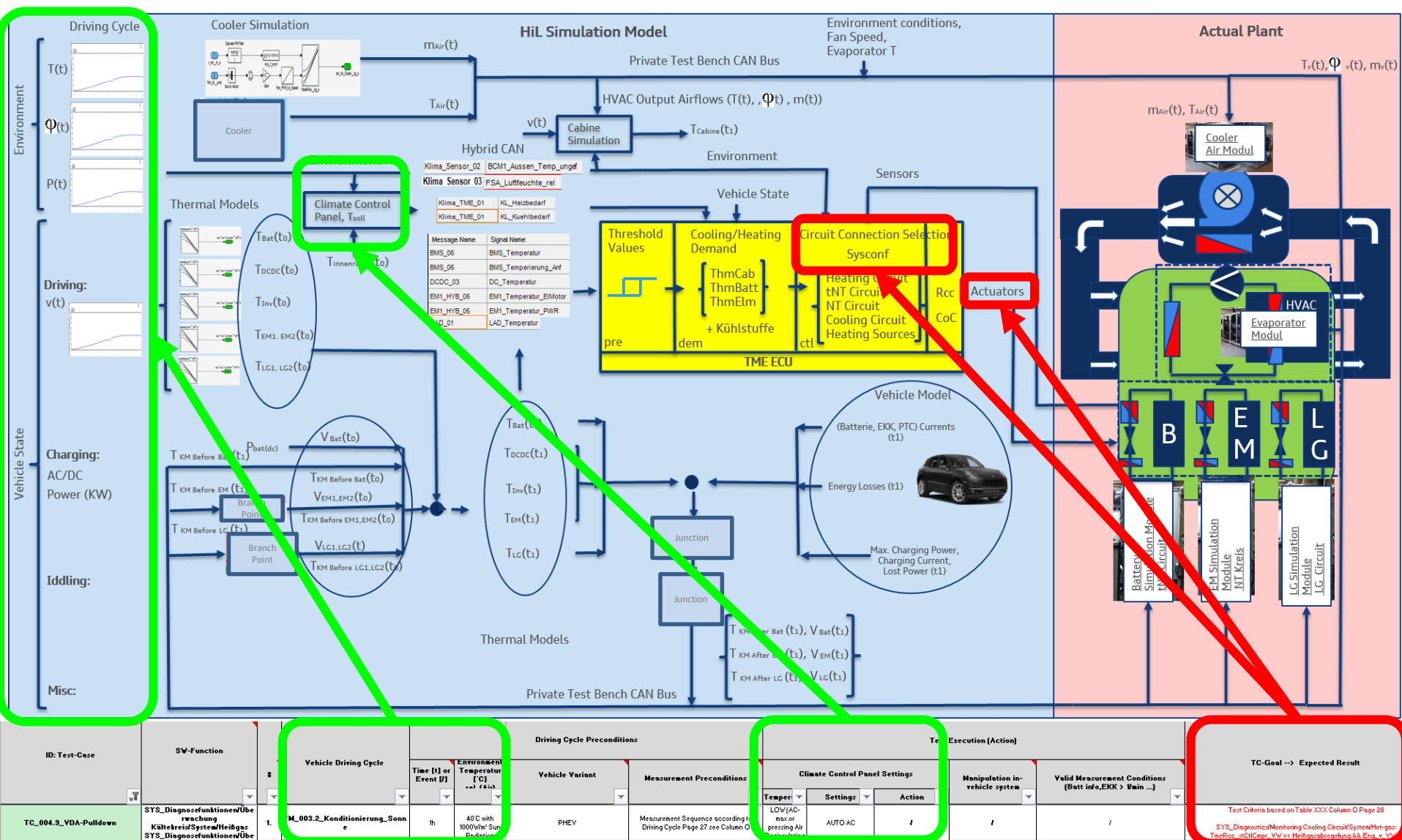
POD-Interface (XCP-on-Ethernet): „TME-ECU <-> VX1131“



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TEST REQUIREMENTS: VEHICLE DRIVING CYCLES AND EXPECTED SYSTEM RESPONSE



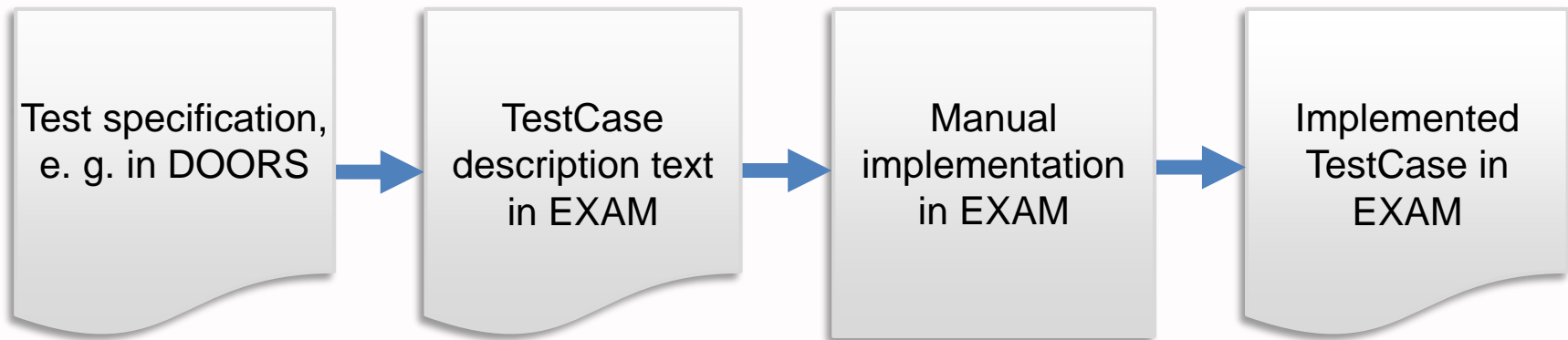
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KEYWORD-DRIVEN TEST TOOL: TEST CASE GENERATOR

Workflow without Test Case Generator

Test cases are implemented manually, according to Test Specifications



Problems:

- Data Maintenance necessary in Several Places
- Slow, error-prone manual Implementation
- High Variance in Implementation

Automatic Generation of Test Cases

Test Specification

Precondition:

10. Ignition on

Action:

20. Stop Sending 'FRA::ESP_21'

30. Wait for DTC '40004' active 20s

Postcondition:

40. Ignition off


Expected Result:


30. Check DTC '40004' active


Operation Mapping

String from Testspec → EXAM Operation

„Ignition on“ →  Switch_ignition_on

„Klemme 15 an“ →  Switch_ignition_on

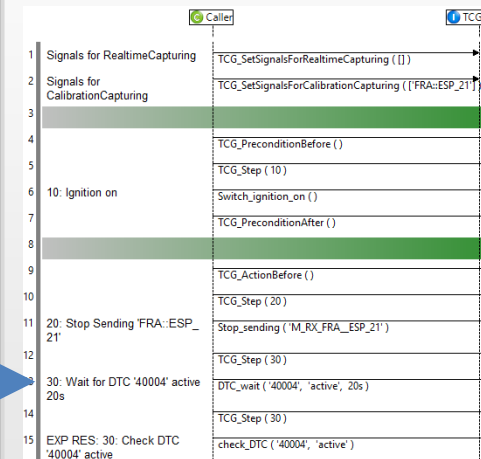
„Stop Sending %1“ →  Stop_sending

„Wait for DTC %1 %2 %3“ →  DTC_wait

...

Sequence Diagram

Generated, executable
TestCase



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USE CASE: PULL-DOWN

Pull-Down: SPEC

Thermomanagement Testspezifikation HIL' aktuell 0.3 in /MLBevo_TME-Sys/03_Software/020 Funktionsspezifikation/Vorlagen/TestUmg/Tme_Hil/80_... DE Deutsch (Deutschland) ? Hilfe JS									
Datei Bearbeiten Anzeigen Erstellen Link Analyse Tabelle Tools Diskussionen Benutzer User Utilities Support Utilities Änderungsmanagement Hilfe									
Anzeigen 47 TCG Sequence Alle Ebenen Langsames Blättern									
Thermomanagement Testspezifikation 1 Pulldown TC_004p9_VDA_Pulldown_									
DOORS ID	Type of Object	Status Specification	AU: Ruppert, Marianne (I/EK-412	Test Case Description	Sequence	Related Projects	Test Level	Test Prio	
169	Heading	not yet specified	1 Pulldown			tbd	tbd	tbd	
171	Testcase	not yet specified	TC_004p9_VDA_Pulldown_Auslegung	Constant speed drive on E-Mode followed by iddling and back to constant speed drive on E-Mode	<p>Precondition:</p> <p>10: Execute Pre_DrivingCycle with the following input parameters 8 and VOKO</p> <p>20: Set Environment Temperatur = 40</p> <p>Action:</p> <p>30: Set sun radiation to 100 W/m²</p> <p>40: Set Status Operation Mode to 6 (Ignition ON)</p> <p>50: Turn Climate control on</p> <p>60: Climate control set to Auto Mode</p> <p>70: Set HVAC Fan to 0 level</p> <p>80: Set climate control panel to MAX temperature</p> <p>90: Check if StateOfCharge of the Battery = 100%</p> <p>100: Start Measurement</p> <p>110: Start Drive Mode, accelerate and keep speed to 32 Km/h</p> <p>120: Start timer with input parameters (1800 s, "evaporator", 180 s)</p> <p>130: Start Drive Mode and stay on iddle 0 Km/h</p> <p>140: Start timer with input parameters (900 s, "evaporator", 180 s)</p> <p>150: Start Drive Mode, accelerate and keep speed to 60 Km/h</p> <p>160: Start timer with input parameters (600 s, "evaporator", 180 s)</p> <p>Postcondition:</p> <p>170: Stop measurement</p> <p>180: Set back initial conditions</p> <p>Expected Result:</p>	MLBevo	Level 2b Secondary	tbd	

Pull-Down: Test Case Description

"Latest" Configuration used by Migration - EXAM - Note: Confidential Data

File Edit Navigate Search Window Help

The screenshot displays the UCAAT software interface. On the left is the 'Model Browser' tree, showing a hierarchy of test cases. The selected item is 'TC_004p9_VDA_Pulldown_Auslegung' under the 'UCAAT2019' project. The main area shows the 'Beschreibung' (Description) tab of the test case. The description is written in German and includes sections for 'Precondition:', 'Action:', 'Postcondition:', and 'Expected Result:'. The 'Action:' section lists a sequence of steps from 10 to 160, detailing driving cycles and climate control settings. The 'Postcondition:' section includes steps 170 and 180. The 'Expected Result:' section is currently empty. The interface also features a top menu bar, a toolbar, and a right-hand 'Outline' pane which states 'An outline is not available.'

Model Browser

- EXAMMODTMEHIL
 - _0_tooling
 - _1_library
 - _TestCaseGenerator [Main->2v2(Read Only)]
 - CreatedByMigration [Main->Latest]
 - _3_mapping
 - _4_commonLib
 - _4_usrCommonLib
 - _5_0_productiveTestbenchLib
 - _5_1_implementationTestbenchLib
 - _5_testbenchLib
 - _6_projectsLib
 - _7_projects
 - _8_testbenchEvaluation
 - lostAndFound
 - sandbox
 - _EXAM_Anwender
 - _EXAM_Anwender_1
 - _EXAM_EigenEntwicklung
 - _EXAM_EigenEntwicklung_1
 - _AU
 - _SK
 - _VW
 - UCAAT2019
 - _usrMapping
 - PulldownOperationMapping.opm
 - Pulldown
 - TC_004p9_VDA_Pulldown_Auslegung
 - SynchronizerTrash
 - templates
 - deprecated
 - EXAMples

Properties | Search | Log | Local Change | Favorites | Problems | History | Progress | Groovy Problems | Console

General | **Beschreibung** | Details | Stereotypes | Relations | Assigned Rights | Effective Rights

Description

Precondition:

10: Execute Pre_DrivingCycle with the following input parameters 8 and VOKO
20: Set Environment Temperatur = 40

Action:

30: Set sun radiation to 100 W/m²
40: Set Status Operation Mode to 6 (Ignition ON)
50: Turn Climate control on
60: Climate control set to Auto Mode
70: Set HVAC Fan to 0 level
80: Set climate control panel to MAX temperature
90: Check if StateOfCharge of the Battery = 100 %
100: Start Measurement
110: Start Drive Mode, accelerate and keep speed to 32 Km/h
120: Start timer with input parameters (1800 s, "evaporator", 180 s)
130: Start Drive Mode and stay on iddle 0 Km/h
140: Start timer with input parameters (900 s, "evaporator", 180 s)
150: Start Drive Mode, accelerate and keep speed to 60 Km/h
160: Start timer with input parameters (600 s, "evaporator", 180 s)

Postcondition:

170: Stop measurement
180: Set back initial conditions

Expected Result:

Description | Beschreibung | History

Pull-Down: Mapping

"Latest" Configuration used by Migration - EXAM - Note: Confidential Data

File Edit Navigate Search Window Help

Link Search go

TestCase Generator Browser EXAMMODTMEHIL

PulldownOperationMapping

Name	Column2	Column3
UmgebungstemperaturEinstellen		
SonnenstrahlungEinstellen		
StOpmEinstellen		
KBT_ON_OFF		
ON_OFF		
Expressions		
	Turn Climate control %1	
MessungStarten		
Expressions		
	Start Measurement	
FzgStarten_FzgV_einstellen		
FzgV		
Placeholder	%1	
DefaultValue		
DefaultShortname		
Unit		
TX/RX		
Expressions		
	Start Drive Mode, accelerate and keep speed to %1 Km/h	
	Start Drive Mode and stay on iddle %1 Km/h	
Fahrmanoeuver_TimerStarten		
MessungStoppen		
Ruecksetzen		
KBT_Auto_or_OFF		

Properties Log Local Change Favorites Problems Progress Search

Property	Value

Pull-Down: Test Case Generation

"Latest" Configuration used by Migration - EXAM - Note: Confidential Data

File Edit Navigate Search Window Help

Link Search go

Model Browser

- EXAMMODTMEHIL
 - _0_tooling
 - _1_library
 - _TestCaseGenerator [Ma
 - CreatedByMigration [Ma
 - _3_mapping
 - _4_commonLib
 - _4_usrCommonLib
 - _5_0_productiveTestb
 - _5_1_implementation
 - _5_testbenchLib
 - _6_projectsLib
 - _7_projects
 - _8_testbenchEvaluati
 - lostAndFound
 - sandbox
 - _EXAM_Anwender
 - _EXAM_Anwender
 - _EXAM_EigenEntv
 - _EXAM_EigenEntv
 - _AU
 - _SK
 - _VW
 - UCAAT2019
 - _usrMapping
 - PulldownOp
 - Pulldown
 - TC_004p9_VDA_Pulldown_Auslegung
 - SynchronizerTrash
 - templates
 - deprecated
 - EXAMples

New

Open

Open In

Show In

Publish... Ctrl+Shift+P

Discard...

Restore Deleted...

History View Ctrl+Shift+H

Refresh F5

Cut Ctrl+X

Copy Ctrl+C

Copy Link Ctrl+Alt+C

Paste Ctrl+V

Delete

TestCase Generator

Generate Implementation...

Update Shortname Mapping

Search for Results

Update

MultiEdit

Refactor

Export

Import

Run Applicable Script

Classification Value Attribution...

ReportUsage Ctrl+U

Assigned Rights

Effective Rights

Beschreibung

Tahoma 10 B I U

Precondition:

10: Execute Pre_DrivingCycle with the following input parameters 8 and VOKO

20: Set Environment Temperatur = 40

Action:

30: Set sun radiation to 100 W/m²

40: Set Status Operation Mode to 6 (Ignition ON)

50: Turn Climate control on

60: Climate control set to Auto Mode

70: Set HVAC Fan to 0 level

80: Set climate control panel to MAX temperature

90: Check if StateOfCharge of the Battery = 100 %

100: Start Measurement

Description Beschreibung History

Pull-Down: Test Case

“Latest” Configuration used by Migration - EXAM - Note: Confidential Data

File Edit Navigate Search Window Help

The screenshot displays the UCAAT software interface. On the left is the **Model Browser** showing a project tree with folders like `_5_1_implementationTestbenchLib`, `_5_testbenchLib`, `_6_projectsLib`, `_7_projects`, `_8_testbenchEvaluation`, `lostAndFound`, and `sandbox`. Under `sandbox`, there's `_EXAM_Anwender` containing `EE65_Intern` and `InteraktivesTesten`. `InteraktivesTesten` includes `AndiGrimm`, `BettinaSieber`, `Calculator`, `Pulldown` (with `TC_004p9_VDA_Pulldown_Auslegung_Orig`, `TC_004p9_VDA_Pulldown_Auslegung_TCG`, and `TC_004p9_VDA_Pulldown_Auslegung_TCG_Sync`), `TC_11_4_Laden_max_plus_VOKO`, and `TestCaseGenerator`. Other folders include `MarkusWiedholz`, `_EXAM_Anwender_1`, `_EXAM_EigenEntwicklung`, `_EXAM_EigenEntwicklung_1`, `_AU`, `_SK`, `_VW`, `UCAAT2019` (with `_usrMapping`), `PulldownOperationMapping.opm`, `Pulldown` (with `TC_004p9_VDA_Pulldown_Auslegung`), `SynchronizerTrash`, `templates`, and `deprecated`.

The main area shows a sequence diagram titled `PulldownOperationMapping`. It has participants `Caller`, `TCG_TestFrame`, and `Fahrmanoe`. The diagram steps are:

- 1 Signals for RealtimeCapturing: `TCG_SetSignalsForRealtimeCapturing ()`
- 2 Signals for CalibrationCapturing: `TCG_SetSignalsForCalibrationCapturing ()`
- 3 (Green bar)
- 4 `TCG_PreconditionBefore ()`
- 5 `TCG_Step (10)`
- 6 10: Führe Pre_Fahrmanoeuver mit Argumente 8 und VOKO aus: `Pre_Fahrmanoeuver ('8', 'VOKO')`
- 7 `TCG_Step (20)`
- 8 20: Stelle Umgebungstemperatur = 40 ein: `UmgebungstemperaturEinstellen ('40', '=')`
- 9 `TCG_PreconditionAfter ()`
- 10 (Green bar)
- 11 `TCG_ActionBefore ()`
- 12 `TCG_Step (30)`
- 13 30: Stelle

 Blue boxes highlight steps 6 and 8. Blue arrows point from the `Precondition:` section of the details pane to these steps.

The **Properties** pane on the right shows details for the selected element:

- General**: `Beschreibung`
- Description**: `Tahoma`
- Details**:
 - Precondition:**

10: Execute Pre_DrivingCycle with the following input parameters 8 and VOKO
20: Set Environment Temperatur = 40
 - Action:**

30: Set sun radiation to 100 W/m²
40: Set Status Operation Mode to 6 (Ignition ON)
50: Turn Climate control on
- Relations**
- Assigned Rights**
- Effective Rights**

The bottom of the interface includes a **Search** bar, **Log**, **Local Change**, **Favorites**, **Problems**, **History**, **Progress**, **Groovy Problems**, and **Console**.

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CONCLUSIONS: ADDED VALUES

Key Take Aways

- Increasing SW Complexity drives the adoption of new Test Methods such as Keyword Driven Testing
- Provides an excellent Common Ground for cross functional Cooperation within the Organization
- The Usage of Test Case Generation sets the first Milestone for a well defined and structured Software Validation Process
- Automatic Test Case Generation raises Productivity and Quality Standards while reducing Time to Market



Thank you for your attention!
Q&A Time!

Time for Questions and hopefully also
for some Answers...

Special Thanks to our Colleagues from Audi (EK-4, EE-I3) and dSPACE!!!