



CAMEO 5

How to Verify and Validate Software Functions



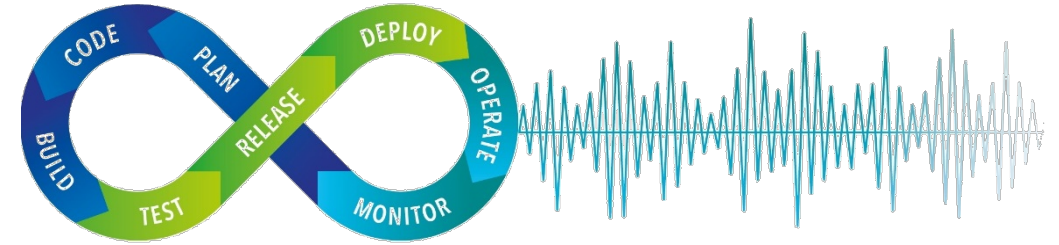
Why Functional Testing?

Transformation of Vehicle Development

Hardware-centric development process



Software-centric development process (DevOps)



Calibration & opt Functional testing

 Simulation

 HiL

 Test Bed  Road

Dedicated tests for dedica Any test on any environment

Defined testing dates (Continuous, automatic test










Verification

(aka "**Functional Testing**" or "**Requirements-based testing**")

Verification is the process of checking that the specifications are met

Real practical test case **example**

Example

Pre-condition	Perform pre-condition steps e.g. initializing measurement tools,...
 Check DTCs	Check/Clear DTCs Generate vehicle scan report with dedicated tools
 Understand Test Case	Read and understand the test case procedure
 Start Measurement	Start measurement
 Request <vehicle speed>	Tester must inject the corresponding fault
 Inject Fault	Inject fault (HW/CAN signal manipulation, calibration change,...)
 Request <Key Cycle>	Command driver to operate vehicle: e.g. provoke healing, vehicle restart,...
 Stop Measurement	Stop measurement
 Check DTCs and Perform Analysis	Generate vehicle scan report Perform required analyses for test checklist.
 Request Driver Comments	Request driver comments on test case.
Post-condition	Check if test was done correct Setup test report Prepare for next test

Drawbacks:

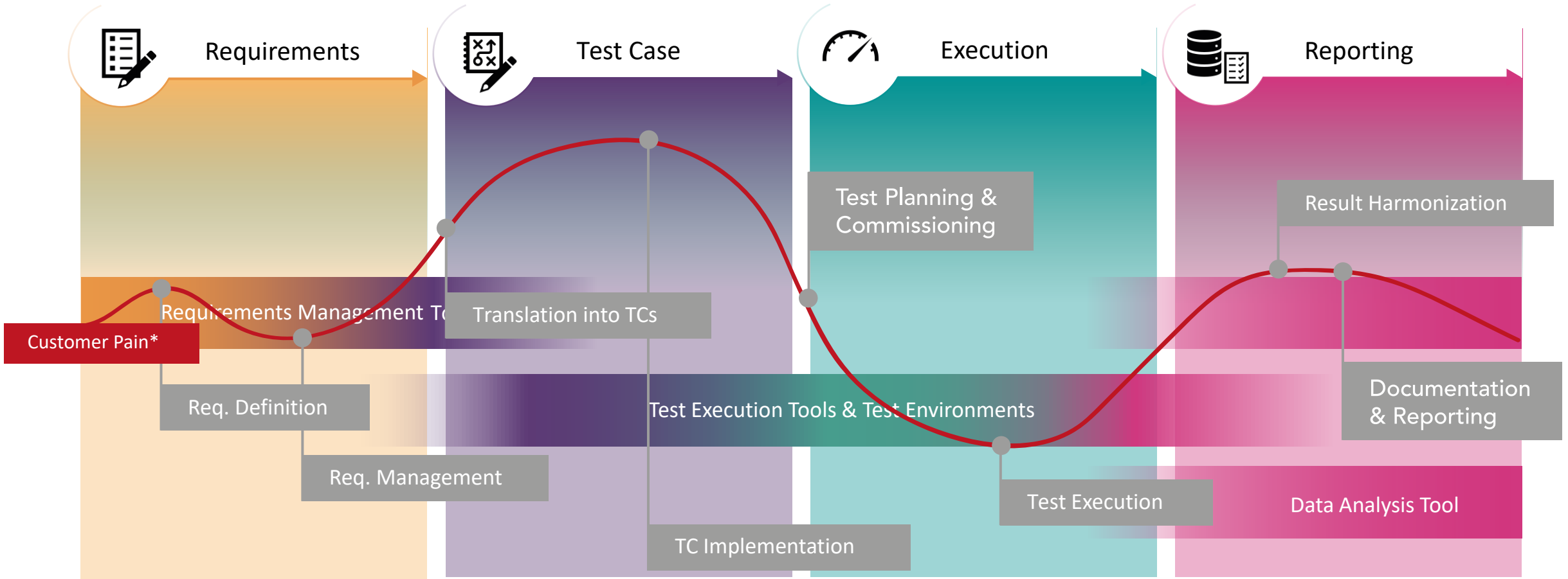
- Typical 2 persons are requested to perform such kind of tests in vehicle
- A high qualified tester is required
- No feedback during testing (i.e. did I perform the test correct?)
- Always a painful post processing is mandatory
- ...

Functional safety (safety functions)

Test type	Driving speed	Short description	Additional info	Description	Remarks
CAN Corruption C1	Low speed (creep)	TRANSM1 (0x104) Trans_ Limhome_ Faults	Fault value: 1	<ul style="list-style-type: none">_ PRNDL = P, key ON to RUN_ Start Data Collection_ Apply brake, key ON to START, PRNDL = D_ Accel to creep speed_ Action: Inject fault on CAN message and note reactions_ record data for 10 sec after action_ Decel to 0 mph in ~6 sec_ PRNDL = P_ key OFF_ key ON to START_ Did the vehicle restart?_ PRNDL = D_ Drive vehicle and note gear shifting_ Decel to 0 mph_ PRNDL = P_ End Data Collection_ Clear codes, key OFF	A simple CAN corruption test case where the specified signal's value is modified to the desired value. The fault is inserted in the CAN network in a way that only one ECU gets the corrupted value.

~ 1800 tests

Functional Testing Workflow



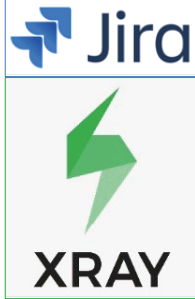
OEM:
60% of whole process
only for test case implementation

*Result of several activities over 18 months
(customer interviews, quantitative surves (internal), company wide workshops)

Seamless Testing over Test Environments

Test Management

*not complete



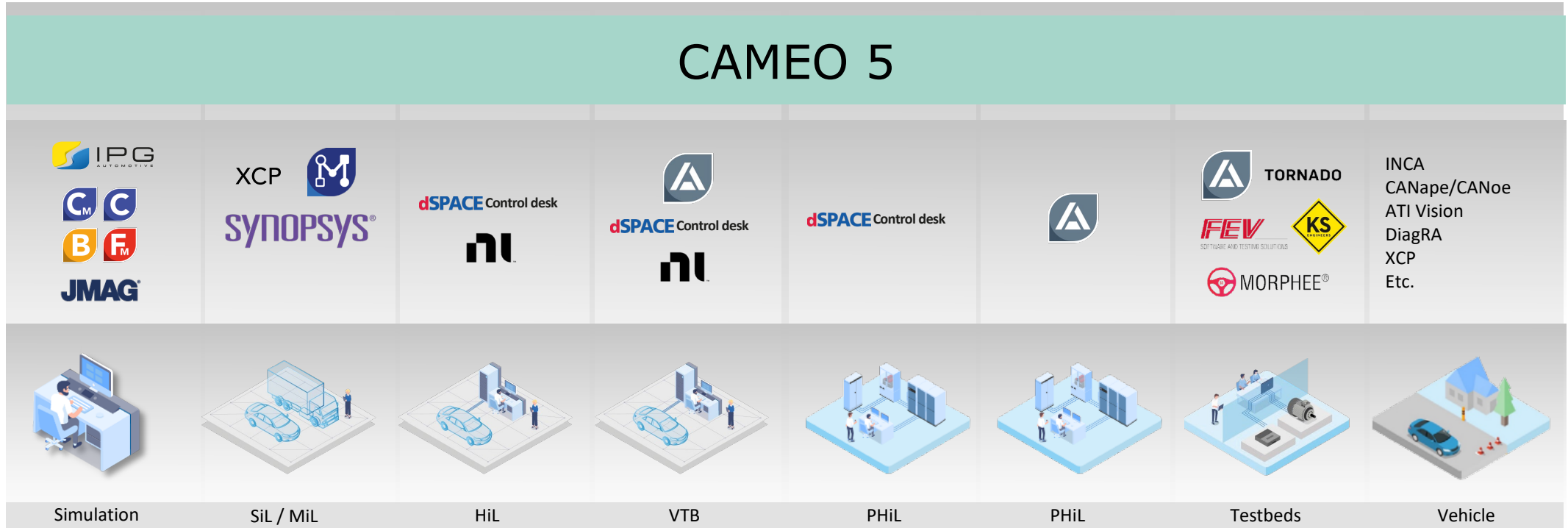
DevOps Integration



Test Control/
Test Sequencing/
Intelligent Testing

Application/ Operating
System/ Test
Automation
*not complete

Environments
*not complete

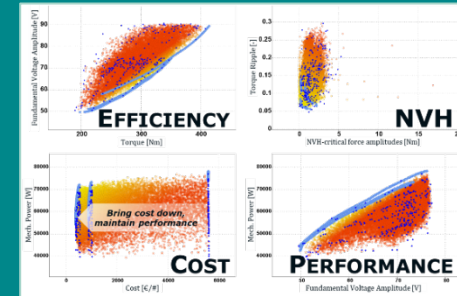


Seamless Testing Over Testing Types

Calibration & Optimization

Trade-offs, Optimize, Improvement, Tuning

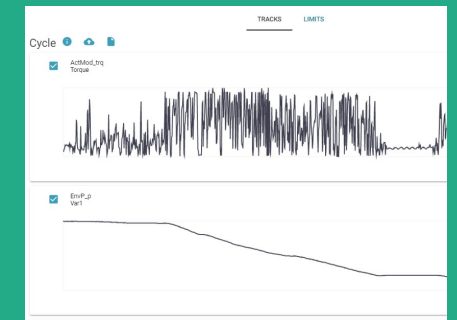
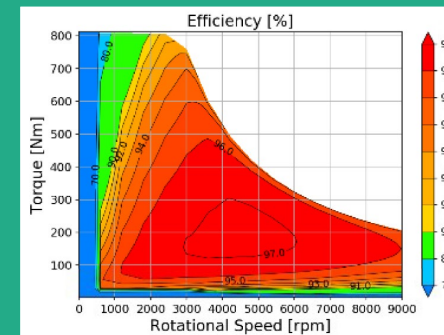
- Optimize Efficiency
- Extend Range
- Increase Power
- Optimize Hardware
- **Example:** E-Motor & Inverter combined Efficiency vs. NVH vs. De-Rating



Validation

Validation is the process of checking whether the specification captures the end-customer's requirements

- Targets Reached?
- Still Improvable?
- Satisfying?
- **Example:** Cooling system and calibration sufficient; E-Drive Torque & Power



Verification

(aka "Functional Testing" or "Requirements-based" testing)

Verification is the process of checking that the specifications are met

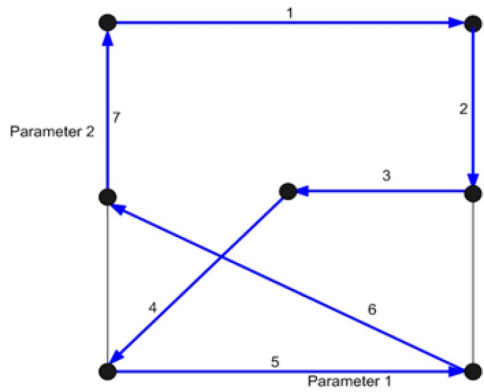
- Fixed Steps
- Fixed Values
- Yes / No
- Failed / Passed
- **Example:** SOTIF, ISO 26262

Key	Fix Version/s	Revision	Executed By	Started	Finished	Defects	Status
CAMEO-60872	CAMEO_4R4		Rosegger, Max AVL/IAT	28/07/2022 12:26	28/07/2022 12:28		PASS
CAMEO-60871	CAMEO_4R4		Rosegger, Max AVL/IAT	28/07/2022 12:12	28/07/2022 12:14		FAIL
CAMEO-60870	CAMEO_4R4		Rosegger, Max AVL/IAT	28/07/2022 11:37	28/07/2022 11:40		FAIL
CAMEO-60869	CAMEO_4R4		Rosegger, Max AVL/IAT	28/07/2022 10:59	28/07/2022 12:13		PASS
CAMEO-60868	CAMEO_4R4		Rosegger, Max AVL/IAT	28/07/2022 10:50	28/07/2022 12:13		PASS
CAMEO-60867	CAMEO_4R4		Rosegger, Max AVL/IAT	28/07/2022 10:46	28/07/2022 12:13		PASS

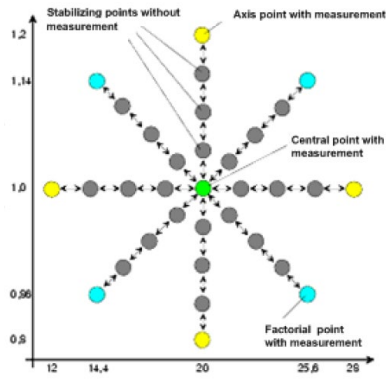
Advanced Testing

NEW Intelligent Testing Types

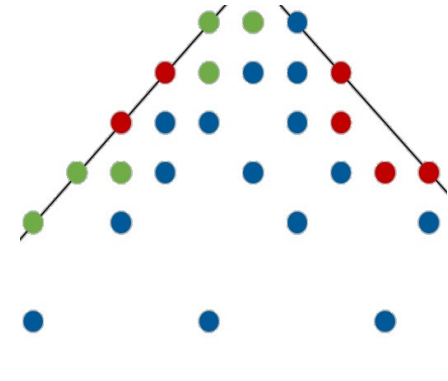
DoE List



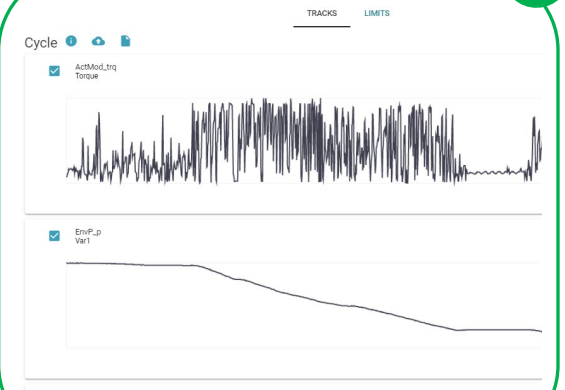
Screening



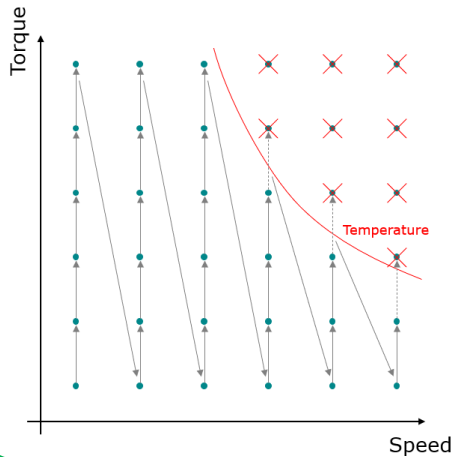
Active DoE



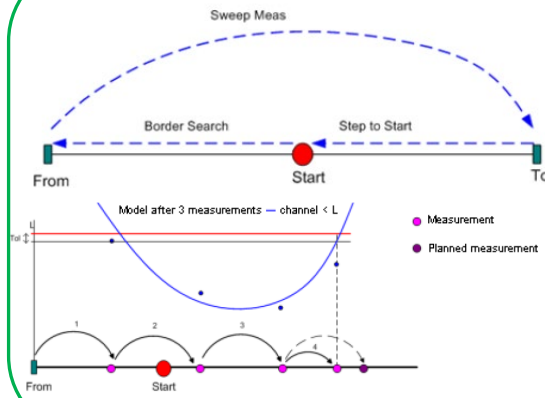
Cycle Testing



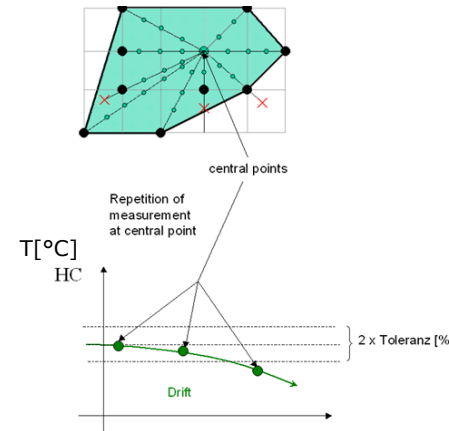
Full Factorial



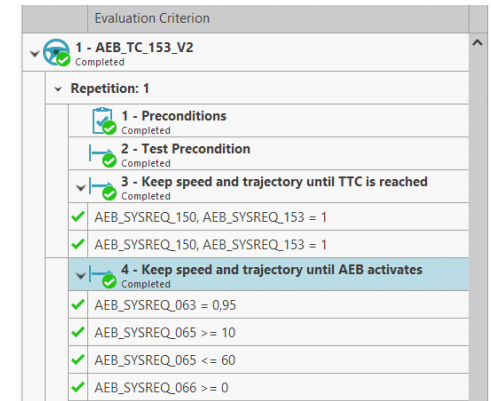
Flex Sweep



Tolerance Check



Functional Testing





Functional Testing in CAMEO



LIVE DEMO



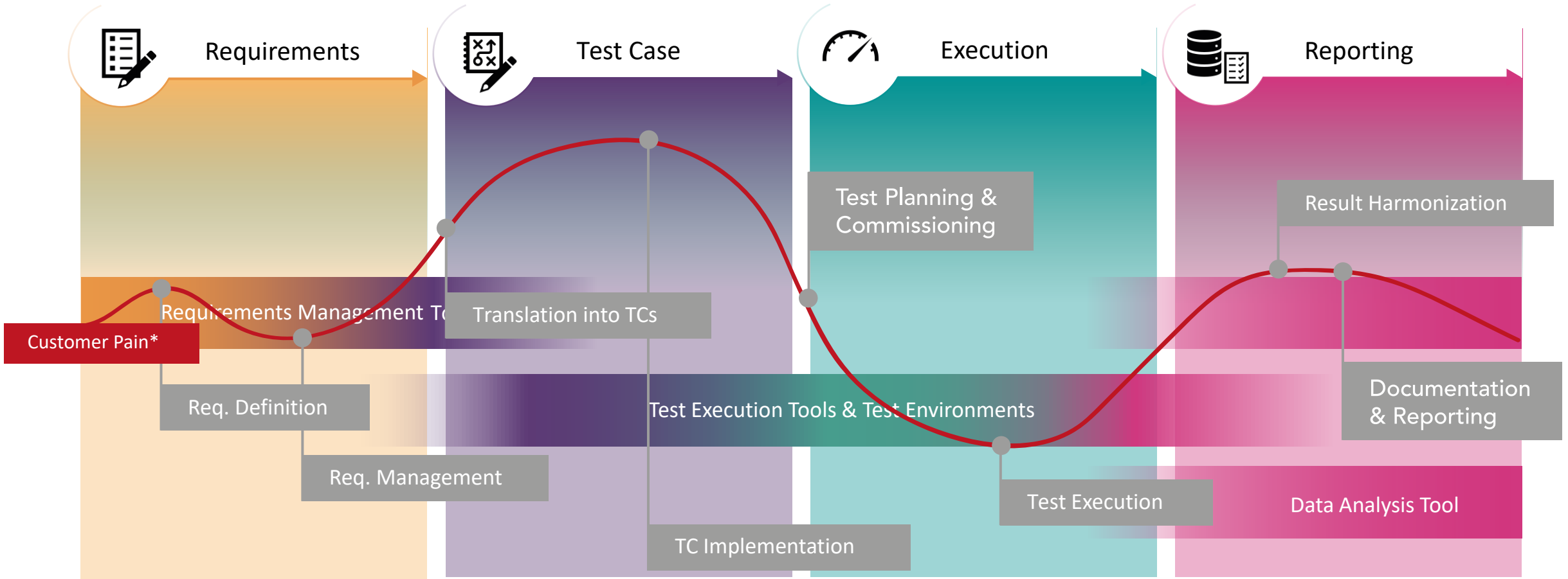
Test case generation

Functional safety (safety functions)

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Functional Testing Workflow



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Example: Test Creation from Prose Functional Test Requirements Exported from CODEBEAMER

CODEBEAMER exported .XLS: Prose Text Test Definitions

ID	Prio	Header	State	Type	Validation
100	Normal	Torque Interface	n/a	Folder	
200	Normal	Testcases	n/a	Folder	
201	Normal	Motor demand torque write	OK	Functional	Motor Demand Torque write signal
					Demand motor torque in Nm
					Send demand motor torque
					Send demand motor torque with 10ms
300	Normal	Electric Mode	n/a	Folder	
301	Normal	Testcases	n/a	Folder	
310	Normal	Low SOC limit vehicle speed	OK	Functional	Low SOC limit vehicle speed
478	Normal	Driver demand motoring torque equivalent to function motoring torque	OK	Functional	Reduced motoring torque set Reduced motoring torque = demand motoring torque
676	Normal	Calc axle demand torque with system limits	OK	Functional	Calc axle demand torque with system limits

Test with identified Steps, Parameters and Validations

Maneuver selection x Results SimulationRange Channels Maneuver execution

Root Directory: D:\CAMEO42\Data\20230329 SMS FT Codebeamer Test Interpretation Heindl

Nr. of Testruns: 1 Continue Autom.

Import, Interpretation & Auto Test Creation

- CodeBeamerImportTest2
 - Torque Interface
 - Motor demand torque write ID_201(4)
 - Electric Mode
 - Low SOC limit vehicle speed ID_310(10)
 - Driver demand motoring torque equivalent to function motoring torque ID_478(11)
 - Calc axle demand torque with system limits ID_676(13)

Whole Maneuver

Low SOC limit vehicle speed ID_310(10)

SATISFIED IF
Satisfied when last step is completed.

VIOLATED IF (one of 0) + x
Drag criteria here...

SKIP IF (one of 0) + x
Drag criteria here...

Postprocessing: **EVALUATE (0)** + x
Drag criteria here...

Postprocessing: **MONITOR (0)** + x
Drag criteria here...

Steps + x ↑ ↓ ↕ ↕

- 1 - Set BMS_LBE = -40
- 2 - BMS_MX_SOC = 95
- 3 - BMS_MN_SOC = 1
- 4 - Actuate Brake
- 5 - DriveMode D
- 6 - Release Brake DriverSOP_Bat_XW
- 7 - When DriverSOP_veh_vLimit_XW == true: HVSys_POWLim_XW = 1

Example: Test Creation from Prose Functional Test Requirements Exported from CODEBEAMER

Create Library Modules and Replace unidentifiable Instructions

Steps

- (X) 1 - Actuate Brake
- 2 - Wait Step

Use Library Module Names directly in Future Requirements

General

Low SOC limit vehicle speed ID_310(10)

Actuate Brake and Wait

SATISFIED IF
Satisfied when last step is completed.

VIOLATED IF (one of 0) + X
Drag criteria here...

SKIP IF (one of 0)
Drag criteria here...

Postprocessing: EVALUATE (0) + X
Drag criteria here...

Postprocessing: MONITOR (0) + X
Drag criteria here...

Steps

- 1 - Set BMS_LBE = -40
- 2 - BMS_MX_SOC = 95
- 3 - BMS_MN_SOC = 1
- ~~4 - Actuate Brake~~
- 5 - Actuate Brake and Wait
- 6 - DriveMode D
- 7 - Release Brake DriverSOP_Bat_YW

1	ID	Prio	Header	State	Type	Validation	Action
14							A*_2: Brake to standstill*, Engage DriveMode C, Accelerate to 1:
15	1000	Normal	Driveability		Folder		
16	1001	Normal	Testcases		Folder		
17	1010	Normal	Check Brake Light	OK	Functional	Check Brakelight	A_1: Actuate Brake and Wait A_2: Release Brake (BrkPed_ActLg = 0)
18							



LIVE DEMO



Integration of CAMEO into CI/CD Toolchain

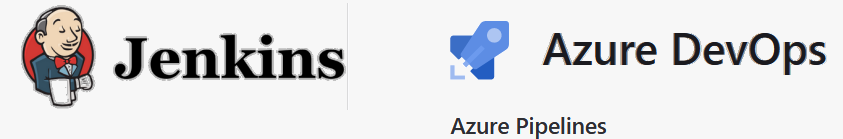
Functional Testing CI/CD DevOps Toolchain Layer Overview

Examples

Software Lifecycle & DevOps Tools



Software Test Automation



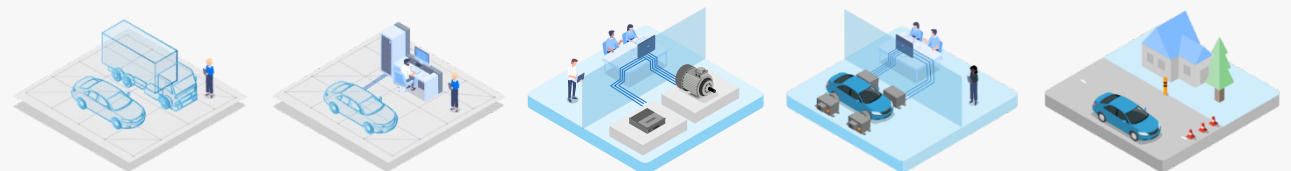
Automotive Unified Test Execution



Automotive Automation & CoSim Systems



Automotive Test Environments



Functional Testing CI/CD Toolchain Integration

PLM/RLM



- Select Scenario Outline
- Select Variables
- Schedule Multiple Tests

```

Test Details
Type: Cucumber
Scenario Outline
Given the UUT temperature is at <UUT temperature>
And the brake fluid level is <Brake fluid level>
And the road gradient is <Road gradient>
When brake fluid level has been measured
Then the displayed message should be <Display message>

Examples:
| UUT temperature | Brake fluid level | Road gradient | Display message |
| 30               | Low               | Flat         | Low             |
| 55               | OK                | Flat         | OK              |
| 80               | Low               | Inclined    | OK              |
| 100              | OK                | Inclined    | OK              |
    
```

- Result Creation
- Report Attachment

Level	Duration	Status
-	-	PASS
-	-	PASS
-	-	FAIL
-	-	PASS

Test Automation

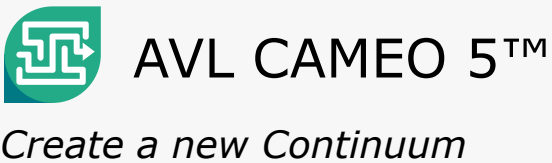


- Select Agent (CAMEO PC)
- Value Transfer
- Call Sequence Setup & Execution

Get test settings from XRAY test instances

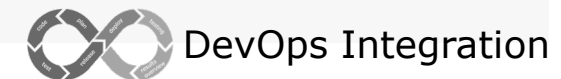
Return test success/fail status

Test Execution



- Test Sequence Generation with Selected Tests & Parameters
- Test Sequence Execution

n Machines





LIVE DEMO



Thank you!

A digital business card for Marijn Hollander is centered on the right side of the slide. It features a circular profile picture of a man with short hair and a beard, wearing a light-colored shirt. Below the photo, the name "Marijn Hollander" is written in a bold, white font. Underneath the name, the title "Senior Group Product Manager | Advanced Optimization & Testing" is displayed in a smaller, white font. At the bottom of the card is a large, square QR code. The entire card is set against a dark grey background with rounded corners, which is itself centered on a black rectangular area.

Thank you



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