



TECHNISCHE UNIVERSITÄT
CHEMNITZ

Faculty of Computer Science
Professorship Computer Engineering

An Educational Platform for Automotive Software Development and Test

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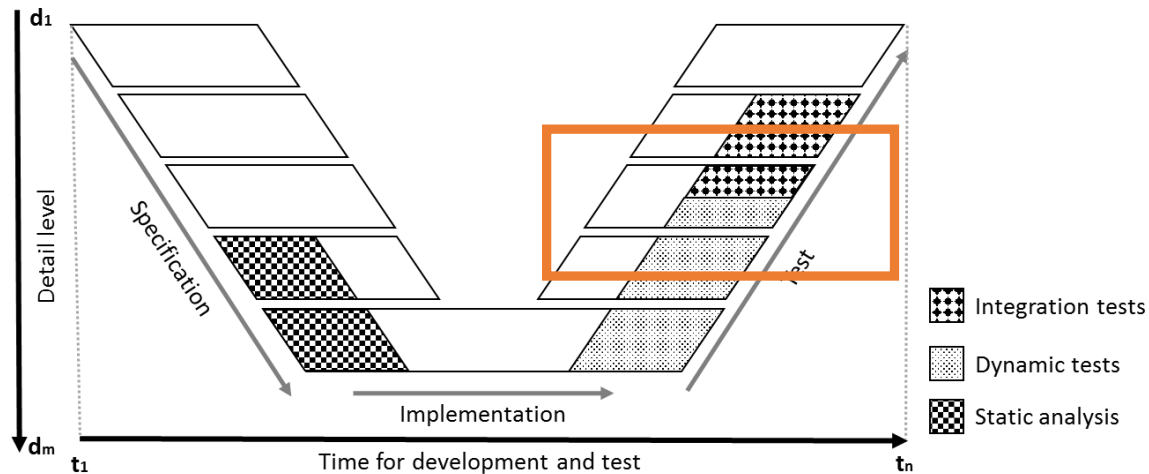
Online, 9th November 2020

Current Situation

- Development of functionality independent from target platform
- Heterogeneous tool environment for ECU development
- Tests cannot ensure functionality without errors
- Costly search of problems in data of test drives
- Support of regular teaching, like active learning units, lecture, online units, etc. with specific tools for software development and test

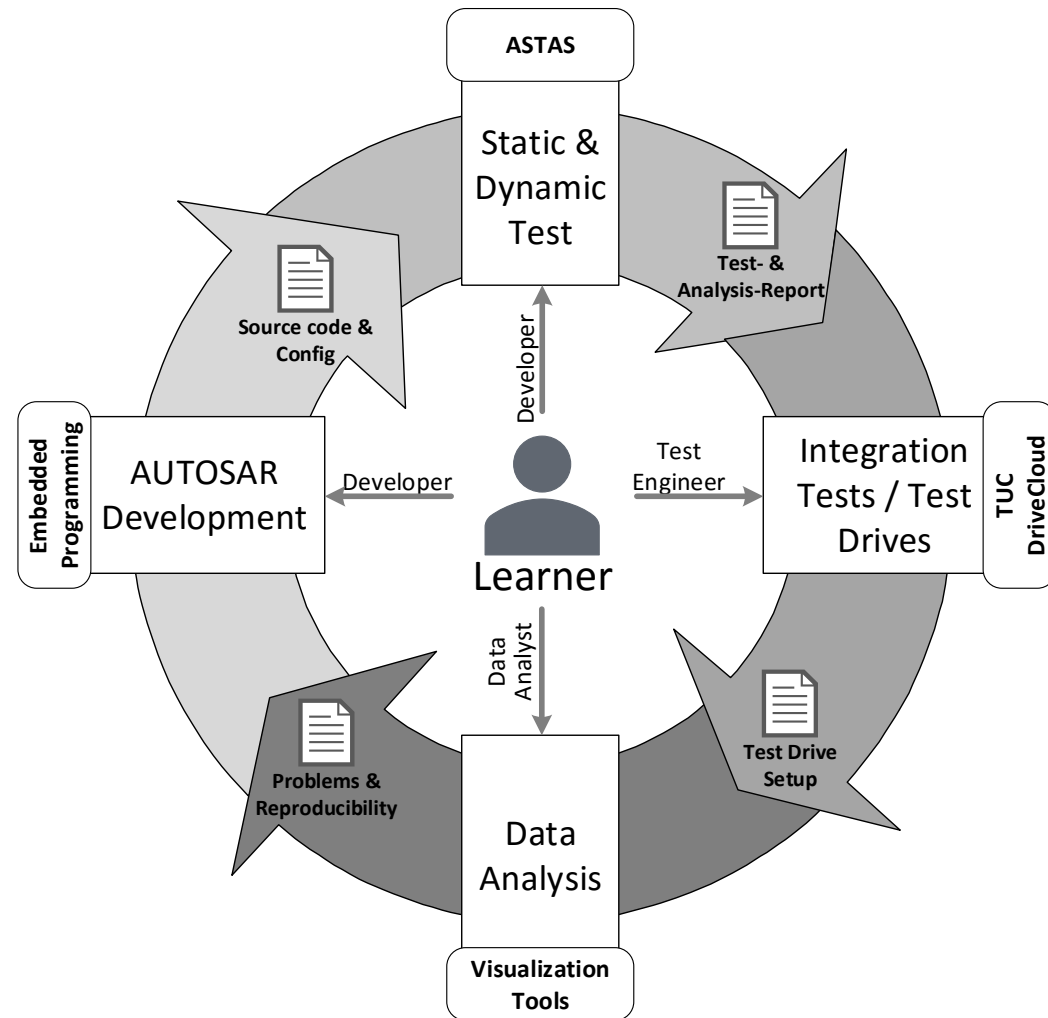
- **Goals:**

- Easy to use for students
- supporting ECU development and test
- Industry near approach



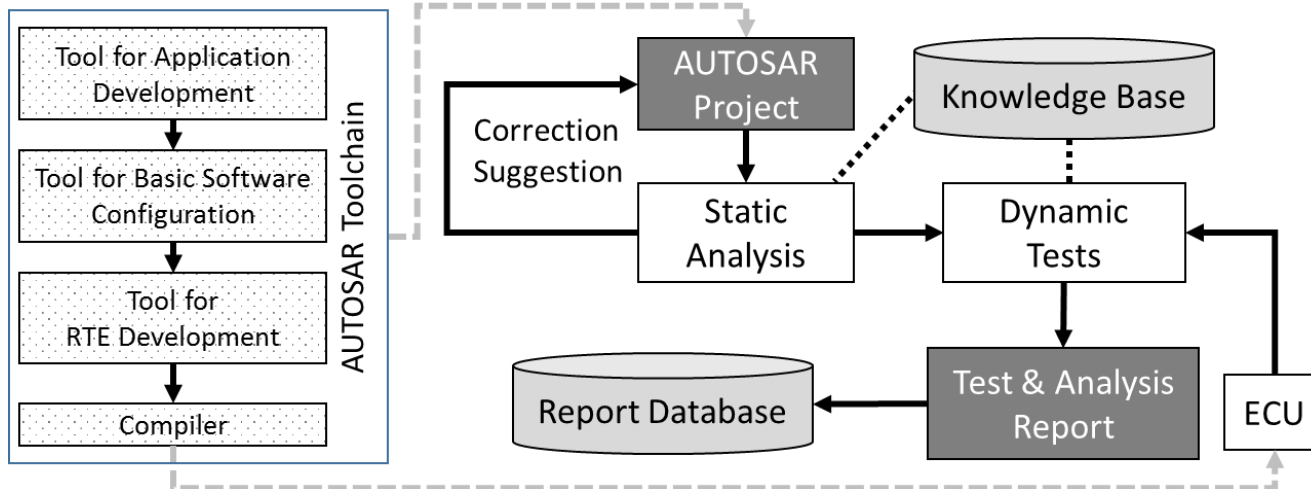
Development Process – Roles of Learners

- Topics Embedded engineering, test and test drive
- Learners can have three roles
 - Developer
 - Test Engineer
 - Data Analyst
- Each role has its own set of tools
- Learner can follow the complete development flow of an automotive software feature



ASTAS – Application specific Test of AUTOSAR Systems

- Prototype for static analysis and dynamic test of AUTOSAR ECUs/projects
- AUTOSAR compliant and usable for different toolchains and AUTOSAR versions
- Architectural knowledge is stored in separated knowledge base
- AUTOSAR tool chain connected to ASTAS for realization of dynamic test
- Static test can support correction suggestion, like connecting open ports, wrong task mapping and incorrect use of data types



Specific Features:

- Application specific test on target platform in successive manner
- Performance analysis, comparison of different configurations
- AUTOSAR specific test report

ASTAS – Screenshot

The screenshot displays the ASTAS - TU-Chemnitz interface. The top menu bar includes FILE, VIEW, TEST SEQUENCE, and TOOLS. Below the menu, there are buttons for START TEST SEQUENCE, SHOW TEST-REPORT, and TRANSFER TEST-REPORT. The main workspace is divided into several sections:

- Project loaded:** XDS found, Database connected.
- LOADED TEST SEQUENCE:** Description: Checking Yellow Car Demonstrator, Author: enn, Date: 12.08.2019.
- CONSOLE:**

```

> Loaded AS-Project
> Connected to AUTOSAR Knowledge Database
> Loaded valid ASTAS Test Sequence
> READY TO START
> Start Test Sequence
> Complete "ARXML-Valid"
> Complete "Runnable Check"

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- Static Analysis:**
 - ARXML-Valid v1.0.0, enn:** AS-VERSION 3.1.0, TYPE S_APP, DESCRIPTION Validates ARXML-Scheme. Includes Database and Timeout options.
 - Runnable Check v1.2.1, enn:** AS-VERSION 3.1.0, TYPE S_APP, DESCRIPTION Checks for illegal Runnable-Calls. Includes Database and Timeout options.
 - Port Connection Analyser v1.4.0, enn:** AS-VERSION 3.1.0, TYPE S_APP, DESCRIPTION Checks Port Connections. Includes Database and Corrections options.
- Dynamic Tests:**
 - BSW CAN Stack v1.0.0, enn:** AS-VERSION 3.1.0, TYPE D_BSW, DESCRIPTION Dynamic BSW Can Stack Test. Includes Database and Timeout options.
 - RTE v2.0.3, enn:** AS-VERSION 3.1.0, TYPE D_RTE, DESCRIPTION Dynamic RTE Test. Includes Database and Timeout options.

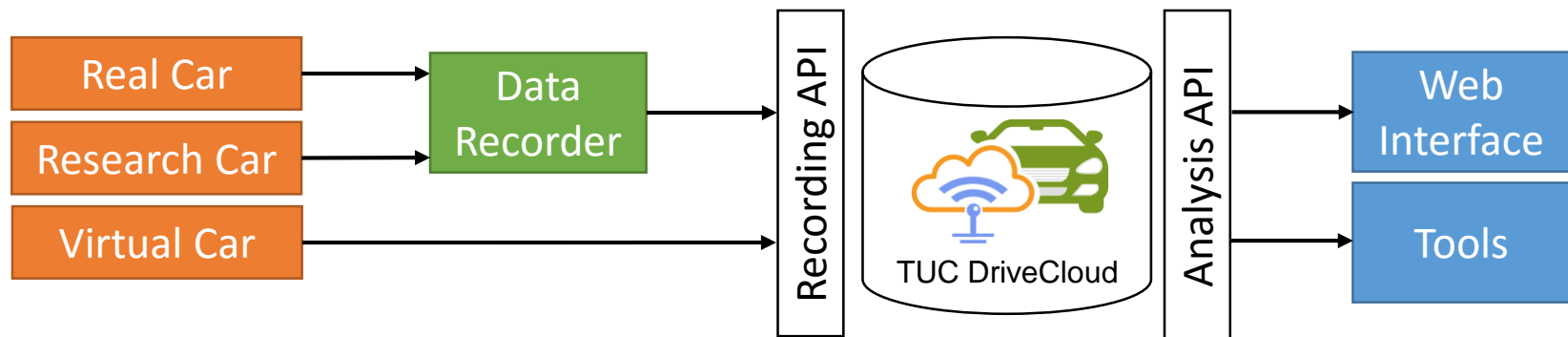
- Test sequence defines a set of module
- Each module can realize one task of static or dynamic test
- Common test report

Necessary:

- AUTOSAR project
- Tool chain and ECU
- Knowledge Base with data for version and product

TUC DriveCloud – Recording Test Drives

- Database platform for test drive data
- Test drive defined by start and end time and set of sensor data streams
- Hardware device records data during test drive and upload data to TUC DriveCloud (live or deferred)
- Recording device can access different kinds of data, for example OBD2, specific data from bus (development access), data from other devices like camera and heart beat of driver
- Virtual test drives can be stored (CARLA drive simulator)
- Web interface for visualization and analysis of data



TUC DriveCloud – Web Interface

The screenshot displays the TUC DriveCloud web interface. The top navigation bar includes a logo, a menu icon, and a user profile labeled 'Demo User'. The main content area is titled 'Test drive details' and includes a breadcrumb trail: 'Home > Test drives > Test drive details'. The interface is divided into several sections:

- Route:** A map showing the test drive path through a rural area with various roads and landmarks.
- Playback control:** A video player interface with a play button, a progress bar, and a car icon. Below the bar are zoom options (1/6x, 1/4x, 1/2x, 1x, 2x, 4x, 8x, 16x, 32x, 64x, 128x) and the current position: 'Aktuelle Position: 19:31:55'.
- Video Stream:** A live video feed showing a first-person view from a vehicle driving on a road.
- ENGINE RPM:** A line graph showing engine revolutions per minute over time. The y-axis ranges from 0 to 4,000 RPM. The x-axis shows time from 7:20pm to 7:30pm on 9/20. The graph shows several peaks reaching approximately 2,000-3,000 RPM.
- Recorded sensor streams:** A section at the bottom for displaying recorded sensor data.

A left sidebar contains navigation options: Overview (Dashboard), Configuration (Vehicles, Sensors, Drive Setups), Data (Recorded Drives, Data Import, Data Export, Access Tokens), and Information (Help, Licenses, Imprint, Data Privacy Statement).

- Test drives are shown on map (based on GPS)
- Video streams are shown (mapping time)
- All sensor data can be shown in diagrams
- Export of test drive to other formats are possible
- Base for Machine Learning

Mapping

ASTAS Test report

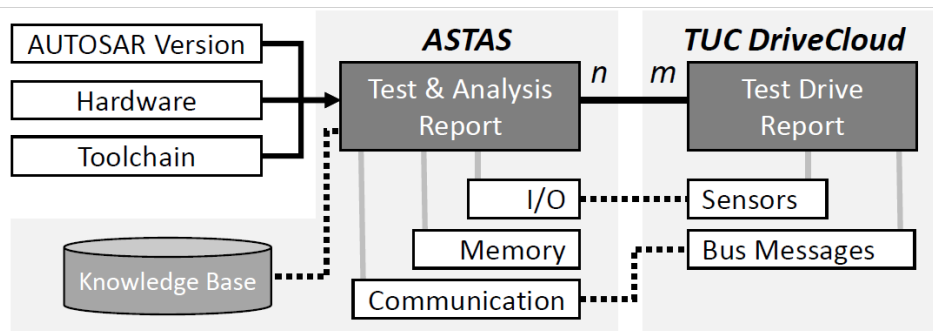
- r messages about static analysis
- s results about dynamic test (basic software and RTE)
- Each entry refers to test object reference in knowledge base

TUC Test Drive Data

- Start and end time
- Pre defined car and driver
- Set of sensors
- each sensor has a number of log entries

→ Mapping

- changes in functionality/architecture can be mapped to sensor values
- Analysis and Test can highlight suspect elements
- Test drive can be prepared, focus on highlighted elements



Educational Use Case

- Automotive Demonstrator Yellow Car
- Set of ECUs, connected by CAN Bus
- Functionality: Remote Control, Light Control,
- Task for student:
 - Extend the current application of Light Control by checking an existing Alive Counter

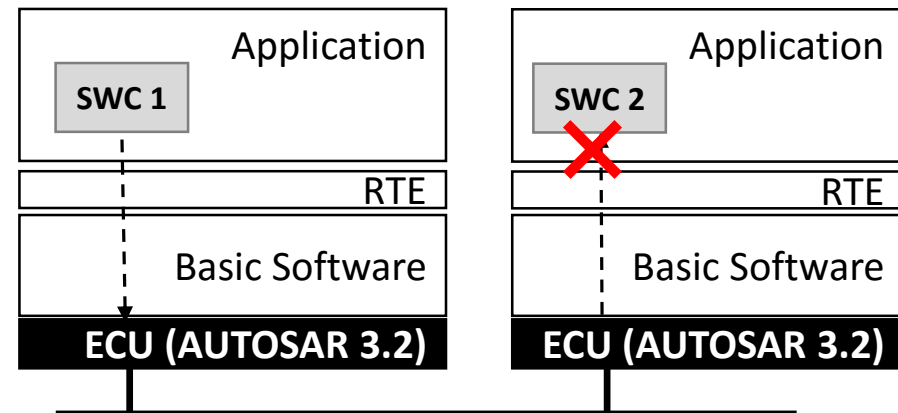


Problem:

- Port in AUTOSAR application is not or wrongly connected
- Basic Software is correctly configured
 - No change of signal value on CAN Bus

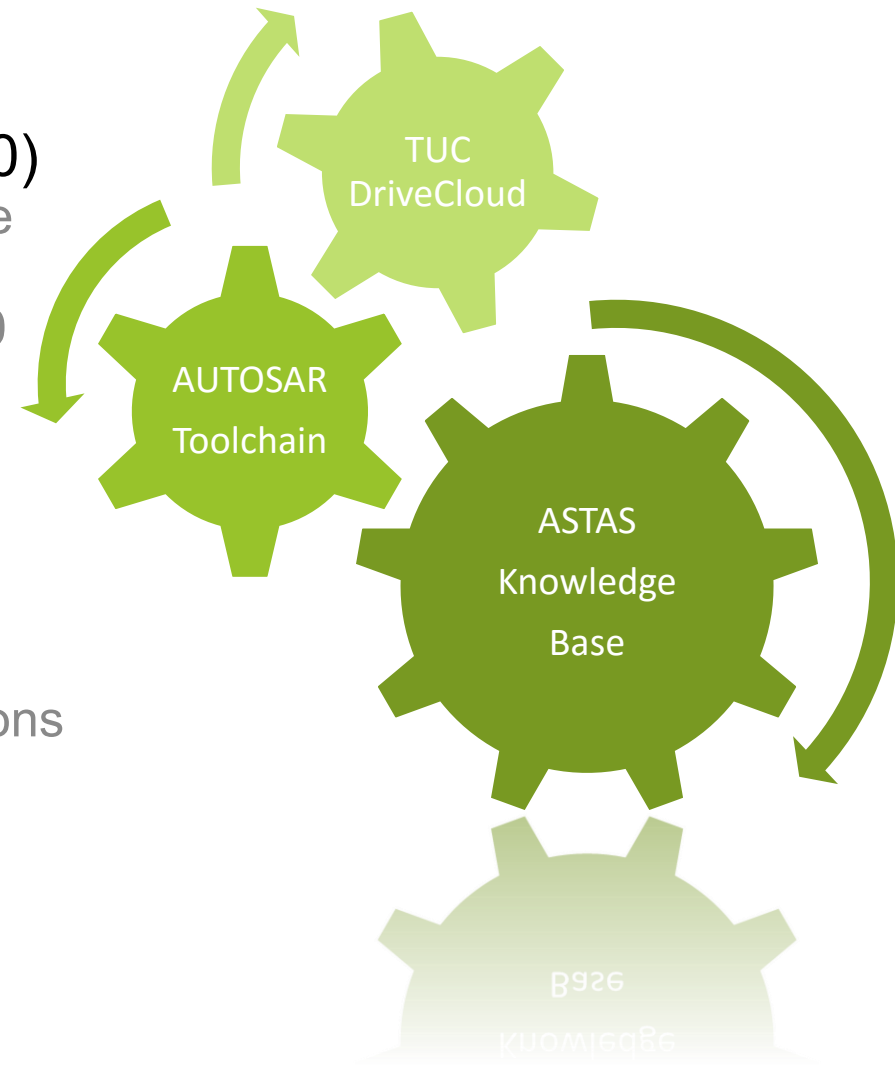
Result:

- ASTAS marks the signal of the open port (static test)
- ASTAS BSW test shows correct behavior
- Highlighted signal values when evaluating test drive
 - ASTAS test report with correction suggestion



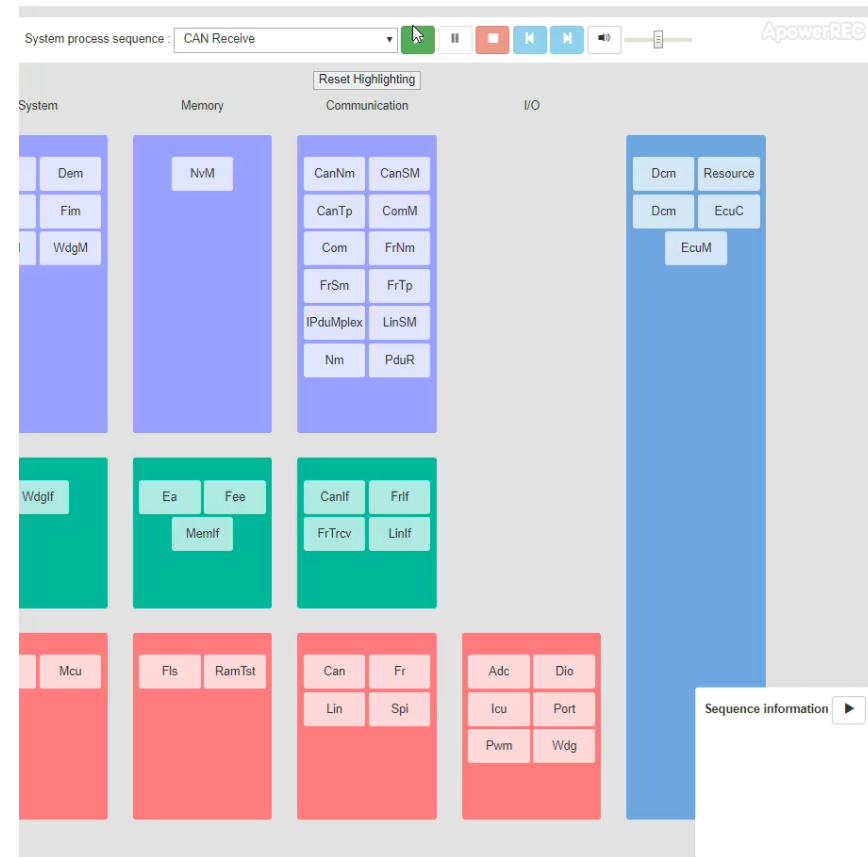
Integrated Tools and Data Sets

- **AUTOSAR Toolchain (2.1, 3.2, 4.0)**
 - Elektrobit tresos Studio / Auto Core
 - dSpace System Desk, VEOS
 - Freescale S12X and STM SPC560
 - TraceTronic ECU-TEST
- **Content ASTAS Knowledge Base**
 - AUTOSAR 2.1, 3.2, 4.0
 - Basic Software Modules and RTE
 - 3000 functions of Basic Software
 - 48 BSW Modules with 1096 functions (3.2)
- **Content TUC DriveCloud**
 - 9 configured cars with 62 sensors
 - 33 drive setups
 - 145 recorded test drives



ASTAS – E-Learning Support

- Learning Management System for visualization automotive specific architecture (here AUTOSAR, Classic Platform)
- ASTAS Knowledge Base as data source
- Different views for learner
 - Abstract view (general overview)
 - Programmers view (functions, etc.)
- Experience data like example projects and best practices
- Scenarios can be used like videos, showing complex processes (stepwise)
- Adaptive Learning → Publication SoftCom 2019



ASTAS – Adaptive Learning

- **Main Idea:** Stepwise Learning based on Skill Level of Learner, Top-Down-Approach
- Five levels for classification of learner
- Each Skill Level activates different information for the learner
- Knowledge of lower levels is always accessible
- Activated information in each level is part of assessment for next level
- Access is realized by item structure in Knowledge Base

Level Name	Accessible Data	Necessary Percent
Undefined	No Data is Presented (No access to the platform)	0
Beginner	Overview and introduction of the OS layers	1 to 30
Medium	Overview of the different areas of the layers	31 to 60
Professional	All software modules and its functionality, functions of software modules	61 to 84
Expert	Animations of OS internal process, dependency between software modules	85 to 100

Summary

- Base for supporting AUTOSAR development and test in combination with test drives
- Supporting information flow between AUTOSAR testing and data of test drives
- Approach contains commercial tool chains for teaching students in standard tools
- Usable for demonstrators, virtual cars, and real cars
- E-Learning tool especially for teaching AUTOSAR

Thank you for your attention.



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