

# INI.FAU

**Model Driven Test Industrialization with MaTeLo and EXAM  
at AUDI AG  
Model Driven Hardware-in-the-loop testing**

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# Motivation

*„In the past vehicle safety has been constructed; In the future it is going to be implemented in software.“*

Dr. U Widmann, AUDI AG, Head of Vehicle Safety

- Automobiles turn into Systems of Systems
  - Testing Method has to cope with Complexity and Variance
  - Testing Time on HIL is scarce
- Efficiency
  - Systematic Testing
  - Significant Testing



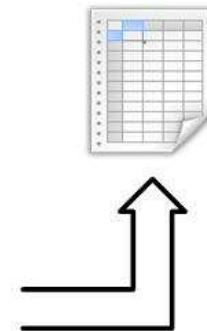
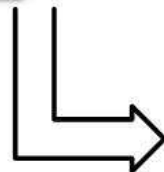
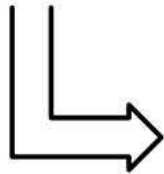
- Motivation
- **Test process at AUDI**
  - EXAM
  - Test Model
  - **Model Driven Testing**
- Tool Chain
  - MaTeLo and EXAM
- Testmodels
  - Start Stop
  - Comfort
  - Energy management
- Outlook

# Extended Automation Method

## *company standardised test automation*

EXAM defines a process, the assignment of tasks, and the tools used to

- manually model test cases graphically in the UML.
- generate test scripts automatically from the graphical descriptions.
- separate the test description and its implementation.
- develop tests enterprise-wide in teams.
- accumulate and structure test know-how.
- to use shareable test automation functionalities.

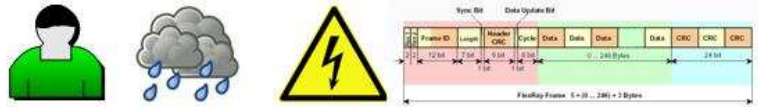


- Manual Creation of test cases
  - awkward
  - error-prone
  - requirements hard to analyze
  - test coverage hard to assess

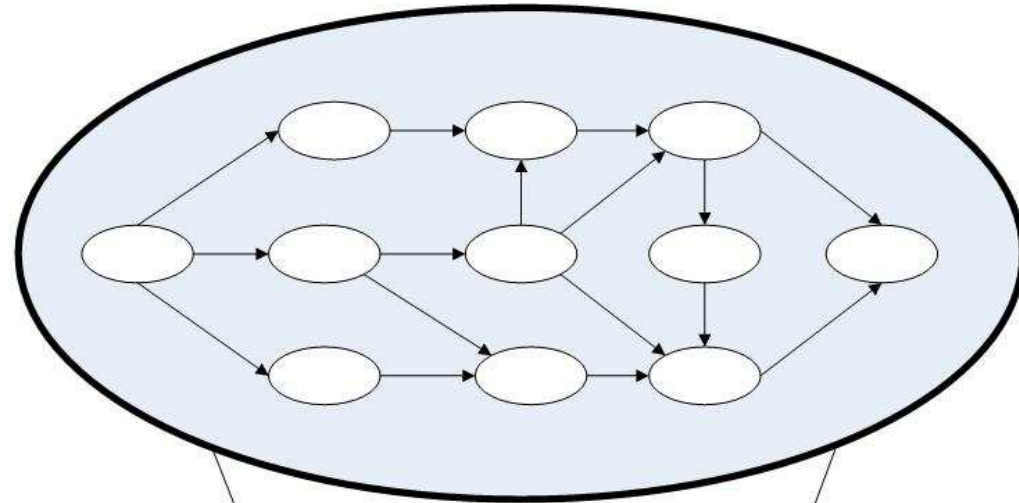
Hardware-in-the-loop simulator (HIL)

# Model Driven Testing

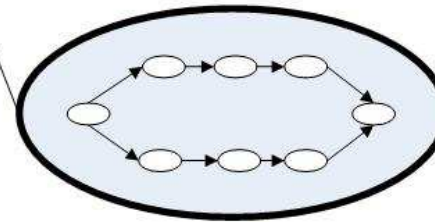
## Markov Chain Usage Model



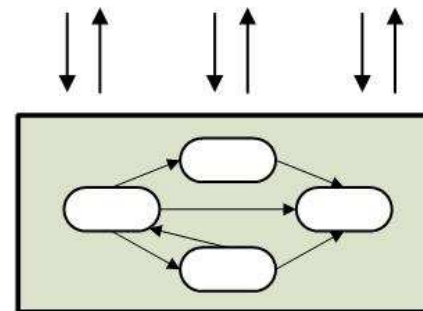
Usage Population  
Possible Sequences of Input  $S^*$



Sample  
Stimuli sequences  $U$  to be executed

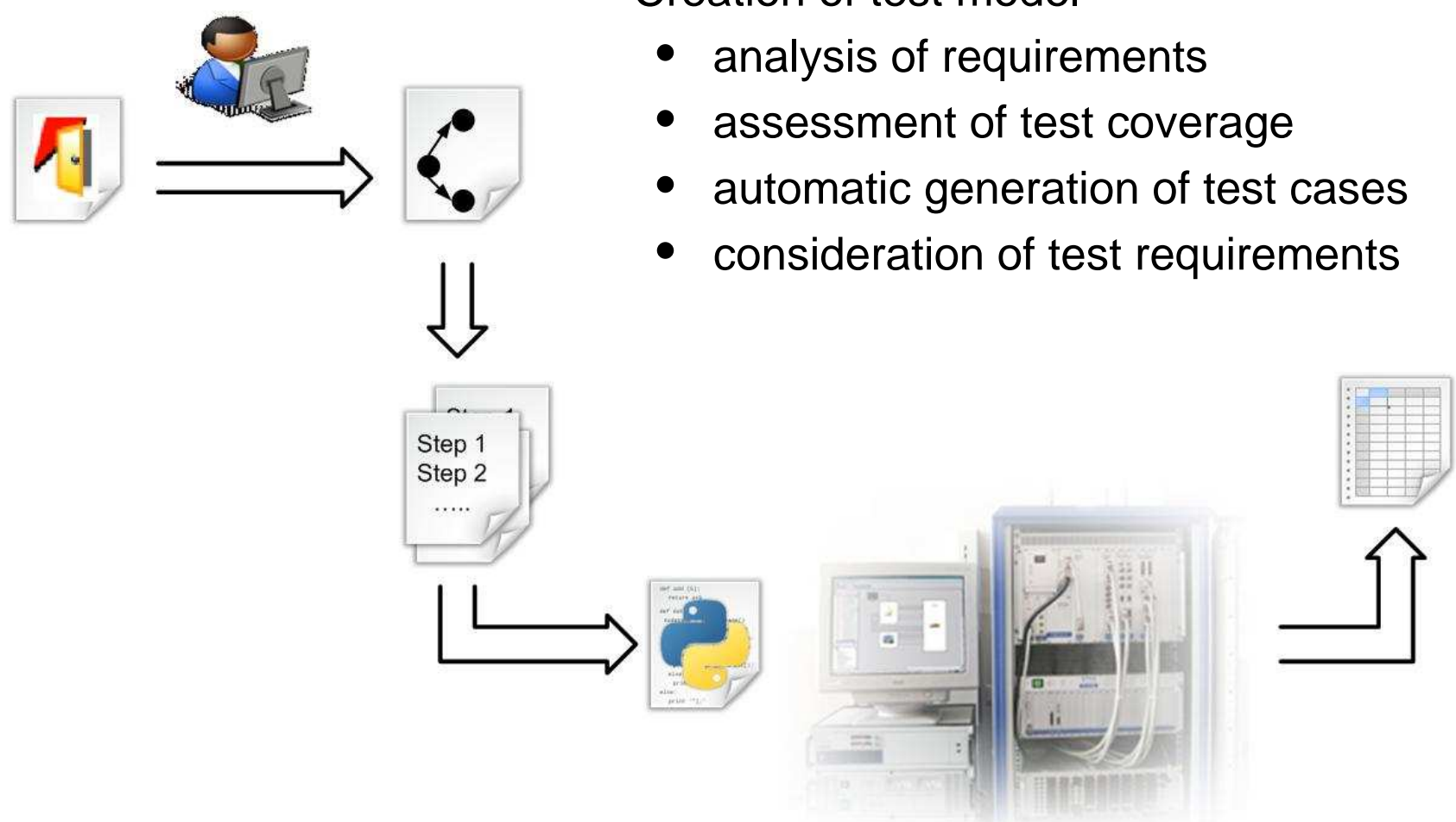


System-under-Test  
Responses  $R$





- Creation of test model
  - analysis of requirements
  - assessment of test coverage
  - automatic generation of test cases
  - consideration of test requirements



Hardware-in-the-loop simulator (HIL)

## Start Stop

- Automatic shutdown of engine during standing phases
- Technique to reduce the CO2 emissions and fuel consumption
- Highly distributed functionality, almost all ECUs participate

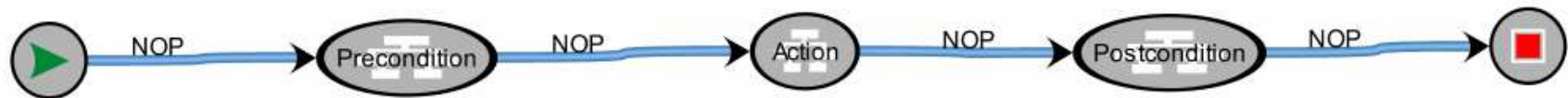


# Test model Start Stop

- Requirement Specification
- Input Domain comprised
  - Passenger Operations
  - Environmental Effects
  - ECUs
- Structure followed EXAM Modeling Guidelines  
(Tool employed for modeling: MaTeLo from All4tec)

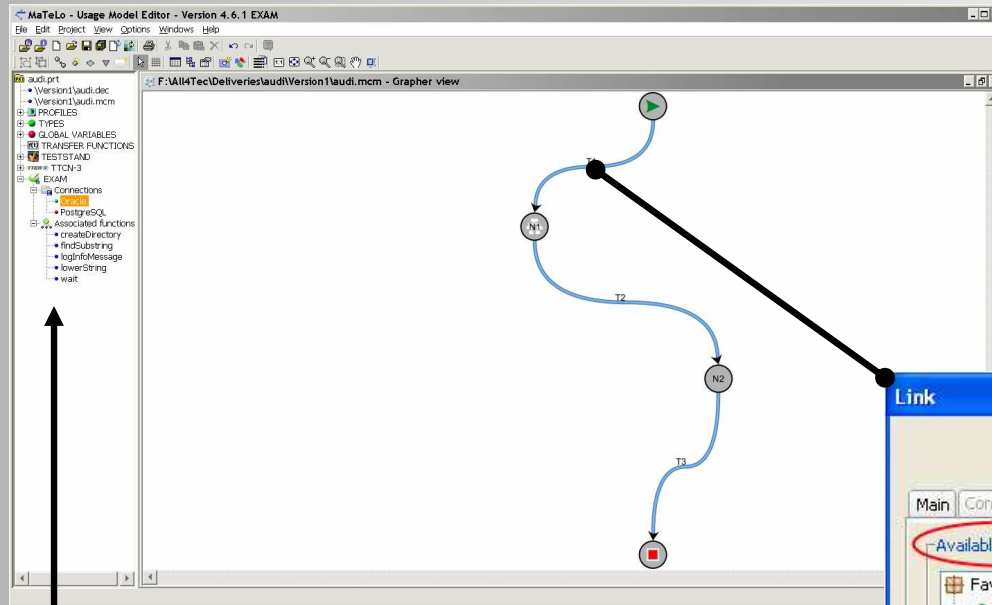
During Creation of the Model it was possible to identify

- one clearly erroneous specification
- three contradictions within the requirements specification
- ambiguities in the specification



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# MaTeLo Editor and



EXAM Library in MaTeLo editor

Link

Name : T1      Comment : My transition comment

Main    Condition    Context - 0    TestStand Functions - 0    Exam Functions - 3    Requirements - 0

Available Function 1

Chosen Functions 2

Function Params 3

Name	Type	Value
sString	Input	testinput
sResult	Value	sNewString

Ok    Cancel

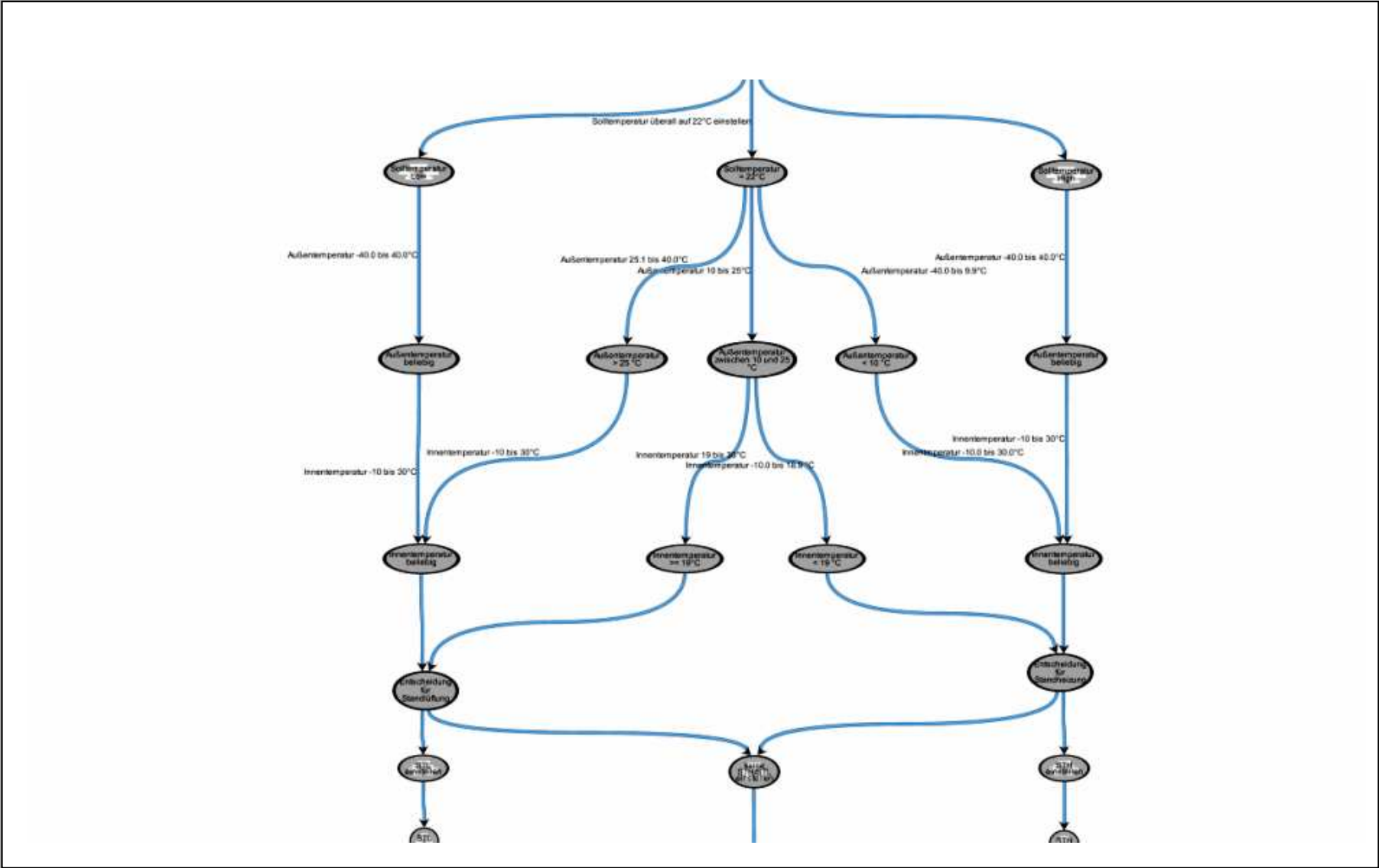
- Associated EXAM objects
- Change Monitoring of EXAM
- Usage Monitoring in MaTeLo Model
- Update in MaTeLo Model

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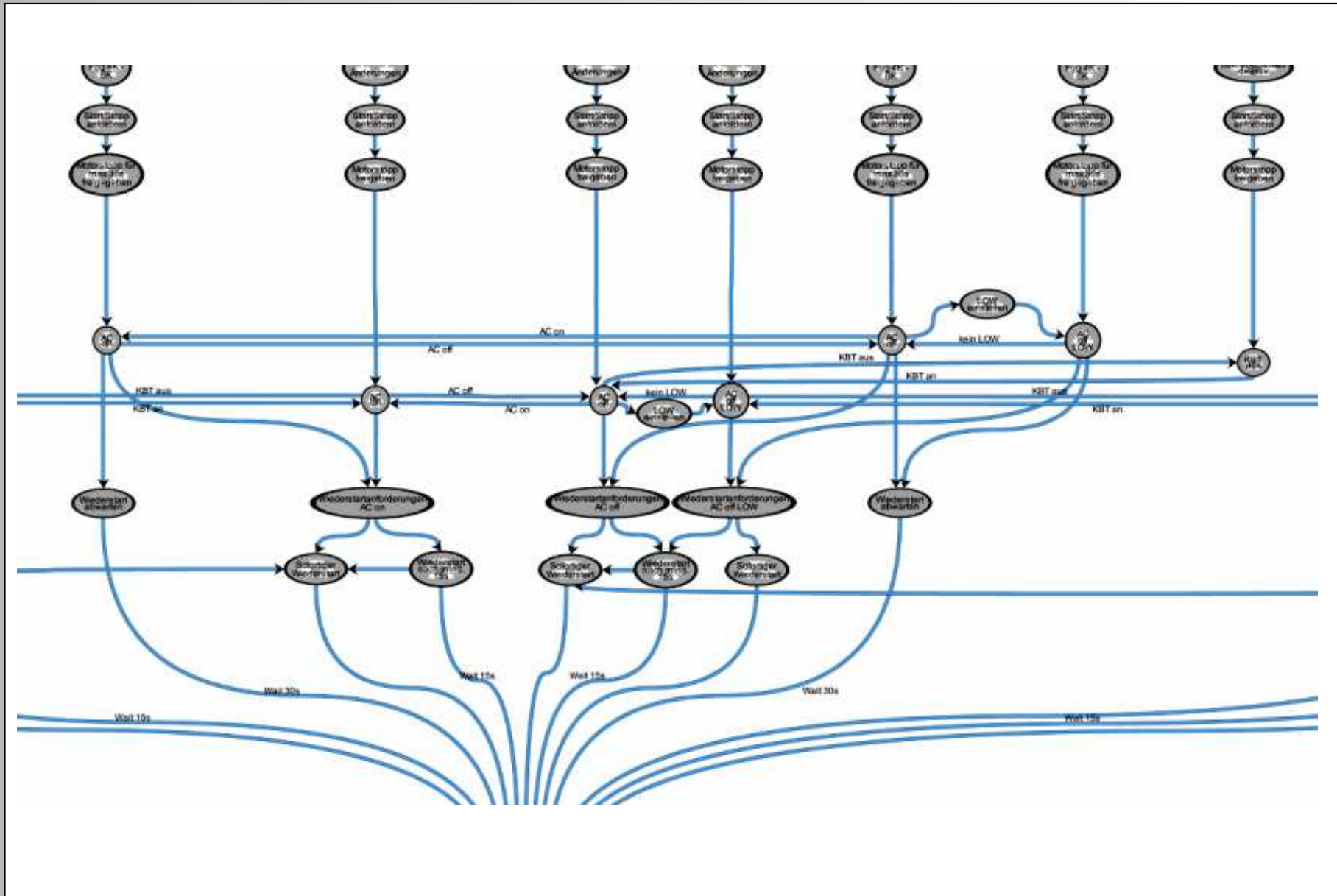
# Testmodels

- Start Stop
  - Power Train
- Energy Management
  - Start Stop
- Comfort
  - Additional Heating
  - MMI Programming
  - Start Stop
  - Interior lighting
- Safety
  - Safety computer

# Comfort Additional Heating



# Comfort Start Stop



## Results

**Clear separation between modelling and programming**

**Result of work of test engineers is available in models**

**Reusability and modifiability is given by the model structure**

**Quality of specification improved: earlier detection of errors**

**Quality of test specification improved by higher systematics**

**Efficient testing through more significant test cases**



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- Analysis of Requirements
- Systematic Generation of test cases
  - Generation Strategies
- Next projects at Audi
  - Comfort
  - Dashboard
  - Energy Management
  - Power Train
  - Integral Safety

**Thank you!**