



Precision. Passion. Partnership.

## Field Report of a tool chain for model based unit level tests for automotive software

Bernd Jakoby & Jörg Hermes

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### Agenda



- Company
- Domain
- Standards & Process
- Unit Level Software Test & Tool chain
- Experience
- Forecast

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### Company

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GETRAG FORD Transmissions



Founded 1. February 2001 as a 50:50 Joint Venture between GETRAG and Ford of Europe

Development and production of transmissions

Full Service System Supplier

Customers: Ford Jaguar, Mazda, Volvo, Land Rover, Chrysler, Changan and Dodge

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Key facts 2006

Turnover

1,04 billion Euro

Production volume

2,03 mio. transmissions

Employees (total)

4.235

in production

3.476

in product development

572

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# Domain

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## Domain Drivetrain

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## Domain Dual Clutch Transmissions – Software

- Works on an operating system from the TCU manufacturer
- Controls Software is separated in logical subsystems
- Architecture designed by an structured analysis
- Safety Concept required a second level safety software
- Most parts are developed by a model based approach

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## Process & Standards

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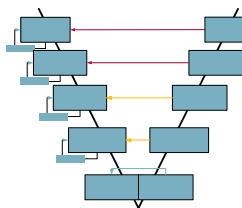
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## Process & Standards



- Software is classified to IEC 61508 SIL2
- Regulatory requirements are addressed in software development process
- Development process is organized by V-Process-Model
- Unit Level Software Testing aspects must be adapted to situation modeled and coded functionality

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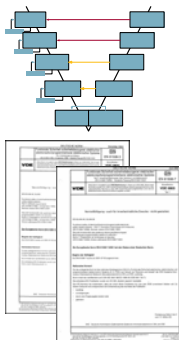
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## Process & Standards



- Which framework for manually coded functionality ?
- How to assure the correct work of
  - Auto coding
  - Compiling
  - Linking
- What are the IEC 61508 SIL 2 requirements for unit level test ?
- Which framework for model based unit level test ?

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## Unit Level Software Test & Tool Chain

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## Unit Level Software Test & Tool Chain

| Req.  | Method                                              | SIL 2 | SIL 1 |
|-------|-----------------------------------------------------|-------|-------|
| A.5.1 | Static analysis                                     | +     | X     |
| A.5.2 | Dynamic analysis and test                           | ++    | X     |
| B.2.1 | Test case execution from boundary value analysis    | ++    | X     |
| B.2.2 | Test case execution from error guessing             | +     | X     |
| B.2.3 | Test case execution from error handling             | +     | X     |
| B.2.4 | Performance modeling                                | +     | X     |
| B.2.5 | Equivalence classes and input partition testing     | +     | X     |
| B.2.6 | Structure-based testing                             | +     | X     |
| A.5.3 | Data recording and analysis                         | ++    | X     |
| A.5.4 | Failures and Black Box Test                         | ++    | X     |
| B.3.1 | Test case execution from cause consequence diagrams | +     |       |
| B.3.2 | Prototyping/testing                                 | +     |       |
| B.3.3 | Boundary value analysis                             | ++    | X     |
| B.3.4 | Equivalence classes and input partition testing     | ++    | X     |
| B.3.5 | Process simulation                                  | +     | X     |
| A.5.5 | Performance test                                    | +     | X     |
| B.6.1 | Performance testing                                 | +     |       |
| B.6.2 | Response time and memory constraints                | ++    | X     |
| B.6.3 | Performance requirements                            | ++    | X     |
| A.5.6 | Interface test                                      | +     | X     |

- IEC 61508 SIL 2 Software Testing Requirements
- Parts will be performed by model based unit level test
- Standard-compliant unit level test demands
  - B.2.1 Test case execution from boundary value analysis
  - B.2.5 Equivalence classes and input partition testing
  - B.2.6 Structure-based testing

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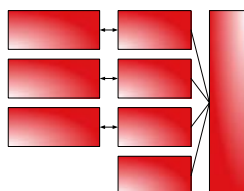
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## Unit Level Software Test & Tool Chain Schematic view of S-Test



- Framework
  - Model Scanner
  - File Generator
  - Test Driver
  - Test Results
- Input & Output interfaces scanned in model file
- Generating a tree in CTE XL compatible file
- Test case specification in CTE XL
- Test driver builds Test bed and test stimulus
- Result evaluation and documentation

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## Unit Level Software Test & Tool Chain CTE & Matlab/Simulink



- Process for test case specifications must define test techniques
  - Equivalence partitioning
 → CTE® (DaimlerChrysler)
- Process for test management
  - Test end criteria by coverage C1 or MC/DC
  - Documentation
 → **Verification & Validation Package Matlab/Simulink®**

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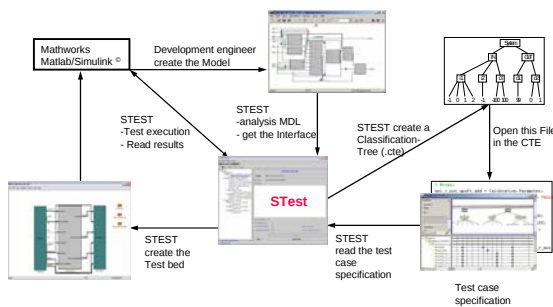
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## Unit Level Software Test & Tool Chain Work & Data flow between STest, Simulink and CTE



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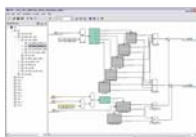
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## Unit Level Software Test & Tool Chain Model analysis



- Source: Simulink Model
- STest: shows the Simulink Model Browser
- Select the subsystem which will be tested
- Extracting: Model and Interface information

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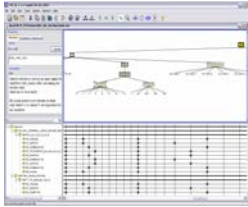
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## Unit Level Software Test & Tool Chain

### Test case specification



- Automatic generation of feature-tree
- Representation of input and output vectors
- Manual test data definition from the feature specification
- Grouping and sequencing of test vector allows definition of complex timed test cases

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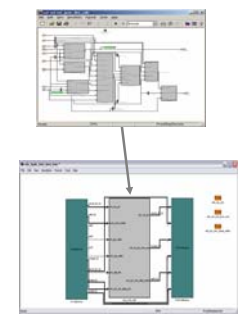
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## Unit Level Software Test & Tool Chain

### Test bed



- Open the source model
- Load CTE-file
- Read basis model settings
- Open a new model
- Build In- and Outframe
- Copy the system from the source MDL into the test MDL
- Set environment settings
- Save the test model

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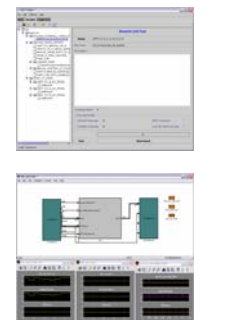
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## Unit Level Software Test & Tool Chain

### Test execution



- Test cases selection
- Disable or enable Simulink coverage report
- Starting test execution
- Test result logging
- Open coverage report
- Save test result into CTE-file
- Create an report as Word-file

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### Unit Level Software Test & Tool Chain

#### Test results and documentation



- Test result logging
- Open Simulink coverage report
- Word test report document
- Save test result in the CTE-file
- Results can be used for regression testing

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## Experiences

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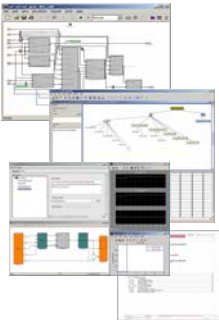
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### Experiences



- May 2006 starts the Project "Model based unit level test"
- Questions:
  - Is tool chain usable ?
  - How to build up a test case repository for each model ?
  - What is a practical documentation standard for software testing ?

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| <div> <div></div> <div>GETRAG</div> </div>                                                         |                                                                                 |                                                                                                                     |
|----------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------|
| Experience<br>Project maturation                                                                   |                                                                                 |                                                                                                                     |
| Pilot Project                                                                                      | Main project phase 1                                                            | Main project phase 2                                                                                                |
| Documentation standard must be established                                                         | Documentation standard must be updated for higher performance                   | Documents are qualified as model specification and set under version control                                        |
| Technique for identification of best test level for model                                          | Top down approach with feature developer interview helps for finding deviations | Top down approach extended with preparation of interview by test engineer                                           |
| Formal Deviation                                                                                   | Functional deviations<br>Formal deviations                                      | Functional deviations<br>Formal deviations<br>Reported by a tracking system                                         |
| High risk deviations found in STest                                                                | Medium risk deviations found in STest. Extension of helpful functionality       | Low risk deviations found in STest<br>Expanding functionality to increase reuse of test cases for more applications |
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Forecast

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- Expanding functionality to trace requirements to test cases
- Expanding functionality to execute Matlab test cases on Target Processor (PIL)
- Transfer responsibility of unit level test execution to developer

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**Precision. Passion. Partnership.**

Thank you for your attention !

*Questions?*

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