Design and implementation of new tool chain for virtual ESC protection
Design and implementation of new tool chain for virtual ESC protection

01 Elektronische Fahrwerksysteme | EFS-34 chassis simulation
02 Tool chain requirement
03 Tool migration project
04 Results and expertise
Elektronische Fahrwerksysteme
EFS-34 chassis simulation
# Company at a glance

<table>
<thead>
<tr>
<th>Company</th>
<th>Fields of activity</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Founded</strong></td>
<td><strong>System integration</strong></td>
</tr>
<tr>
<td>2009</td>
<td>Divisional Director - Markus Brummer</td>
</tr>
<tr>
<td><strong>Location</strong></td>
<td><strong>System software development</strong></td>
</tr>
<tr>
<td>Ingolstadt/Wolfsburg</td>
<td>Divisional Director - Stefan Sollmann</td>
</tr>
<tr>
<td><strong>Interest</strong></td>
<td><strong>Interdisciplinary functions</strong></td>
</tr>
<tr>
<td>GIGATRONIK Group (51%)</td>
<td>Divisional Director - Raimund Hofmayer</td>
</tr>
<tr>
<td>Audi Electronics Venture (49%)</td>
<td></td>
</tr>
<tr>
<td><strong>Employees</strong></td>
<td><strong>IN/VE – Innovation management and pre-development</strong></td>
</tr>
<tr>
<td>315 (April 2016)</td>
<td>Divisional Director - Stefan Sollmann</td>
</tr>
<tr>
<td><strong>Company management</strong></td>
<td></td>
</tr>
<tr>
<td>Wilhelm Schmitt, Audi AG</td>
<td></td>
</tr>
<tr>
<td>Dr. Edwin Tscheschlok,</td>
<td></td>
</tr>
<tr>
<td>GIGATRONIK Group</td>
<td></td>
</tr>
</tbody>
</table>
To increase the speed of automotive electronics innovations and developments, AEV enters into collaboration with technology companies.
EFS-34 chassis simulation

- Real test drive
- Environment simulation
- Virtual test drive
- Real-time capable vehicle dynamics
- Multibody systems
02 Tool chain requirement
Personnel and resources planning

Scope [%]

Starting point

Planning from 2011

Topics
transfer
EFS

Personnel development

Employees [%]

Scope [%]


Employees [%]

0 50 100 150 200 250 300

0 100 200 300

Personnel development

EFS-34 chassis simulation | Christoph Kossira, Dr. Paul Spannaus
ESC test field structure and standardisation

- Universal vehicle dynamics models
- Variant reduction
- Universal simulator
- Combination of dry/wet ESC cubes
- Standardisation of ESC cubes
- Connection to Audi IT
- Structuring of test area
- Implementation of night run
- Occupational Health and Safety
Personnel and resources planning

Scope [%]

Starting point

 Topics transfer EFS

Planning from 2011

Employees [%]

Option 1 planning without change to tool chain

Option 2 planning with tool chain change

Personnel development

Adaptation required


EFS-34 chassis simulation | Christoph Kossira, Dr. Paul Spannaus
Tool chain requirements

State of the art & standardised interfaces

Potential for certification

Professional tool environment

Flexible & intuitive operation

Connection to Group standards (e.g. EXAM)
Tool chain for business process outsourcing

Internally developed Matlab environment for ESC simulation

- No standardised interfaces
- veDYNA as vehicle dynamics model
- Error-prone, low stability
  - 30% night run abort rate

- Over 400 functionally dependent scripts
  - Time-consuming training and maintenance
  - Certification not possible

- No connection to ODIS & EXAM

Tool chain requirements not met
Target tool chain

Test task

During development

Requirements-based

Doors

Results management

Database result

Test evaluation

Report creation

Simulation tool

Manoeuvre development

Vehicle dynamics model

Manoeuvre control

Framework

Model management

Test automation

EXAM

(Test control)

Database

Test result

Report

creation

Versioning

Sub version

Interface simulator/
hardware

ControlDesk

During development

Requirements-based

Doors

Database

Test result

Report

creation

Versioning

Sub version

Interface simulator/
hardware

ControlDesk

EFS-34 chassis simulation | Christoph Kossira, Dr. Paul Spannaus
## Catalogue specifications comparison

<table>
<thead>
<tr>
<th>Requirement</th>
<th>Provider 1</th>
<th>Provider 2</th>
<th>Provider 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Standard components models</td>
<td>●</td>
<td>●</td>
<td>●</td>
</tr>
<tr>
<td>Own models integration</td>
<td>●</td>
<td>●</td>
<td>●</td>
</tr>
<tr>
<td>dSPACE hardware platform</td>
<td>●</td>
<td>●</td>
<td>●</td>
</tr>
<tr>
<td>Signal manipulation</td>
<td>○</td>
<td>○</td>
<td>●</td>
</tr>
<tr>
<td>Measurement simulation</td>
<td>○</td>
<td>○</td>
<td>●</td>
</tr>
<tr>
<td>Adaptive driver</td>
<td>○</td>
<td>○</td>
<td>●</td>
</tr>
<tr>
<td>Animation</td>
<td>●</td>
<td>●</td>
<td>●</td>
</tr>
<tr>
<td>Manoeuvre creation (graphical)</td>
<td>●</td>
<td>●</td>
<td>●</td>
</tr>
<tr>
<td>Roads definition (graphical)</td>
<td>○</td>
<td>●</td>
<td>●</td>
</tr>
<tr>
<td>Process automation</td>
<td>○</td>
<td>●</td>
<td>●</td>
</tr>
<tr>
<td>FMI/FMU</td>
<td>○</td>
<td>●</td>
<td>●</td>
</tr>
</tbody>
</table>

EFS-34 chassis simulation | Christoph Kossira, Dr. Paul Spannaus
## Evaluation to prototypical implementation

<table>
<thead>
<tr>
<th>Criterion</th>
<th>Provider 1</th>
<th>Provider 2</th>
<th>Provider 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Test creation effort (test catalogue #2)</td>
<td>100 %</td>
<td>50 %</td>
<td>25 %</td>
</tr>
<tr>
<td>Test execution duration #2</td>
<td>100 %</td>
<td>n.r.</td>
<td>15 %</td>
</tr>
<tr>
<td>Test migration effort</td>
<td>100 %</td>
<td>n.r.</td>
<td>35 %</td>
</tr>
<tr>
<td>Development phase testing</td>
<td>-</td>
<td>n.r.</td>
<td>+</td>
</tr>
<tr>
<td>Tech. Support</td>
<td>-</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td>Familiarisation time</td>
<td>-</td>
<td>-</td>
<td>+</td>
</tr>
<tr>
<td>Operability, usability</td>
<td>-</td>
<td>o</td>
<td>+</td>
</tr>
<tr>
<td>Model changes effort</td>
<td>-</td>
<td>n.r.</td>
<td>+</td>
</tr>
<tr>
<td>Debugging</td>
<td>-</td>
<td>n.r.</td>
<td>o</td>
</tr>
</tbody>
</table>

n.r. = not rateable
Financial expenditure for simulation tool migration

<table>
<thead>
<tr>
<th></th>
<th>Provider 1</th>
<th>Provider 2</th>
<th>Provider 3</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Licences</strong></td>
<td>2</td>
<td>1</td>
<td>3</td>
</tr>
<tr>
<td><strong>Migration expenditure</strong></td>
<td>3</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td><strong>Internal migration costs</strong></td>
<td>1</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td><strong>Maintenance per year</strong></td>
<td>3</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td><strong>Total costs</strong></td>
<td>2</td>
<td>1</td>
<td>3</td>
</tr>
</tbody>
</table>

Ranking: 1 = best in comparison, descending order
Personnel and resources planning

Scope [%]

<table>
<thead>
<tr>
<th>0</th>
<th>50</th>
<th>100</th>
<th>150</th>
<th>200</th>
<th>250</th>
<th>300</th>
</tr>
</thead>
</table>

Starting point

Migration start

Planning from 2011

Cost benefits

Option 1

no change

Option 2

planning with tool chain change

Adaptation required

Personnel development

Scope [%]

Employees [%]

0 | 100 | 200 | 300
03 Tool migration project
Test case migration for test catalogue #2 example

Test cases [%]

0 100%

6.1 20.1 3.2 17.2 2.3 16.3 30.3 13.4 27.4

Migrated

Total

Before = after

Evaluations
EFS-34 chassis simulation tool migration status
(27/04/2016)
### Number of vehicle variants

<table>
<thead>
<tr>
<th>Platform #</th>
<th>Drivetrain</th>
<th>Transmission</th>
<th>Body</th>
<th>Axles</th>
<th>Steering</th>
<th>Wheelsys</th>
<th>Brake</th>
<th>Engine</th>
<th>Transmission</th>
<th>Sensors</th>
<th>Restbus</th>
</tr>
</thead>
<tbody>
<tr>
<td>A1</td>
<td>Conventional</td>
<td>Four-wheel drive</td>
<td>Automatic</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>A2</td>
<td>conv.</td>
<td>Four-wheel drive</td>
<td>Manual gearbox</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>B2</td>
<td>conv.</td>
<td>Front</td>
<td>Manual gearbox</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>B3</td>
<td>PHEV</td>
<td>Four-wheel drive</td>
<td>Automatic</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>B4</td>
<td>conv.</td>
<td>Four-wheel drive</td>
<td>Automatic</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>D1</td>
<td>EV</td>
<td>Four-wheel drive</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>E1</td>
<td>conv.</td>
<td>Four-wheel drive</td>
<td>Automatic</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>E2</td>
<td>PHEV M1a</td>
<td>Four-wheel drive</td>
<td>Automatic</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>E3</td>
<td>conv.</td>
<td>Four-wheel drive</td>
<td>Automatic</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>F1</td>
<td>MHEV</td>
<td>Four-wheel drive</td>
<td>Automatic</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>J1</td>
<td>PHEV</td>
<td>Four-wheel drive</td>
<td>Automatic</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>J2</td>
<td>conv.</td>
<td>Four-wheel drive</td>
<td>Automatic</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>J3</td>
<td>MHEV</td>
<td>Four-wheel drive</td>
<td>Automatic</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>J4</td>
<td>conv.</td>
<td>Four-wheel drive</td>
<td>Automatic</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>J5</td>
<td>MHEV</td>
<td>Four-wheel drive</td>
<td>Automatic</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>J6</td>
<td>conv.</td>
<td>Four-wheel drive</td>
<td>Automatic</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Results and expertise
ESC simulators utilisation

**Migration:** 30% reduction in active simulators

Documented downtime not including setup time

Productive test bench operation

**Effective utilisation**

- **2015:** approx. 40%
- **2016:** approx. 75%

Average utilisation

Available resources
## Figures, data, facts about ESC testing tool migration

<table>
<thead>
<tr>
<th></th>
<th>Starting point</th>
<th>As of 06/2016</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Degree of automation</strong></td>
<td>low</td>
<td>EXAM -&gt; test control</td>
</tr>
<tr>
<td><strong>Test cases migrated</strong></td>
<td>100 %</td>
<td>98.4 %</td>
</tr>
<tr>
<td><strong>Test bench operating time for catalogue</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>#2</td>
<td>#4</td>
<td>#5</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>**Processing time #2</td>
<td>#4</td>
<td>#5**</td>
</tr>
<tr>
<td><strong>Test creation duration with evaluation</strong></td>
<td>100 %</td>
<td>50 %</td>
</tr>
</tbody>
</table>
Personnel and resources planning

Scope [%]

100
200
300

150
250
300

0

Employees [%]

200
300

100
200

0


Starting point

Planning from 2011

Option 2 planning with tool chain change

Personnel development

Topics
transfer
EFS

Personnel and resources planning

EFS-34 chassis simulation | Christoph Kossira, Dr. Paul Spannaus
Central tool chain successes in ESC testing

**Automation**

- Coding (vehicle installation state)
- Writing of data records (vehicle parameters – tyre data)
- Setting of adjustment channels (field data acquisition)

=> full coverage possible over weekend

- Next step: Sequences of multiple successive catalogues
- Objective: Time to full protection of an entire baseline
Migration difficulties and challenges

• Evaluation adjustment: phase-based to manoeuvre-based evaluation
• Common manoeuvre description understanding
• Creation of shared team knowledge
• Continuous test operation (5 test executions during migration)
• New software and interface adaptation during operation: Decision as to whether required adjustment with fixed deadlines should be implemented in new or old tool chain
• Spirit of transformation and active risk management
Success factors

- **Test automation responsibility** by experienced employees
  - Stringent migration specifications and mandatory use of new standards
  - Migration speed tracking
  - Adaptive support for decreasing migration speed

- **Free radicals**: targeted direct/indirect support and kappa shifts

- **Tried and tested training programme**: Tool chain immediately mandatory for all testers
  - Professional support for all participating software manufacturers (purchasing tools)

- **Great use of teams**
Thank you!