Mastering the complexity of drivability, driving performance and energy efficiency at Audi in a collaborative simulation environment

André Pinnel, Christian Gnandt, Dr. Clemens Hepperle (TESIS DYNAware)
Rainer Misch (Audi AG)

Presentation at the Grazer Symposium 2016
Challenges of Virtual Development at OEMs

Example: WLTC

Different modelling granularity
Specific test focus
Specific toolchains

Development Engine
Exchange
Other Departments
Development Overall Vehicle

Images (top left, top right): Audi AG
Project Focus at AUDI

- Enterprise simulation framework
- Energy Management: performance, consumption, drivability
- Development, adjustment and parameterization of models and controllers
- Management of data, models functions, projects and results
- Vehicle comparison
- Evaluation of CO$_2$ reduction potentials
- Validation

Simulation Environment

- Conventional Drivetrains
- PHEVs
- BEVs
- ...

- Tool Connector
- Simulation Execution
- Variant Management
- Model Management
- Workflow Management

Source: Audi
Enterprise Framework

- IT-administered software installation
- 20 developers, 30 operators for performance and energy management simulation at Audi
- Users with and without expert modelling and simulation know-how
- Support of models with various complexity
- Support of tasks with hundreds of variants vs. detailed analyses of specific effects
- Heterogeneous toolchains

Central repository
- Pre-/Postprocessing functions
- Model library
- Parameter library
- Administration

Working group 1
Model definition
- Test benches
- Measurement data processing

Working group 2
Model definition

Working group 3
Test operation

Working group 4
Parameter creation

Current working set up for energy management tasks

Connect to further working groups
Tool Connectors and Connected Systems

TESIS DYNAware DYNA4: simulation framework, project data management
TheMathworks Matlab / Simulink / Stateflow: vehicle, environment, tasks
Microsoft Excel: data preparation, overview lists and post-processing
AVL Concerto: post-processing, validation, measurement data analysis
NI Diadem: post-processing, validation, measurement data analysis
openMDM: database for measurement data
Subversion: versioning of models, functions, parameters and projects
Jira: job and bug tracking
Wiki: documentation pages
Variant Management

- Template models for relevant vehicle topologies
- Model and data exchange across departments
- Multiple exchange mechanisms for model parts and/or model parameters

- Automated generation of Excel overview lists for
  - Models and libraries
  - Vehicle configurations and dependencies
  - Component parameters
Variant Management

- **Supported variant mechanisms**
  - Parameter variants
    - Value variants incl. switching of dimension
    - Data set (parameter file) variants
  - Model variants
    - DYNA4 Component and DYNA4 Module management
    - Structured parameters influencing model behaviour
    - Simulink variant subsystems
    - Simulink configurable subsystems
    - Simulink S-Function exchange

**Key benefit:** Powerful variant management system enabling re-use and exchange of variations

**Key benefit:** Support of existing model variant mechanisms from component development groups
Model Management

Model architecture

- Open Simulink / Stateflow models which are property of Audi
- Interface definitions located in libraries
- Generic interface libraries for mechanical, electrical and thermal signals
- Strict naming conventions for Simulink signals and trace variables
- Export of turnkey-parameterized models for other applications
- Exchangeable “physics plus controller”-entities
Model Management

“Virtual Test Bench” models

- Test benches for combustion engine, electric motor, gearbox, battery, …
- Validation of component parameters
- Detached test environment for developers and integrators
- Definition of interfaces
- Documentation of interfaces

Source: http://blog.audi.de/2012/10/25/neues-motorenprufzentrum-eingeweiht
Workflow Management

Task definition
- Simple and complex tasks with loops and parameter variations

Task automation
- Batch simulation of many tasks with a variety of vehicles and variations

Pre- and post-processing
- Specialized for each driving task
- Overall power and energy checks
- Signal mapping
  - Names, units, offsets, scaling
  - Measurements to simulation stimulus
  - Simulation to post-processing format
  - Simulation to measurement format
Outlook

Possible steps for the future

- Improvement and automation of quality checks
  - Nightly builds and test runs
  - Job control via Jenkins
- SVN checkout
- Test runs use the DYNA4 Remote API
  - Passed / failed criteria definition and report
- Closer integration with other enterprise processes
  - System support for the reuse of existing model parts in HiL Applications
  - Engineering Data Management Systems
Conclusions

Holistic simulation process support

- Development processes for complex systems are complex. They are subject to regular changes.
- Toolchains are and will remain heterogeneous.

That leads to …

Key requirements for enterprise simulation frameworks

- Flexibility: Solutions have to be tailor-made, adaptable to all specific tools.
- Open interfaces: Every tool has to be open for interacting with others.
- Automation: Every tool has to have the possibility to be remote-controlled.