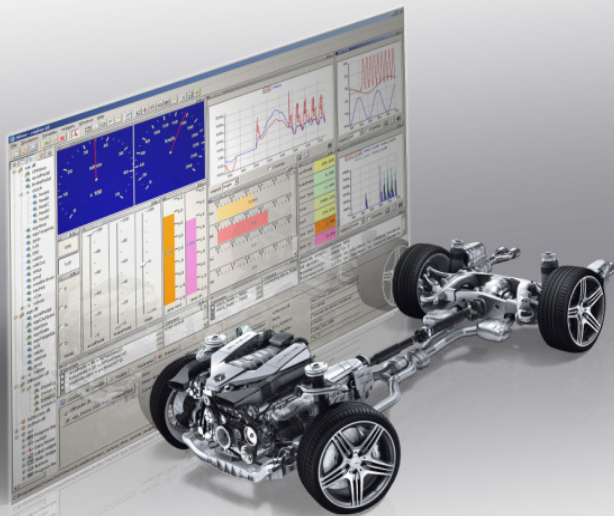


Virtual ECUs for Developing Automotive Transmission Software

Dr. Thomas Liebezeit, Jakob Bräuer, Roland Serway (IAV)

Dr. Andreas Junghanns (QTronic)

Innovative Fahrzeug-Getriebe und Hybrid & Elektro-Antriebe, Dezember 2011



Virtual ECUs for Automotive Software

Agenda



- **Motivation**
- Software-in-the-Loop setup
- Debugging
- Experience
- Conclusion

Virtual ECUs for Automotive Software

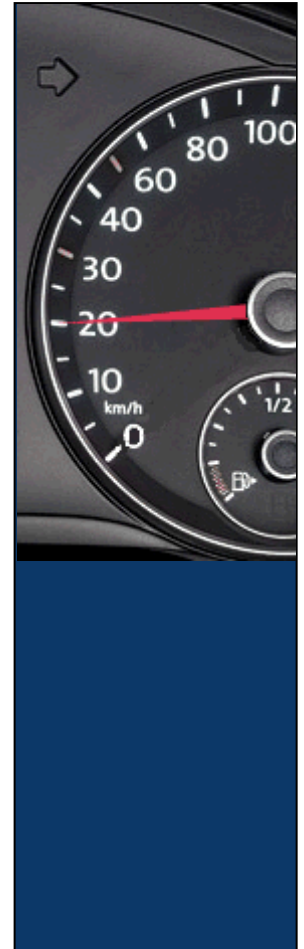
Motivation and objective

- **Motivation**

- Series Transmission Software development
 - Different software variants
- Functional behaviour testing
 - dSpace Hardware-in-the-Loop (HiL) systems and test vehicles
 - Limited possibilities for troubleshooting and analysis of software
 - Fully utilized HiL systems

- **Objective**

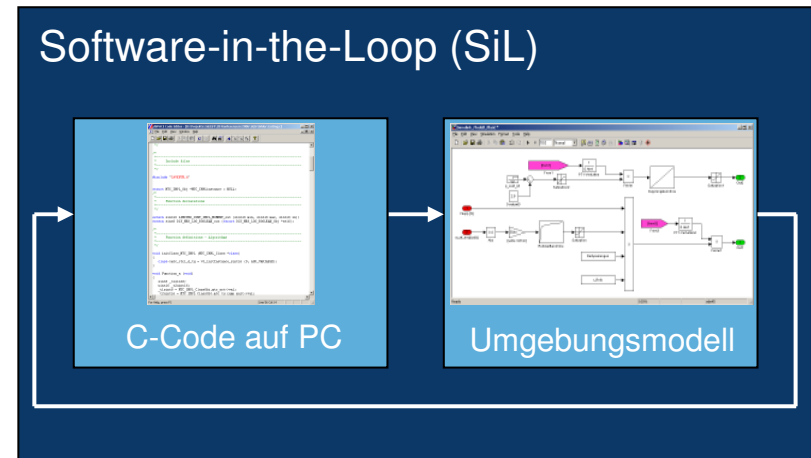
- Debugging of series transmission function software



Virtual ECUs for Automotive Software

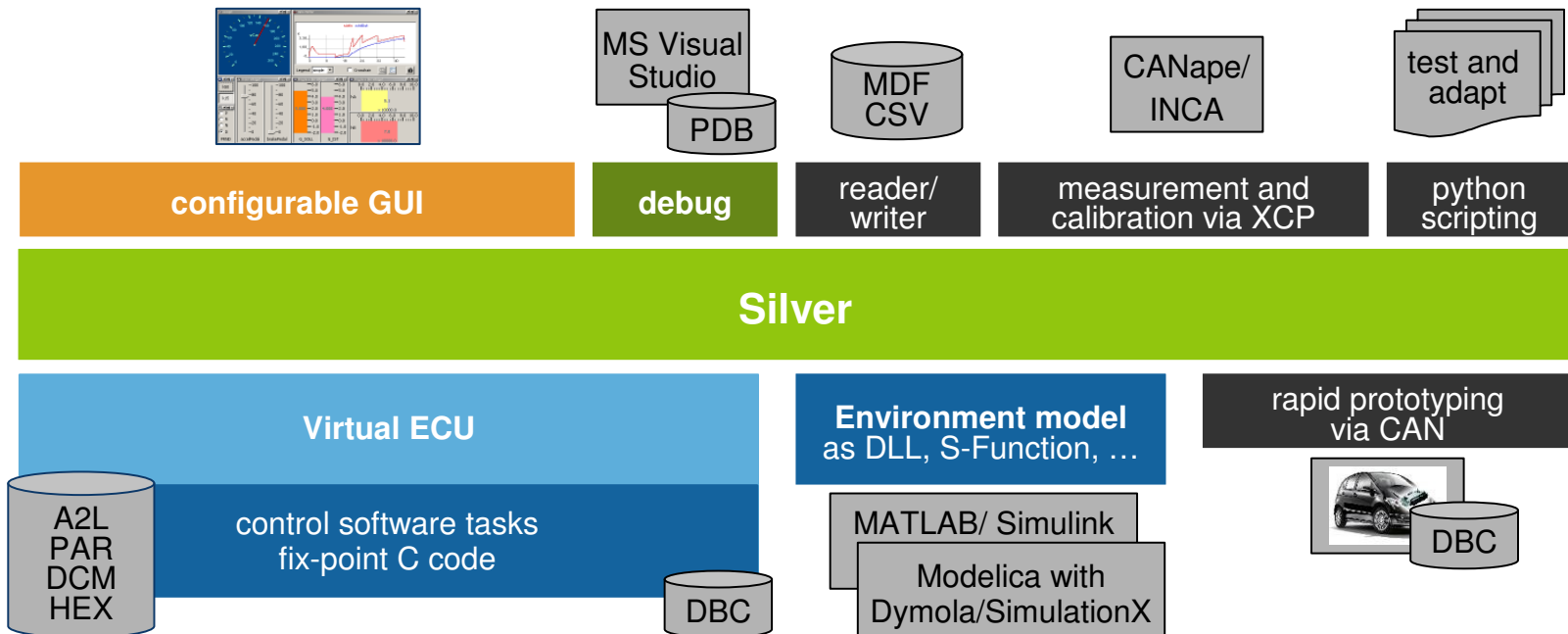
IAV's boundary conditions

- Usage of Software-in-the-Loop
 - Runs completely on Developer PC
 - Enables convenient debugging
- Full-featured debugging
 - Break points (fix, conditional)
 - Reading and changing of run-time variables
- No code changes allowed
- Full process control by IAV
- All-time deployable by developer
- Reuse standard data sources (A2L, PAR, DBC)
- Consistency over X-in-the-Loop (SiL, HiL)



Virtual ECUs for Automotive Software Silver

- Silver from QTronic GmbH
 - Software-in-the-Loop (SiL) simulation environment
 - All relevant automotive standard formats supported
 - Allows debugging via Microsoft Visual Studio
 - IAV has already experience with Silver



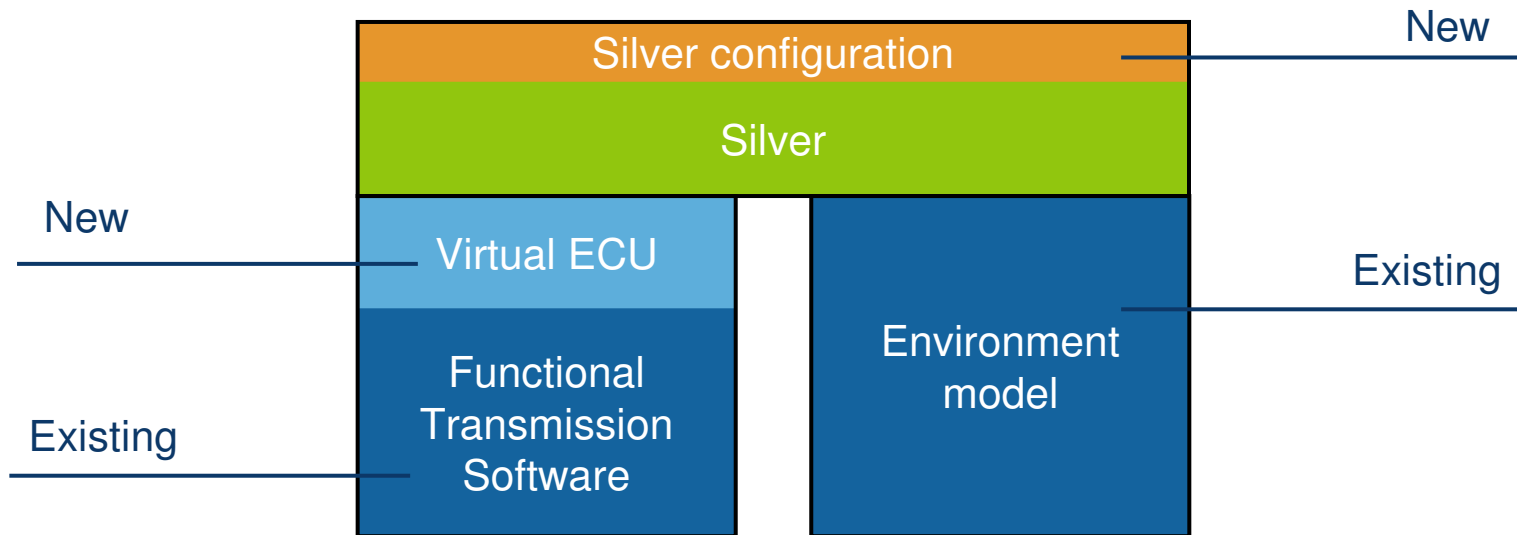
Virtual ECUs for Automotive Software

Agenda



- Motivation
- **SiL setup**
- Debugging
- Experience
- Conclusion

Virtual ECUs for Automotive Software SiL Setup

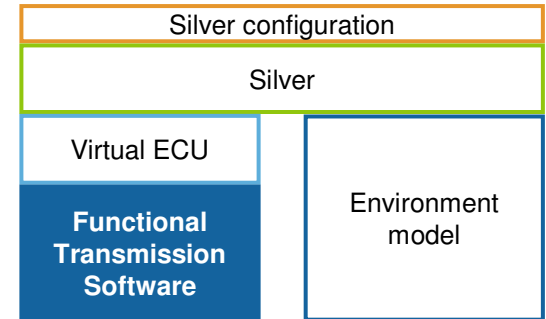


Virtual ECUs for Automotive Software

SiL Setup: Transmission Software

- **Transmission software**

- C-Code (Hand coded, auto code from TargetLink)
- Mostly accessible as code, some as LIB
- Interface to Virtual ECU
 - ECU BIOS calls
 - get/set functions for sensor, actuator, CAN data
- SiL task
 - Compile for PC processor (x86, Microsoft C Compiler)
 - Current developer code



Virtual ECUs for Automotive Software

SiL Setup: Virtual ECU

- **Virtual ECU**

- Hardware and software

- IO interface to Silver-API
 - Input and output signals
 - Virtual CAN

- Timing

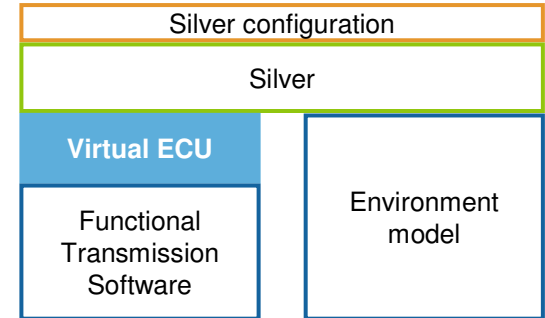
- Task slices

- BIOS functionality

- Non-volatile memory

- SiL task

- Write C-Code using Silver Basis Software (SBS)
 - New: Virtual CAN

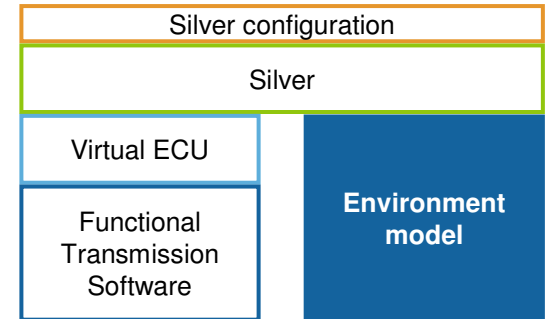


Virtual ECUs for Automotive Software

SiL Setup: Environment Model

- **Environment model**

- Longitudinal vehicle dynamics and CAN rest bus
- SiL task
 - Reuse existing HiL model
 - Implemented in Simulink
 - Adjust Timing
 - Switch block set to Silver block library (IO, CAN)
 - Compile for PC processor (x86)
 - Silver simbuild tool
 - Real Time Workshop
 - Microsoft C Compiler
- Rollout via version control system

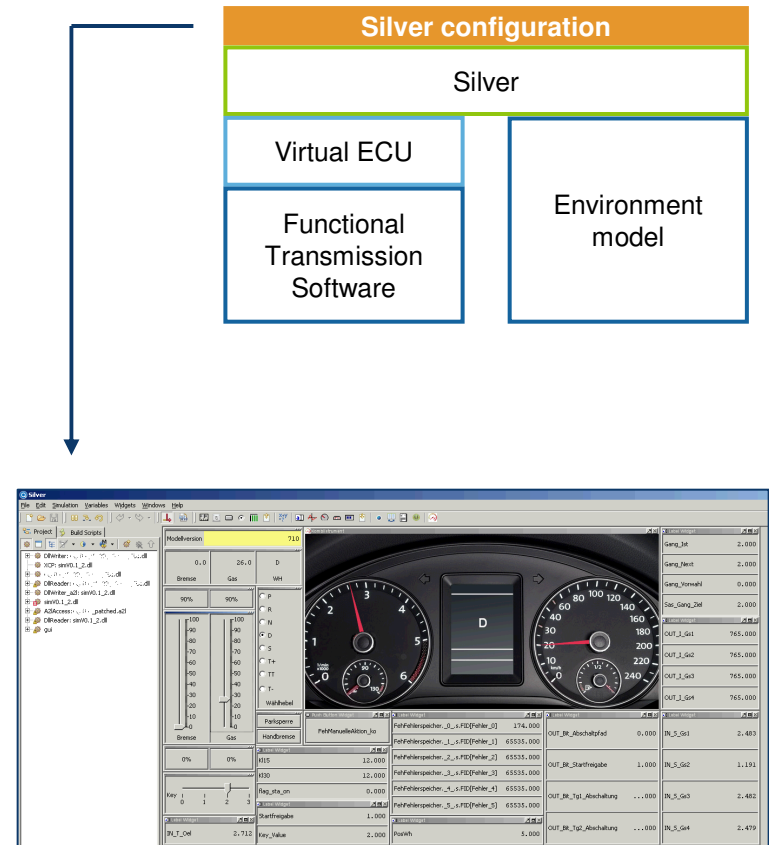


Virtual ECUs for Automotive Software

SiL Setup: Silver Configuration

- **Silver configuration**

- Graphical user interface
 - Start/ stop simulation
 - Interact with simulation (gear lever, accelerator and brake pedal)
 - Display and change elementary information
 - Software: A2L measurement signals and parameters
 - Model: Status information
- PAR file flashing
- Access A2L
- SiL task
 - Setup new experiment



Virtual ECUs for Automotive Software

Agenda



- Motivation
- SiL setup
- **Debugging**
- Experience
- Conclusion

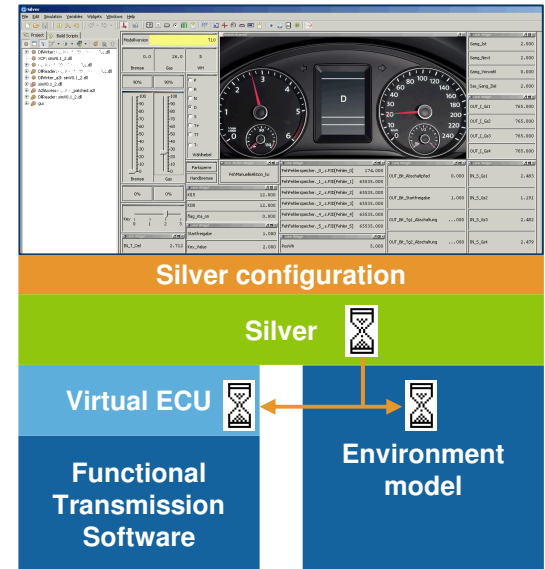
Virtual ECUs for Automotive Software Debugging

• Characteristics

- SiL setup (as described before) with current developer software
- Stops whole simulation (incl. environment model)
- Configuration is easily adaptable

• Debugging focus

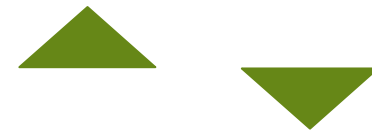
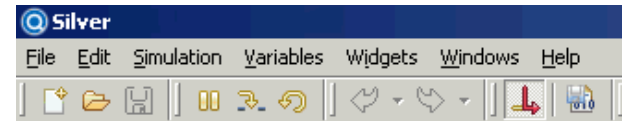
- Situations that are difficult to produce
- Timing errors
- Re-simulation of vehicle measurements
- Fault simulation
- „Living code“



Virtual ECUs for Automotive Software Debugging

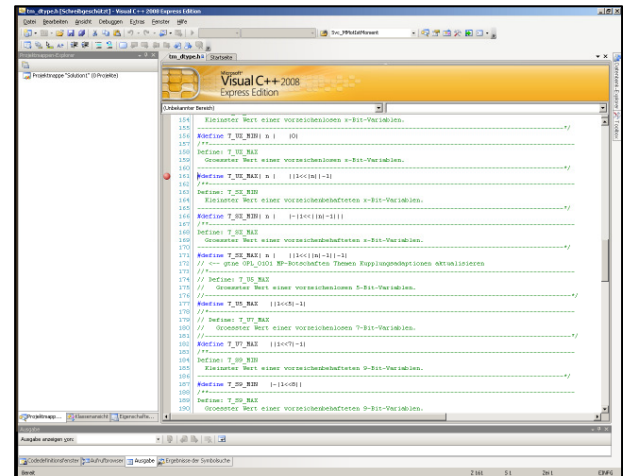
- **Silver Signal debugging**

- Stop Silver simulation at arbitrary time
- Analyse signals (with history even new added)



- **Code debugging**

- Open QTronic Silver with correct experiment
- Open Microsoft Visual Studio
 - Open C file
 - Set break point(-s)
 - Attach to Silver process
- Start Simulation
- Debug



Virtual ECUs for Automotive Software

Agenda



- Motivation
- SiL setup
- Debugging
- **Experience**
- Conclusion

Virtual ECUs for Automotive Software

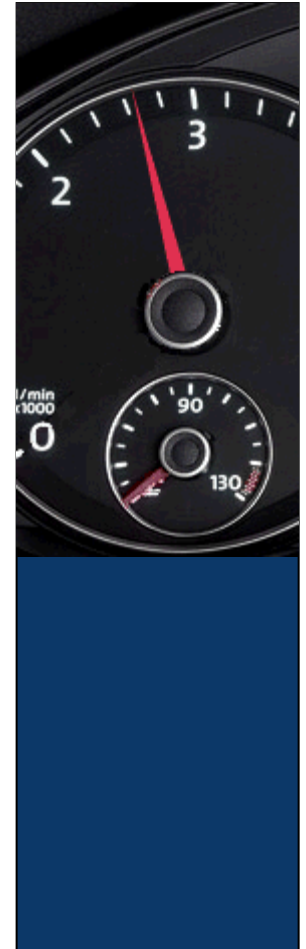
Experience: Build up and maintenance

- IAV had already experience with Silver usage
- First build up of SiL Setup
 - Work of IAV (with help from QTronic)
 - Effort: 6 MM
- Maintaining/ updating effort
 - Keep running since 1 year
 - Tasks
 - Adapting to function software changes (frequently)
 - Model updating (less frequently)
 - Change to new Silver API 2.4:
 - Better access to model data
 - Use build in CAN
 - Process improvements
 - Effort: ca. 1/2 developer



Virtual ECUs for Automotive Software Experience

- Added value from debugging
 - New quality of debugging
 - Step through code
 - Full access to all variables
 - Full history of signals in Silver
 - Analysis times reduced
 - Faster change-analysis-change cycles
- User acceptance
 - Growing acceptance
 - Advantages are fully accepted
 - High availability requested



Virtual ECUs for Automotive Software

Agenda

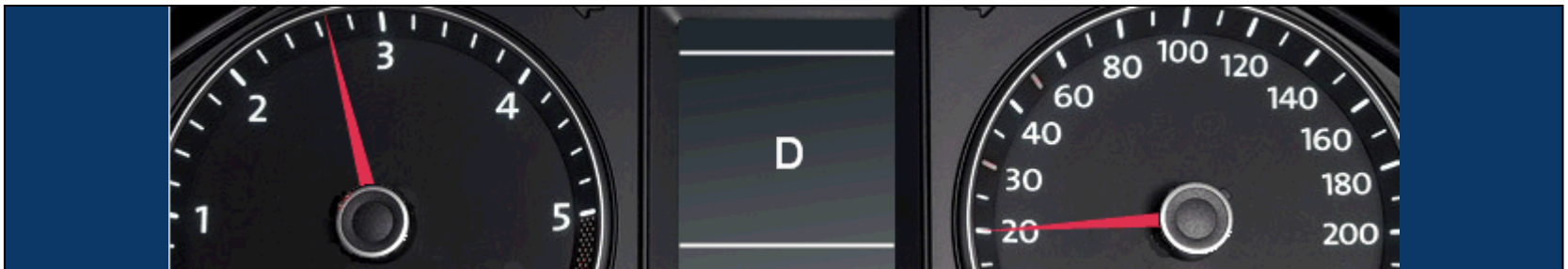


- Motivation
- SiL setup
- Debugging
- Experience
- **Conclusion**

Virtual ECUs for Automotive Software

Conclusion

- Silver enables build up of automotive SiL simulations easily
- Debugging at SiL level is successful
- SiL will be established soon
- Additional use cases planned for SiL simulation



Thank you!

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