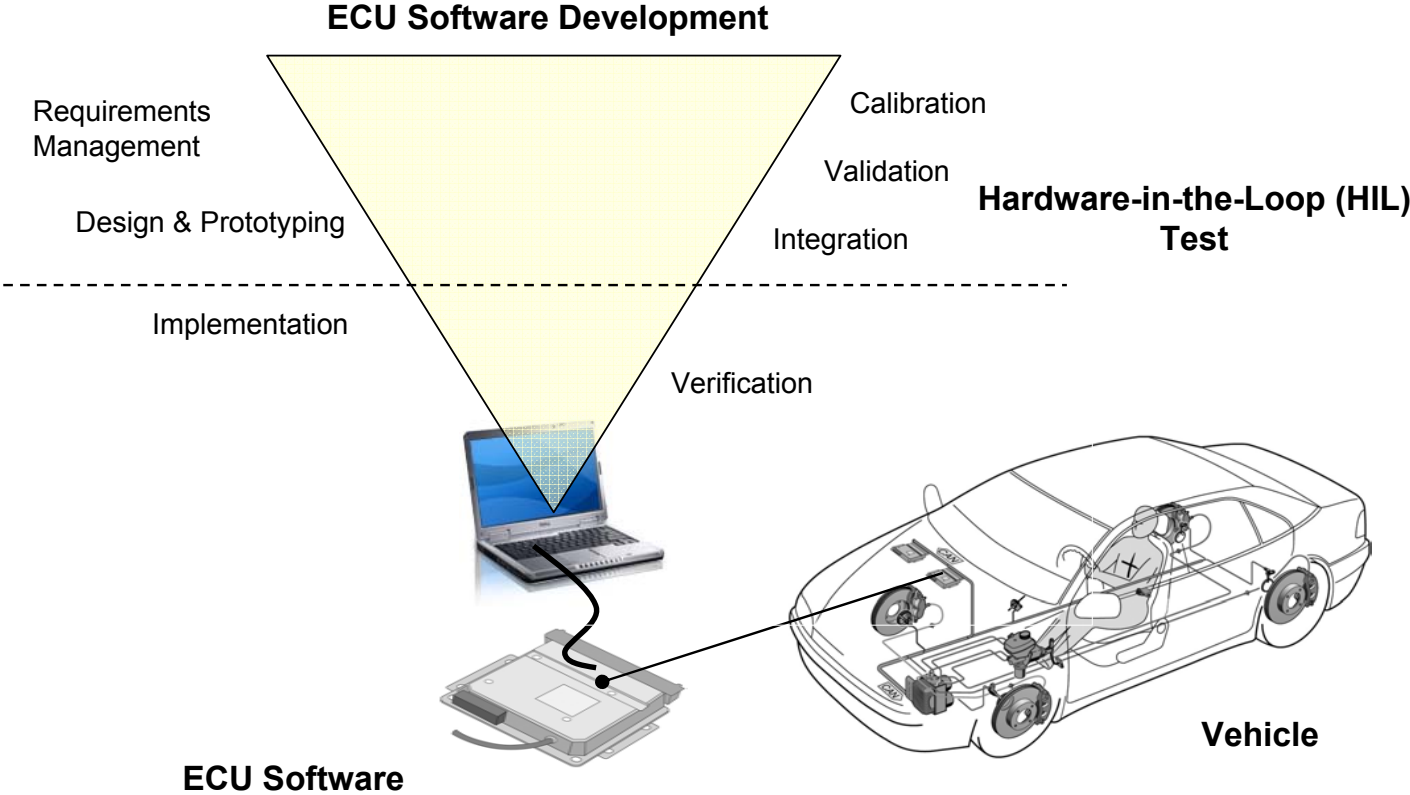




INCODIO® - a new Tool for automotive SIL applications

Stuttgart Symposium Automotive & Engine Technology – March 2007, 21st
Dr. Thomas Zurawka, Olaf Meyer, SYSTECS Informationssysteme GmbH

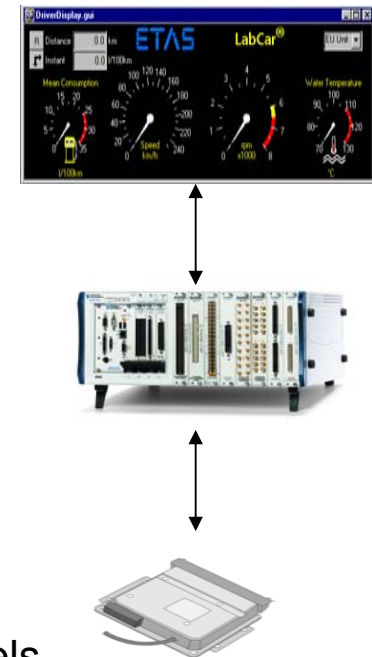
Overview



HIL – Current Status

- **ECU Validation** with HIL Technology
 - **widely used** for Validation of a Vehicle (Component)
 - important part of Vehicle Development Process
 - Value Proposition for Customers has been proven
 - i.e. higher Quality of Vehicles and ECU Software

- **ECU Calibration** with HIL Technology
 - still **less used** due to inappropriate Vehicle Models



HIL – fundamental Disadvantages *)

- **huge effort** for Installation and Operation
- **very expensive**
- **less flexible** due to limited Re-Configuration of Hardware
- separate Validation of ECU Hardware and ECU Software **not possible**
 - indeed we have here a
„Hardware & Software - in - the Loop“ Technology

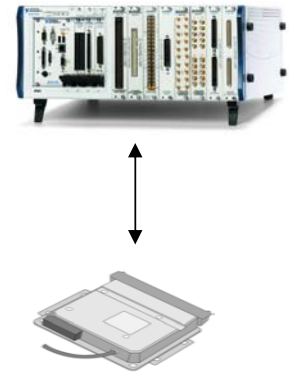


*) see also Hanselmann, dSpace; 11. Euroforum Jahrestagung „Elektronik-Systeme im Automobil“, München, Fachtag Systems Engineering, February, 15th 2007

HIL – Summary

- fundamental **Disadvantages** of HIL- Technology **cannot be removed !**
 - due to **hardware-based** connection to an ECU

- Which Technology can overcome these deficiencies ?
 - **Software-in-the-Loop Technology !**

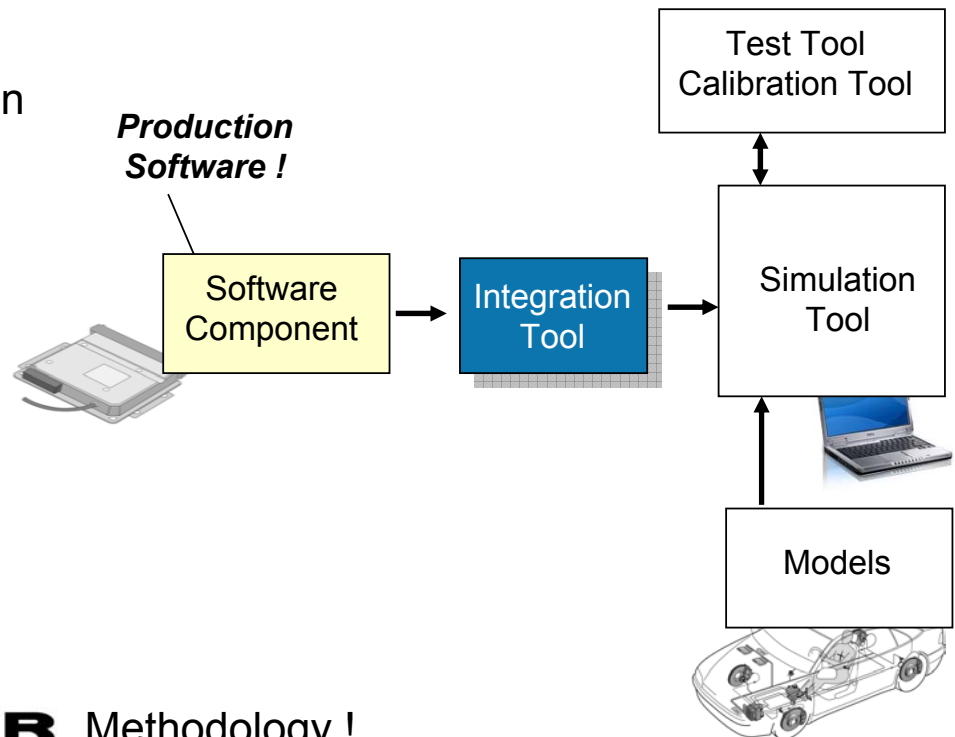


SIL – an emerging Technology

- **Software-in-the-Loop (SIL)**

- **less effort** for Installation
- **less expensive** than today's HIL solution
- **flexible** and easily re-configurable
- Last but not least: better support of

AUTOSAR Methodology !

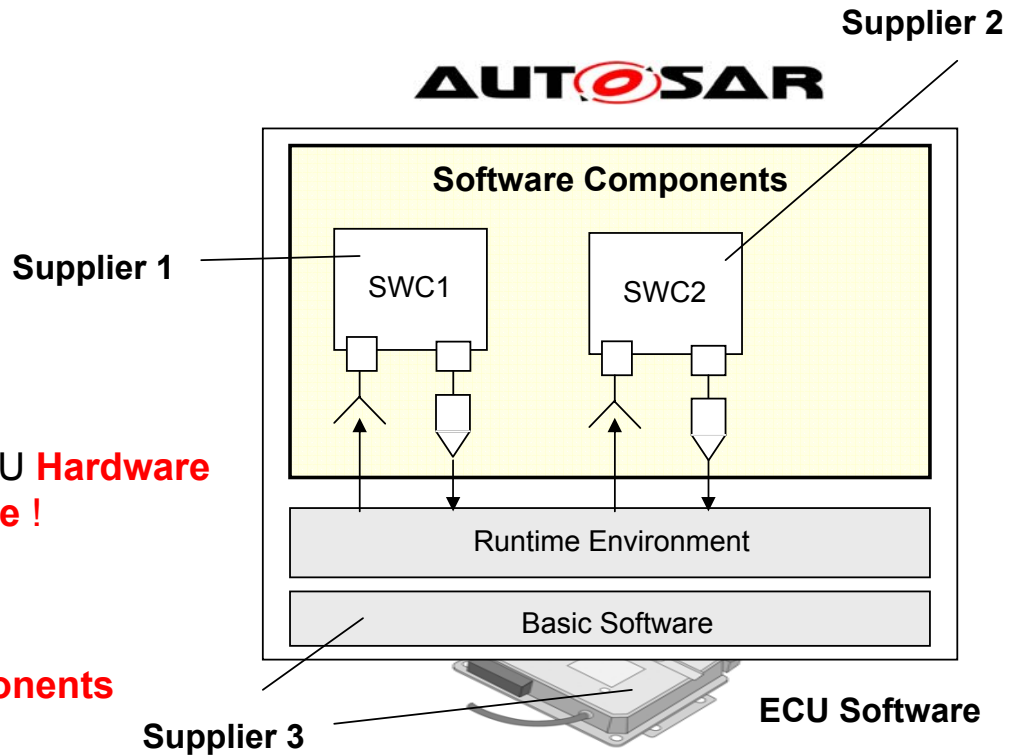


SIL – an emerging Technology

- AUTOSAR

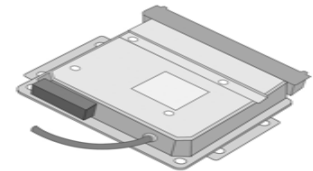
- component based Development and Validation of ECUs

- HIL & SIL for ECU Hardware & Basic Software !
 - SIL for ECU Software Components



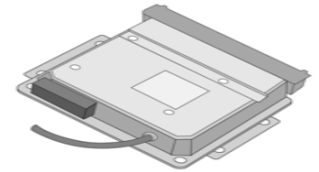
SIL – What is this exactly ?

- **Virtual Validation** and **Calibration** of ECU Software, e.g.
 - **C Code** and / or **Object Code** for **Production ECU's !**
 - high efficient implementation of Calibration Data
 - Use of special arithmetic Libraries
 - Use of special C Language constructs
 - „Struct“, „Union“, „Pragma“, „Macro“...
 - hand-coded or automatically generated C Code based on Models for ECU Software

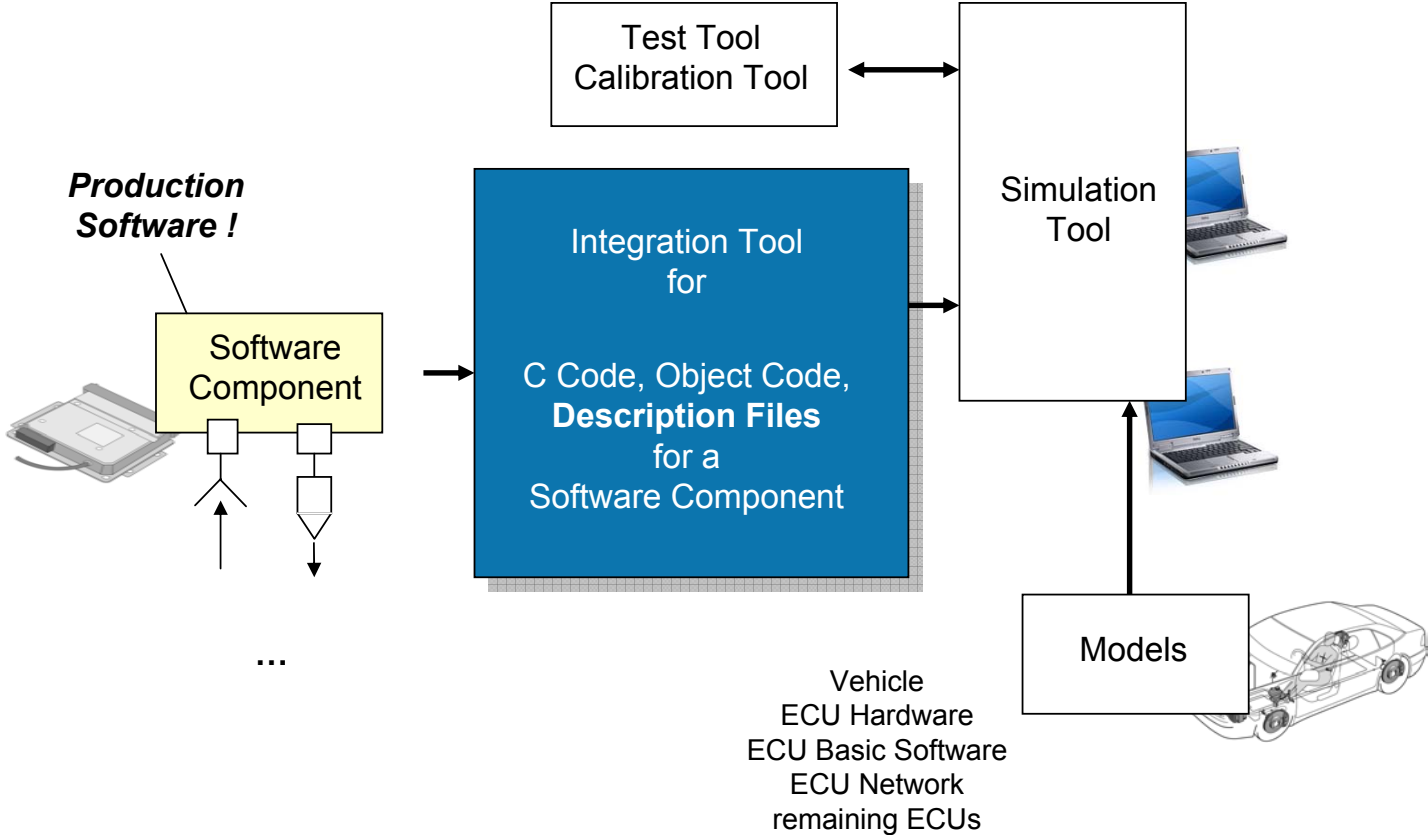


SIL – What is this exactly ?

- **Virtual Validation** and **Calibration** of ECU Software, e.g.
 - **no** Use of Matlab/Simulink, ASCET Models, ...
 - Behavior is different to Production Software !
 - **no** Use of C Code for Prototyping ECU's
 - Behavior is different to Production Software !

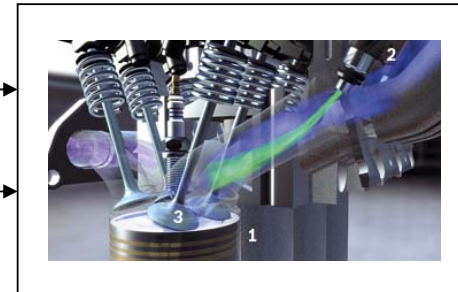


SIL – The Technology in a Nutshell



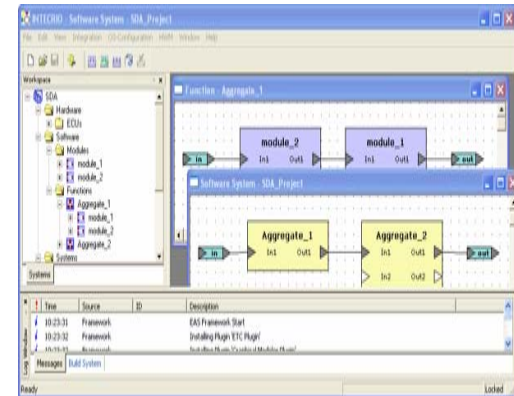
SIL – Which Models must be available ?

- **Vehicle Models**, which allow a Validation a Calibration in the Lab
 - is as well mandatory for HIL applications!
- **Models** for ECU Network
 - i.e. CAN-Bus Simulation
- **Models** for remaining ECU's in the Vehicle
 - i.e. CANoe Models
- **Models** for ECU Hardware & Basic Software
 - i.e. for NVRAM, EEPROM; **will be simplified AUTOSAR !**



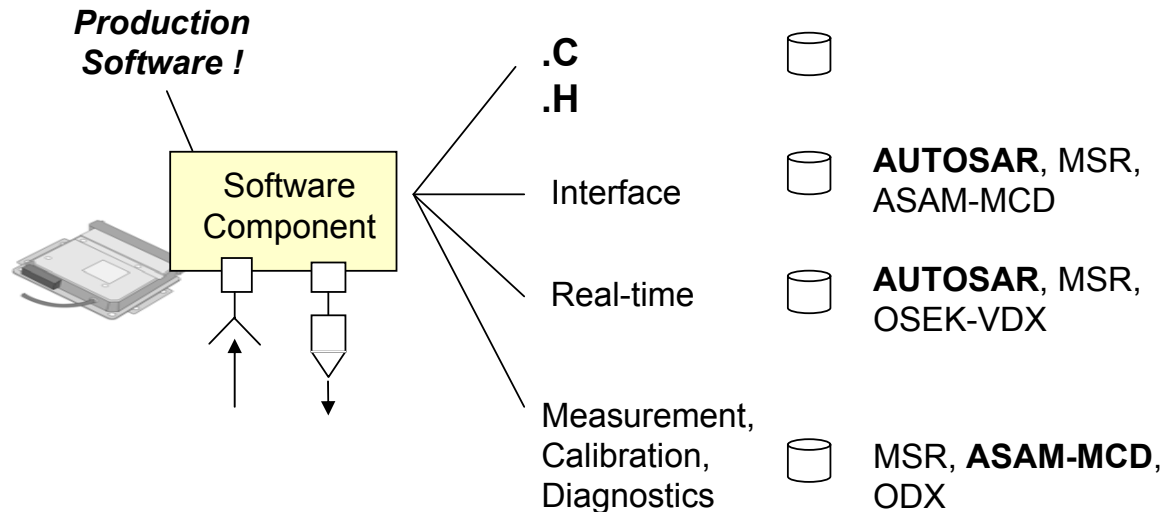
SIL – What is the job of the Simulation Tool ?

- **Open Interfaces** for Integration of C Code
- Integration of Models from different Tools
 - MATLAB®/Simulink®, ASCET, ...
- **PC (s)** as a Simulation platform
 - in Real-time; faster than Real-time
- **Measurement** and **Calibration** of physical Variables
 - i.e. by an open Interface for ASAM-MCD-2MC



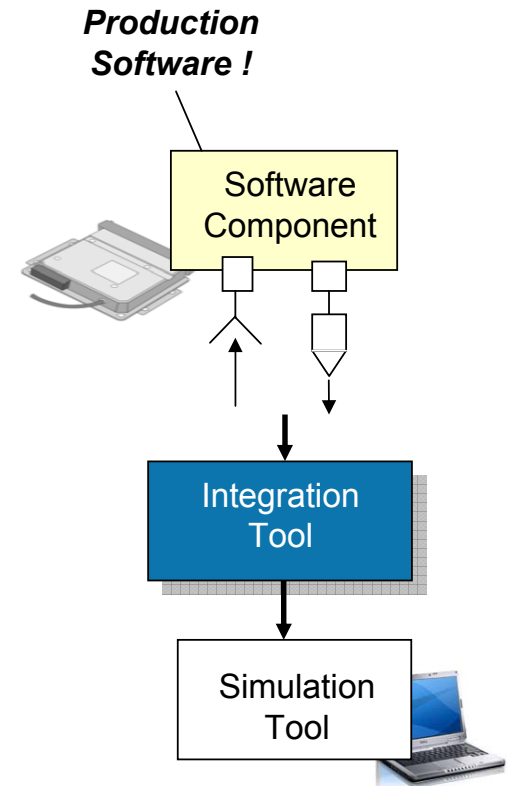
SIL – What is the job of the Integration Tool ?

- Support of different **Description formats** for Software Components



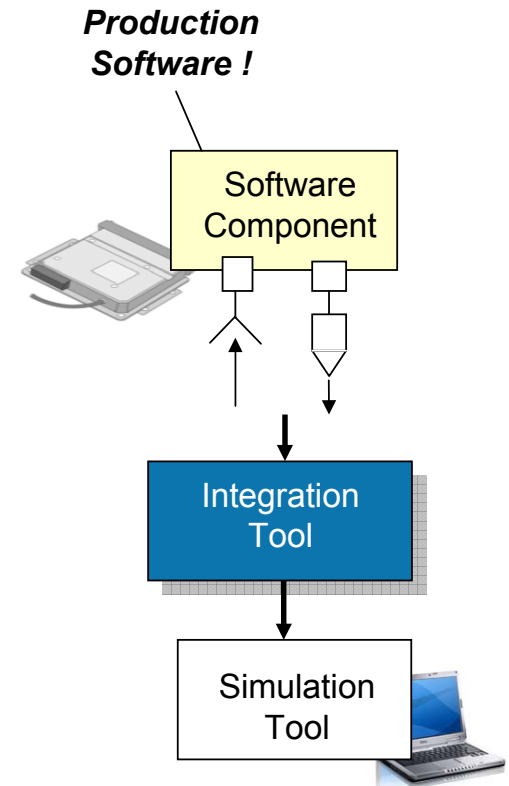
SIL – What is the job of the Integration Tool ?

- **simple Integration of C-Code**
 - Less additional Effort
 - i.e. **no** Definition of Functions and Variables in the Simulation Tool
 - Support of memory optimizing C Language constructs
 - „struct“, „union“, ...
 - Re-Definition of special C statements
 - i.e. „CONST“ -> „VOLATILE“
 - enables Calibration of Variables during Simulation



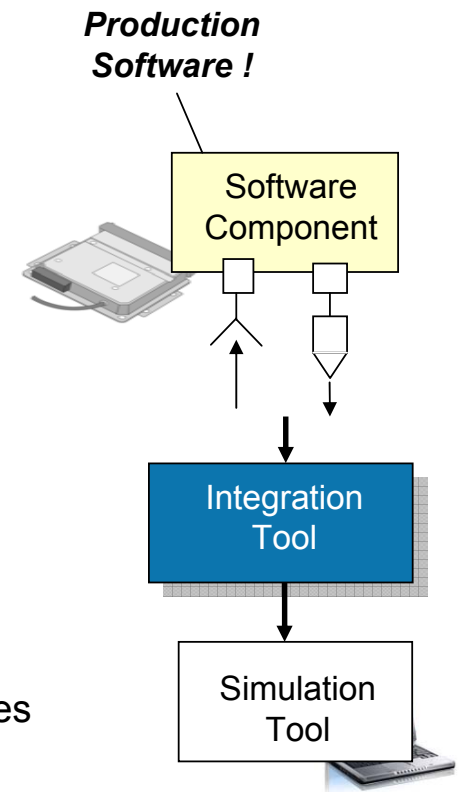
SIL – What is the job of the Integration Tool ?

- Support of **Measurement & Calibration** during Simulation
 - i.e. by Support of **ASAM-MCD-2MC**
 - enables Measurement of physical Variables of the Production ECU Software
 - enables Calibration of Parameters, Curves and Maps during Simulation
 - **arbitrary Record Layouts** of Production ECU Software must be supported

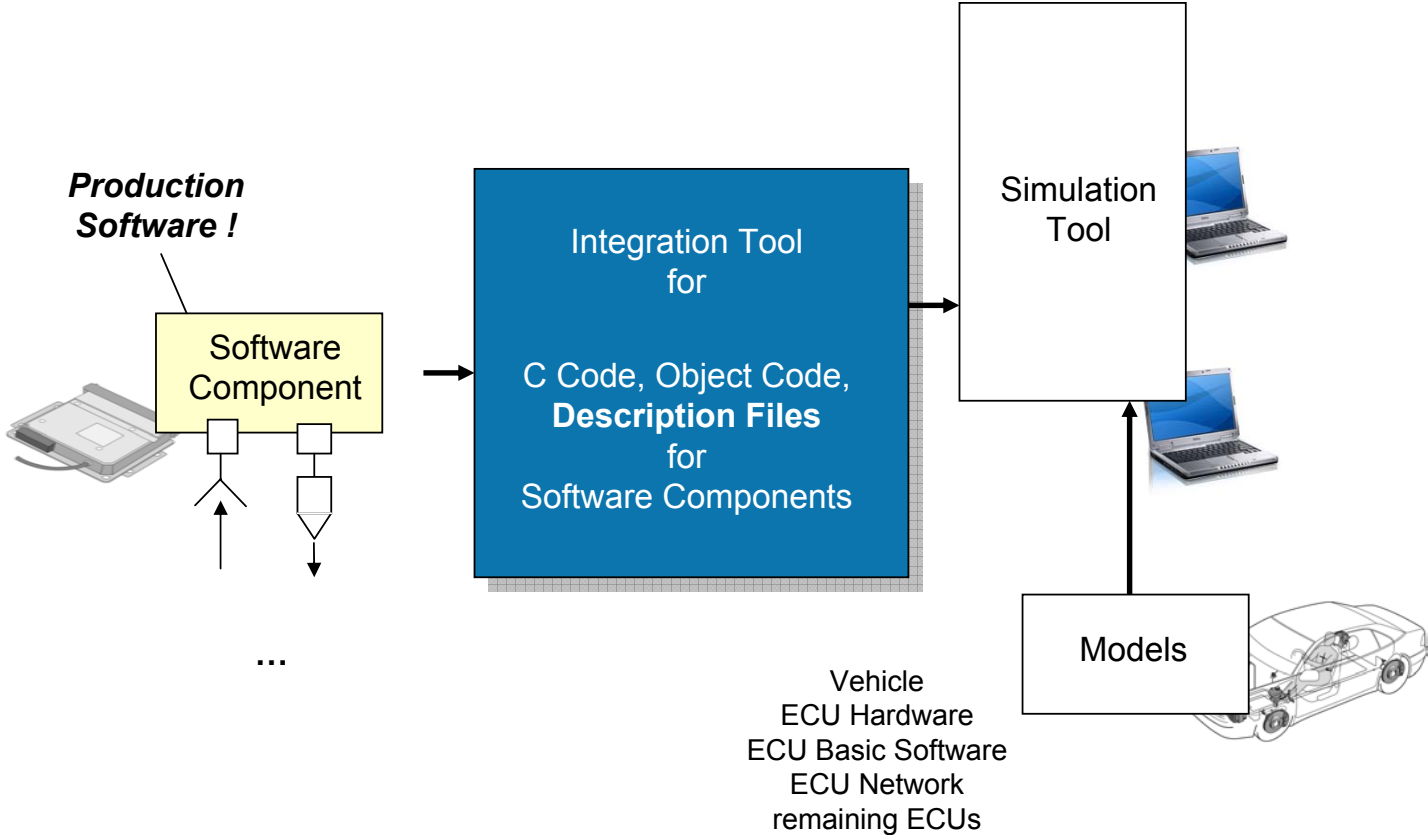


SIL – What is the job of the Integration Tool ?

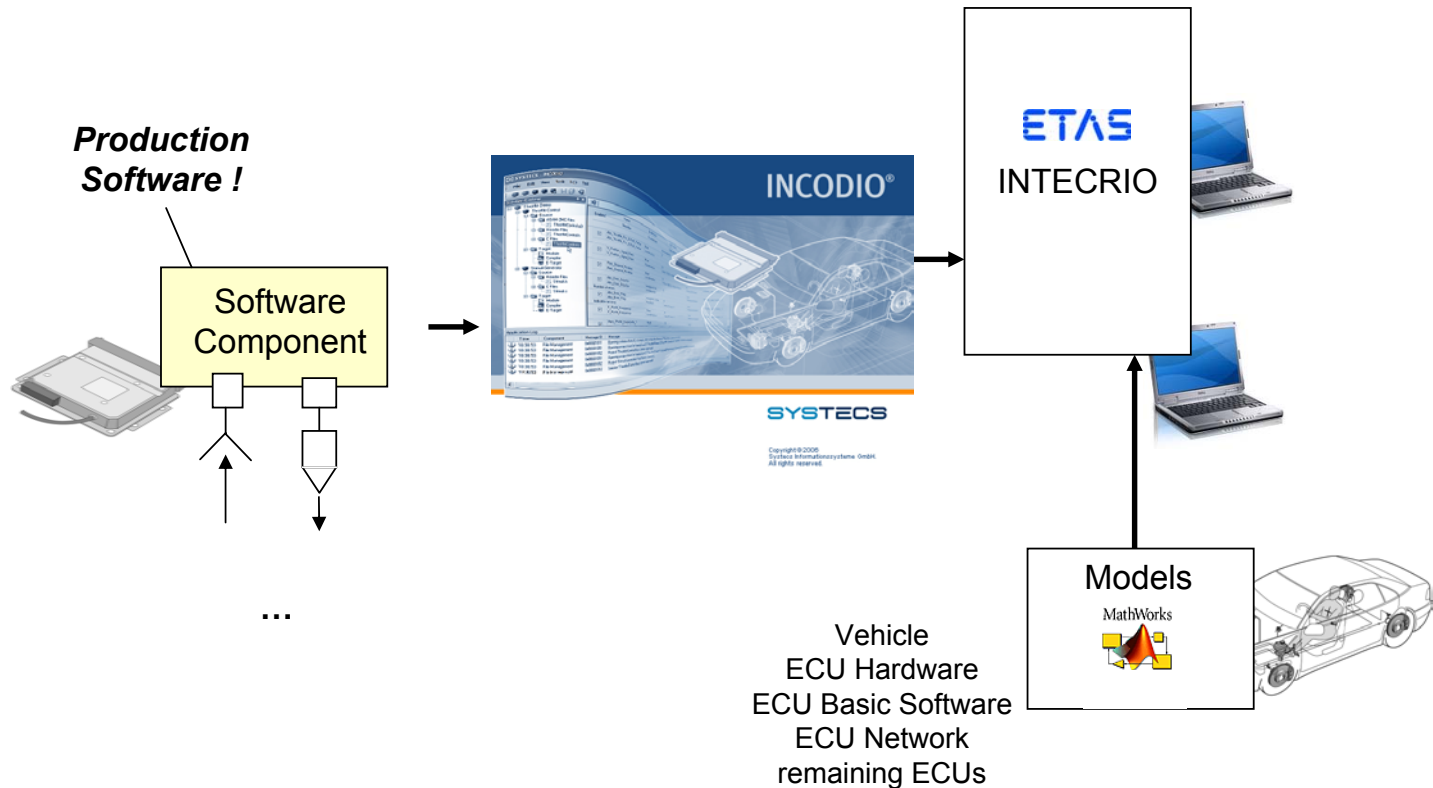
- Identification of **Interfaces** and **Real-time behavior** of a Software Component
 - i.e. by Support of the **AUTOSAR** Description
 - enables Stimulation und Input and Output interfaces
 - enables automatic Identification of Processes / Runnables
 - enables Specification of „Priority“, Trigger Mode“, „Period“, ... of Processes / Runnables



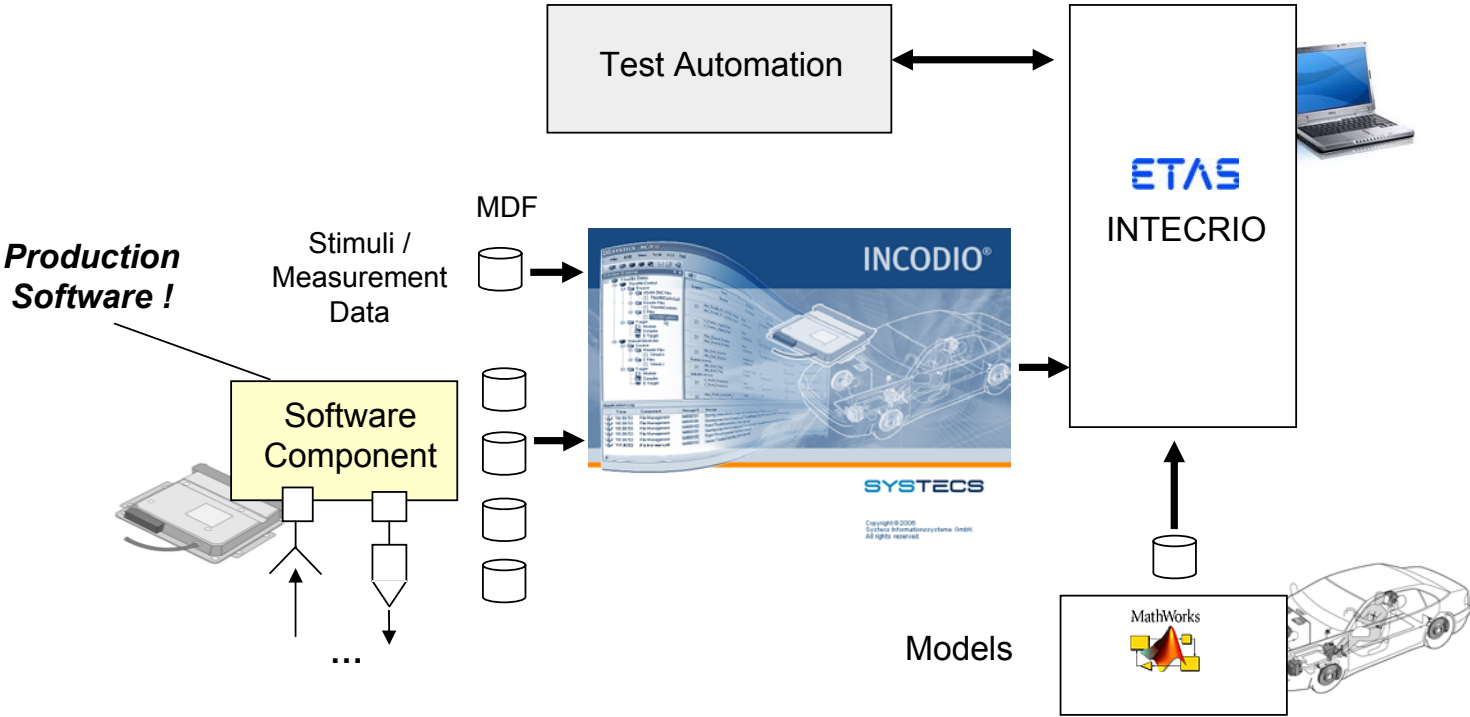
SIL – Which Tools are ready for use ?



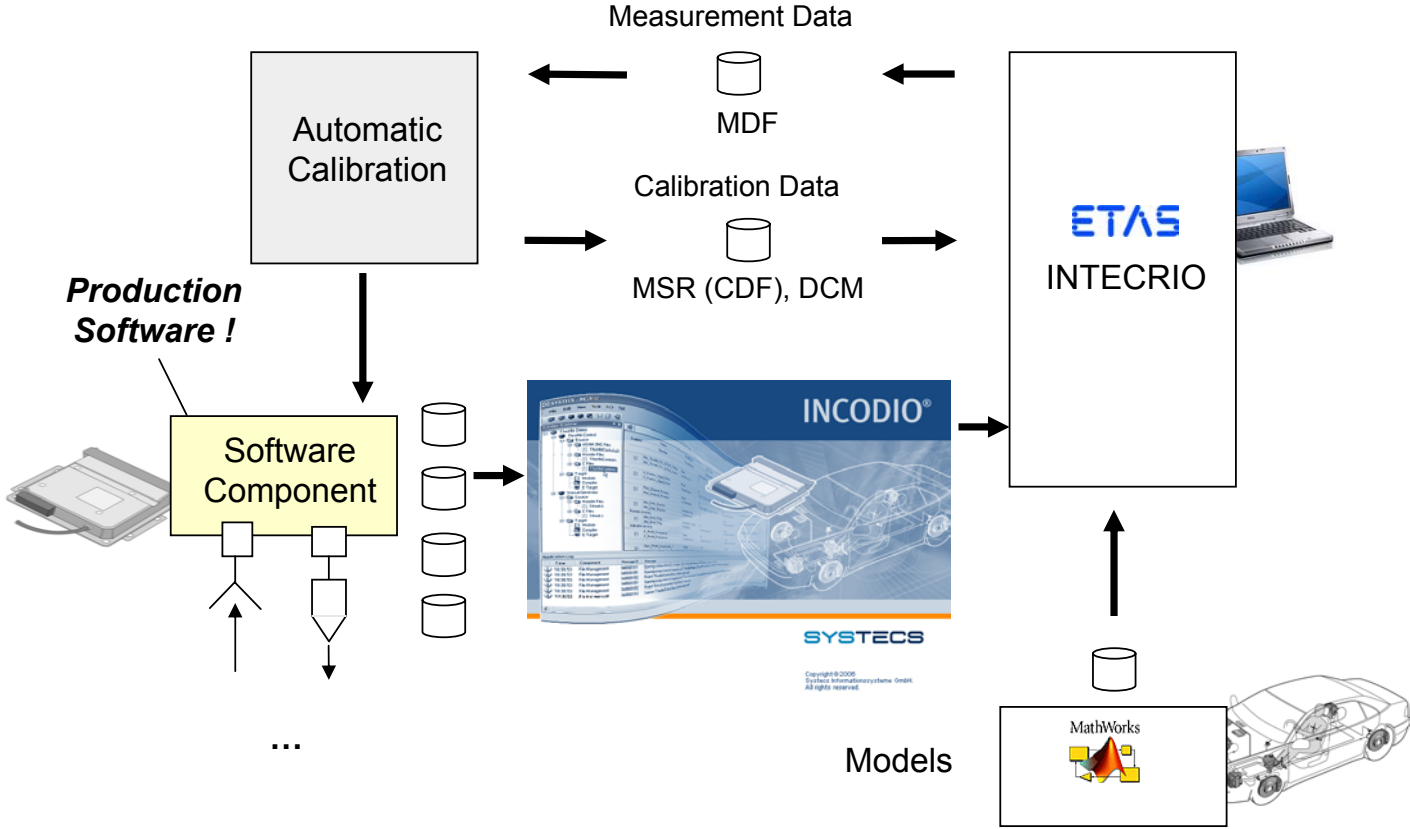
SIL – Which Tools are ready for use ?



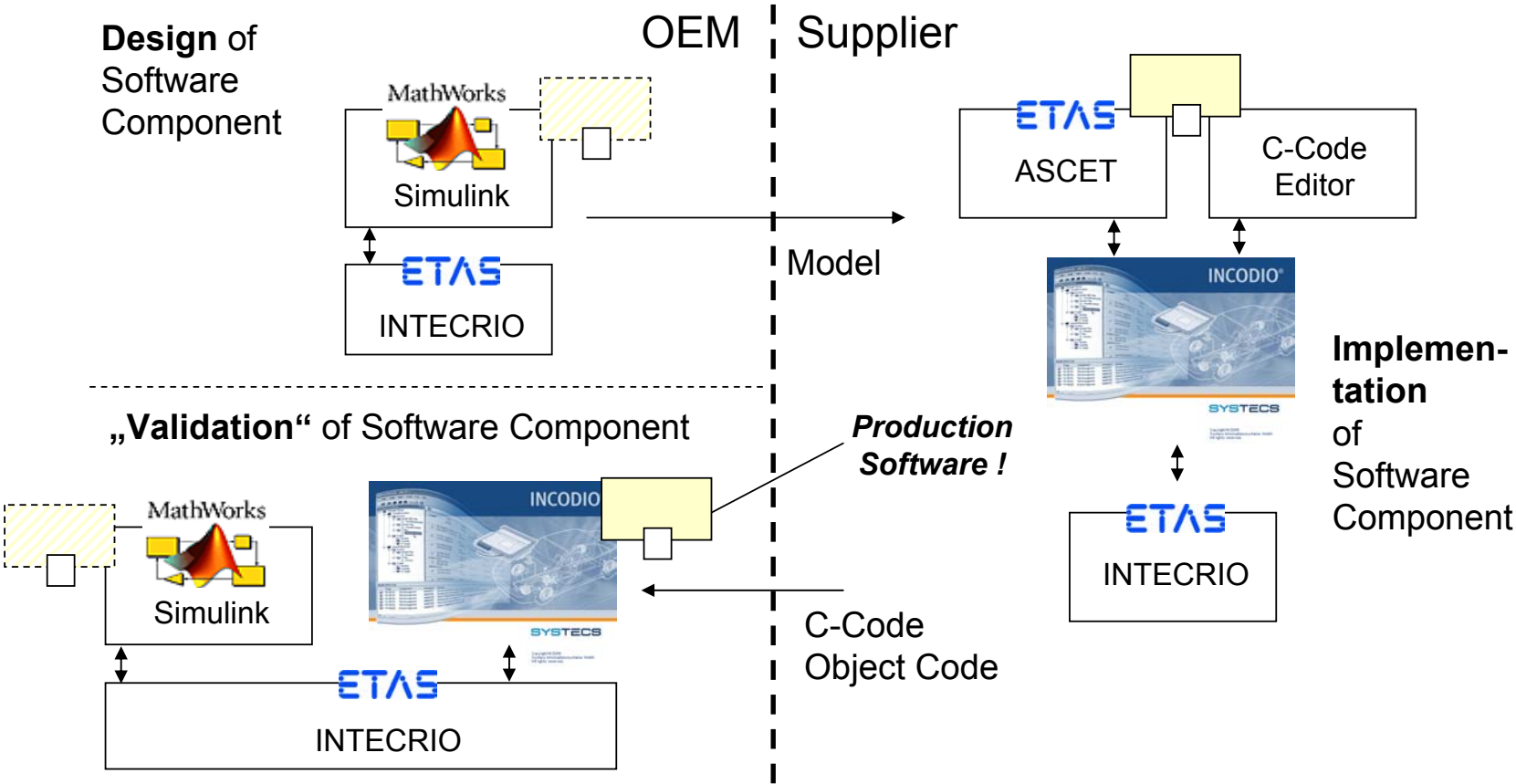
SIL – Validation of Production Software



SIL – Calibration of Production Software



SIL – Comparison of Model with Production Software



Summary

- **HIL** Technology plays, despite fundamental Disadvantages, an **important Role** in today's Vehicle Development Process
- Importance of **SIL Technology** will **steadily increase**
 - SIL avoids the Deficits of HIL
 - SIL additionally supports the component based Validation within the **AUTOSAR** Methodology
- **INCODIO®** and **INTECRIO** are excellent Tools for SIL applications

