Fraunhofer IIS

EffektiV

HiL Firmware Prototyping Using an COSIDE® Asynchronous Motor Model

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Agenda

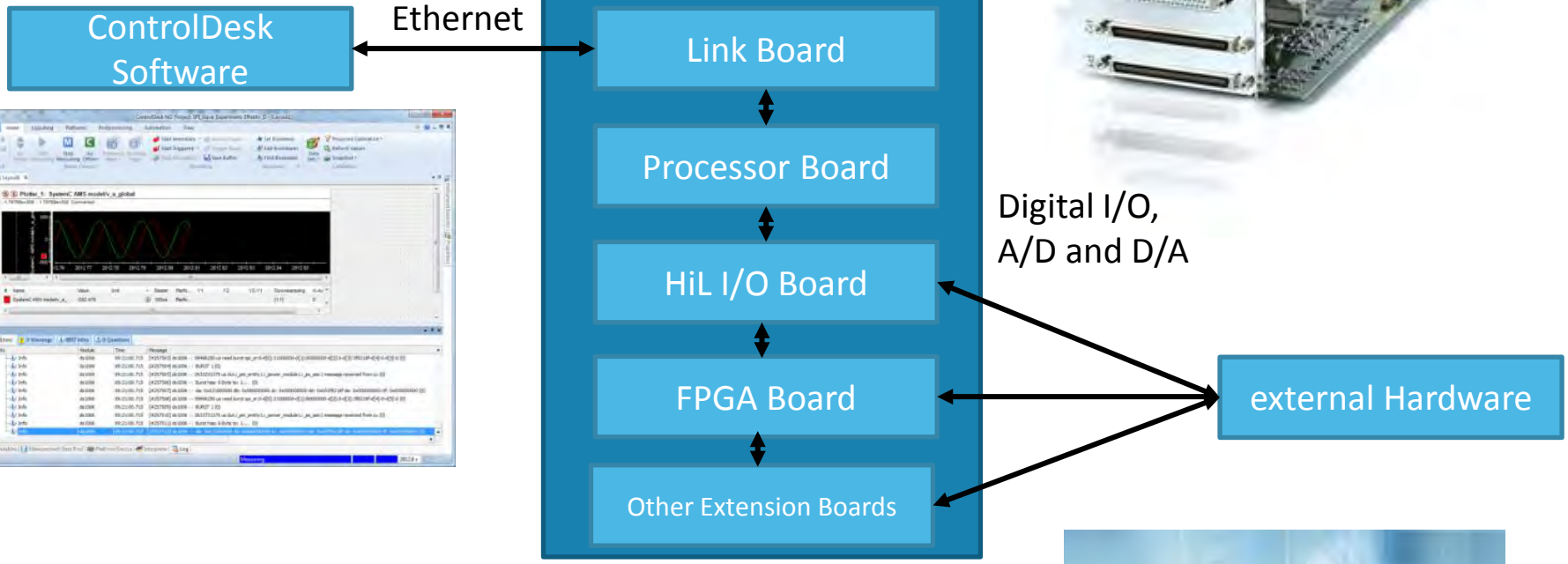
1. **Introduction**
   - EffektiV Project
   - HiL Intro
   - Example System
   - Motivation: Why HiL?
2. Tooling
3. Failure Injection
4. Demonstrator

Research project EffektiV

- Virtual stress tests for intelligent motion control systems
- German BMBF research project
- Fraunhofer as subcontractor of SIEMENS
- Consortium

- Our Focus: Hardware in the Loop Simulations with SystemC AMS

HiL Introduction



- **Other Extension Boards for specific needs (high speed or precision) or additional interfaces (LIN …) available**

Source: dSPACE

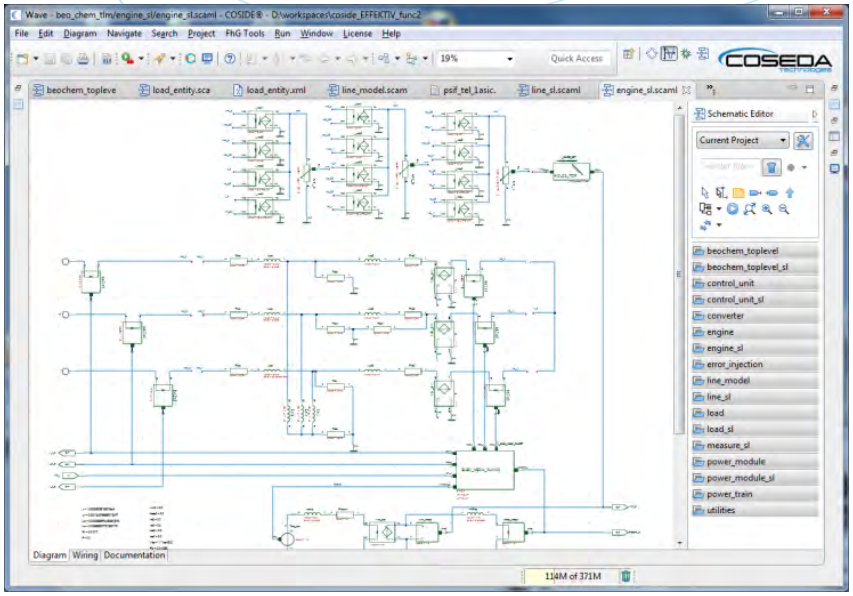
Why HiL?

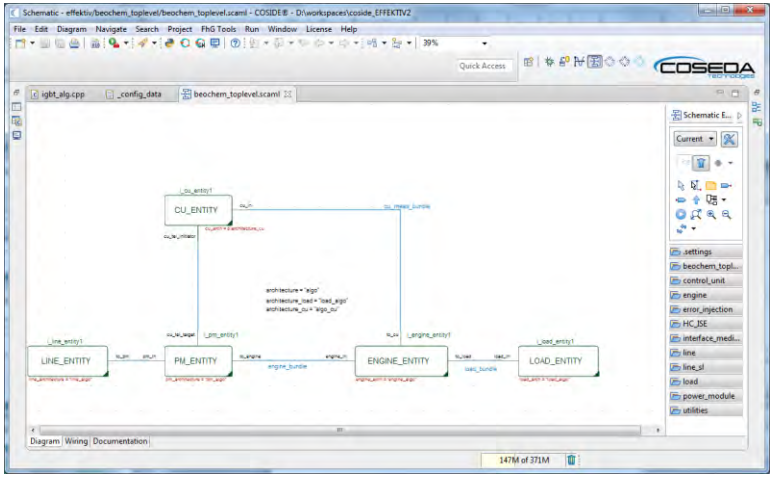
- **Debug –** Accessibility and Traceability from Signals for error root cause analysis
- **Speed/Detail –** Tradeoff between model speed vs detail level
- **Failure Injection –** Possibility to manipulate expected behavior to evaluate system robustness

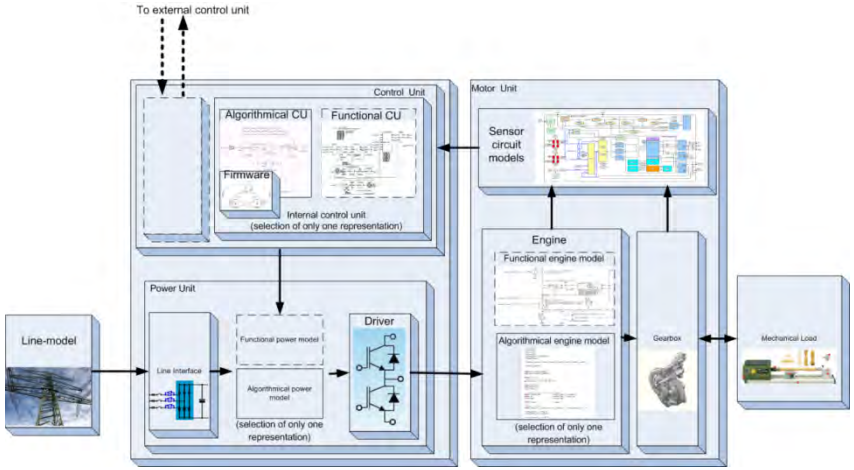
Pure Virtual	Real Hardware	Mixed (HiL)
• Debug ++ • Environment model (+) - Virtual Sensors • Speed/Detail -- • Failure Injection ++	• Debug -- • Environment model (+) - Hardware Sensor • Speed/Detail ++ • Failure Injection --	• Debug + • Environment model (++) • Both possible • Speed/Detail + • Failure Injection +

Example System

- **Motion-Control-System**
  - Control Unit (CU)
  - Power Module (PM)
  - Engine
  - Load
  - Line-Module







Why HiL? (2)

- **Task: Firmware development on the Control Unit (CU) for an asynchronous Motor**
- **Setup:**
  - CU as prototypes or hardware revision
  - SystemC AMS of PM, engine, load, line model running on dSPACE
- **Advantages:**
  - Realistic Firmware environment for CU through the use of real hardware
  - Use of proven failure injection models within SystemC AMS
    - Enables also the exploration of critical corner cases, which would destroy the real hardware

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   - Tooling Environment
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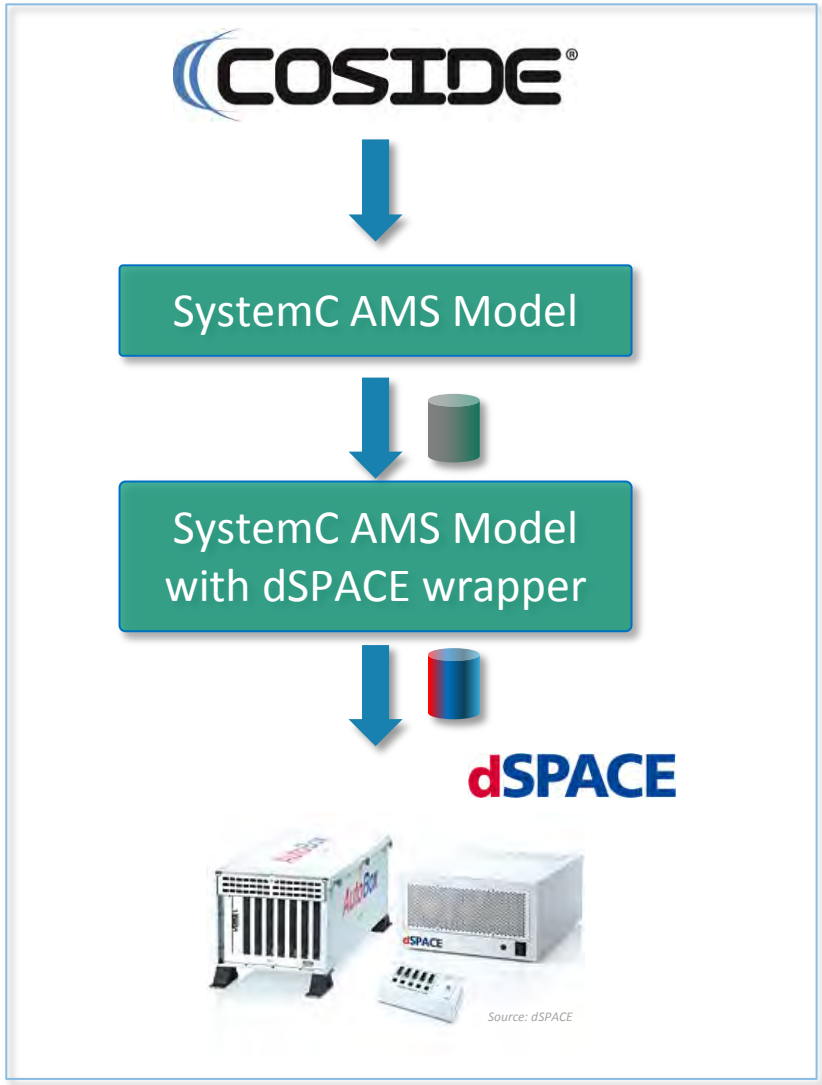
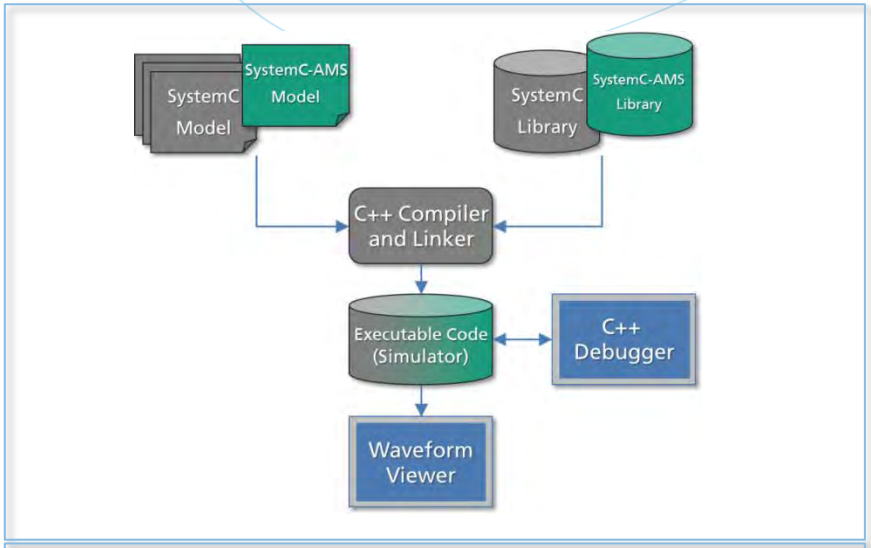
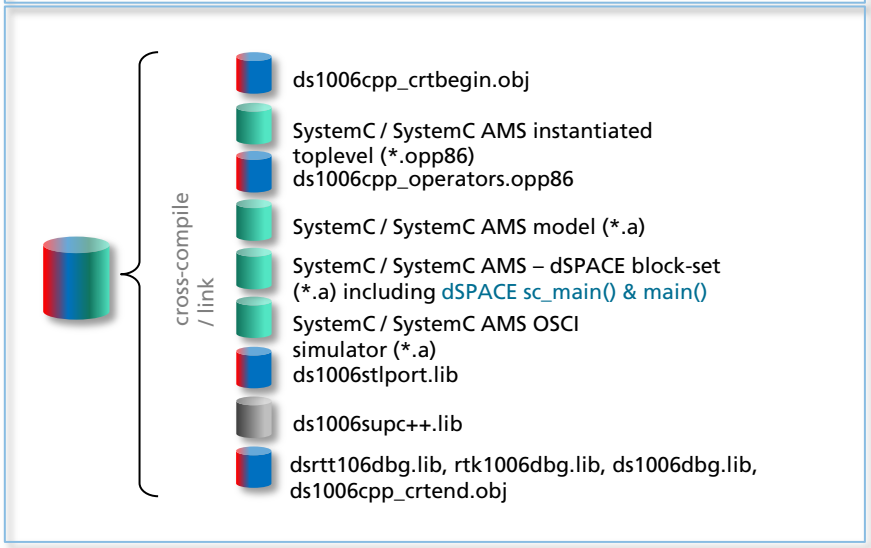
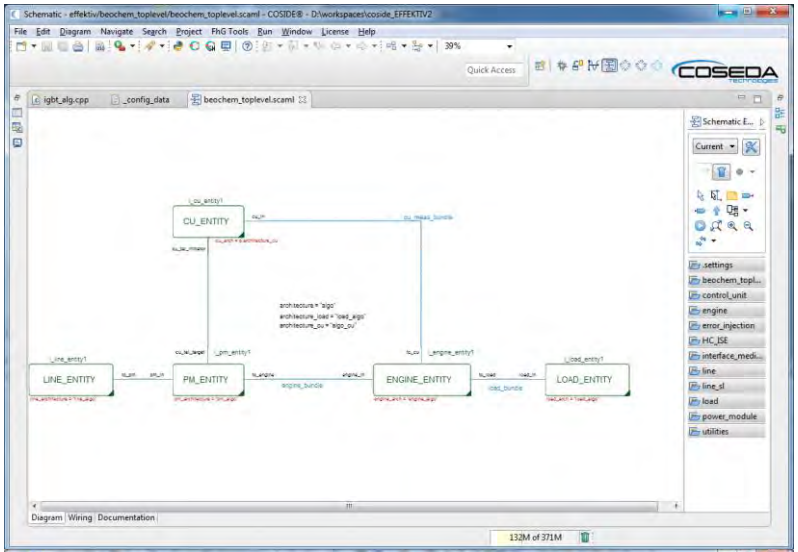
SystemC-AMS Executable

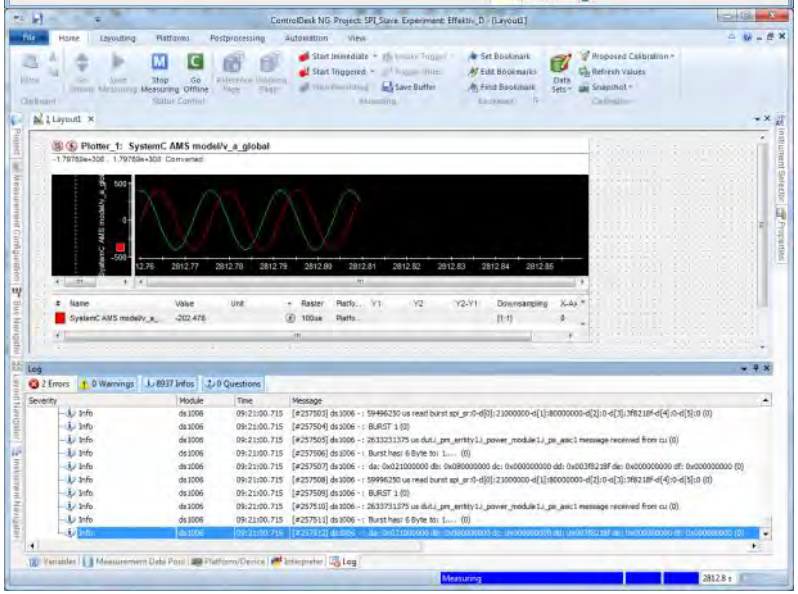


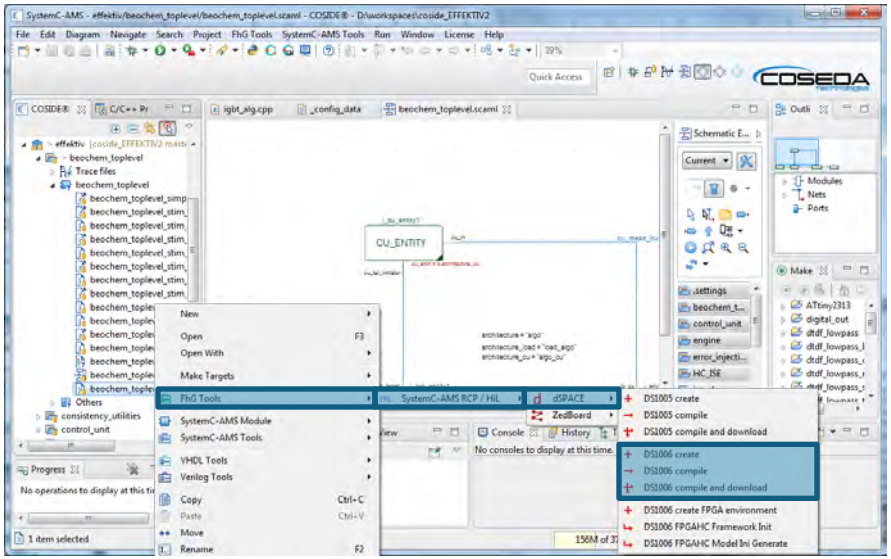




Development Environment

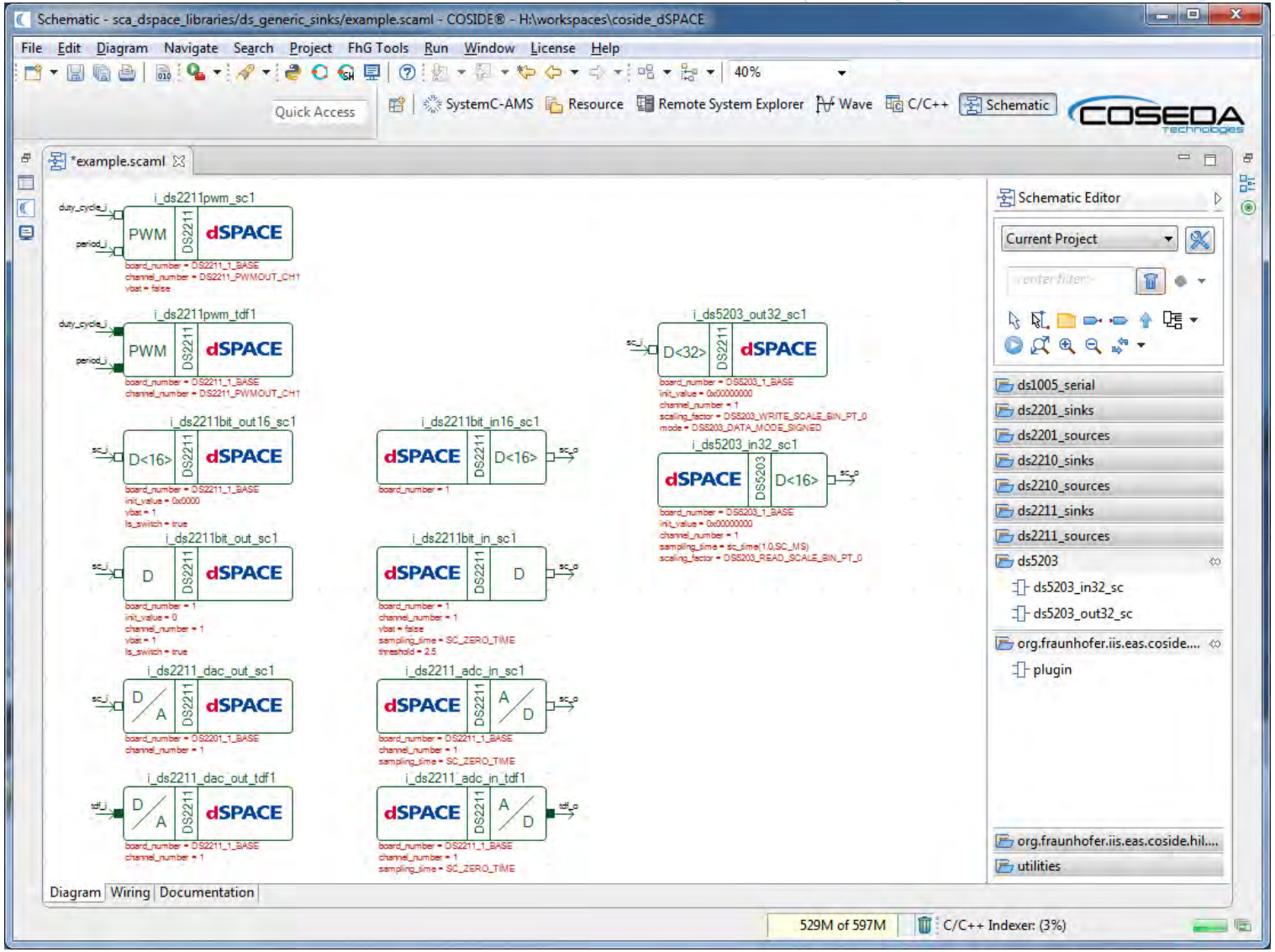






a) COSIDE® model entry
b) dSPACE specific Menus
c) ControlDesk Waveforms & Console

Interface Library



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Fault Injection

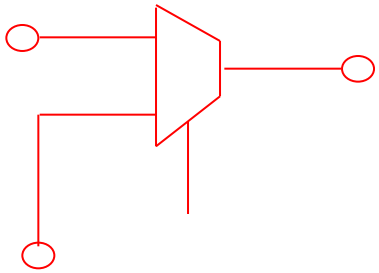
- **Properties**
  - Non intrusive failure injection, without model changes
    - Failure cases are connected into the netlist dynamically during runtime
    - Thread based for independent de/-activation
  - Failure scenario are build up hierarchically
    - Reusability (e.g. failure structures and scenarios)
    - Unified interfaces (for e.g. initialization, de/-activation)
  - Error location and time can be scattered statistically
    - Use of extensive statistic library

Fault Injection - hierarchical structure

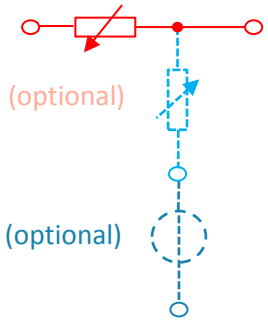
- **Hierarchical test structure**
  - Testbench
  - Testcase/Stimuli without failure injection ← includes additional fault stimuli
- **Extended hierarchical test structure with failure injection**
  - Failure stimuli (describes location and time behavior)
  - Fault scenario – combination of Fault models e.g. SPI
  - Fault models – e.g. Stuck at, Open-Short, Cross Talk …
  - Low-Level-Fault models (e.g. SC/TDF: MUX, ELN: resistor…)

COSIDE® Fehlerbibliothek

For sc/ tdf connections



for ELN networks



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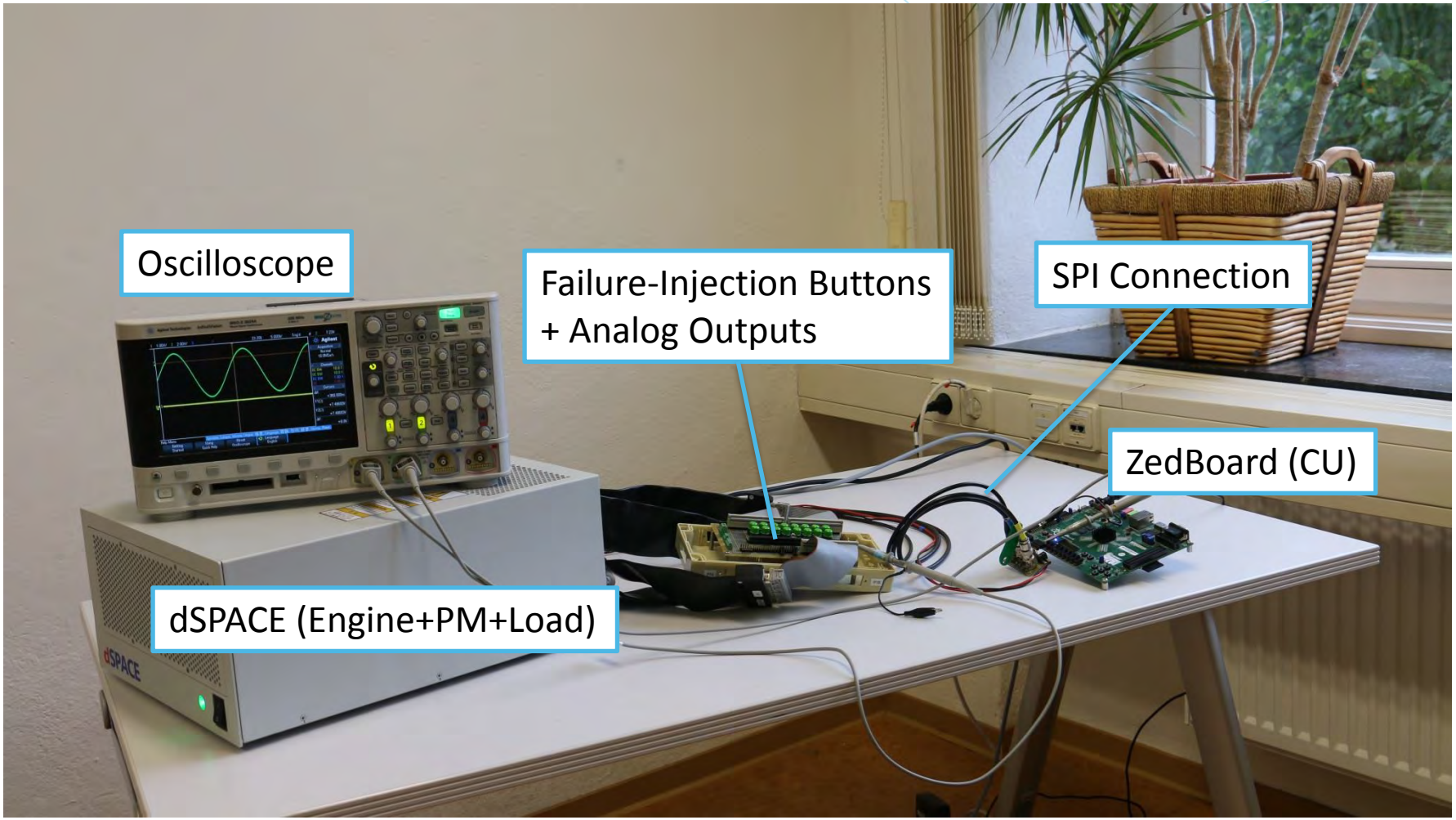
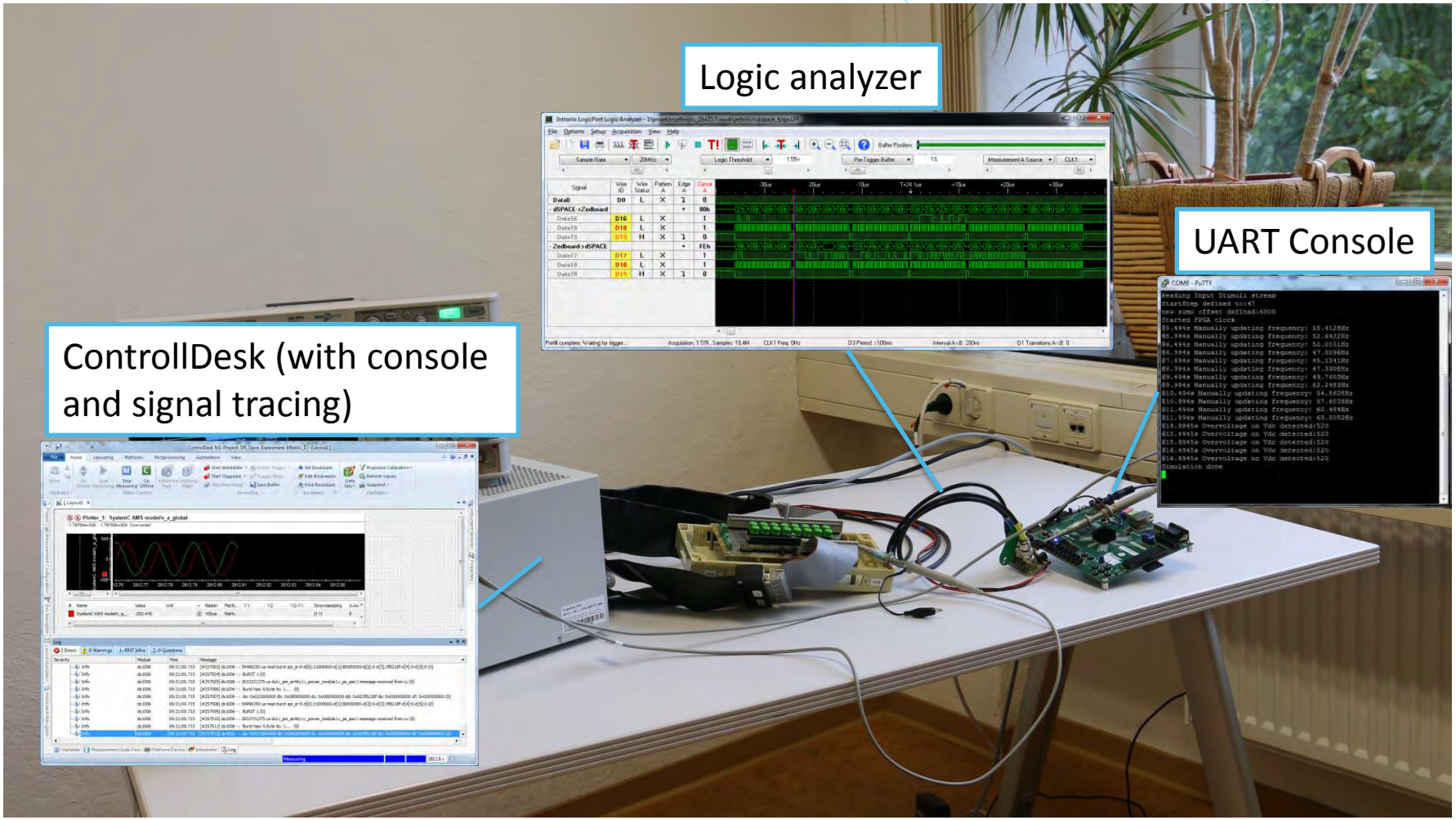
Prototyp Demonstrator



Debug interfaces



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GEFÖRDERT VOM

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Thank you for your attention!

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