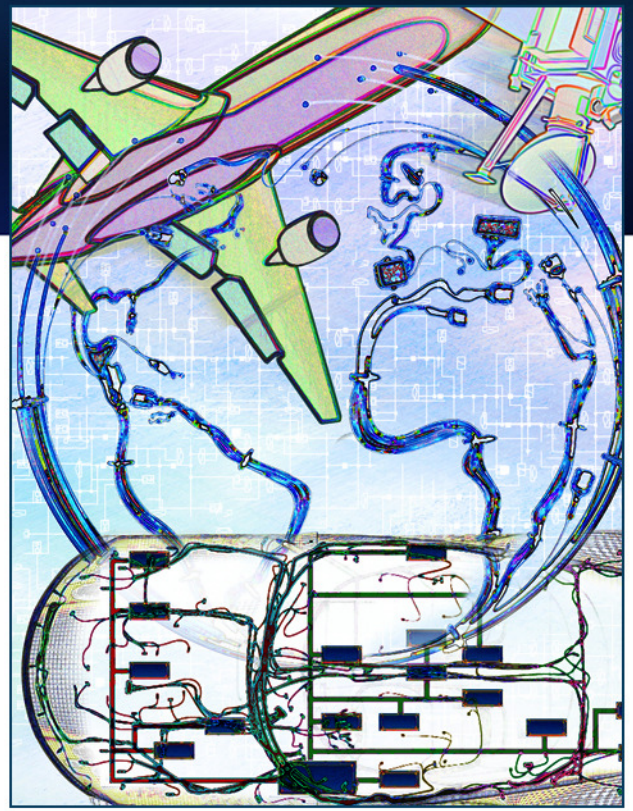
AUTOSAR E/E System Design
VSx Tool Chain Overview



Kai Wu

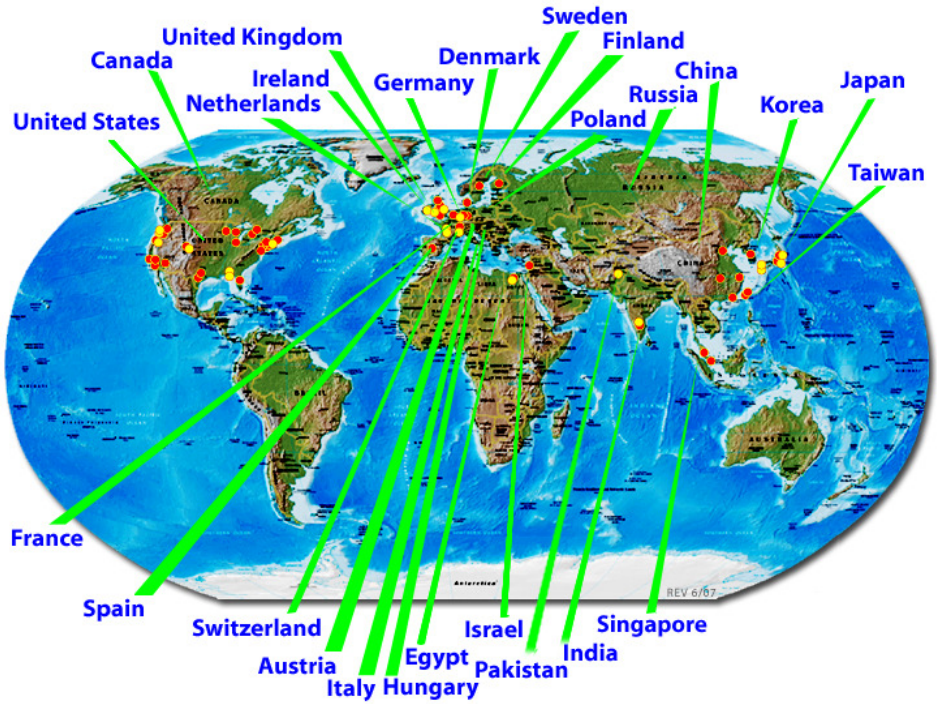
Technical Marketing Engineer

March 2010

Mentor Graphics®

Mentor Graphics a Leading Technology Driver in Electronic Design Automation (EDA) since 1981

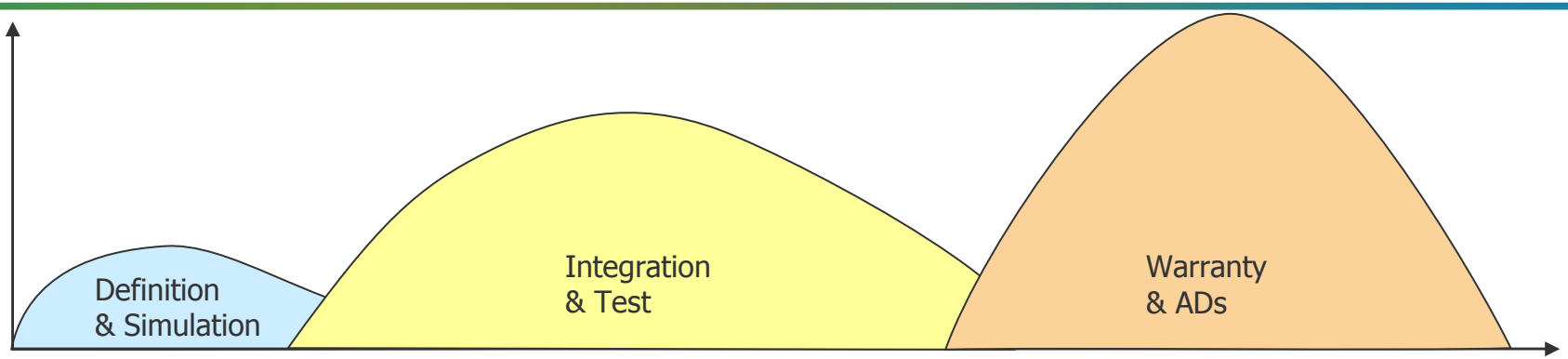
- Revenue of $790M in 2008
- Market share ~23% of worldwide EDA market
- Largest ECAD supplier to the automotive electronics industry
- One of the largest SW companies in the world (66th)
- 4,500 employees worldwide
- Acquired Volcano (VCT) in May 2005
- Member of AUTOSAR since 2004



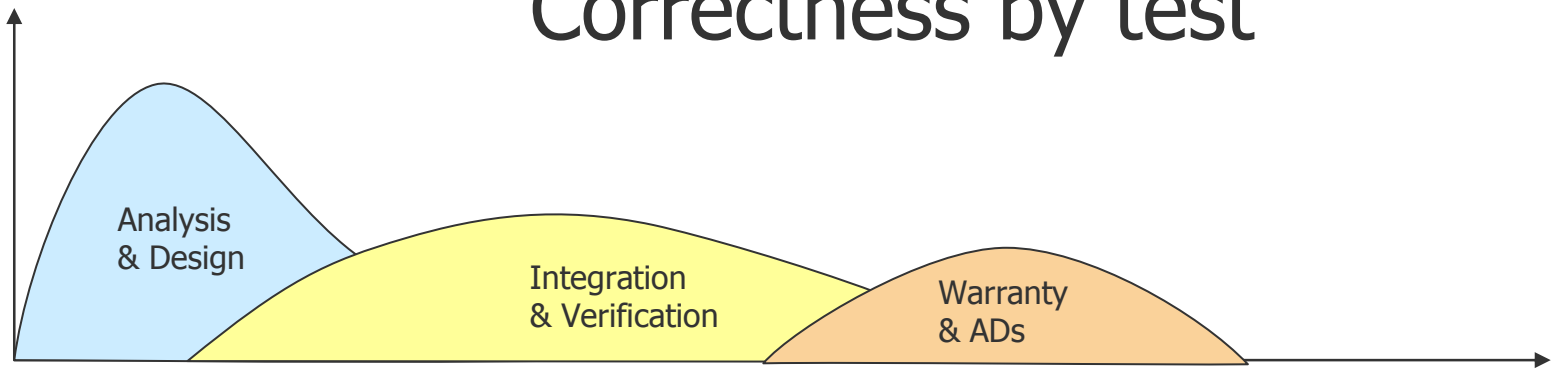
Guiding principles for Mentor VSx tools

- Enable ”front-loading” of development
- Enable shifting as much as possible of the validation effort to a virtual environment
- Use standard terminology and data exchange formats
  - AUTOSAR
  - Eclipse
  - EAST-ADL
- Cover the whole flow from requirements to SW and ECU implementation
- Enable customers to step-by step adapt individual parts of a complete solution

Frontloading the E/E Development



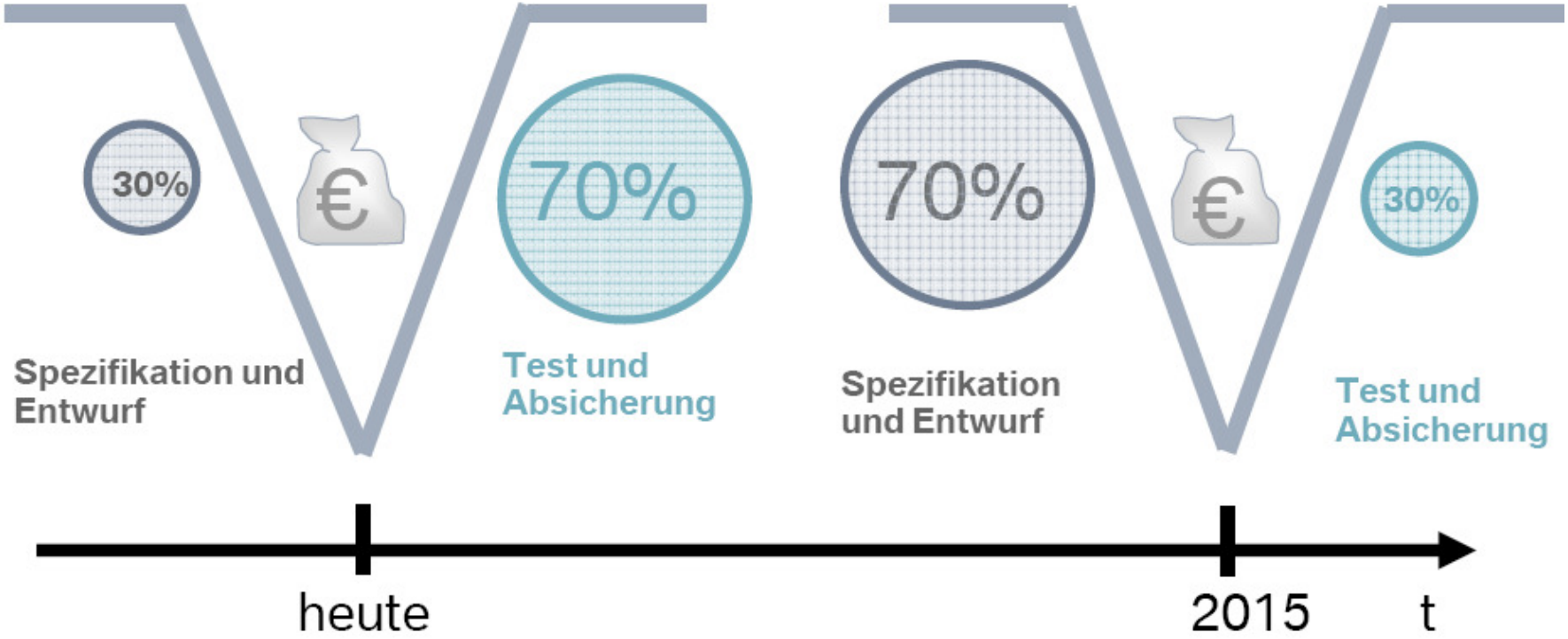
Correctness by test



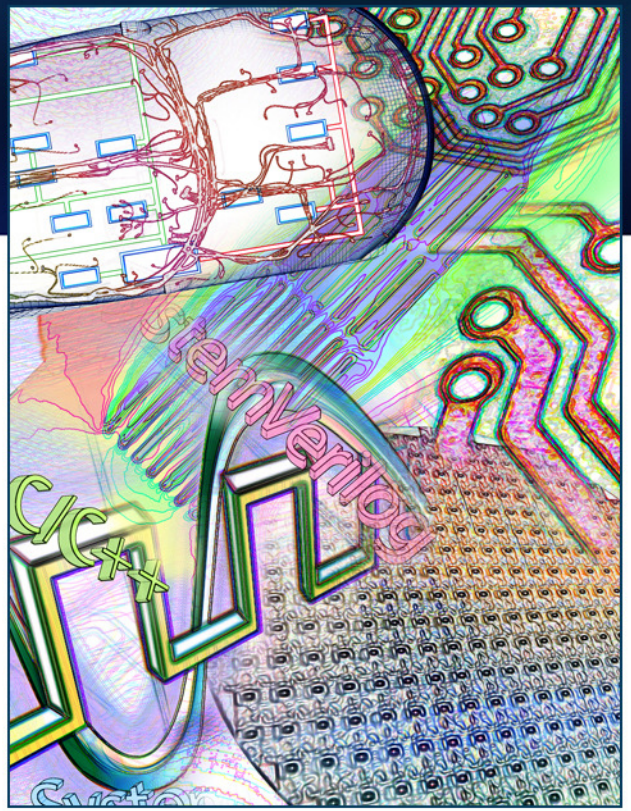
Correctness by design

BMW Example

AUTOSAR Tag
@ BMW Group
E. Frickenstein
BMW Group
16.01.2008



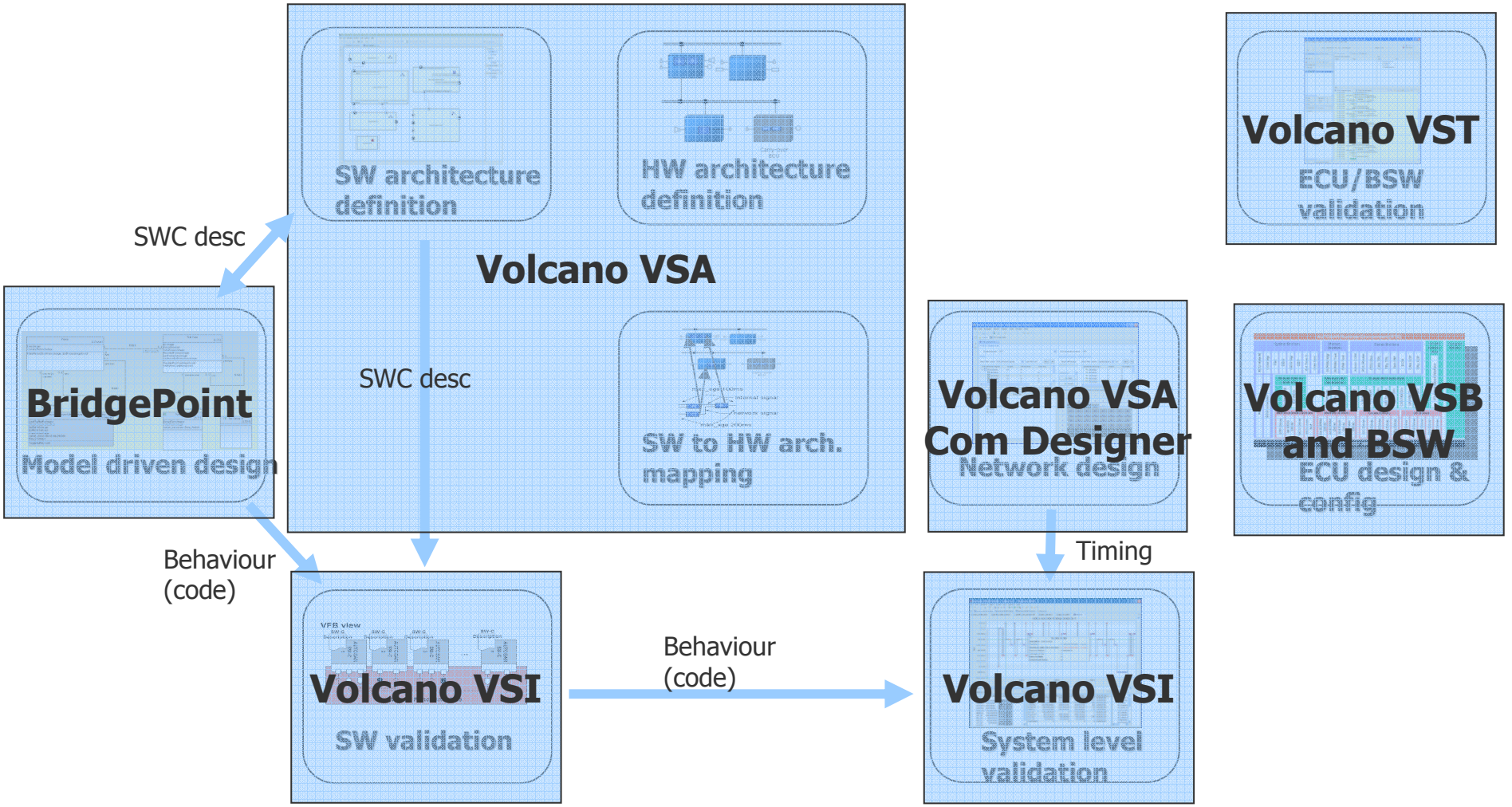
➔Change from testing to correctness (impossible) to design to correctness!
➔Frontloading is the main subject of Electronic Design Automation!
➔Mentor is the company, which can take you there!



Products overview

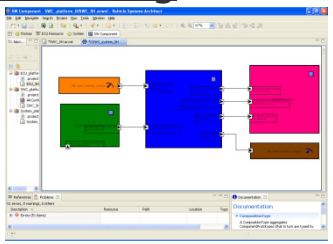
Mentor Graphics®

Mentor VSx AUTOSAR SW development tools

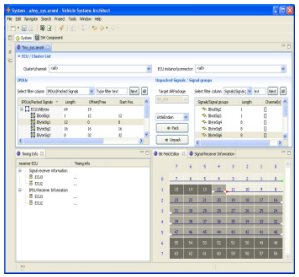


VSx Toolchain

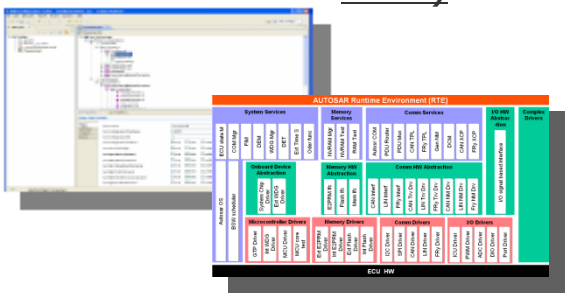
E/E Architecture & Authoring

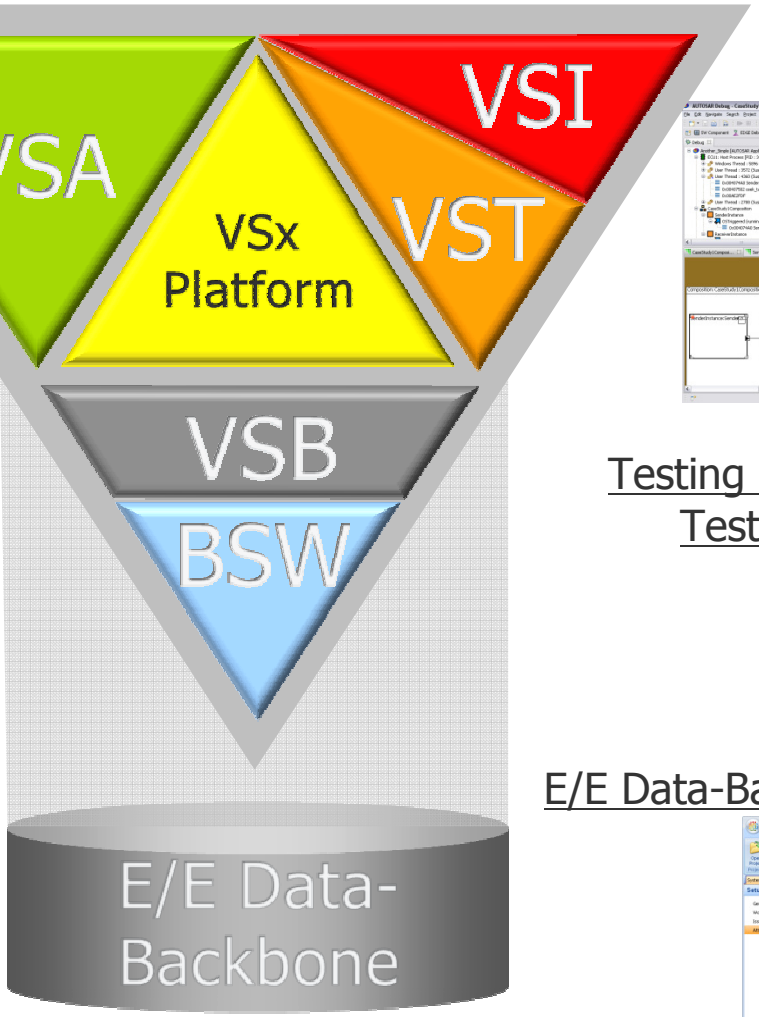


System Design

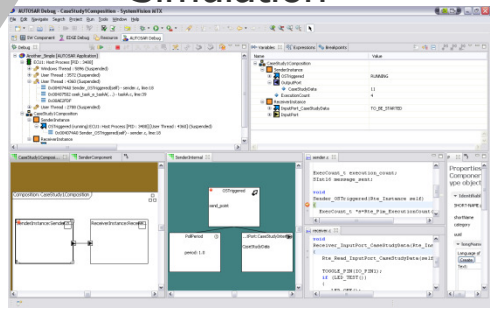


Implementation (ECU Config + BSW)

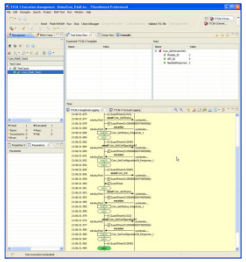




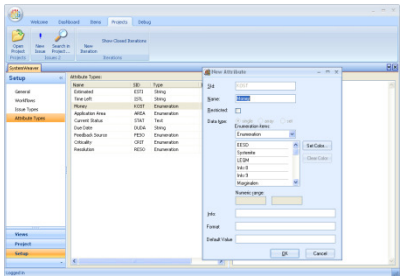
Validation and Simulation



Testing and Conformance Testing



E/E Data-Backbone



Tools Overview

E/E Architecture & Authoring

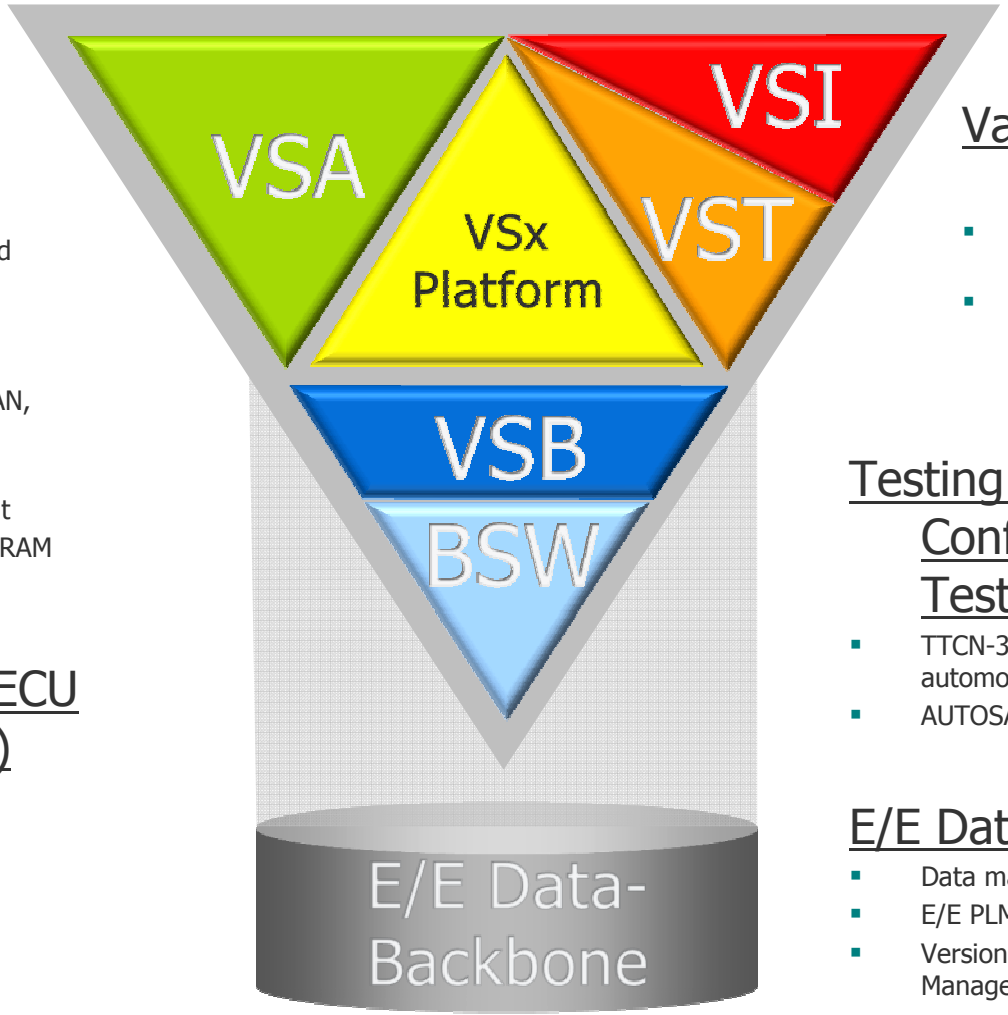
- E/E Architecture Exploration
- System and ECU Design
- SWC, CSWC and deployment
- AUTOSAR and EAST-ADL based
- Concurrent engineering

System Design

- Network Design for (LIN, CAN, FlexRay)
- System and ECU Design
- SWC, CSWC and deployment
- RTE, Diagnostics (ODX), NVRAM

Implementation (ECU Config + BSW)

- ECU Configuration
- AUTOSAR BSW



Validation and Simulation

- Distributed simulation, debugging and validation of SWC
- xtUML and IDE based SW development

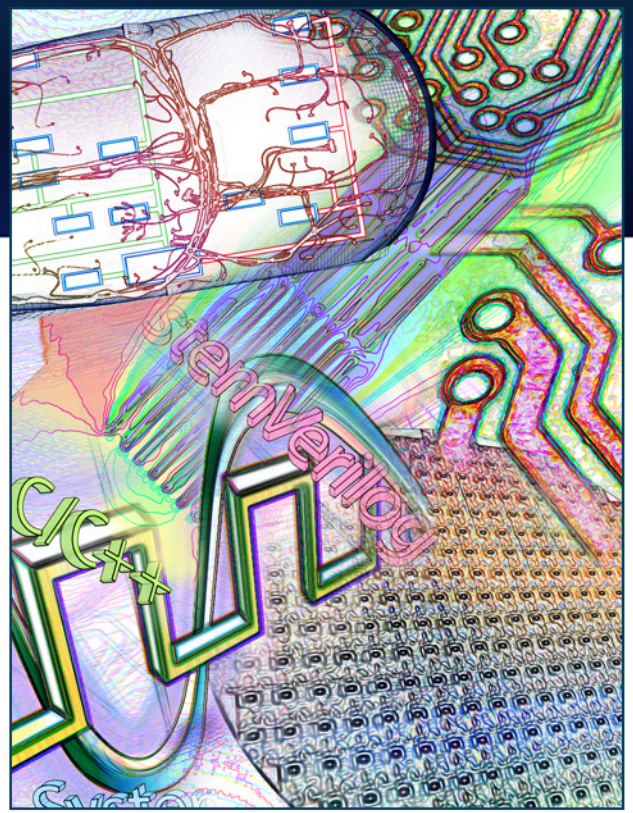
Testing and Conformance Testing

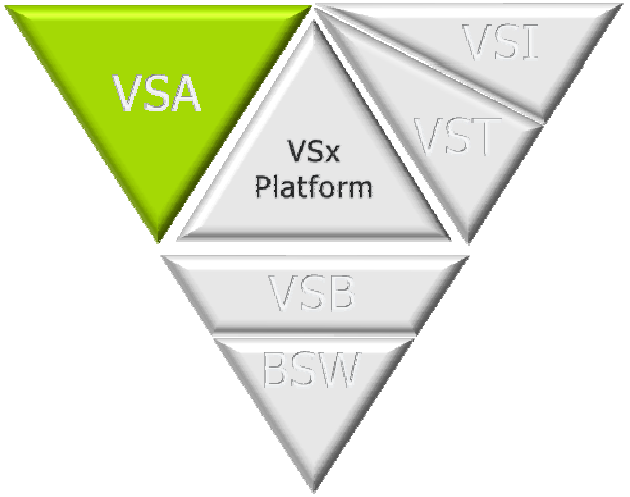
- TTCN-3 based testing of automotive SW (on PC and Target)
- AUTOSAR conformance testing

E/E Data-Backbone

- Data management
- E/E PLM
- Version, Release and Variant Management

VSA
Vehicle Systems Architect





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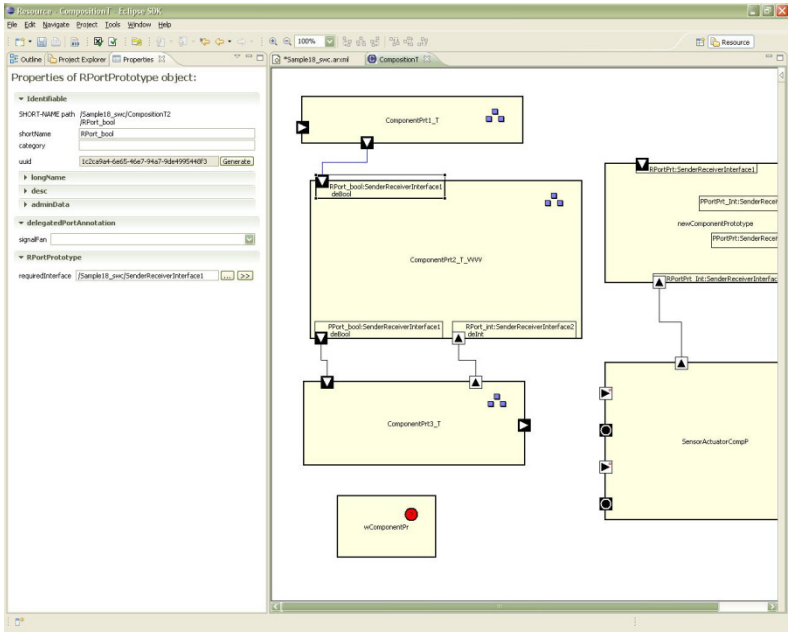
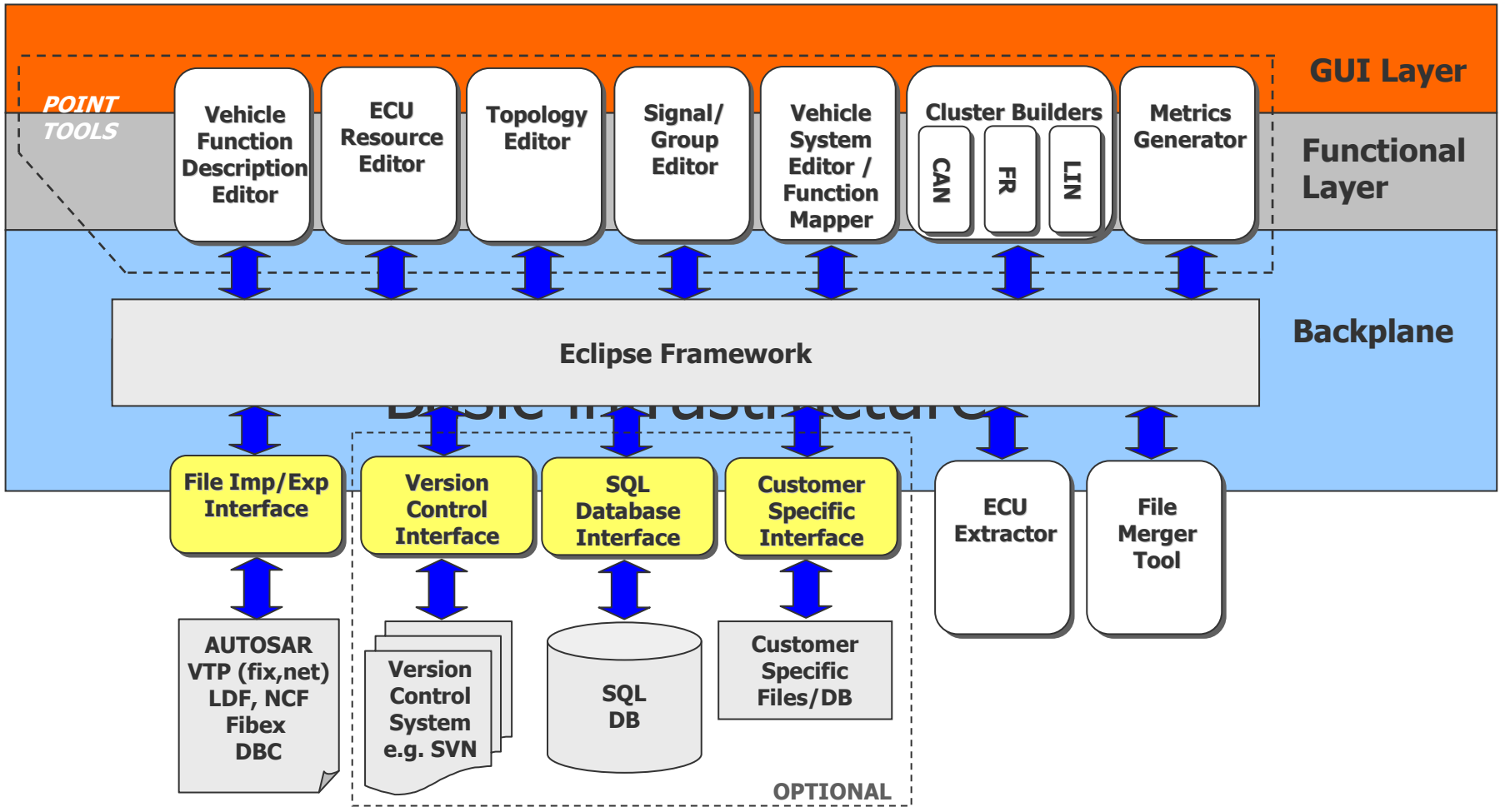
Volcano VSA

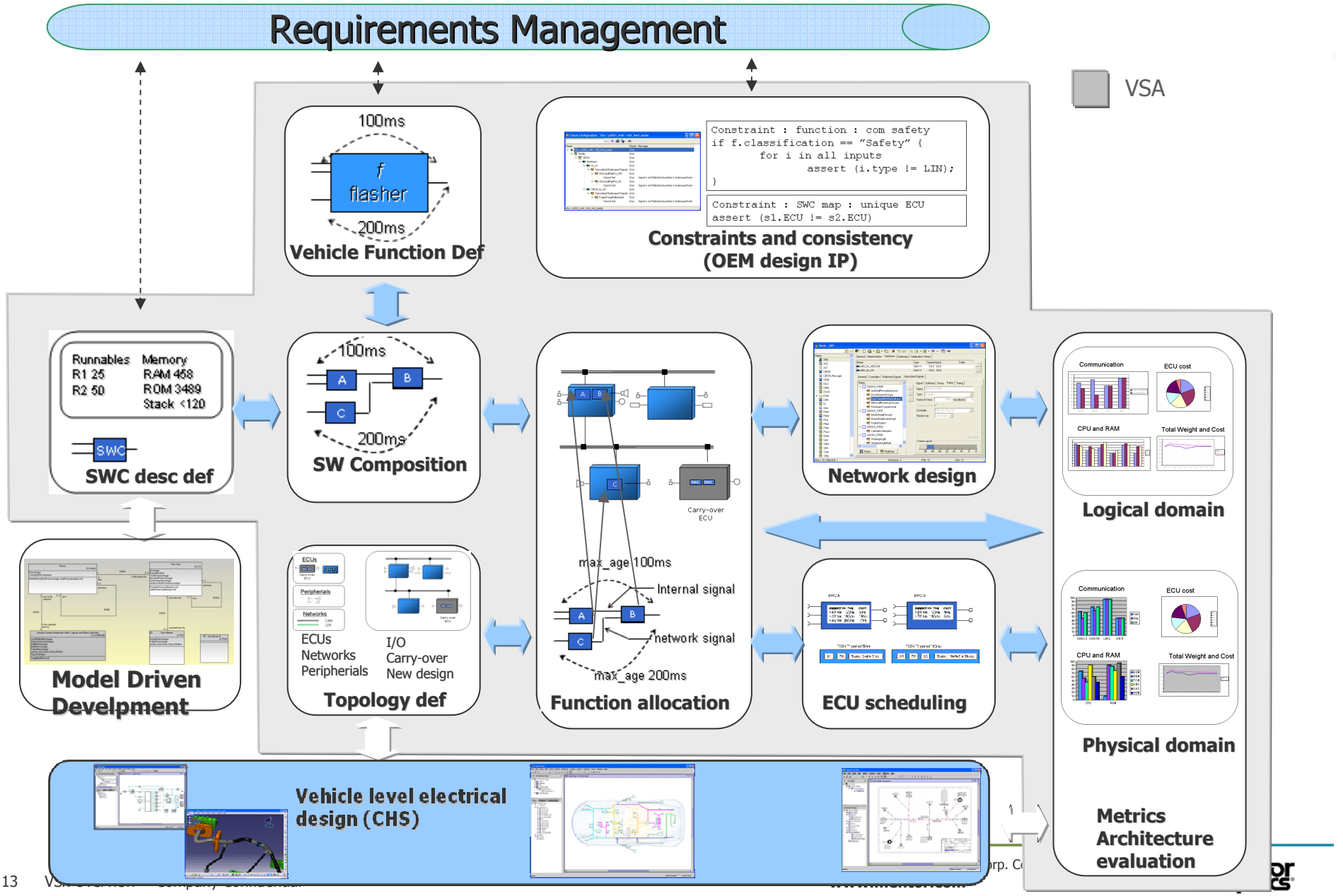
- VSA is a system level design tool for vehicle SW, electronic and communication systems
- Currently VSA is focused on development and implementation level
- VSA is being extended into various areas:
  - High-level function design
  - E/E Architecture design support
  - Design Data Managment
  - Variability management



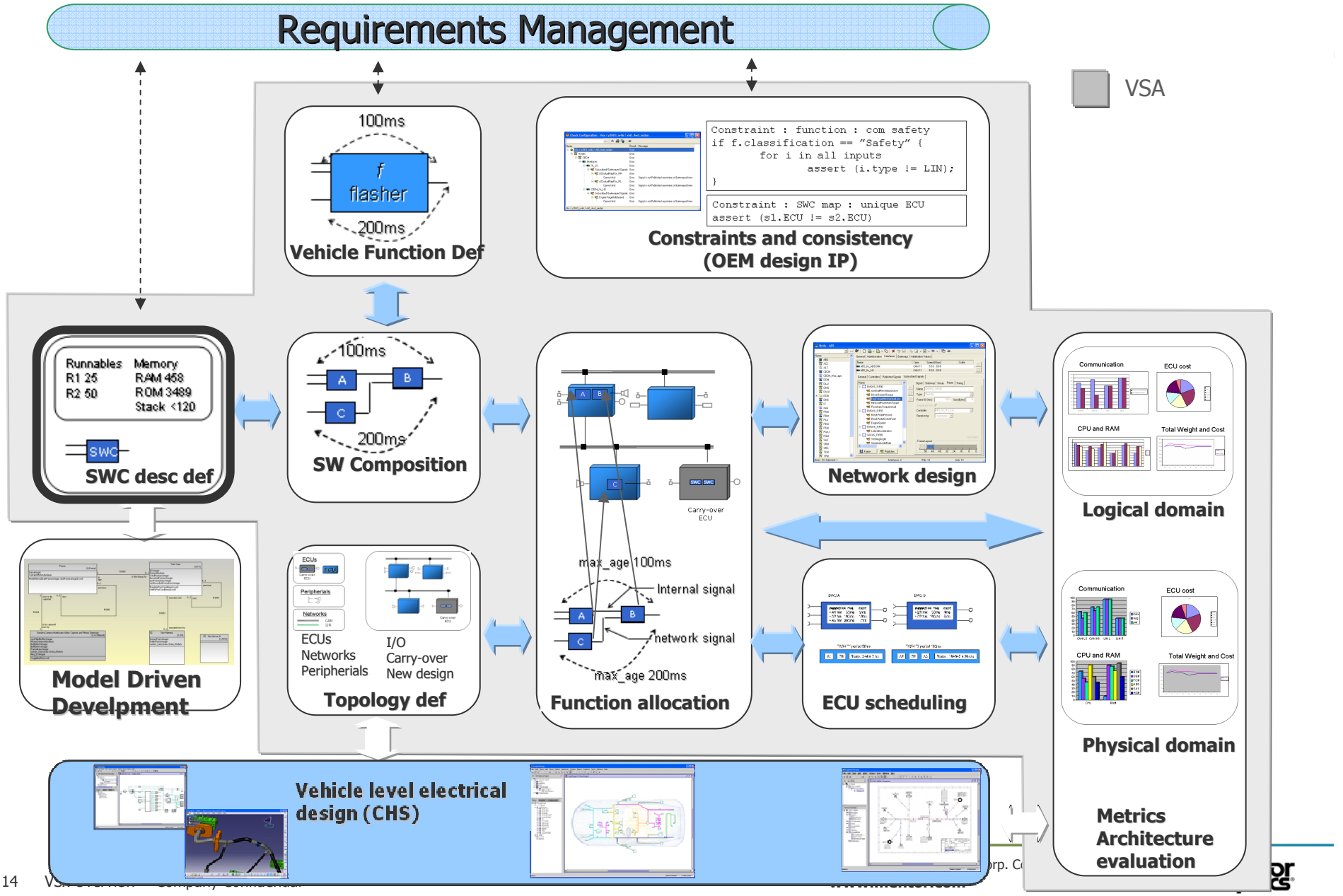
VSA Technical Overview



VSA – Activities

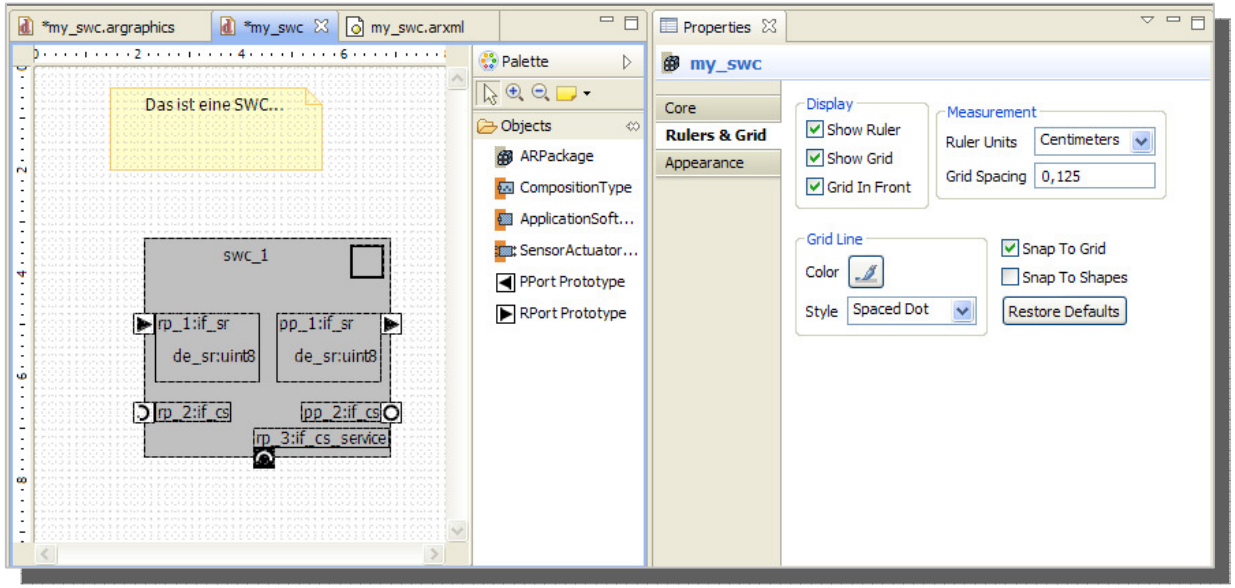


VSA – Activities

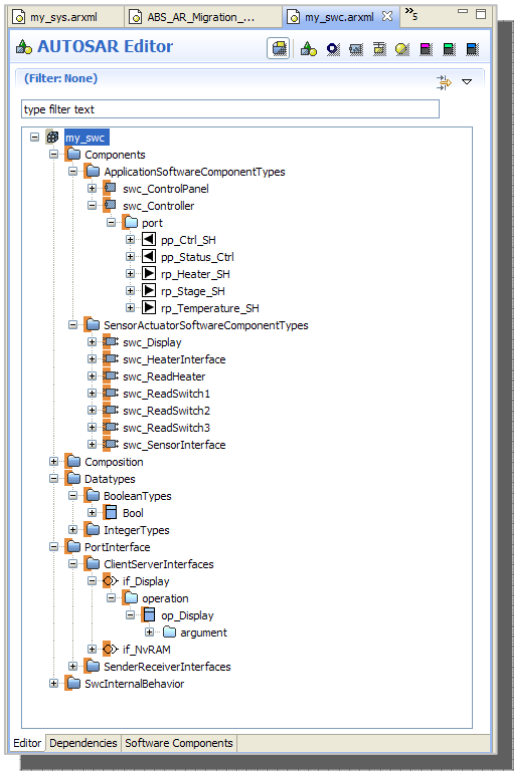


SWC definition

- Define ports,interfaces, runnables
- Graphical or tree-like views



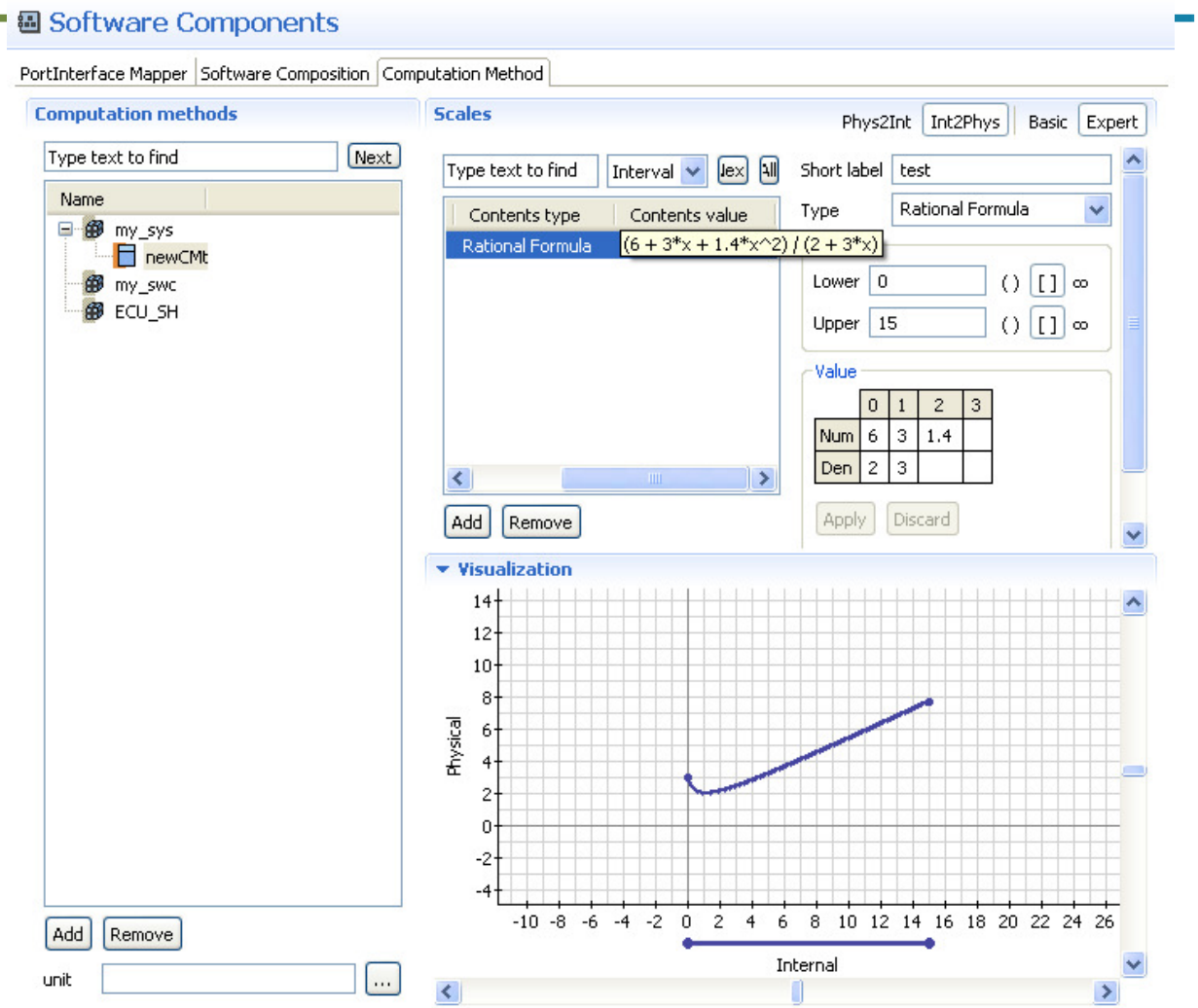
Graphical SWC editor



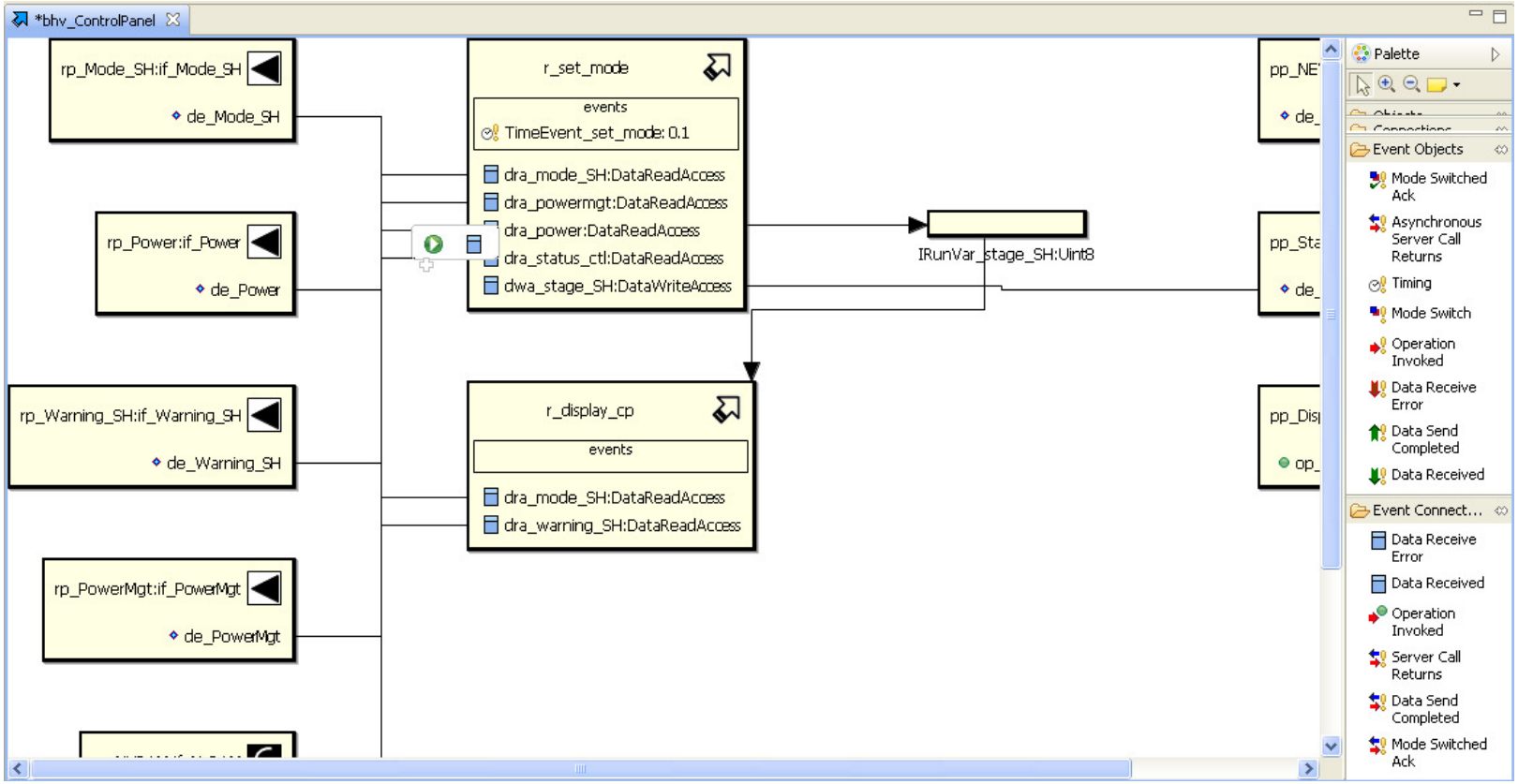
AUTOSAR Editor

Compu-method definition

- Graphical editor to define relation between internal and physical values
  - Rational function
  - Linear
  - Piecewise linear
  - Constants
  - Texttable
  - ...

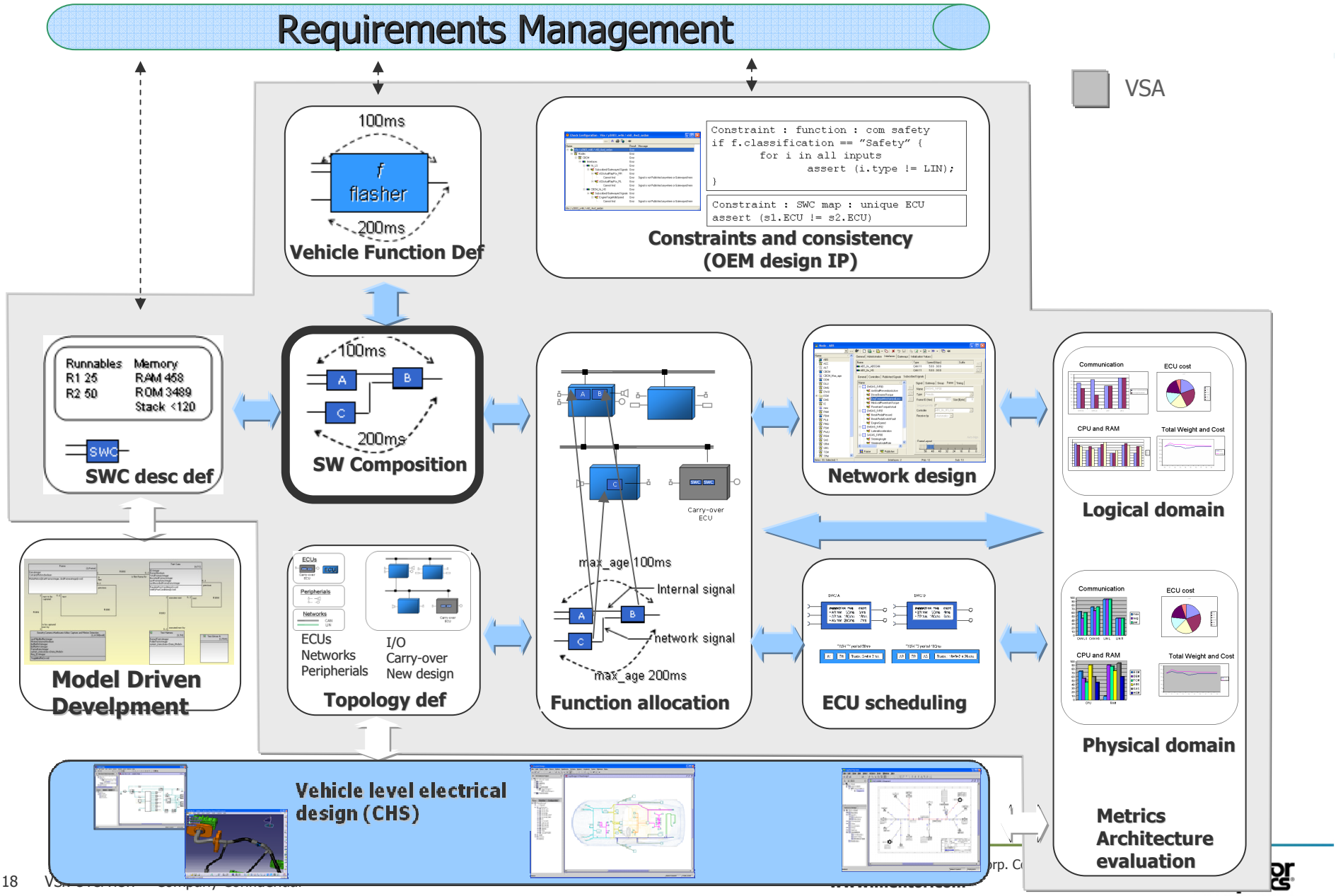


Runnable Editor



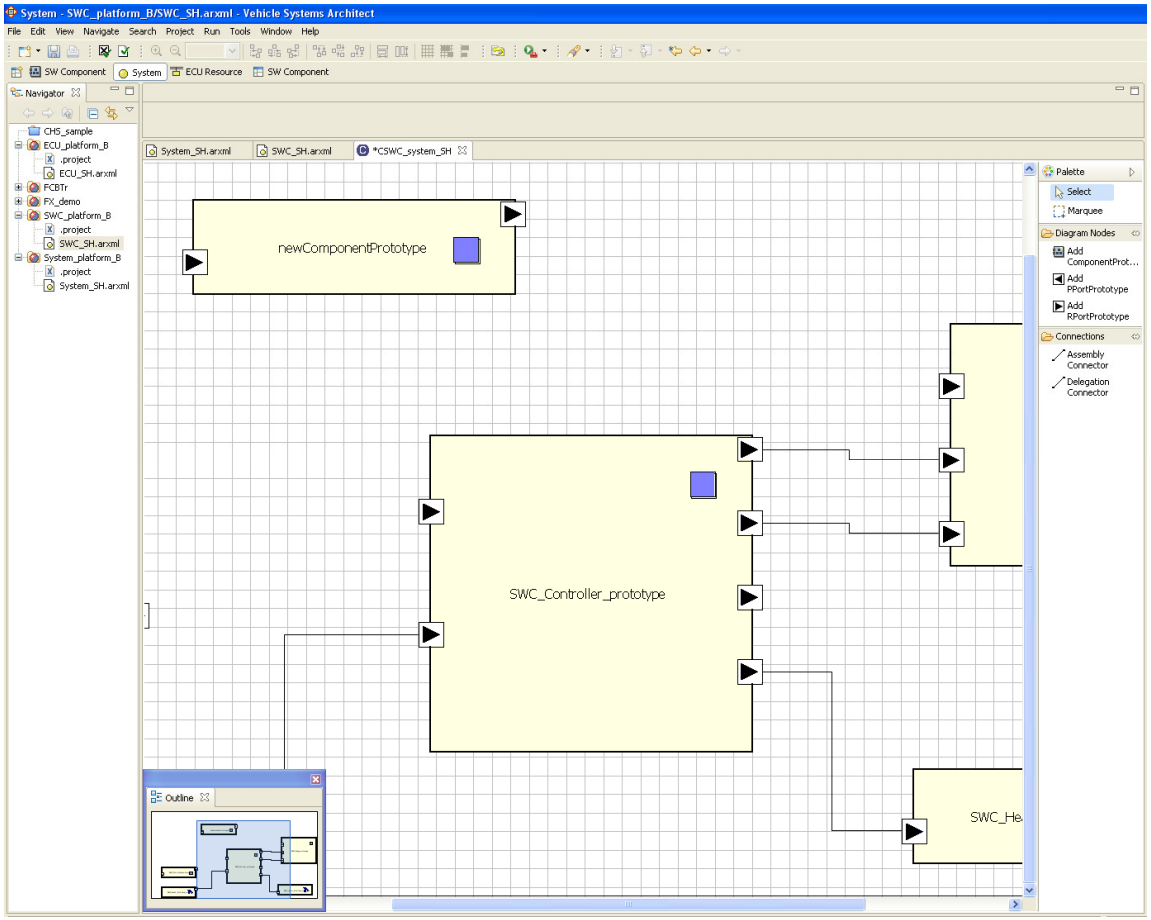
- Runnables
- Interrunnable variables
- RTE Events
- Data send/receive points

VSA – Activities

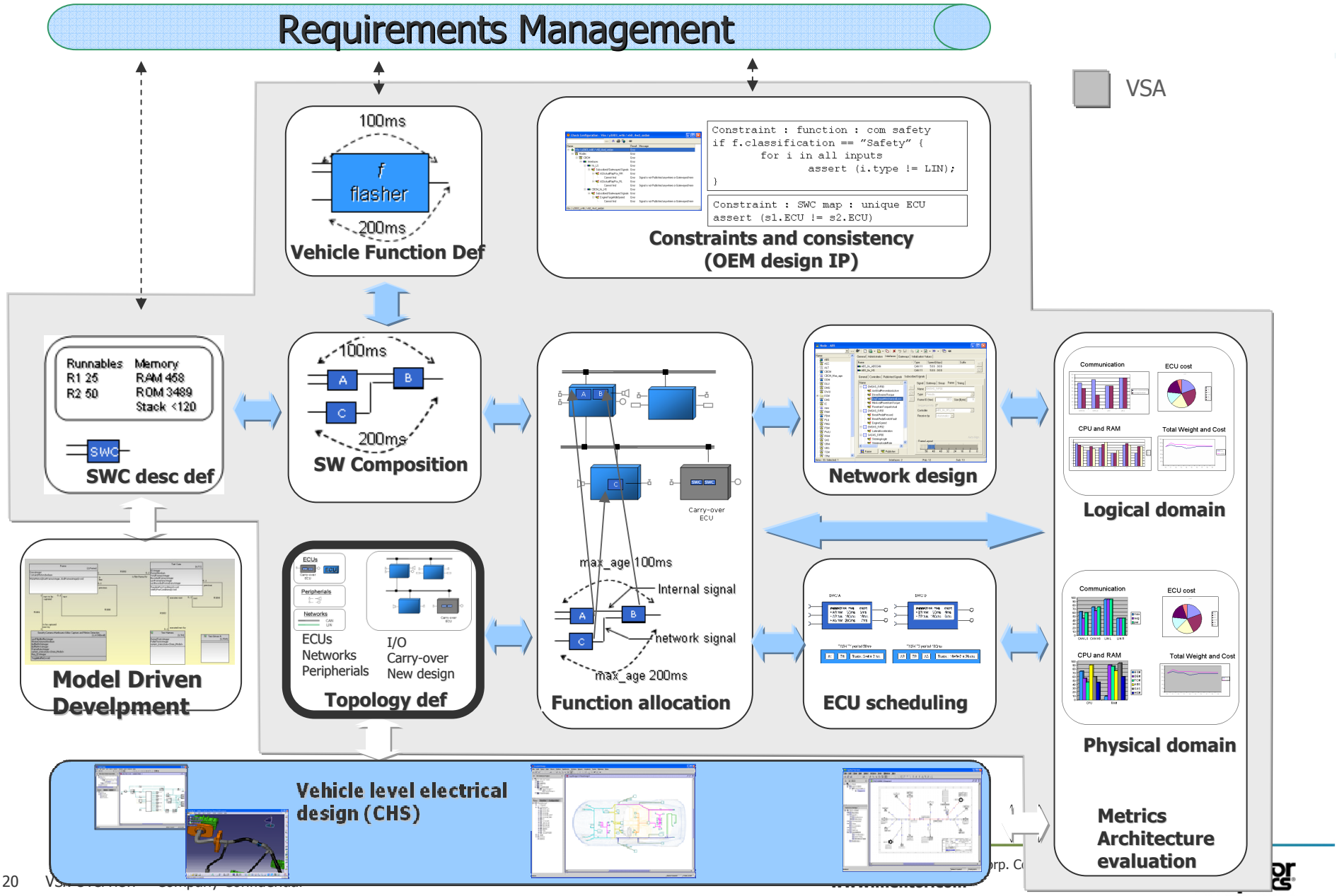


SW composition definition

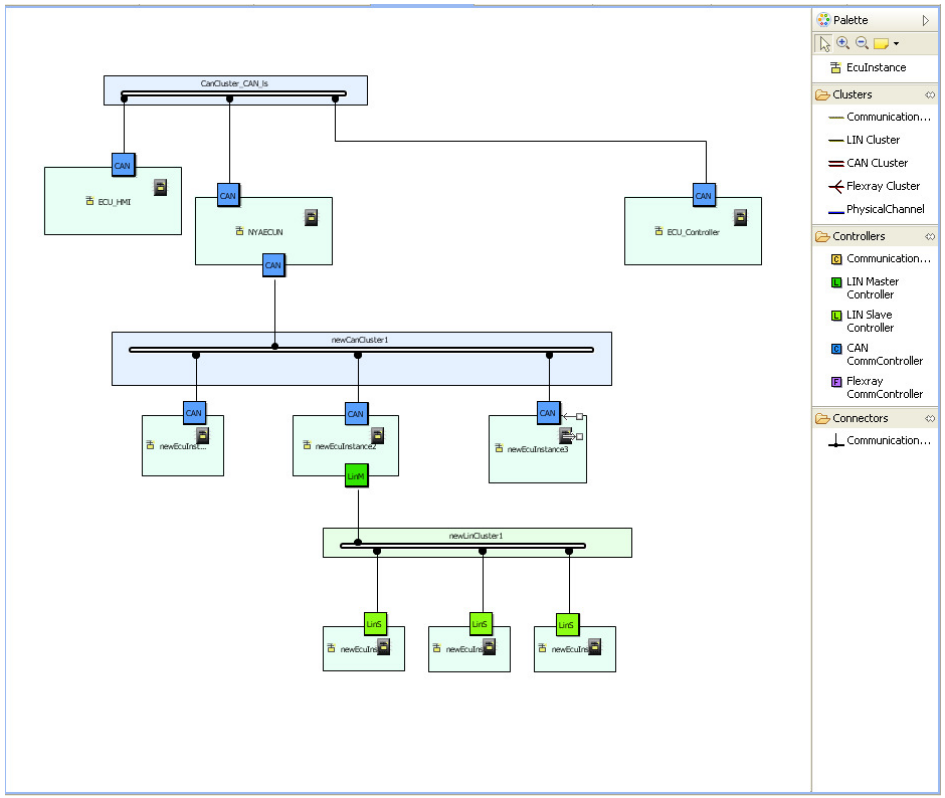
- Graphical design of SW compositions
- Zoom in/out
- Outline view
- Delegation ports



VSA – Activities

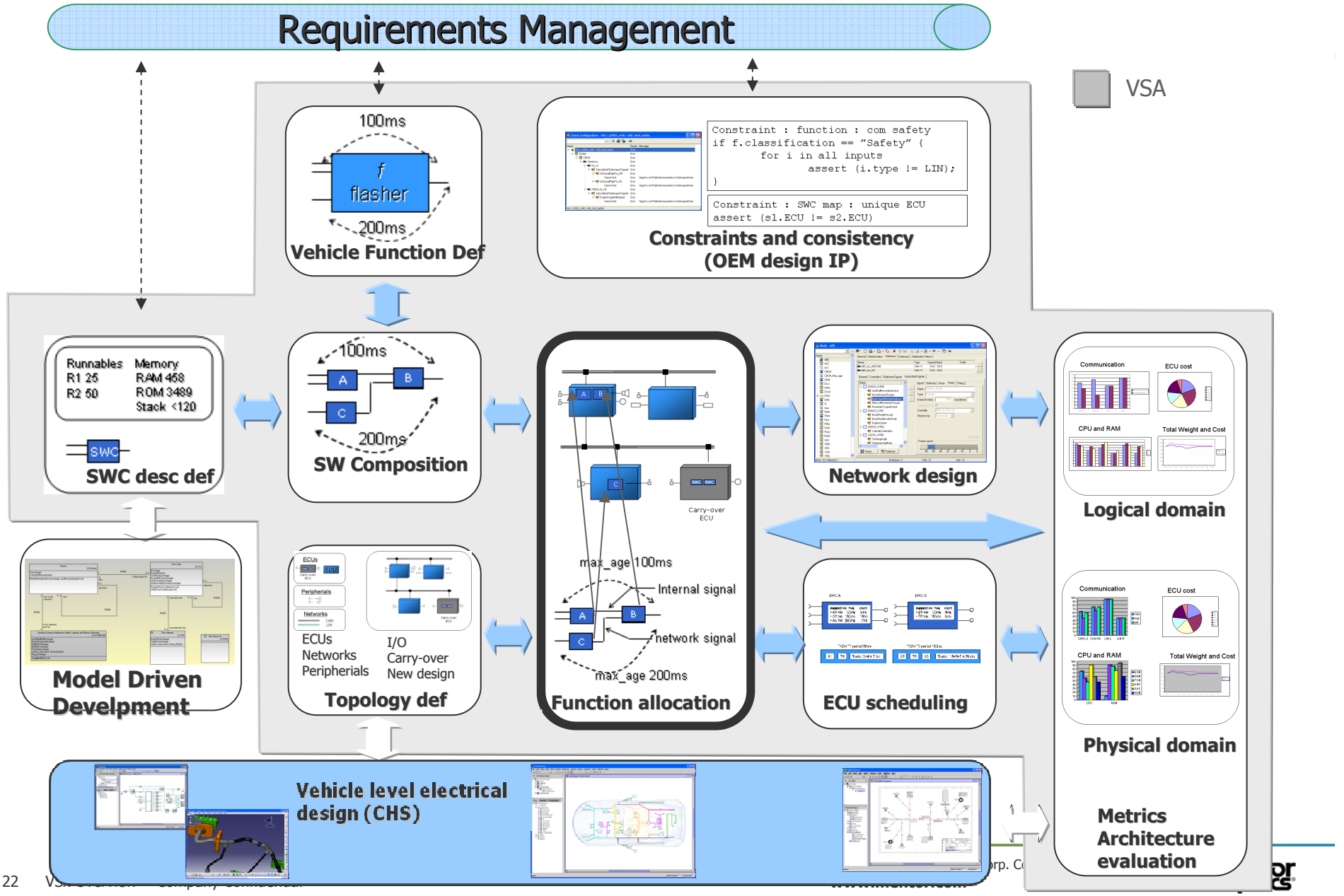


Topology Definition



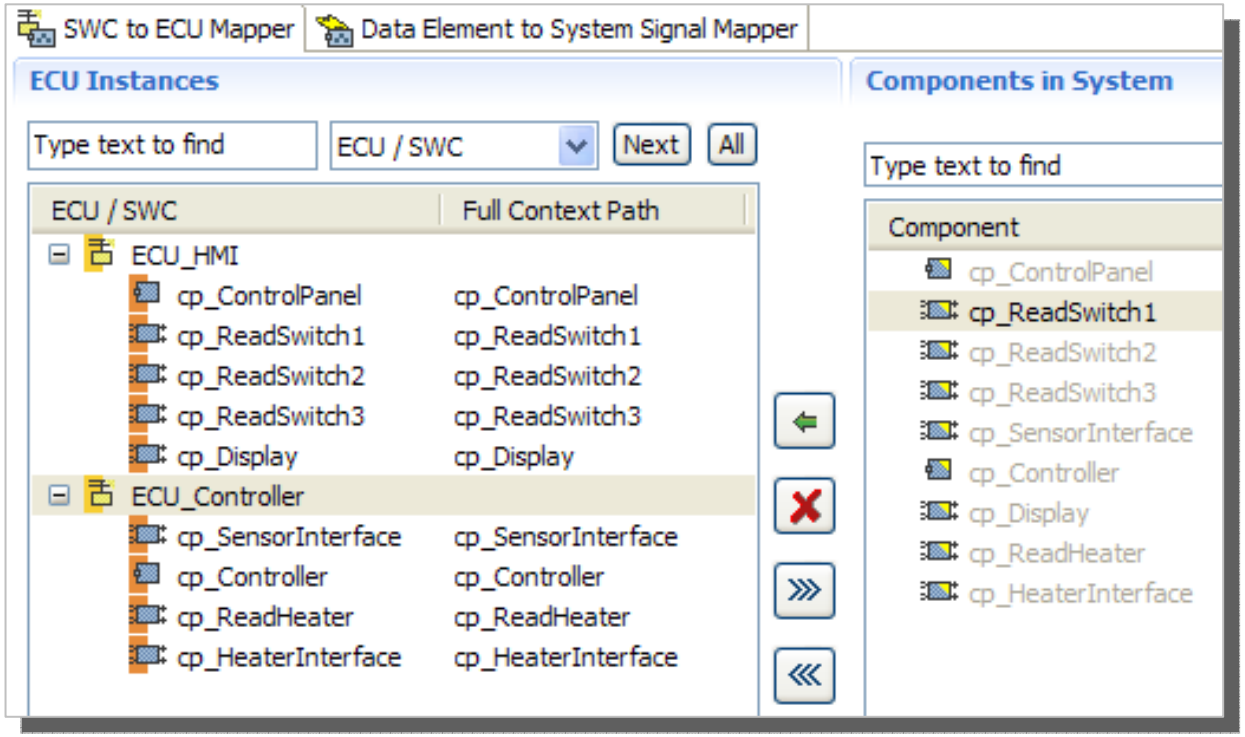
- **ECUs**
- **NEtworks**
- **Communication interfaces**
- **Communication Connectors**

VSA – Activities



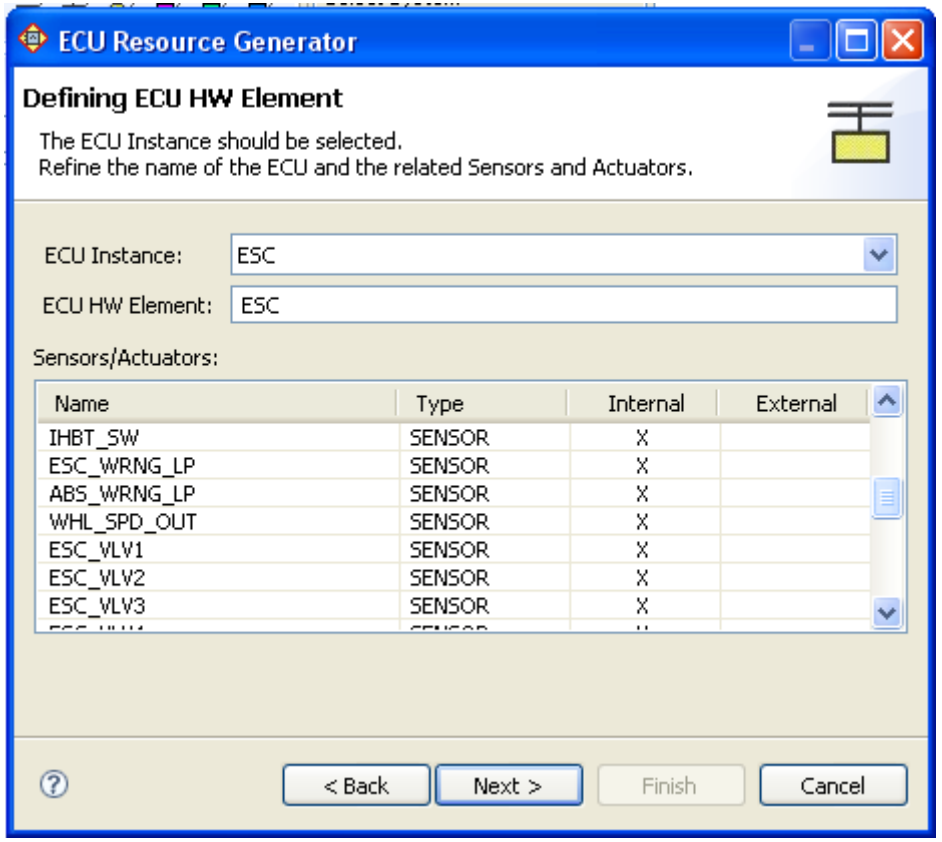
SWC to ECU mapping

- Map SWC to ECUs
- Search by typing

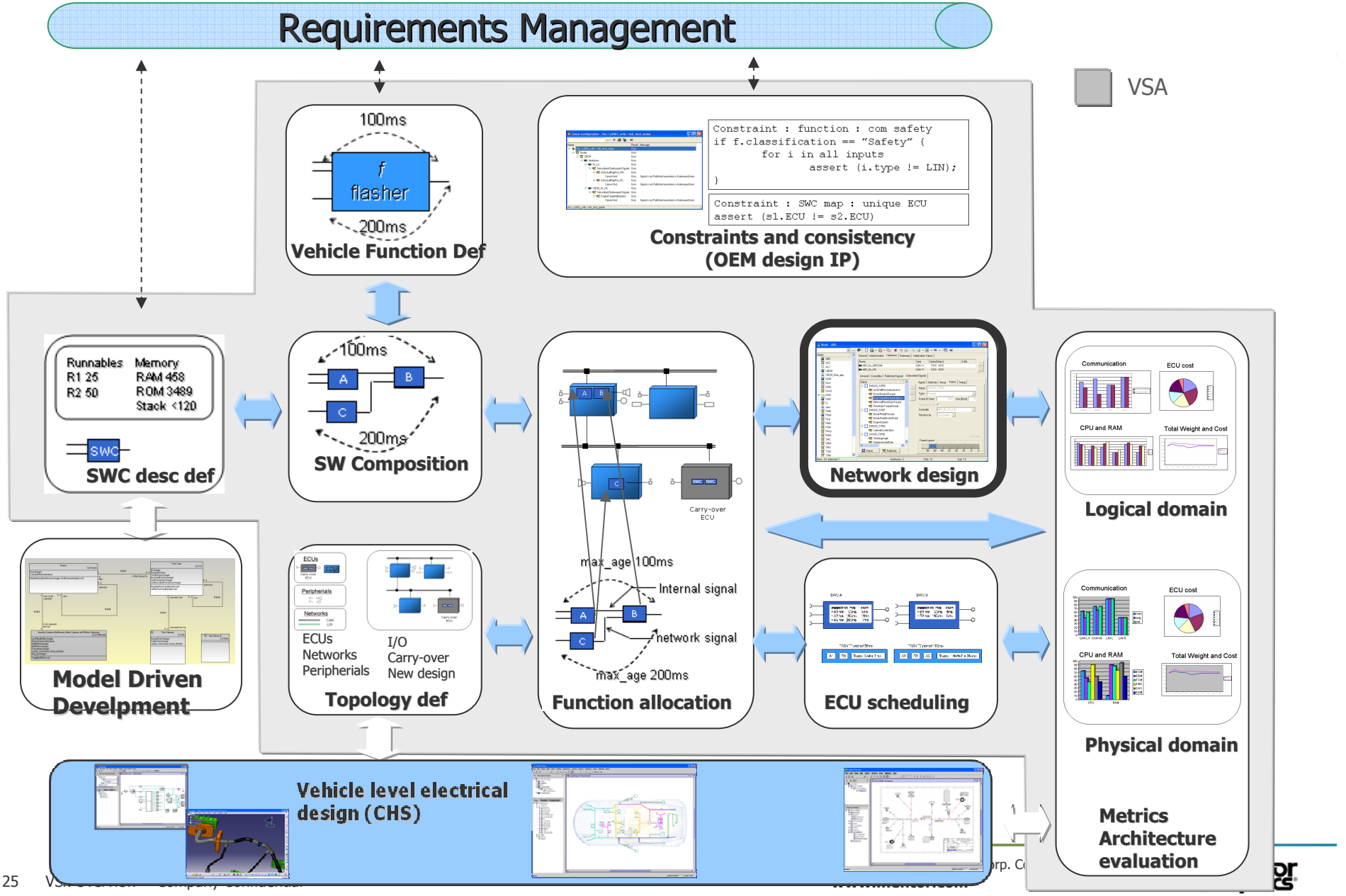


ECU Resource Generator

- Generates ECU resource based on system design
- Allows user to define additional ports and pins
- Select external/internal property

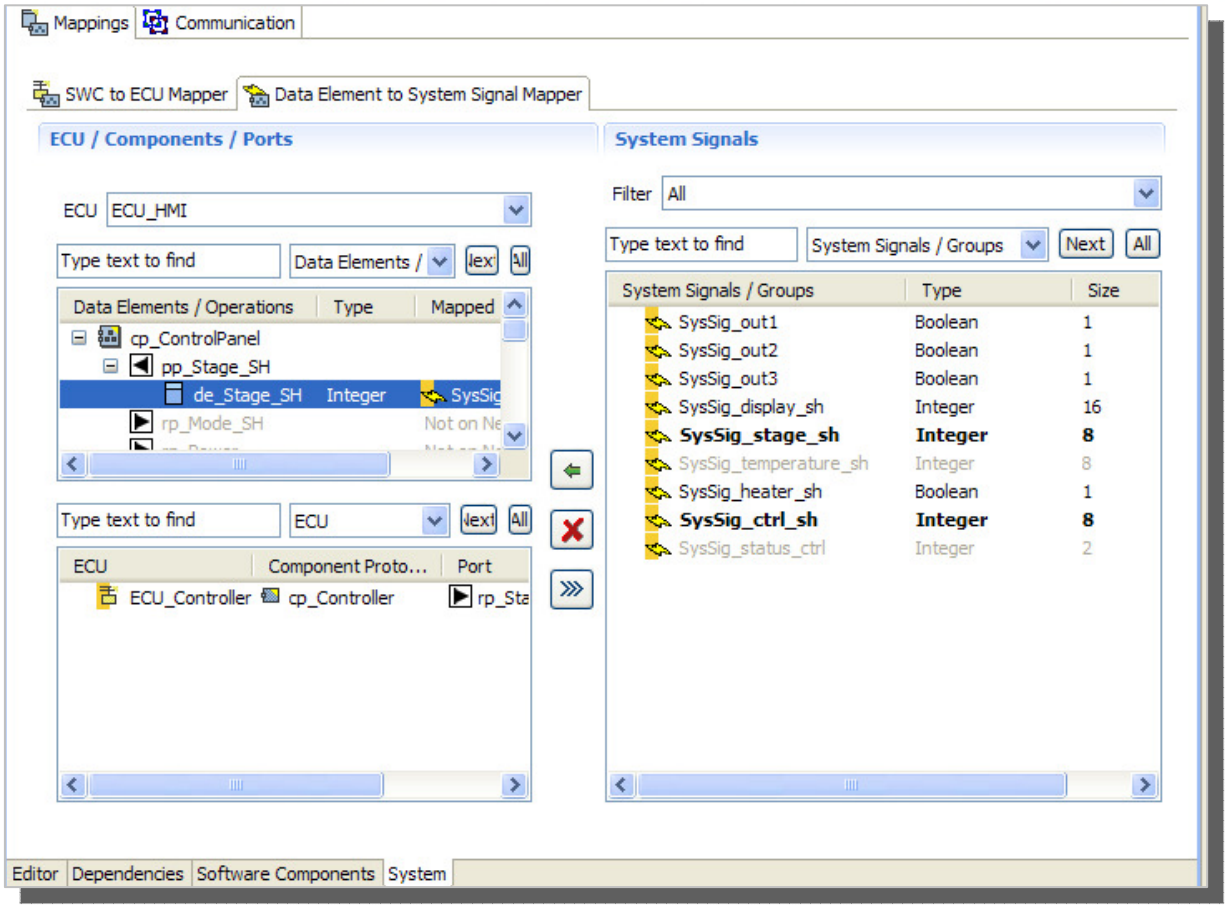


VSA – Activities



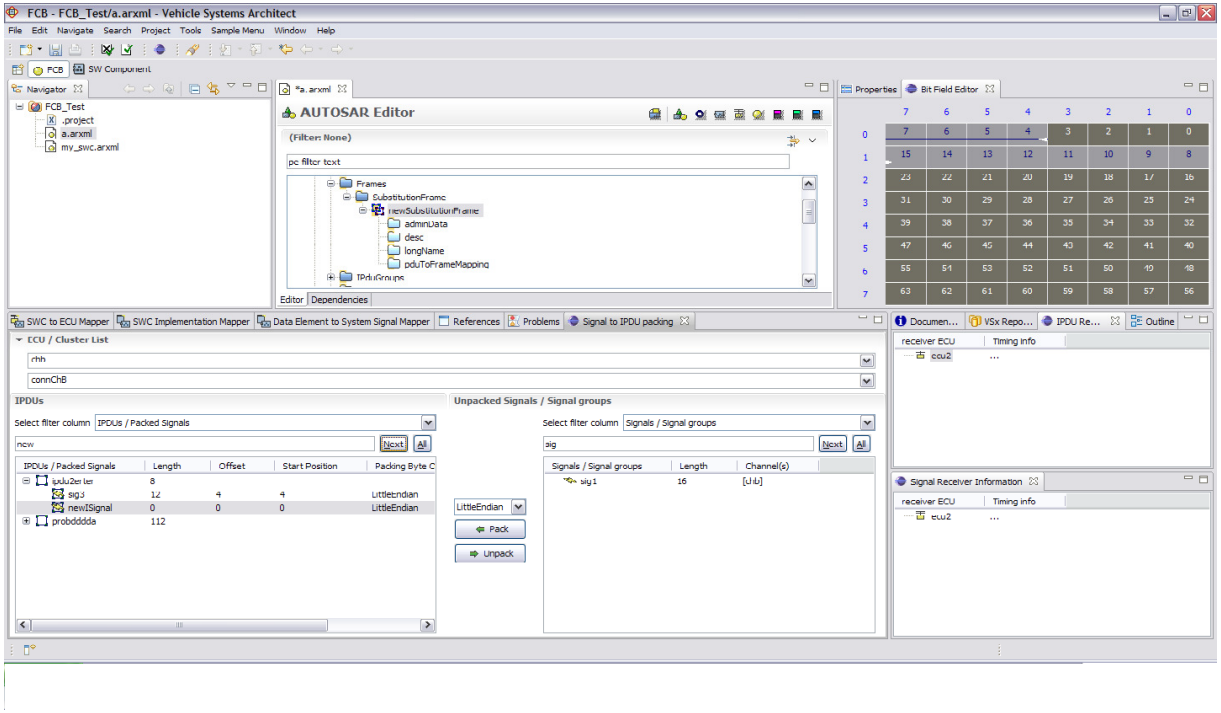
System Signal to Data element mapping

- Define the relation between SWC data elements and system signals



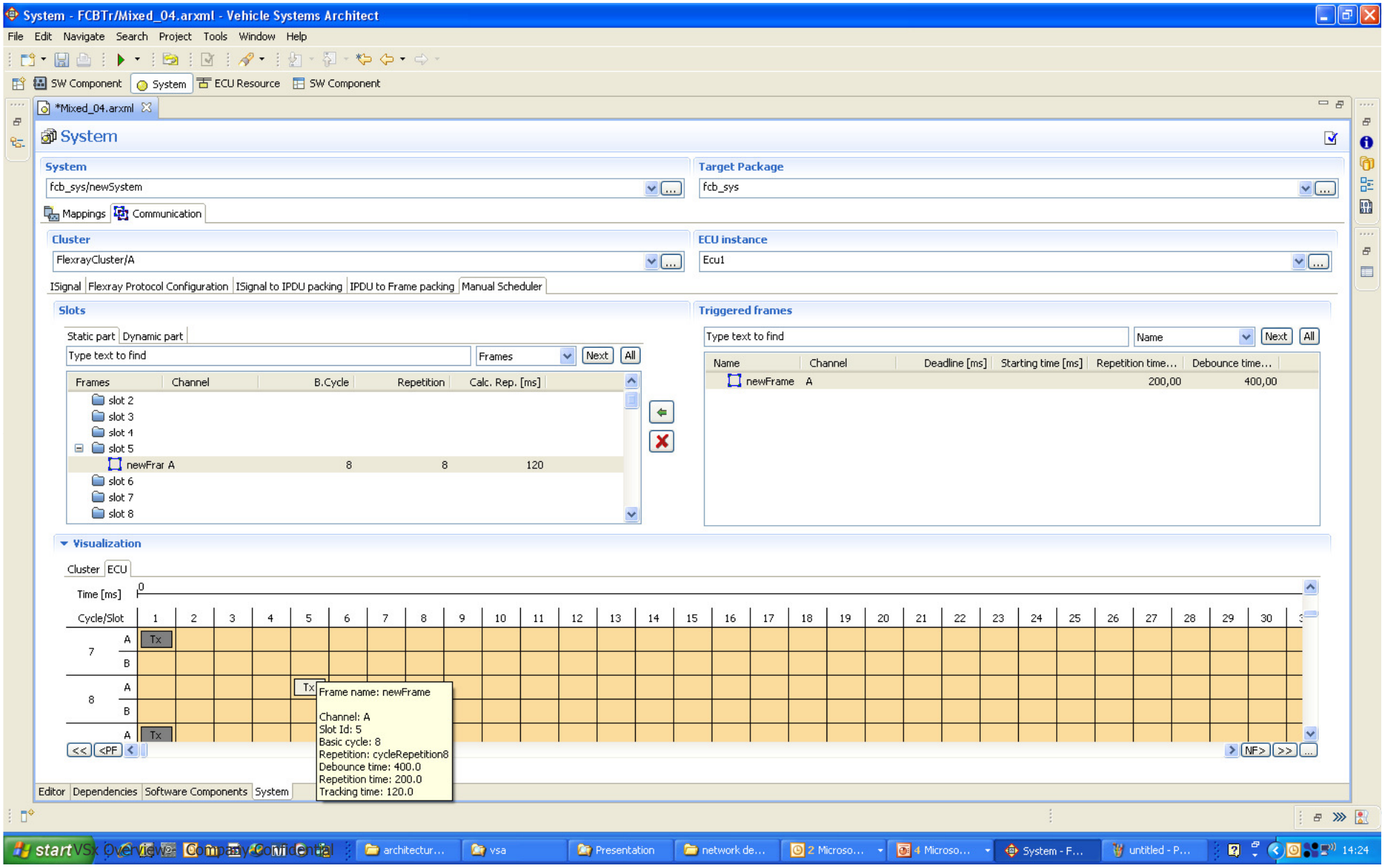
Network Design
VSA - Com Designer (option to VSA)

- AUTOSAR based network design
  - ISignal to IPDU mapping
  - IPDU to frame mapping
  - consistency check

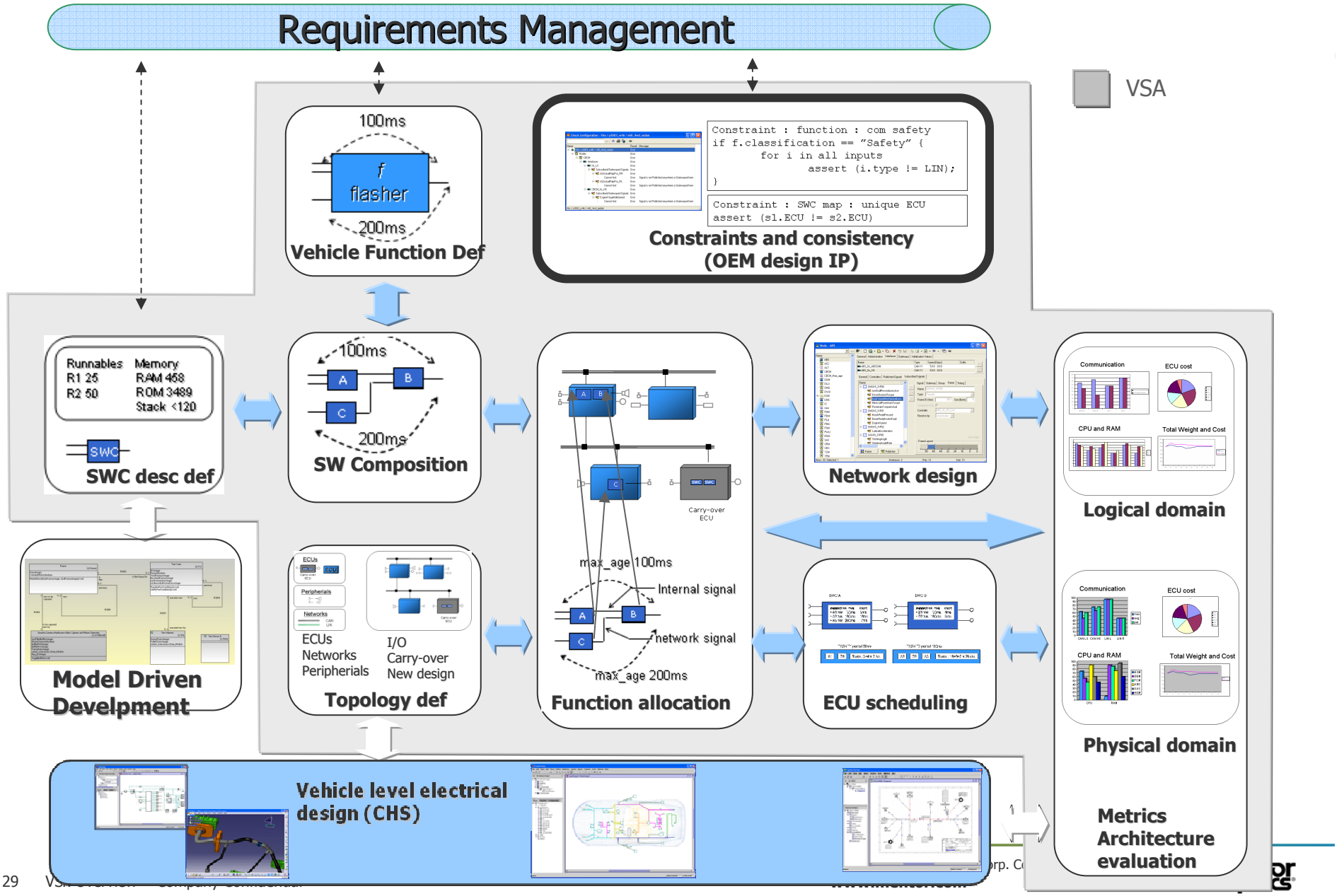


- **The Com Designer options are separate products for each protocol type (CAN, LIN, FlexRay)**

Manual FlexRay Scheduler



VSA – Activities

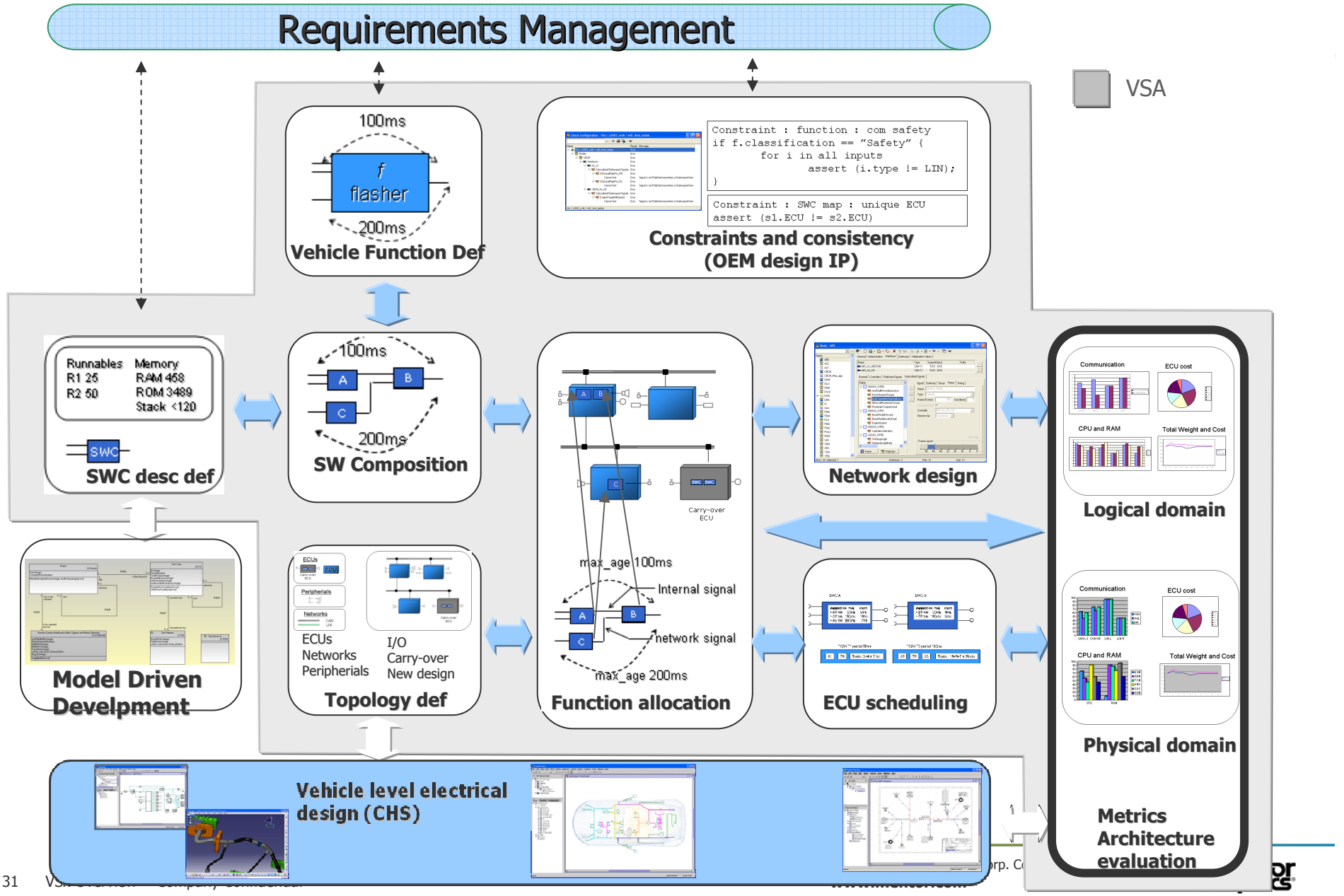


Script support

- Scripts can read/ write from the VSA data model
- Implement custom consistency checks, reports, small features etc
- Can be used for almost any task, not only consistency checks

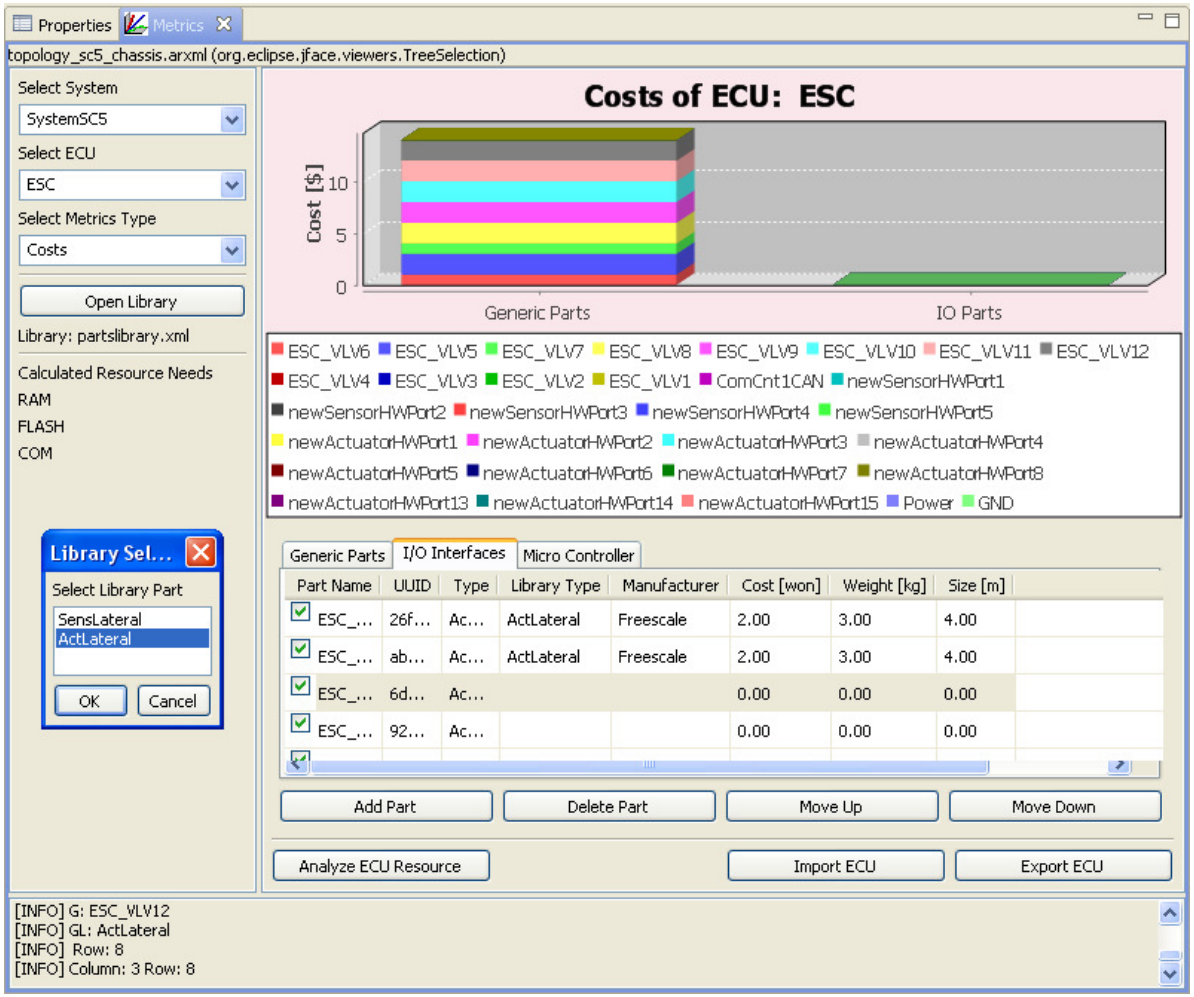
```
/**
 * Get list of SWCs for all packages
 * @return {[String, AtomicSoftwareComponentType, ARPackage]} Returns a list of SWCs
 */
function getSwcList()
{
    var root = ModelUtils.getModelRoot(am);
    // Get list of ARPackage
    var packages = root.getTopLevelPackage();
    var swcList = new Array();
    var total=0;

    // Loop all packages
    for(var i = 0; i < packages.size(); i++) {
        var pck = packages.get(i);
        var pckEl = pck.getElement();

        // Check each element in this package
        for(var j = 0; j < pckEl.size(); j++) {
            for (var c = 0; c < swcTempl.length; c++) {
                var element = pckEl.get(j);
                if(element instanceof swcTempl[c][1]) {
                    swcList[total] = [packElementBundle(pck,element), element, pck];
                    total++;
                }
            }
        }
    }
    return swcList;
}
```

VSA – Activities

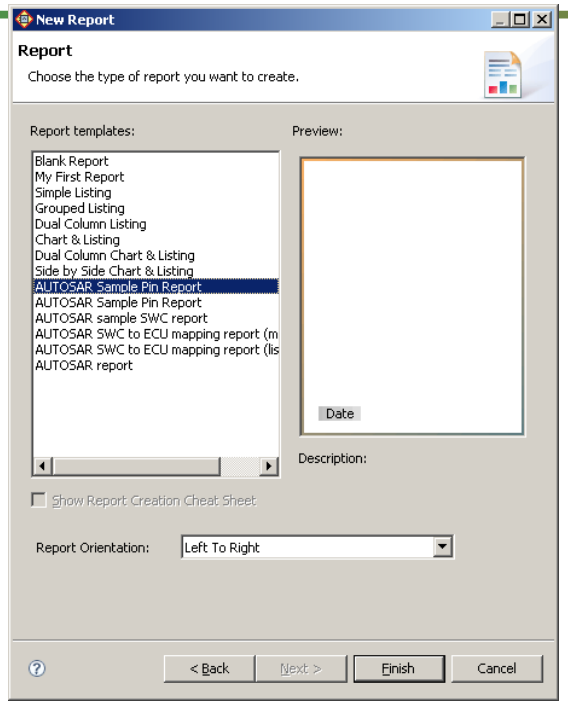


Metrics Generator

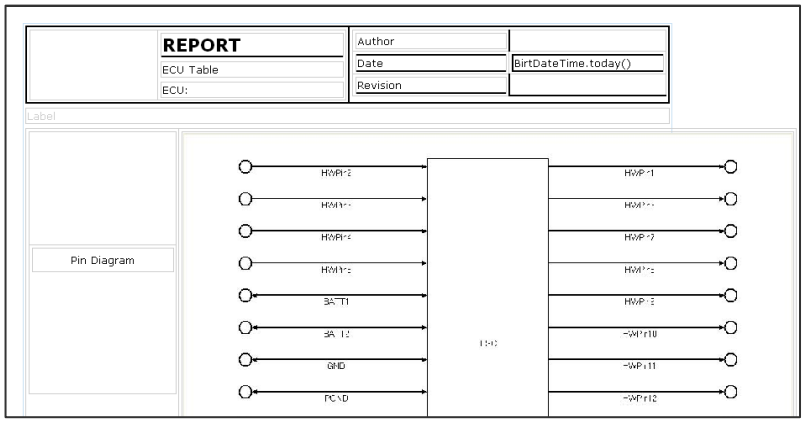
- Defined metrics concept
- Implemented metrics generator
- Parts library



Configurable Report Engine

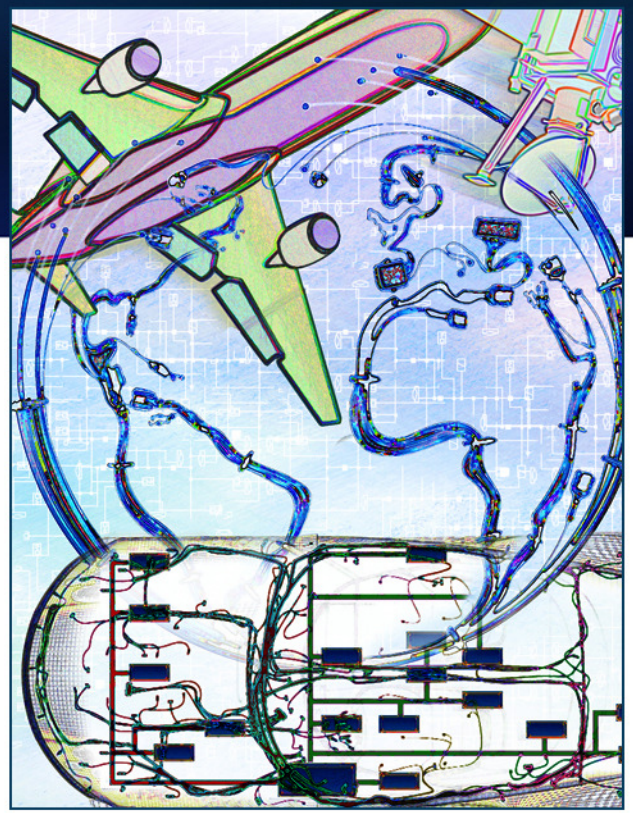


Vehicle	COST	WEIGHT	SIZE
SystemSC1	12.00	25.00	26.00
SystemSC2	11.00	27.00	25.00
SystemSC3	10.00	19.00	23.00
SystemSC4	5.00	13.00	11.00
SystemSC5	11.00	23.00	25.00
SteeringSystem	20.00	34.14	29.60
Target Value	44	99	



- User can configure content and layout
- Reads data from the VSA data model

- Present data in various formats
  - Table
  - Diagram
  - Pictures
  - Text
  - PDF, HTML, Word, Excel



Multi-user and other supporting features

Multi-user

Merge tool

Timing model

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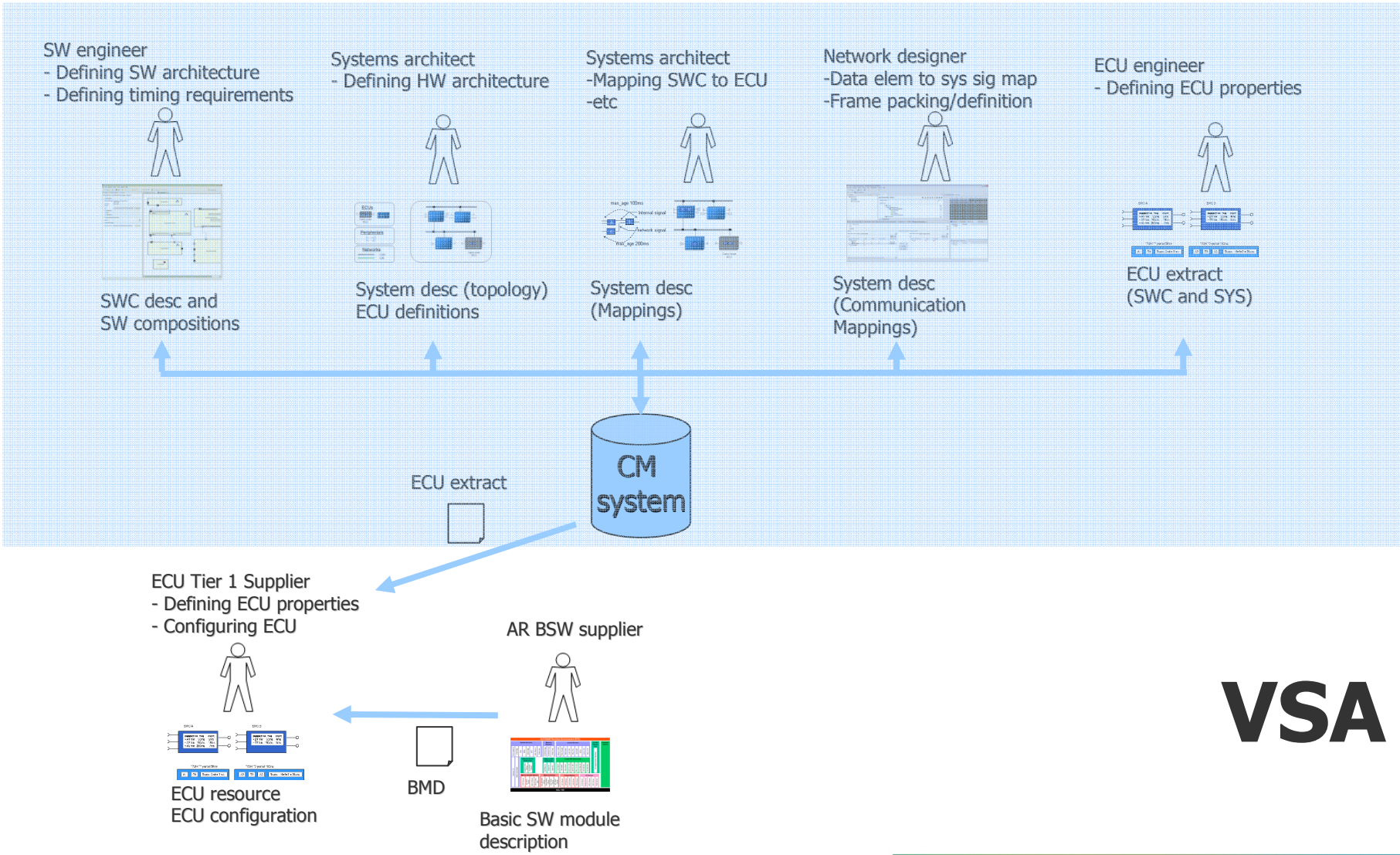
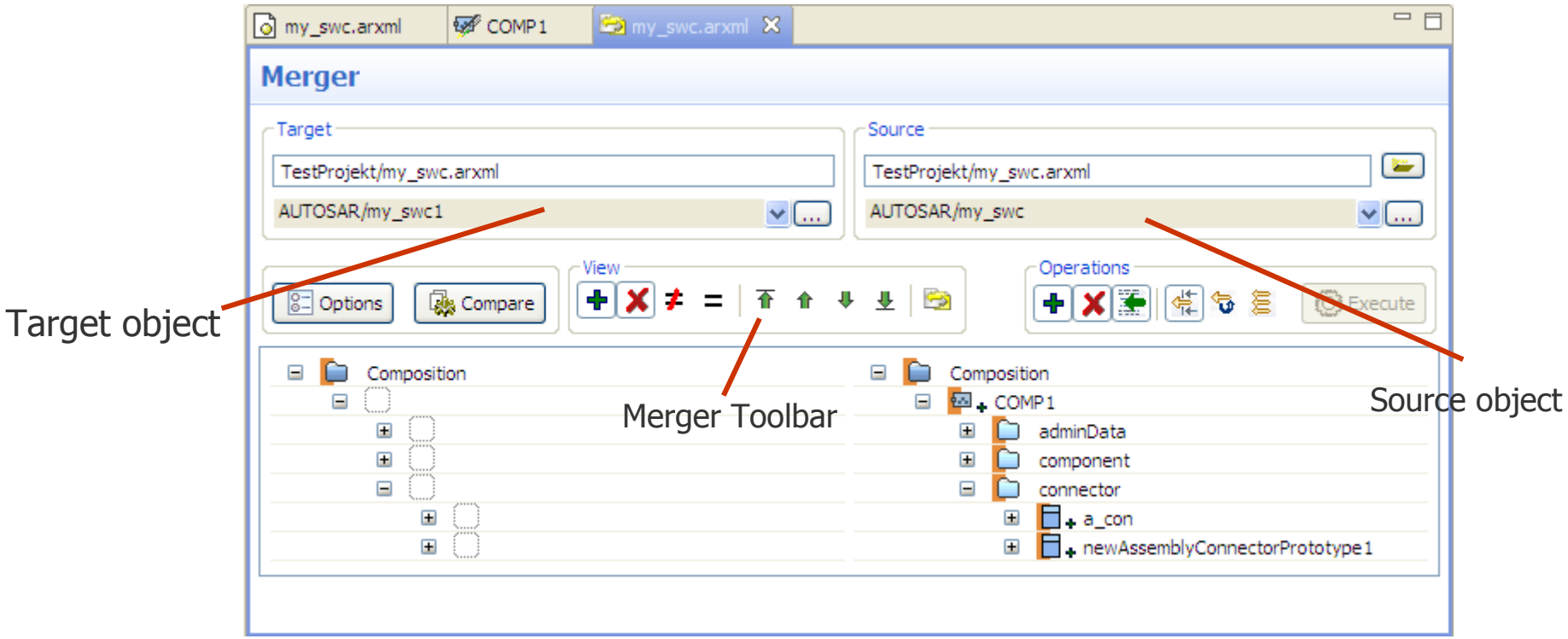
VSA and AUTOSAR – roles (simplified)



VSA

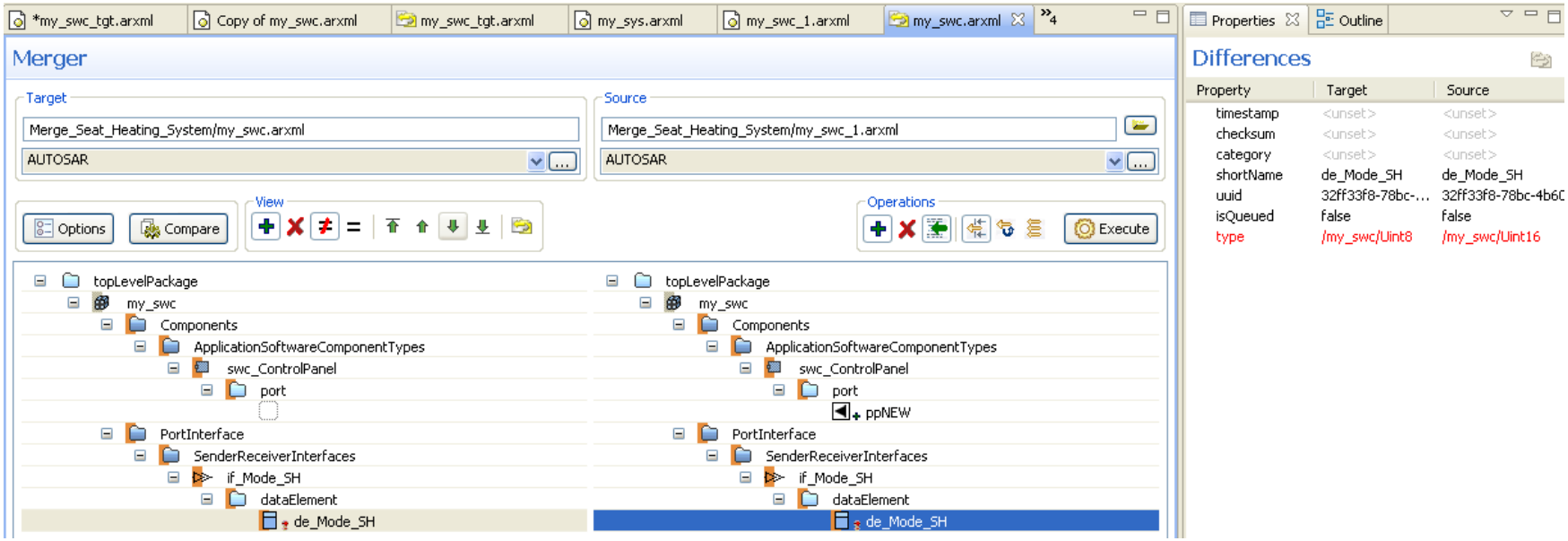
VSA Merge Tool

- **The VSA merge tool allows merging objects that has been updated by different sources**
  - **Enables iterative development in separate tools**
  - **Enables merging data modified by supplier or OEM respectivly**

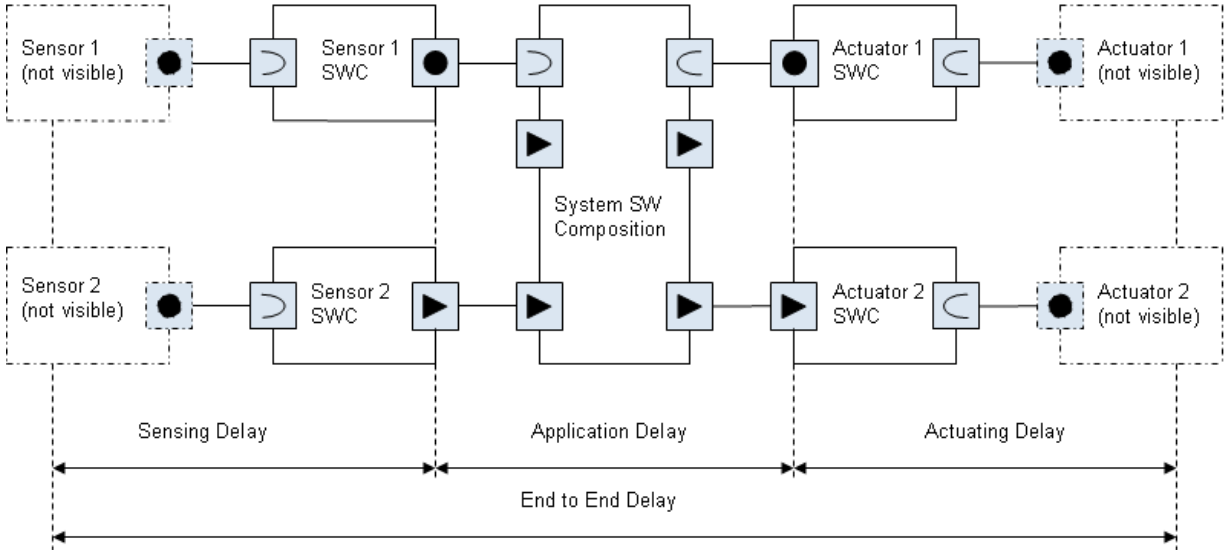


VSA Merge Tool

- Displays difference of objects and allows merging selected elements and properties



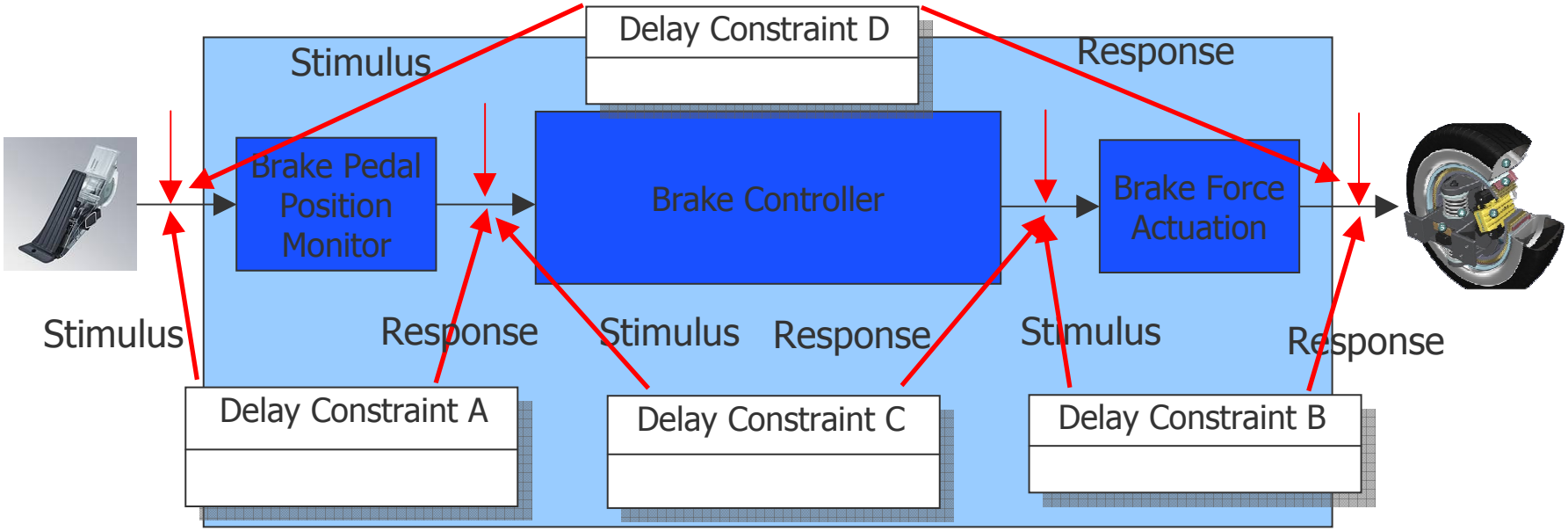
VSx Timing Model



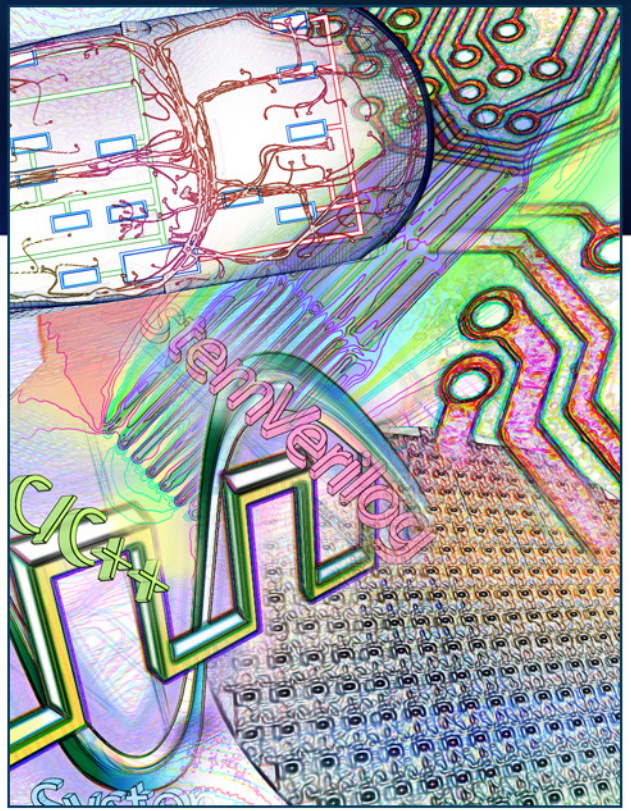
- Uses AUTOSAR and TIMMO (EAST ADL) timing model
- A full system timing model covering from sensor read to actuator effect
- Based on defining events and timing requirements between the events

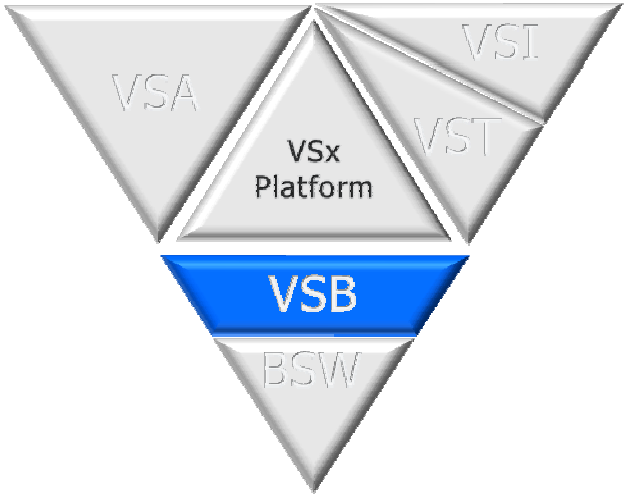
VSx Timing Model

- Covers timing requirements of ”Delay”, ”Synchronization” and ”Repetition” type
- Event chains can be defined to cover true ”end to end” timing requirements for a function



ECU SW design and configuration - VSB





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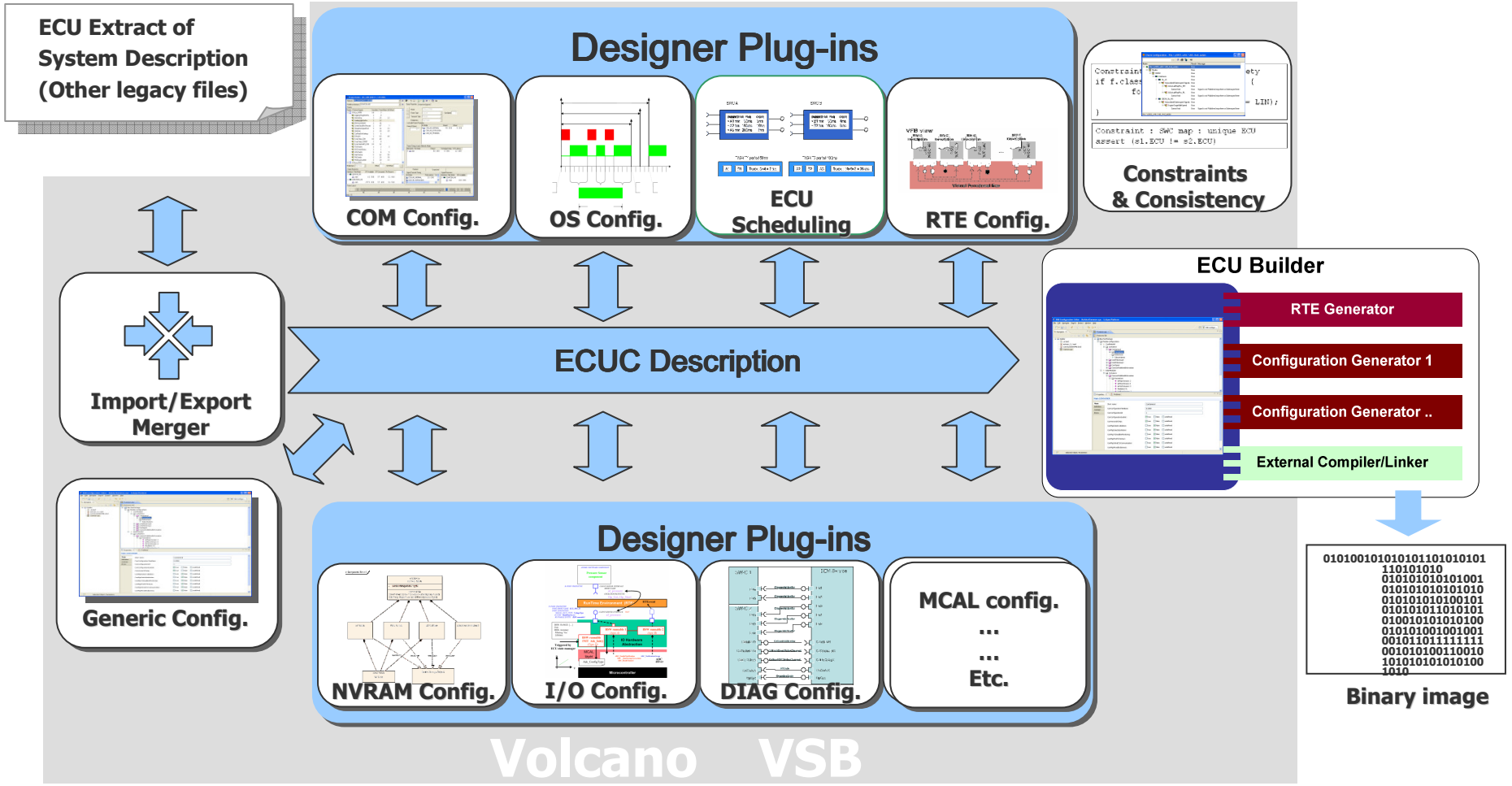
Volcano Vehicle Systems Builder (VSB)

- Tool for ECU SW developers/integrators that need to:
  - Transform parameters from Extract of System description into ECUC parameters for a specific set of BSW modules
  - Configure BSW module ECUC parameters
  - Create BSW module descriptions
  - Integrate and build ECU software and BSW module software
  - Get design help for specific set of BSW modules

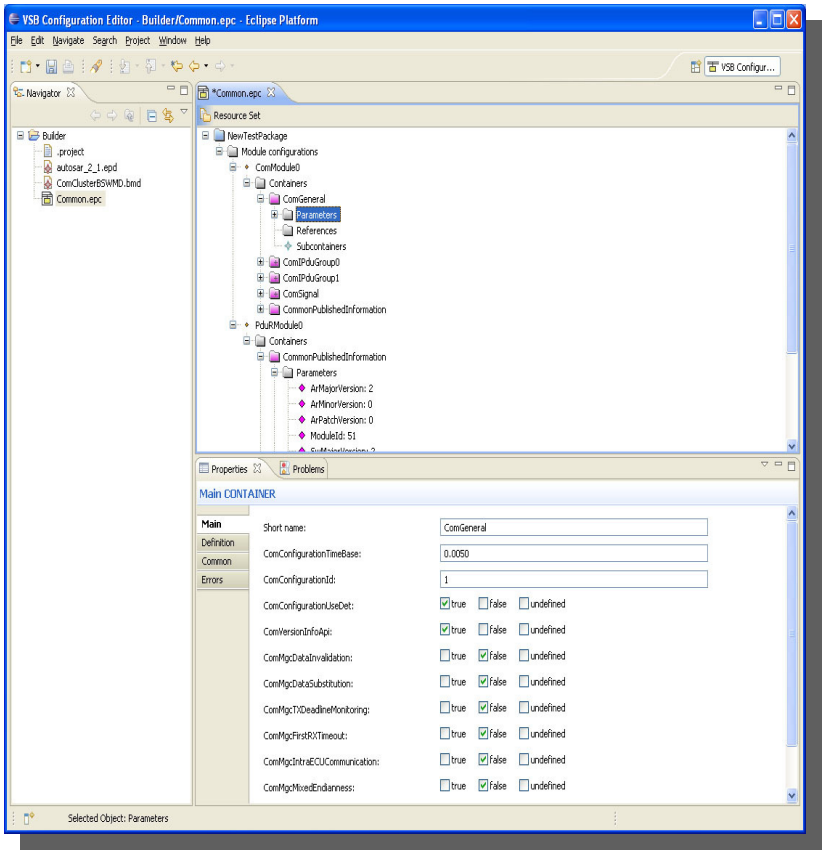
- VSB is containing several point tools, the most important are:
  - BSW module generic configuration editor
  - Designer Profile plug-ins (helps configuring a specific BSW module)
  - RTE generator
  - ECU project builder

Volcano VSB

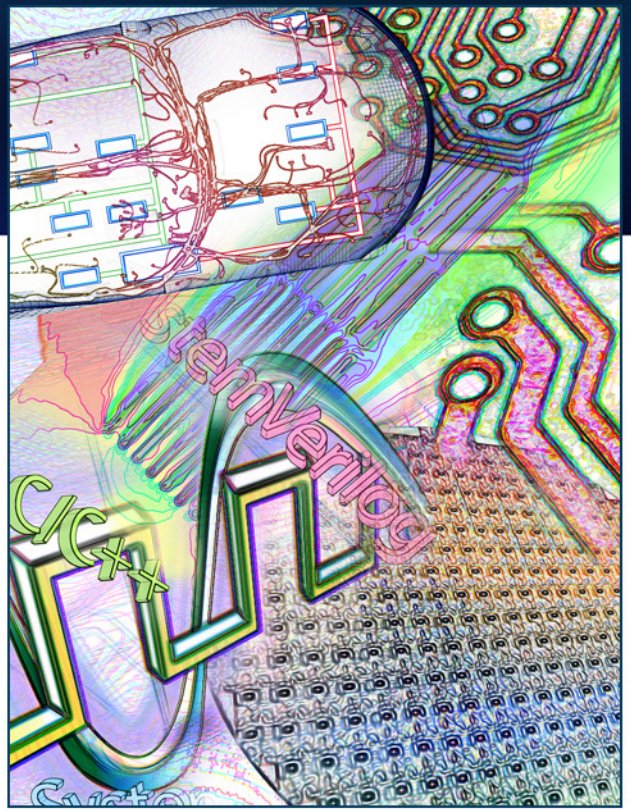


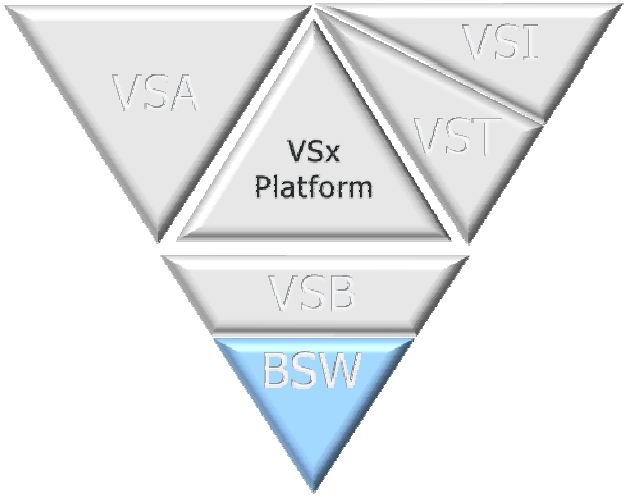
VSB BSW Configuration Editor

- Two types of Configuration Editor
  - Generic
    - A generic tree editor for advanced users
    - Supports configuring OEM specific modules
  - Specialized (Designer Profile plug-ins)
    - Hides AUTOSAR complexity
    - Enhanced GUI
    - Targeting complex AUTOSAR modules:
      - Communication (CAN, LIN and FR)
      - NVRAM
      - OS, RTE, SchM
      - Diagnostics
      - I/O hardware abstraction
      - etc….
- Consistency and constraints
  - Automatic handling of AUTOSAR dependencies
  - Supports User defined constraints
- ECU builder plugin
  - Integrated make system to minimize build effort



Embedded Software or Basic Software - BSW





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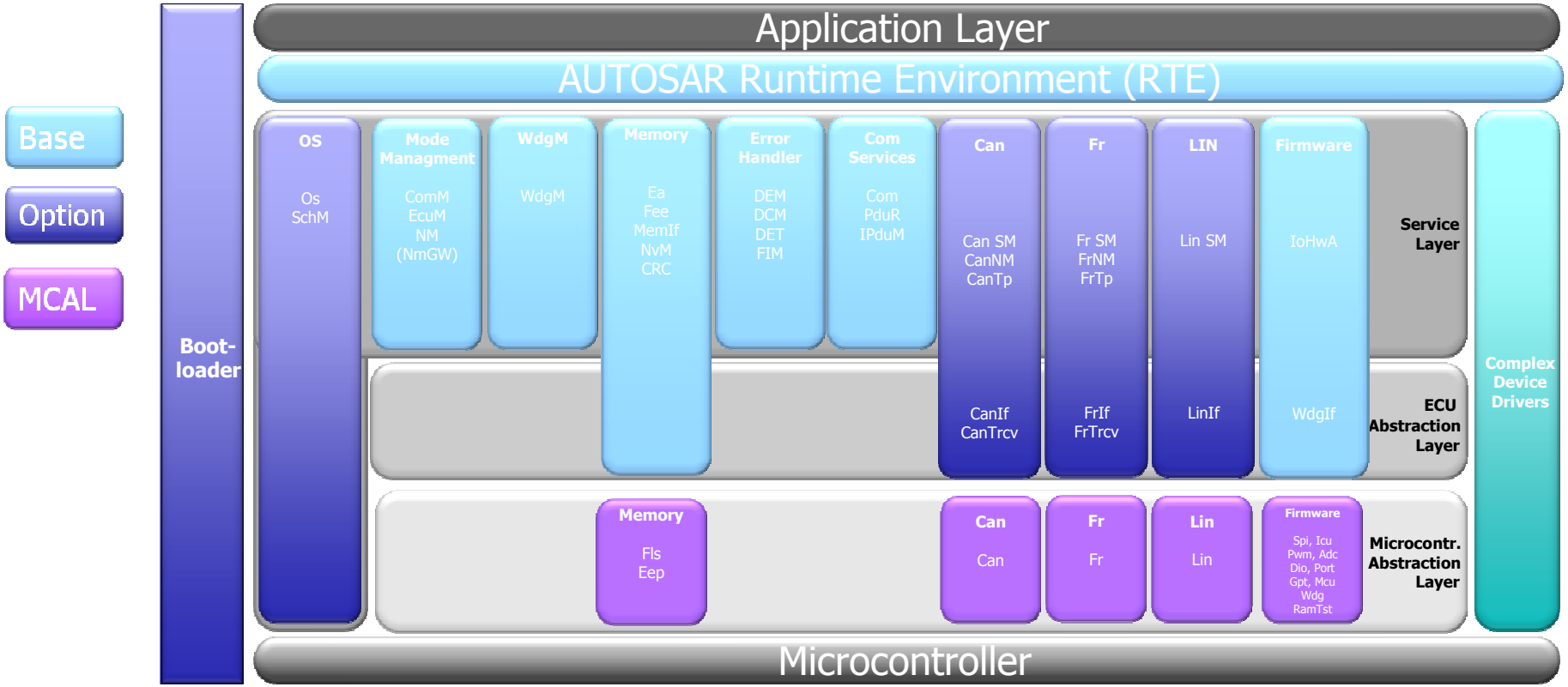
AUTOSAR Basic Software Overview

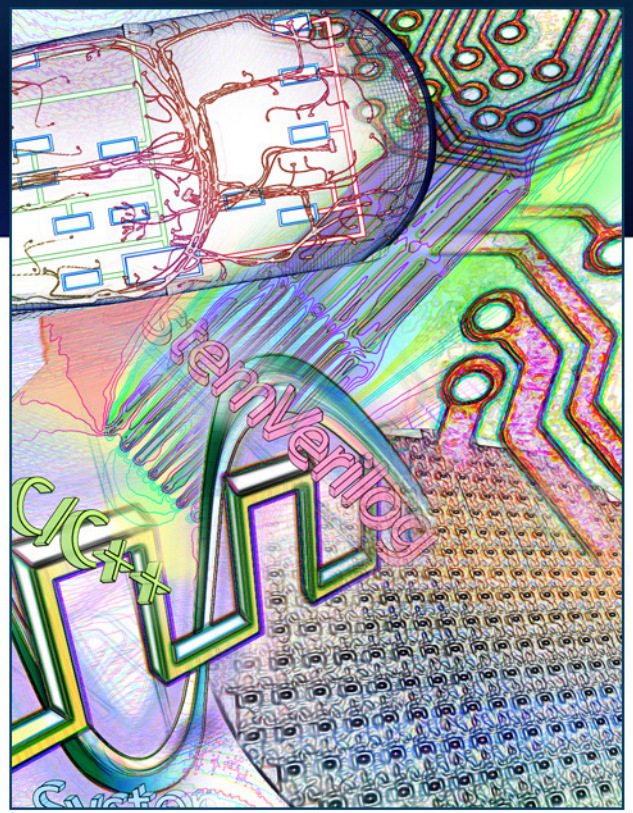
- Currently at AUTOSAR version 3.0.2
  - Standard AUTOSAR BSW
    - Reference MCU: NEC V850 / GreenHills compiler
    - Complete stack available now
  - Optimized AUTOSAR BSW (Nano)
    - BSW stack footprint requirements: ROM < 130kB, RAM < 8kB
    - Reference MCU: S12XEP100 / Metrowerks CodeWarrior compiler
    - Release available Q1 2010
    - Major Nano configurations done = Minimized configuration effort
- Design/configuration tools
  - VSB – Configuration editor/design tool
  - VSC – configuration generators

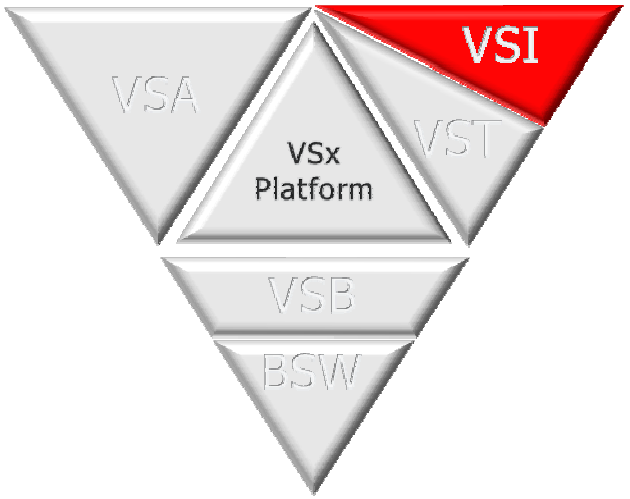
AUTOSAR BSW 3.0.2 stack



BSW is ported to target hardware and delivered as fully validated object libraries

VSI
Vehicle Systems Integrator





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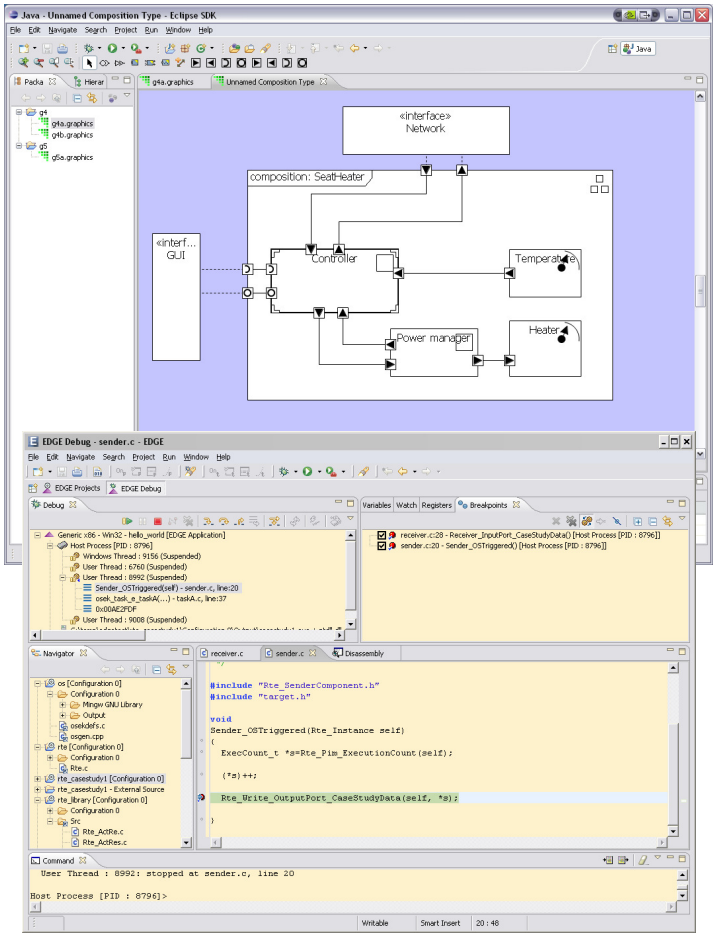
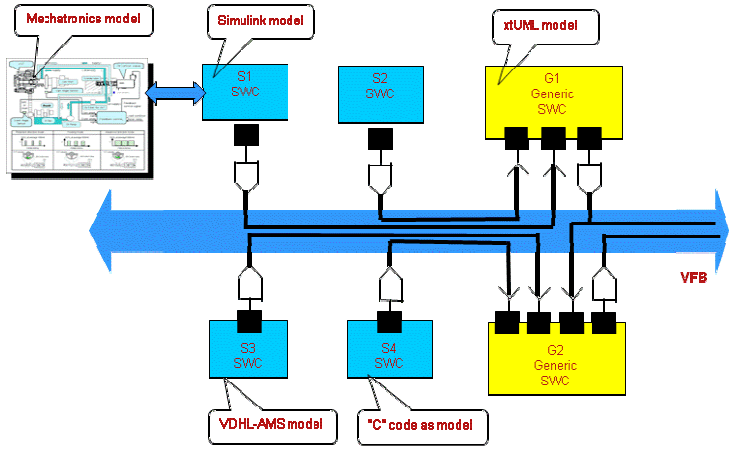
Virtual Systems Integrator



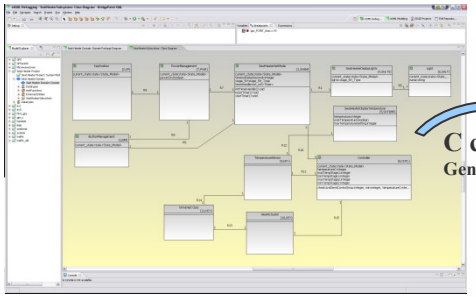
- Multi-lingual multi-processor Model Driven Development environment
- Design verification and validation of embedded software in distributed systems
- Initial target: AUTOSAR
- Integrates C/C++, UML, Simulink, EDGE debug, etc



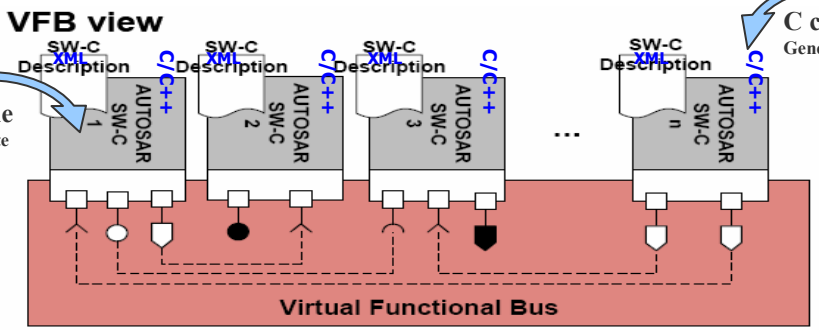
VSI Application Software Development

Sourcing functionality

Software Modeling

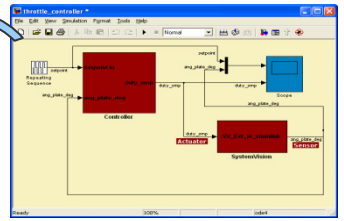


C code
Generate



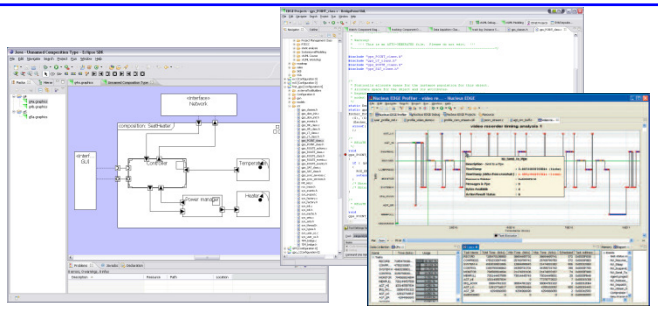
C code
Generate

Algorithmic Modeling

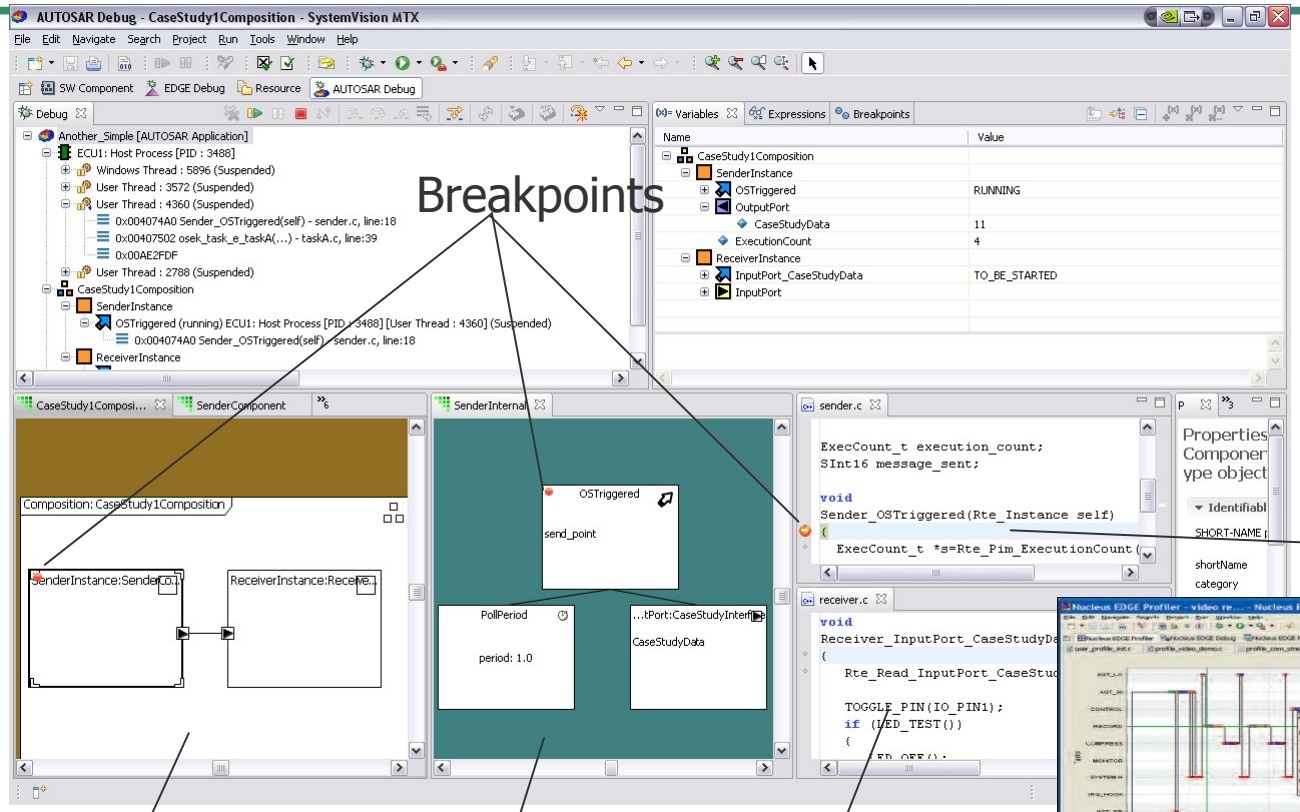


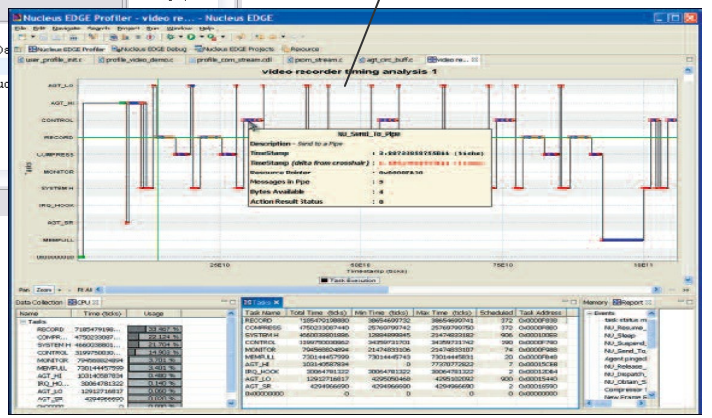
Operating System | System Services

Models use code generated from
BridgePoint UML, Simulink, etc. or hand coding



VSI Tool Suite

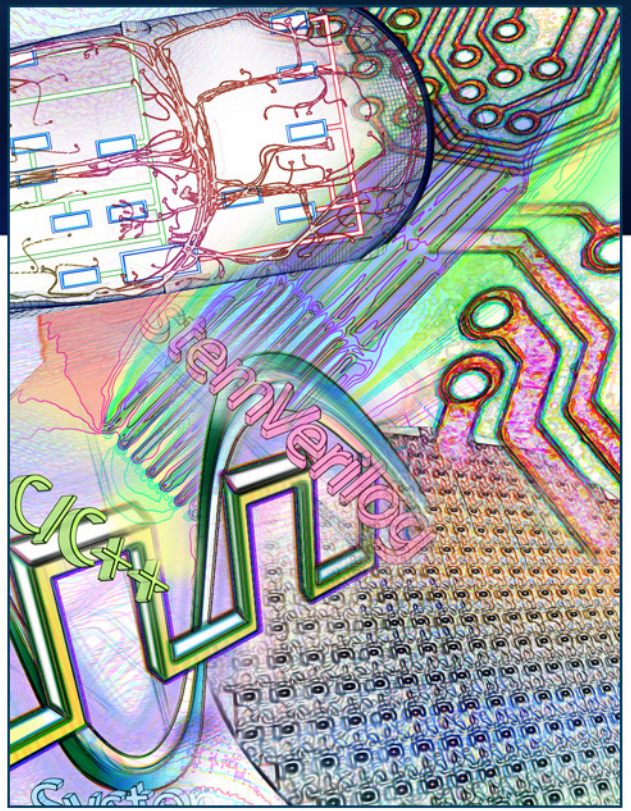




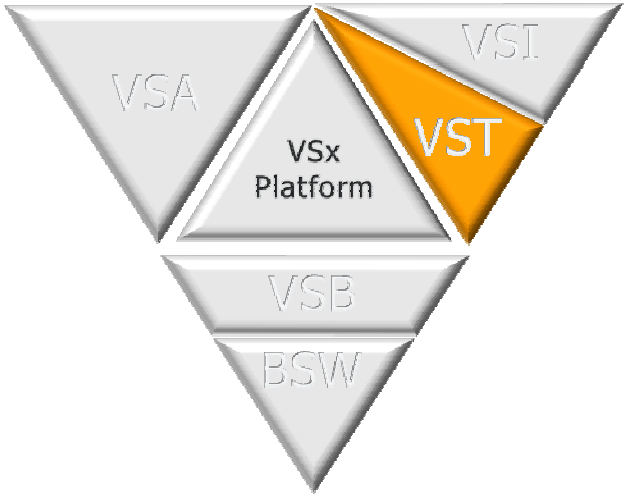
Profiler, Code and Data Trace

Benefits of an AUTOSAR System Simulator

- Excellent Collaboration
  - OEM and Tier1 communicate around executable models
  - Achieve early specifications
    - Required functionality is communicated unambiguously, before architectural decisions are made
  - Achieve early integration and test
    - Specifications with integrated functions and verification suites increase chances of first-time success
- Verification is fast and accurate
  - Simulates at a high-level of abstraction
- Integrate functions from multiple tools
  - Functionality is best expressed in multiple domain-specific modeling languages
- Use native modeling tools
  - Developers remain in familiar tools, preserving investments into existing tools and libraries



VST
Vehicle Systems Test



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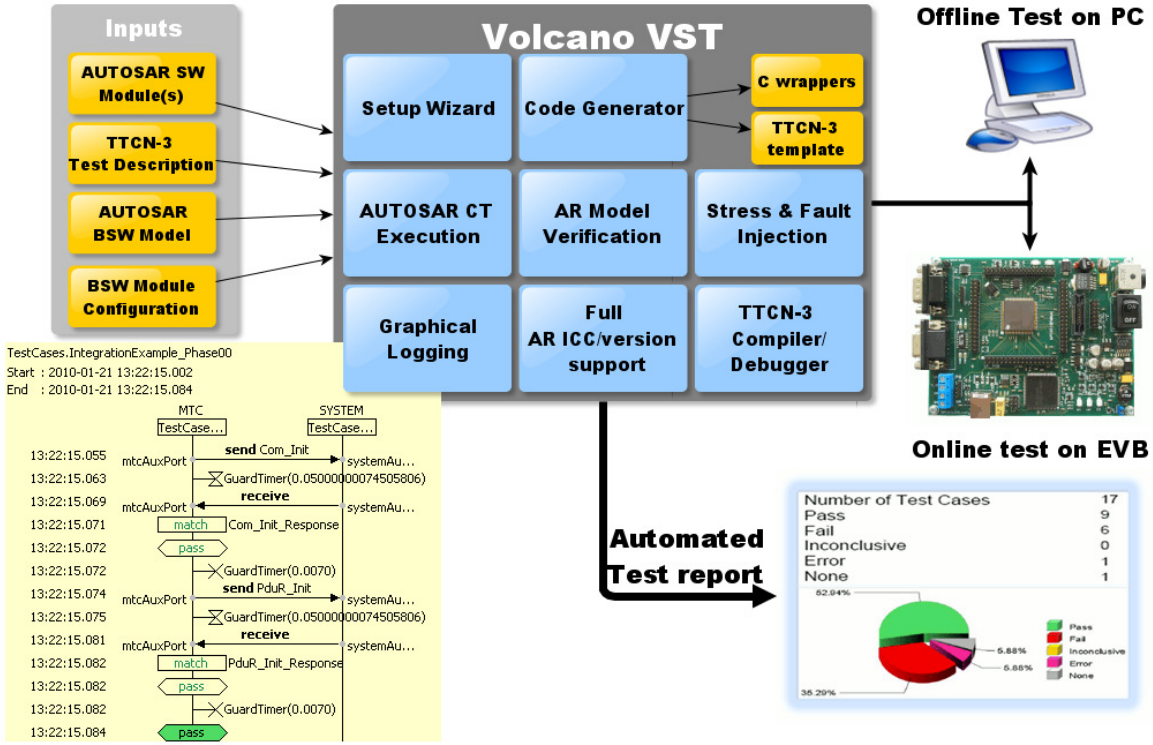
VST

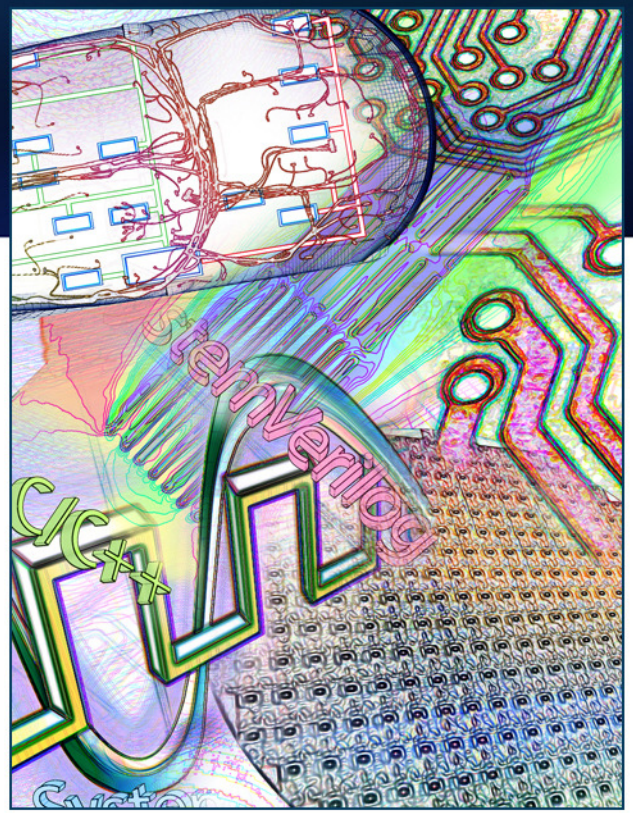
- Unified test environment for all AR BSW modules
- Full compliance with AR conformance tests (TTCN3 based)
- Minimized testing implementation effort
- Automatically generates
  - Upper/Lower layers stubs
  - TTCN-3 triggers/responses records
  - Test reports
- Minimized test execution time
- Achieves easy integration between BSW modules from different sources

VST – Vehicle Systems Tester



- One single environment for Test Development, Execution and Reporting.
- A generic test tool, not limited to AUTOSAR SW testing
- Direct execution of the AUTOSAR CTS
- Test Execution either on Target or on PC
- Based on well known and open Standard Language (TTCN-3) for Portability
- Automatic code generation of test object wrappers and TTCN-3 templates
- Automatic report generation

Development Flow and Organizational coverage



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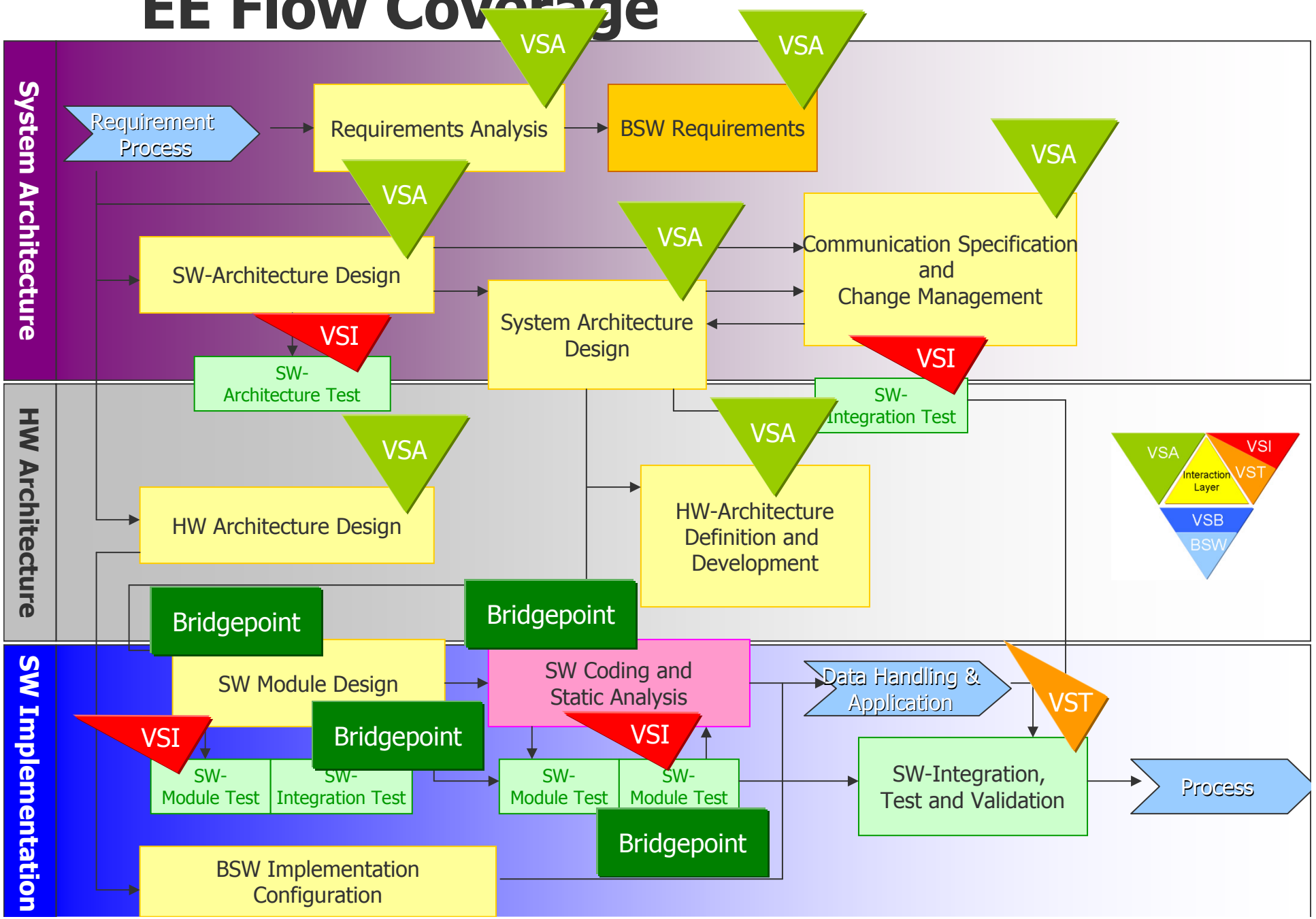
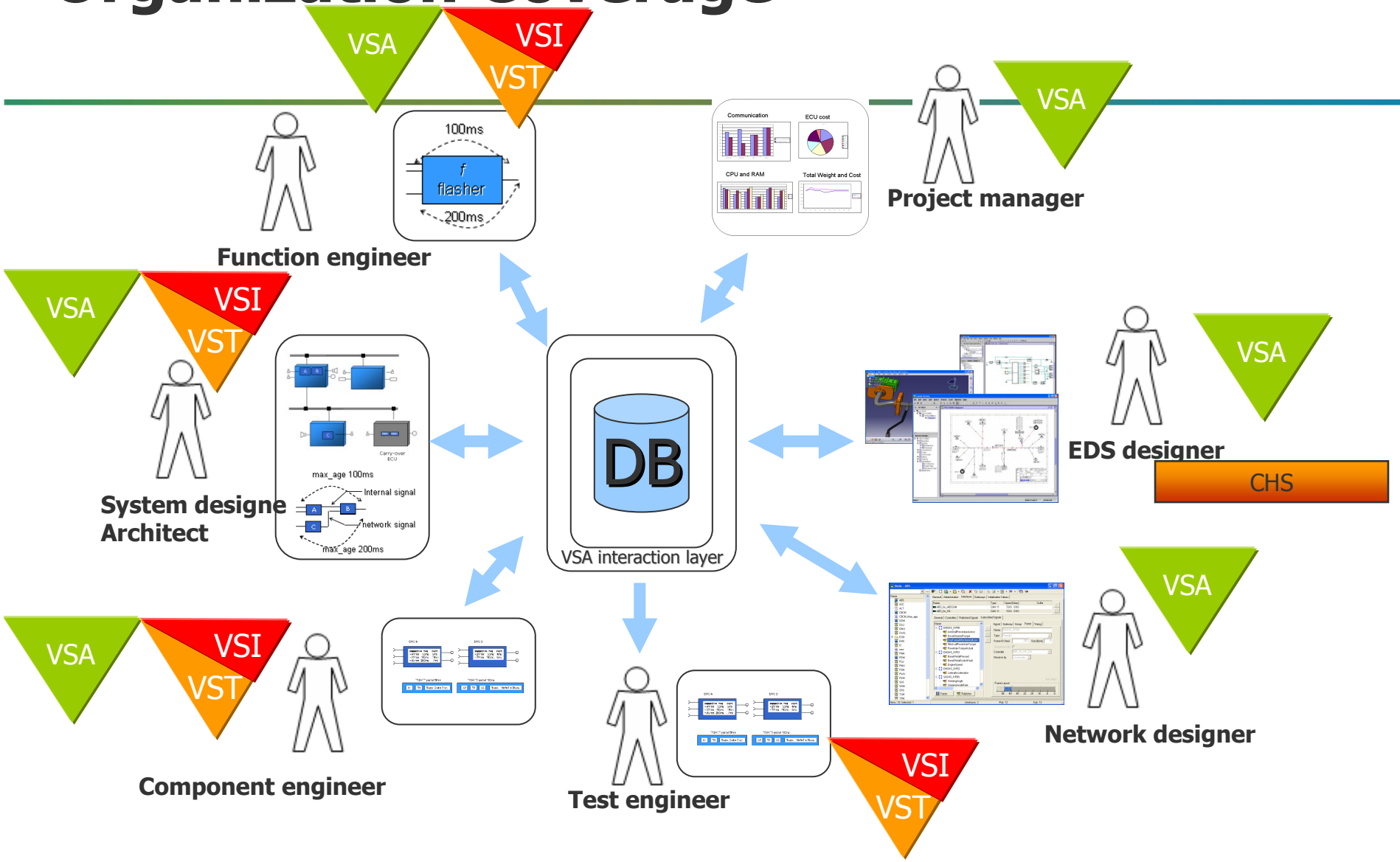
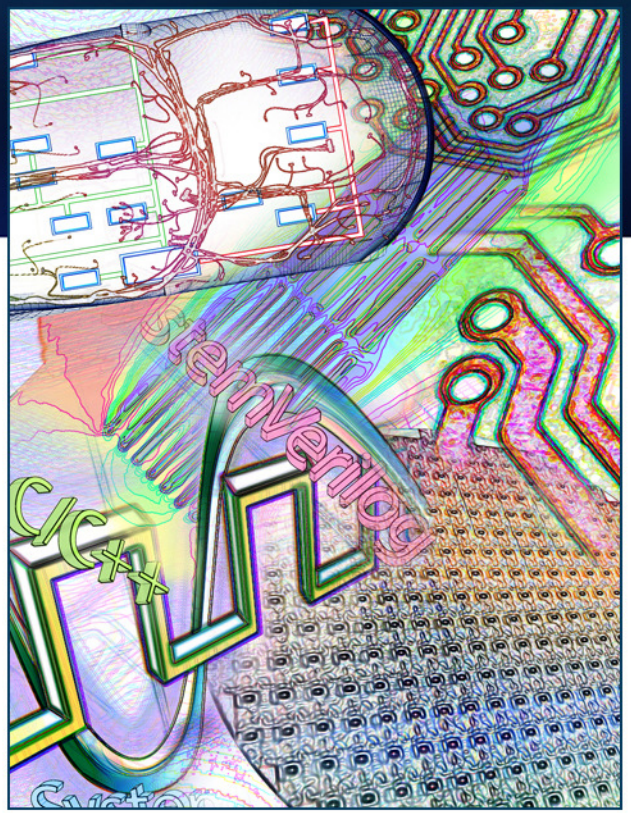
EE Flow Coverage



Organization Coverage





Roadmap and direction

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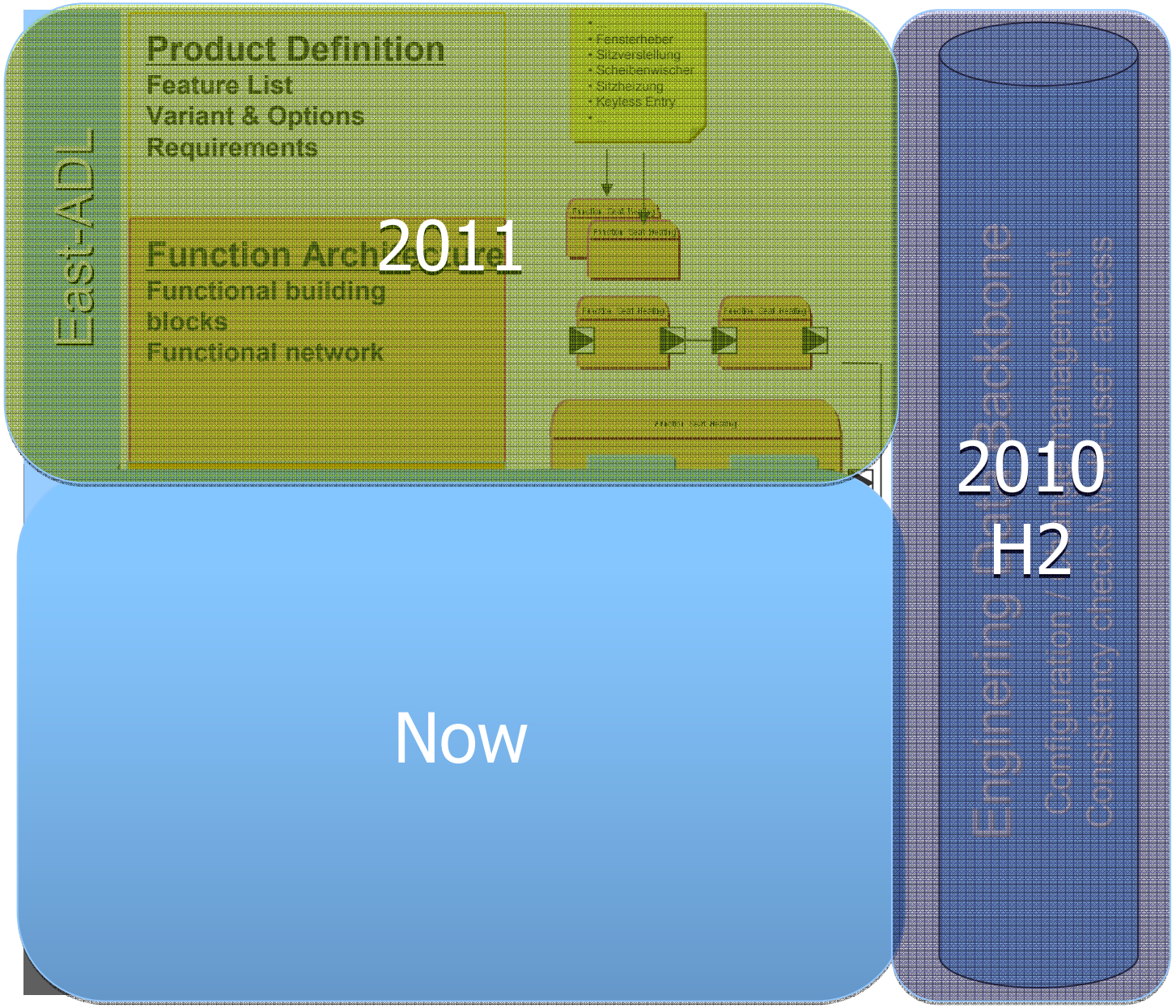
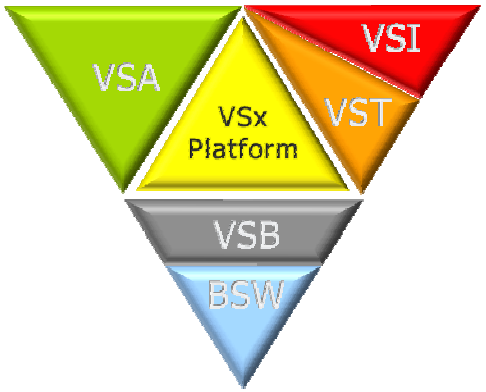
Mentor Graphics Automotive Network Design – Short Term Direction

- Establish VSx Tool Chain with initial products VSA, VSA COM FlexRay, VST, VSI (Now)
- BSW and VSB AR 3.0 (Now)
  - FlexRay AR 3.0 Now
  - Rest (LIN, CAN, OS, RTE etc.) Q1 2010
- Add manual Network Design LIN, CAN, FlexRay, Ethernet (H1 2010)
- Introduce design automation
  - Network Design synthesis (H2 2010)
    - Algorithms for LIN and CAN from VNA
- Add support for massive multi-user capabilities with central data-repository (H2 2010)



Summary

- Mentor Graphics Vehicle Systems Design Suite covers
  - Architecture design
  - Network Design
  - ECU configuration, design and test
  - VFB level simulation
  - Implementation in ECUs



- Overall goals
  - Enable optimisation of the E/E architecture
  - Enable (early) virtual verification of the system
  - ”Correctness by design”
  - Digital Continuity from requirements to realisation

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