SysML for embedded automotive systems

SysCARS methodology

Group Electronics Expertise and Development Services

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Valeo Key Figures 2012

Sales
11.8 Bn €

Employees
72,600

Countries
29

Research & Development Centers
61

Production Sites
125

Order intake:
15.8 Bn €

Platforms of distribution
12

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Valeo worldwide ranking

Model-Based System Engineering at Valeo

- System Process
- Roles & Organization
- Tool Selection
- Pilot Projects
- SysML Profiling
- Deployment

Years:
- 2006: System Process
- 2008: Roles & Organization
- 2010: Tool Selection
- 2012: SysML Profiling
- 2014: Pilot Projects
Examples of Pilot Projects with SysML-SysCARS

Motivations for Model-Based System Engineering

**Area of Automotive Embedded Systems**

- **Increasing complexity**
  - Mechatronics systems
  - Business models
  - Organizations involved
  - Safety regulation (ISO 26262)

- **Model-Based System Engineering**
  - Higher level of formalization and traceability
  - The model as a shared description to coordinate interdisciplinary works
  - Capitalization of know-how and design justifications
  - Improvement of efficiency thanks to “early validation” and reuse
Towards a model-centric approach

- **Technical effort**
- **Formalization Effort**
- **Requirement Management effort**
- **Distributed Concurrent engineering**

**DOCUMENT CENTRIC**
- Focus engineers on design justification and robustness
- Avoid transfer of formal design artifacts to poor textual statements
- Efficient handling of traceability in models

**MODEL CENTRIC**

**Improving efficiency by transitioning from textual to model descriptions**
System Modeling Tooling
To Support Valeo System Engineering Process (TFG12)

- Difficulty to keep different viewpoints consistent
  - Requirements
  - Use cases (test cases) and scenarios
  - Operational modes and system states
  - Functional/physical breakdown and architecture description

SysML as de Facto standard
- Standardized by OMG
- Independent from commercial tools
- XMI interchange format (to be improved)
- Increasing penetration in industrial sector

System Modeling Steps and Viewpoints

- Stakeholders Needs Definition
- Requirements Analysis
- Logical Architecture Design
- Physical Architecture Design
- Components Needs Definition

**PROBLEM STATEMENT**
« WHY IS THE SYSTEM NEEDED »
Understand system needs from user point of view

**ABSTRACT SOLUTION**
« WHAT THE SYSTEM SHALL DO »
Specify system services and interfaces that will solve user problem

**LOGICAL SOLUTION**
« HOW INTERNAL FUNCTIONS PROVIDE EXPECTED SERVICES »
Define logical architecture and internal functions

**PHYSICAL SOLUTION**
« HOW SYSTEM PARTS PERFORM INTERNAL FUNCTIONS »
Define system parts and internal functions allocation onto parts

SysML as the de facto standard to capture multiple SE viewpoints
Valeo SysCARS Methodology

(SysCARS: System Core Analyses for Robustness and Safety)

- SysML alone not sufficient
  - Syntax but no semantics
  - Many diagrams and artifacts sometimes redundant
  - Provided without any methodology
  - A pre-existing System Engineering process is required

- SysCARS as a precise guideline to use SysML
  - Sequence of modeling activities to be performed
  - Subset of SysML diagrams and artefacts to be used
  - Defined semantics ensuring model consistency
  - Stereotypes and templates for automatic documentation generation

SysCARS-CS Optimized Workflow

1a. Stakeholders Needs Definition
1b. Usage
1c. User Scenarios
1d. Modes

2a. External Interfaces
2b. Main Services
2c. System Scenarios
2d. States

3a. Logical Functions
3b. Logical Architecture
3c. Log Internal Interfaces

4a. Candidate Solutions
4b. Physical Architecture
4c. Phy Internal Interfaces
4d. Phy Internal Scenarios

On carry over projects Logical Architecture design is bypassed
Workflow-driven Approach

SysML Valeo Profile

- Learning curve and standardisation
  - Complexity of SysML tooling for non software specialists
  - SysML / SysCARS slow learning curve
  - Heterogeneity of results on different projects

- Valeo Profile embedding SysCARS workflow
  - Predifined package structure
  - Guidance on the correct ordering of modeling activities
  - Guidance on the relevant diagram to be used at each modeling step
  - Stereotypes automatically put on artefacts, depending on modeling step

VALEO Profile to help System Architects throughout the workflow
A new model is no more empty...

Workflow diagram monitors SE activities

Pre-defined Package Structure

Embedded SysCARS Workflow

Workflow Menu
Available features depend on workflow state

Customized contextual Toolbar

Customized contextual Menu

Stereotypes are automatically set

Stereotype for Documentation

Requirements Attributes
Automatic Generation of Documentation
Independence Between Data and Documentation

Templates taking into account Valeo entities and customer specificities

Model Verification Policy

- **SysML simulation not (yet) adapted**
  - Limitations of SysML tools capabilities
  - Completeness of models not sufficient
  - Skills required antagonistic to (generalist) system engineers job profile

- Static verification preferred to simulation
  - Traceability rules defined by SysCARS data model
  - Local traceability analysis with SysML tool
  - Global traceability analysis with traceability tool (Reqtify)
  - In the future, using a modeling rule checker
Local Traceability Verification

Stakeholder Needs Requirement Table

Traceability checking now and modeling rule checker in the future

Global Traceability Verification

Stakeholders Needs Definition

Requirements Analysis

Logical Architecture Design

Physical Architecture Design
Coupling to Requirement Management Tools
Centralized vs Distributed Approach

- Centralized requirement management not optimized
  - Redundancy between models and external repository contents
  - Loss of time when re-writing requirements from models to ext. repository
  - Loss of information when translating model items to natural language
  - Loss of semi-formal verification possibilities

- Distributed requirement storage
  - People working with tools well adapted to their discipline
  - User requirements synchronized with the external repository
  - System and component requirements only formalized inside SysML
  - Component specifications generated from the SysML model

Distributed Requirement Management

USER
Customer
Customer Needs
Repository
User Requirements
RIF/ReqIF
Traceability Results
SYSTEM
Architecture Breakdown
COMPONENT
Component Requirements
Architecture Tools
Component Specifications
REQTIFY
Product Discipline
Development Tools
COMPONENT Discipline
Refined Requirements
Design/Validation Elements

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Implicit Traceability Links

Blocks automatically populated, no textual requirement writing needed
Explicit Traceability Links

Explicit traceability links used for non functional requirements

SysCARS Traceability at Architecture Level

SysML Model Artifacts

SysML Requirements

System (or System Element) (Block)

- Parameters (Values)  V-x
- Functions (Operations)  F-y
- Dynamic Behaviour (State Machine)

Non functional Requirements:
- Global constraints
- Measurements of Performance (MoP)
- Functional performance requirements
- State/Transition performance requirements
- Interface performance requirements
Conclusion

Model-Based System Engineering at Valeo

- **Process**: System Engineering Process (Valeo TFG12)
- **Methods**: SysCARS Methodology (CS for carry over, XS for innovation)
- **Tools**: SysML + Valeo Ergonomic Profile + Document Generator + Doc. Templates
- **Organization**: System Architect trained to SysCARS
MBSE Topics of Interest

- Synchronizing with Safety analyses (ISO 26262)
- Lean System Engineering life cycles and agility
- Product line management and reuse of COTS
- Link to multi-physics simulation for trade-off analyses
- Methods for verification of models
- Model-based testing for complex systems

Towards a functional digital mock-up for early validation

Your questions are welcome