

Guidelines for Model Based Systems Engineering

Dr. D. Steinbach
Mission Management
Cassidian®
Ulm, Germany
dierk.steinbach@cassidian.com

Abstract—Cassidian® is working on modeling guidelines. We present our approach and report first results and findings to illustrate progress and direction of our work.

Systems Engineering; Model Based; Guidelines; Rules

I. INTRODUCTION

In Model Based System Engineering (MBSE) Cassidian® uses modeling tools (i.e. software tools) to support the Systems Engineering (SE) tasks. In doing so, two aspects are of especial importance.

System definition using system models: Models are used to design and in particular to define systems regarding, e.g.

- structural aspects such as physical, functional, logical system structure (system breakdown, states, functions, parts, product breakdown structure),
- algorithms (mathematical, protocols, etc.) implemented in the system and system performance,
- physical properties of the system (thermal, mechanical, electromagnetic, etc.).

Second, validation of the system definition using system models.

Modeling tools offer a variety of benefits. The main advantages are:

- Standardized and unambiguous notation (syntax and spelling). A given modeling tool realizes a single notation, typically following the SysML standard.
- An inherently consistent system definition and design is achieved by uniquely defining each system item and function in the model. Any redundancy is avoided.
- Automated consistency checks can be performed based on the data in the software tool. Executing the model and simulating the system behavior checks correctness of system definition and design. In other words, we prototype the system or parts of it e.g. algorithms.
- Engineering configuration management (CM) is facilitated based on the functionalities and CM support as provided by the modeling tools.
- System models form a solid basis for the collaboration between different stakeholders, e.g. system, software and hardware engineering. The System Model may be

re-used in software engineering, e.g. for code generation.

In order to realize these benefits in industry a harmonized usage of system models is required within Cassidian. Common modeling guidelines need to be established. For this, a variety of challenges needs to be overcome: accommodation of different system design methods, diverse understanding of e.g. abstraction levels, SysML ambiguities, tool specificities etc.

II. WORKING GROUP

In 2010 the MBSE Working Group was established within Cassidian® and the SE process and method were analyzed in view of MBSE. The working group found that several SE teams use models and that a common basis, i.e. a detailed definition in addition to the Cassidian® Business System, is required for MBSE. In turn, the development of a SE Guide [1] and Modeling Guidelines [2] were launched. This started with an elicitation of the objectives of the MBSE. Below, we report first results and findings in progress in order to illustrate the direction of our work.

III. MODELING MAP

As a first result of our activities, we found that the coordination of different modeling approaches previously highlighted requires a common understanding of a variety of topics, such as:

- model structure and notation (syntax and spelling),
- relation between System Model data and other data held separately,
- interface between modeling on one side and SE process and method on the other side,
- modeling process and method,
- modeling tool characteristics.

In order to provide orientation, we organized the topics in the MBSE aspects shown in TABLE I.

The aspects are covered in documents as follows: The Cassidian® Business System and SE Guide [1] define SE Process, Method and Results. The Modeling Guidelines will cover the aspect Modeling as well as Interface between SE and Modeling and later the Tooling aspect.

In line with this the Modeling Guidelines are based on the SE Guide. They complement the SE guide regarding MBSE.

TABLE I. MBSE ASPECTS: MODELING MAP

SE Process ^a	Interface between SE and Modeling ^d	Modeling ^c	Tooling ^f
SE Method ^b			
SE Results ^c			

a. Steps, input, output, activities, responsibilities, contributions, decisions, etc.

b. Which aspect is analyzed / designed with which method and to what level of detail; Interface / transition between the analysis with different methods e.g. Structured analysis and system specification, Harmony™, data flow diagrams, state charts, entity relationship diagrams, etc.

c. Concepts / Analysis / Design, Products / Specifications

d. Items (results), which constitute the model; Activities and steps which are performed by / in the model; Place / documents, where the modeling results will be documented and / or used; Relationship between the model contents and system engineering artifacts.

e. Views, diagrams and elements with their usage, meaning and notation; Model structure; Relations and dependencies between views, diagrams and elements; Order of and transitions between the activities

f. How the modeling will be realized in a specific tool

IV. MBSE STRUCTURE

As a second result of our work we structured the SE process and the MBSE method as shown in Figure 1 below. The SE process is depicted in the middle, its associated traditional SE artifacts on the left and the system model artifacts on the right.

In the SE process we identify requirements elicitation and system design. Concerning the system model artifacts we distinguish for both between Functional, Logical and Physical Architecture. This is in line with [3], [4] and [5].

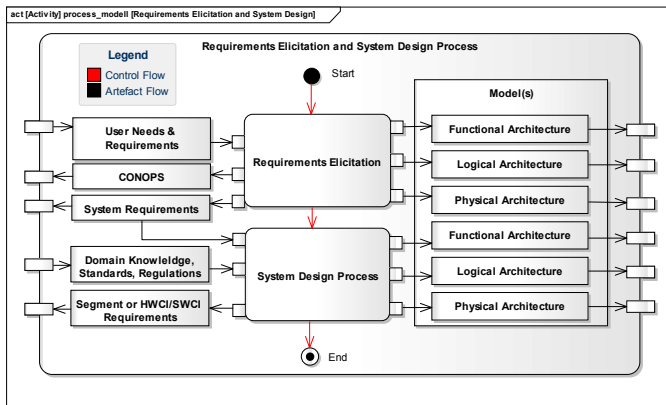


Figure 1: SE Process and MBSE Structure (up to design)

V. MBSE RULES

As a third result of our work we are defining MBSE rules. They formalize our harmonized understanding within Cassidian. Below we list a few examples out of a big variety

- Regarding model artifacts not only traditional abstraction levels (system, sub-system, component, software, hardware) are distinguished but also required system functions and performance on one hand and derived functions and system elements on the other.

- Resolution of the SysML ambiguity, e.g. for discriminating shared and part associations [7]: "SysML defines no specific semantics or constraints for properties with shared aggregation, but particular models or tools may interpret them in specific ways" [6].
- Take into account tool specifics, e.g. only unidirectional associations allow for re-use of the model part at the target end in other models.
- Accommodation of two different functional analysis methods: Object Flow Oriented (OFO) and Service Request Oriented (SRO) method [7]. The SRO method focuses on state charts for the detailed analysis, decomposition and description of the system. The OFO method focuses on activity diagrams. Despite this, the diagrams are still consistent. E.g. in both methods, the block stereotype is applied to activities and activities are represented as blocks. Block definition diagrams are used to decompose the system functions into their functional blocks.

VI. CONCLUSIONS AND OUTLOOK

From the experience of harmonizing the different approaches to systems engineering using models in Cassidian we highlight three conclusions. First, a clear structure of the problem is crucial for a common understanding (e.g. Modeling Map, MBSE Structure). Second, focusing on rules strongly facilitates the convergence of model usage in systems engineering. Third, even though varying design methods exist, mandatory diagrams in fixed form (defined in modeling guidelines) will allow for aligned MBSE. Based on the above experience and results we will establish modeling guidelines to further synchronize and improve systems engineering.

ACKNOWLEDGMENT

D. Steinbach thanks Prof. H. Daembkes for sponsoring this activity.

REFERENCES

- [1] F. Scheerer, M. Leute, "Systems Engineering Guide" Cassidian internal Handbook 2011.
- [2] F. Scheerer, D. Steinbach, M. Leute, S. Ackva, J. Stohr, D. Bank, O. Bender, P. Lingott, "Modeling Guidelines" unpublished
- [3] INCOSE Systems Engineering Handbook "A Guide for System Life Cycle Processes and Activities", v. 3.2, January 2010
- [4] IEEE Standard for Application and Management of the Systems Engineering Process, IEEE Std 1220™-2005, 2005
- [5] Systems Engineering – System life cycle processes, ISO/IEC 15288, 2002-11-01
- [6] OMG SysML v1.2, June 2010
- [7] M. Leute, "MBSE Guideline using SysML" unpublished.