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Towards a maturity assessment scale for the Systems Engineering assets valorization to facilitate Model-Based Systems Engineering adoption

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CONTEXT AND OBJECTIVES

In the context of engineering practices transition from a document-based approach towards Model-Based Systems Engineering (MBSE) approaches, it is necessary to demonstrate to end-users how MBSE will help them design their system, even if their daily routines are disrupted. However, unlike engineering practices that can change, engineer's know-how is sustainable and remains key to the development of good systems. For that purpose, previous works have shown the relevance of patterns for the capture of engineering assets and their valorization through reuse (Wu et al. 2018). Yet, it appears that the current trend to adopt MBSE methodologies (Figure 1) does not make enough sense for engineers to take the leap towards these new approaches (Huldt and Stenius 2018), as the gap with engineering practices is too significant.

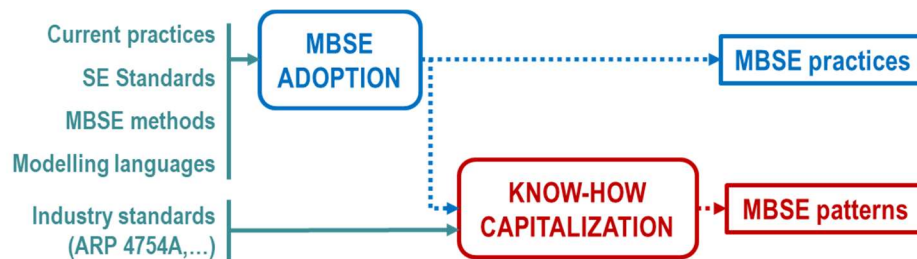


Figure 1. Current trend for the adoption of MBSE methodologies

Unlike the current trend to capitalize on know-how after a development in MBSE, the adoption process should consider engineer's know-how before rushing towards modelling (Figure 2). In the proposed approach the process starts by extracting System Engineering (SE) patterns. Among them, some will meet the needs of engineering teams more than others. It is therefore these patterns who will be modelled and integrated into an MBSE approach. This approach allows engineering teams to choose the patterns that will have the most added value for them, and thus facilitate the adoption of MBSE methodologies.

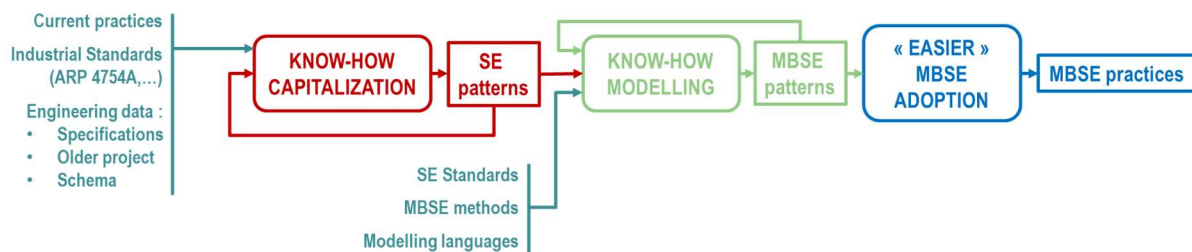


Figure 2. Proposed approach for the adoption of MBSE methodologies

The aim of this article is to propose a scale to evaluate the maturity of the valorization of Systems Engineering assets. This paper assumes that this valorization process consists in the highlighting of valuable engineers' know-how to be disseminated to other engineers at the time and at the level of comprehension needed. It means that, if the final goal is to reuse SE assets, other processes are necessary to achieve these expectations. As promoted in the software

community, systematic reuse will allow significant gains in development productivity and quality (Garcia et al. 2007). Thus, in order to develop reuse strategy, a maturity scale will make it possible to determine the level of maturity at which a company is operating. In this way, it will be possible to assess the margins for progress and therefore to estimate the necessary efforts to improve their maturity through a corresponding action plan.

STATE OF THE ART

A maturity scale provides a systematic framework to assess the maturity of products developed by an organization. But, there are also many maturity models proposed for different issues related to development and reuse processes. Research works in the software community have been done and propose various practices and models to mature reuse activities. For example, the Reuse Capability Model (RCM) is providing a method for determining the software reuse capability of an organization (Rine and Sonnemann 1998), by defining five levels to evaluate and plan improvements for organizations reuse capability. However, as assessment concerning development and reuse process needs to be done in multiple dimensions it appears that a complete maturity model needs to cover multiple criteria. In that sense, the RiSE Maturity Model proposed by (Garcia et al. 2007) includes four perspectives addressing organizational, business, technological, and process issues. The main purpose of the RiSE Maturity Model is to support an incremental adoption and implementation of software reuse practices. Recent work by (Younoussi and Roudies 2016) has compiled and compared these and other maturity models for software to provides a classification of each model depending on criteria and parameters to help a company choose the right approach.

In the SE community, maturity model for deploying SE processes (Cornu et al. 2012) or measuring the use of MBSE have been developed but have not yet studied in detail the assessment of valorization and reuse of SE assets. Before the well-known CMMI (Software Engineering Institute 2010), a Systems Engineering Capability Maturity Model (SE-CMM) (Software Engineering Institute 1995) has been developed, but reuse aspects were not taken into account. In the CMMI, practices on reuse are established at a high level, and lack of instructions on the operational side. Thus, it appears that there is a need to help companies to assess their current performances on their reuse processes and to provide guidelines to improve them. The answer to this need is through the definition of a maturity scale of the valorization of SE assets, as proposed in the next section.

MATURITY SCALE

This article proposes a multiaxial scale which includes five levels of maturity by axis, in order to cover the different aspects of the process of valorization of SE assets (Figure 3 **Erreur ! Source du renvoi introuvable.**). This allows quantifying, on the one hand, degrees of maturity (M_I, M_L, M_R) that will be specific to some activities (Identification, Library classification, Reuse), and on the other hand, an overall level of maturity (M_{VSEA}) that will depend on the level on each axis. This scale leans on the CMMI and proposes to adapt its maturity level definition to the specific needs of SE assets.

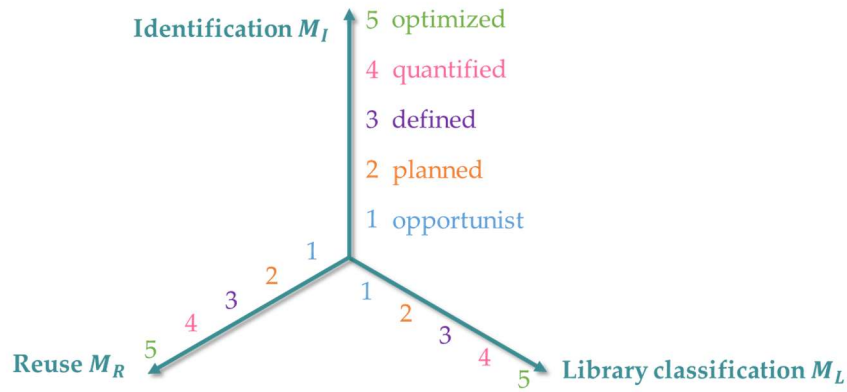


Figure 3. Proposed maturity scale

The particularity of this scale is that there are dependency links between the axes. Indeed, the final goal is to reuse assets to disseminate know-how, but also to ease and speed up future developments. However, this is not possible without having first identified those assets. Also, reuse will be more efficient if assets are well classified in libraries. This means that the identification axis is the start to every process, and that its level of maturity is constraining other axes. That is why, this scale assumes that:

$$M_R \leq M_I$$

$$M_L \leq M_I$$

Once these conditions have been set, it is possible to define the overall maturity level of the valorization of SE assets (M_{VSEA}) as follows:

$$M_{VSEA} = \min(M_I, M_L, M_R)$$

The description of each level of maturity is detailed in Table 1.

Table 1. Detailed description of each level of maturity

| | | AXIS | | |
|-----------------------|----------|---|---|--|
| | | Identification | Library classification | Reuse |
| MATURITY LEVEL | 0 | No identification of reusable elements | No library classification | No reuse from previous projects |
| | 1 | Opportunistic identification of reusable elements from previous projects, without method (uncomplete vision) | Awareness: "I already saw something like this"; Opportunistic oral sharing of reusable elements: "we already done this way", use of paper board... | Opportunistic reuse by copy/paste from previous projects, without method; manual adaptation |
| | 2 | Planned identification of reusable elements, without method (uncomplete vision) | Planned sharing of formalized elements (communication, archiving...) identified as reusable (texts, models...) | Planned reuse by copy/paste from previous projects, without method; manual planned adaptation |

| | | | |
|---|---|--|--|
| 3 | Defined identification method: classification in function of defined abstraction levels | Defined capitalization method: sharing organized around a sharing structure | Defined reuse method: defined selection of reusable elements and transitions between defined abstraction levels |
| 4 | Quantified measure of defined identification method efficiency (identification time, costs...) | Quantified measure of defined capitalization method efficiency (classification time...) | Quantified measure of defined reuse method efficiency (direct reuse or adaptation time...) |
| 5 | Optimization: continuous improvement of identification method | Optimization: continuous improvement of classification method | Optimization: continuous improvement of reuse method |

SE assets vary depending on the level of maturity. In the context presented in the first section, patterns are SE assets, but SE assets should be considered as patterns only from maturity level 3 (defined) and above.

CONCLUSION & PERSPECTIVES

This first version of maturity scale for the valorization and reuse of SE assets allows an assessment of current practices. It also guides the elaboration of an action plan to improve current maturity.

In future works, the axes of the maturity scale will be refined and completed in order to take into account MBSE assets: model identity card, assessment of models maturity (for example depending on various metrics such as version number and number of instantiations,...), tools supporting model reuse,...

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