

Master thesis @ ISAE-SUPAERO, 4-6 months

Model transformation survey

Contact: Jean-Charles Chaudemar, jean-charles.chaudemar@isae-supaero.fr

Co-tutor: Xavier Thirioux

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Scientific domain: Formal methods, systems engineering, computer science

Context and Objectives

The research activities of the department of Complex Systems Engineering at ISAE-SUPAERO mainly focus on developing the new assets of Model Based approaches at early-design phase. Model-Based Systems Engineering approaches (MBSE) enable to organise all needed concepts (people, products and processes) around a methodology for the design of systems. Another approach based on Multidisciplinary Design Analysis and Optimisation (MDAO) enables to validate design sizing-solutions and to seize physical system features such as mass evolution, thermal convection, in the early design phases of the system's life cycle [3][4]. The identified bottleneck to be solved is a seamless integration of MBSE, and MDAO approaches with emphasis on certification and application to drones [7].

In the context of the internship, our main objective is to formalize the transition from a MBSE model to a MDAO model and vice versa, which highlights a methodological framework for a system design analysis.

Description

The axiomatic category theory paves the way for the model transformation throughout the graph transformation [1][2]. In a model-driven engineering approach, the model transformation defines a process of linking two models/domains at least in terms of consistent semantics between them. For instance, when it comes to software engineering, the implementation of this transformation link is depicted by a compiler from a high-level language (specification) into a code source [5]. As for a system viewpoint, models rely on productions or artefacts of engineering methods, thus only high-level languages are considered over early design phases [6][7].

The certification process imposes an early verification and validation for the development of models at each stage, but also the consistency of their transformation. Thanks to formal methods, a few model transformations leverage theorem provers [5]. To do so, a formal semantics of the source domain together with a formal semantics of the target domain have to be defined. To avoid reinventing the wheel, a thorough literature survey is compulsory. The languages, the scope of each domain, the formal methods are all concepts to delve more deeply for the sake of the model transformation.

Work agenda

The roadmap of the intern will be organized around three main tasks:

- 1) To do a state-of-the-art or survey about model transformation in general, and for MBSE and MDAO approaches, specifically: there exist tools for each approach, but a few questions can be raised about the semantics and about the interoperability.
- 2) To identify key properties for this model transformation: e.g., how to state the correctness?
- 3) To propose a strategy for a domain specific modelling language that supports this model transformation: e.g., could we propose a refinement method?

Expected skills

The applicant holds a master degree in computer science or systems engineering. In addition to the tasks about the setting out of a domain specific modelling language and method, the applicant will develop own method or high-level language. Fluency in English and soft skills are required abilities.

IT skills are as follows:

- languages: C, Java, Python, QVT, ATL
- modelling: **MBSE**, formal methods

References

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- [3] Martins, J. and Lambe, A. Multidisciplinary Design Optimization: A Survey of Architectures. AIAA Journal, 51(9), pp.2049-2075, 2013.
- [4] Lambe, A. and Martins, J. Extensions to the design structure matrix for the description of multidisciplinary design, analysis, and optimization processes. Structural and Multidisciplinary Optimization, 46(2), pp.273-284, 2012.
- [5] Cheng, Z., Tisi, M. and Douence, R., 2020. CoqTL: a Coq DSL for rule-based model transformation. Software and Systems Modeling, 19(2), pp.425-439.
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- [7] Chaudemar, J.-C., and de Saqui-Sannes, P. "MBSE and MDAO for early validation of design decisions: a bibliography survey." 2021 IEEE International Systems Conference (SysCon). IEEE, 2021.