Usability of Systems Modelling Environment, an Empirical Study

Jean-Marie Gauthier[1], Cyril Hatchi[2], Jérôme Fasquel[1], Julien Baclet[1], and Pierre Gaufillet[3]

[1]IRT Saint Exupéry, Methods and Tools for Complex Systems, Toulouse, France
[2]Human Design Group, Toulouse, France
[3]Airbus Defense and Space, Toulouse, France

Keywords: Systems Modelling; User Interfaces; Human Factors; Automation;

1 Introduction

Model-Based Systems Engineering (MBSE) tools are crucial for managing the complexity of modern systems, yet their adoption remains limited due to steep learning curves and confusing interfaces. While recent advancements have been made in MBSE tool design (Pinquié *et al.*, 2023), many users report that traditional tools often add complexity rather than simplify tasks. A complete MBSE approach relies on three key elements: a modeling language, a modeling method, and a modeling tool, all of which are typically implemented within broader industrial engineering processes. These layers of complexity pose significant challenges and hinder the widespread adoption of MBSE (Chami and Bruel, 2018).

Prior research highlight the importance of user-centric design and Human Factors Engineering in improving MBSE tools (Abrahão *et al.*, 2017), but significant usability challenges persist: studies point out the need for broader user profiles, better integration of UX experts, and a focus on scalability and collaborative modeling (Kalantari and Lethbridge, 2022). These issues remain under-explored, leaving a gap between the technical potential of modelling tools and their ease of use. Our study contribute to this field by focusing on task-based interfaces and Human Factors Engineering principles to reduce the learning curve and improve the usability of MBSE tools.

As a starting point, our work assumes the following hypothesis **H1**: MBSE tools will primarily continue using 2D diagrammatic and textual representations for systems modeling, as these remain the dominant approach, with no major breakthroughs expected in the near future. Under this assumption, we explore the research questions **RQ1**: How can task-based interfaces, integrated with Human Factors Engineering principles, optimize user interactions in systems modelling, enabling users to focus on their engineering tasks and knowledge rather than the complexity of tool operations?

To address our research question, we developed EasyMOD, a web-based modeling tool featuring a task-based interface for creating and refining functional and logical architectures, as well as function-to-component allocation. These tasks follow a structured workflow. EasyMOD implements diagram filtering, static validation, and automatic diagram generation centered on selected nodes, amongst other tools. The main objective of this paper is to assess the usability of EasyMOD through an experimental study involving industry participants of varying MBSE expertise.

2 Methods

The study involved 16 participants, primarily from the aerospace industry, with varying backgrounds in MBSE. They began by completing a profile detailing their professional experience, followed by a 15–20 minute tutorial on EasyMOD's key features. The experiment was then structured around two exercises. In the first exercise, participants reproduced a simple architecture from an image and step-by-step instructions, allowing us to observe their navigation and use of basic functions. The second exercise, designed to mimic real-world scenarios, involved refining a subsystem architecture based on an incomplete and inconsistent set of requirements. This task was based on an existing drone model with 13 components and 38 functions, featuring a complex diagram with numerous flows. Participants refined the functional architecture, introduced new components and flows in the logical architecture, and allocated functions and flows to components to address and fulfill the given requirements.

A mixed-methods approach was employed for data collection, including video-recorded user observations, standardized questionnaires like the System Usability Scale (Brooke, 1996), the User Experience Questionnaire (Laugwitz *et al.*, 2008), and post-exercise interviews. Auto-confrontation interviews following each exercise allowed participants to reflect on their interactions, providing deeper insights into their decision-making processes. This method yielded both quantitative and qualitative data, offering comprehensive insights into the tool's usability across different expertise levels.

3 Results

In the first exercise, participants successfully reproduced the simple architecture with an average completion time of 8 minutes. During the second exercise, participants effectively refined the subsystem based on incomplete requirements, with an average completion time of 35 minutes.

The preliminary SUS score averages 80, with a confidence interval of 73.387 to 86.613, suggesting favorable usability perceptions. For the UEQ, the overall score is 1.536, indicating an above average user experience, compared to standard UEQ benchmark. The pragmatic score is 1.768, suggesting that the tool effectively meets users' needs. However, the hedonic score is 1.304, indicating that the experience is engaging or enjoyable for users. For both the SUS and UEQ, a confidence level of $p = 0.05$ was considered for each item.

4 Discussion

Positive feedback on navigation and participants' confidence suggests that EasyMOD's design effectively reduces the learning curve, partially validating our initial hypothesis. An overall System Usability Scale (SUS) score of 82 provides 95% confidence that EasyMOD's usability is categorized as "good" to "excellent." The average scores for positively phrased SUS items (1, 3, 5, 7, and 9), around 4 out of 5, indicate that EasyMOD's task-oriented approach facilitates clear and intuitive user interactions. In contrast, item 4, regarding the need for technical support, showed significant variability, suggesting that while EasyMOD is generally easy to learn, the complexities of MBSE may still require novices to seek additional support for understanding its concepts.

The User Experience Questionnaire (UEQ) results provide a nuanced view of user experience. Participants rated EasyMOD as helpful and efficient, with pragmatic quality scores averaging 1.768 on the [-3; +3] scale, affirming its functionality. However, feedback highlighted areas for improvement, particularly with the auto-layout feature. Moderate satisfaction emerged in hedonic evaluations, particularly for item 7 ("Conventional" vs. "Original"), which received an average score of 0.86, indicating a perception of conventionality and lack of innovation. This suggests that while EasyMOD is functional, it may not sustain long-term user engagement due to perceived lack of novelty. The high variance for this item (standard deviation of 1.35) indicates diverse perceptions that could be influenced by individual expectations.

In summary, initial findings are promising, indicating EasyMOD's potential to enhance usability in MBSE tasks. To validate these results, we plan to continue the study with a control group using established MBSE tools such as CAMEO or Capella, which will provide deeper insights into user experience, particularly concerning creativity and innovation.

References

Abrahão, Silvia *et al.*, (2017). "User experience for model-driven engineering: Challenges and future directions", *2017 ACM/IEEE 20th International Conference on Model Driven Engineering Languages and Systems (MODELS)*. IEEE, pp. 229–236.

Brooke, J (1996). "SUS: A quick and dirty usability scale", *Usability Evaluation in Industry*,

Chami, Mohammad and Bruel, Jean-Michel (2018). "A survey on MBSE adoption challenges", *INCOSE EMEA Sector Systems Engineering Conference (INCOSE EMEASEC 2018)*. Wiley Interscience Publications.

Kalantari, Reyhaneh and Lethbridge, Timothy C (2022). "Characterizing ux evaluation in software modeling tools: A literature review", *IEEE Access*, Vol. 10, pp. 131509–131527.

Laugwitz, Bettina, Held, Theo, and Schrepp, Martin (2008). "Construction and evaluation of a user experience questionnaire", *HCI and Usability for Education and Work: 4th Symposium of the Workgroup Human-Computer Interaction and Usability Engineering of the Austrian Computer Society, USAB 2008, Graz, Austria, November 20-21, 2008. Proceedings 4*. Springer, pp. 63–76.

Pinquié, Romain, Wang, Haobo, and Noel, Frédéric (2023). "Human-Centric Co-Design of Model-Based System Architecture", *Procedia CIRP*, Vol. 119, pp. 146–151.