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***Abstract*—This document is a model and instructions for LaTeX. This and the IEEEtran.cls file define the components of your paper [title, text, heads, etc.]. *CRITICAL: Do Not Use Symbols, Special Characters, Footnotes, or Math in Paper Title or Abstract.**

***Index Terms*—cyber-physical systems, mbse, sysml, modeling guidelines**

I. Introduction

Modern Cyber-Physical Systems (CPS) are technical systems that combine mechanical, electronic, and software subsystems with physical elements embedded in the real world. The development of CPSs is becoming increasingly complex and challenging, due to their interdisciplinary nature and the need to ensure seamless integration between their physical and computational components [2], [3].

Model-Based Systems Engineering (MBSE) is a methodology for the development and management such complex systems, that addresses issues arising from the complexity and interdisciplinary nature of CPS, and provides the agility required to adapt to changing requirements and technologies. MBSE incorporates a centralized system model as the primary source of information, throughout the system lifecycle [2]–[6], [10], [11], [13]–[15].

SysML v1 has been widely adopted as the standard for modelling CPS and served as a key enabler MBSE. SysML v1 is a graphical, general purpose modelling language that is defined as an extension of the Unified Modeling Language (UML). Because it was built on top of UML, SysML v1 inherited several limitations from UML, that limited it's expressiveness and usability for CPS modelling. However, it still provided a solid foundation for specifying and analyzing a systems's behaviour, structure and requirements [3], [4], [7], [9], [11].

The release of SysML v2 represents the next generation of the Systems Modeling Language, designed as a comprehensive overhaul of SysML v1 that address it's limitations and enhance the efficacy of MBSE practices. Unlike it's predecessor, SysML v2 is built upon the Kernel Modeling Language (KerML), this approach ensures that SysML v2 inherits a formal semantic foundation, that is crucial for enhanced percision and automation in MBSE workflows. [3], [4], [7], [9]–[11].

While these advancements introduced by SysML v2 are promising, the abstract nature of the language still presents challenges for ensuring consistent modeling practices across diverse engineering teams. Model inconsistencies creates a high risk of redundant effort, potential modeling errors, and lack of reuse of system elements, preventing them from being aggregated into a coherent overall system model. Therefore, mechanisms for implementing and enforcing modeling guidelines must evolve to leverage the native formal capabilities of SysML v2, that enable effective model verification processes throughout the development lifecycle [2]–[4], [9], [10].

Within the context of model analysis, a distinct differentiation between model validation and model verification is necessary.

Model validation is a form of static analysis that ensures a model's structural and semantic correctness. By detecting inconsistencies ranging from syntatic errors to mismatched data types, validation guarantees the model's precision and coherence. This process as a critical quality control, ensuring the model is reliable before it undergoes transformation or dynamic verification [4], [14].

Model verification, conversely, is a dynamic analysis technique focused on ensuring that the system specified by the model behaves exactly as intended under various conditions, thereby confirming behavioral adherence to specifications [14].

This work investigates the difference between mechanisms for implementing modeling guidelines in SysML v1 and SysML v2. We analyze the implications these differences have on model verification processes, by looking into a couple of specific scenarios.

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II. Theoretical Background

A. MBSE

By emphasizing the use of **formal models** throughout the system lifecycle, MBSE supports the design, analysis, and verification of system representations, promoting consistency, traceability, and reusability across engineering processes. MBSE enables system architects to respond more quickly and effectively to numerous changes in requirements that occur during the development process.

In this context, the Models are crucial for specifying the high-level, architecture, functionality, uses cases, requirements, and constraints of the technical systems.

B. SysML v1 Foundations

C. SysML v2 Foundations

III. Results

A. SysML v1 Implementation of Modeling Guidelines

B. SysML v2 Implementation of Modeling Guidelines

C. Comparative Analysis

IV. Discussion and Implications

V. Conclusion and Outlook

Acknowledgment

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