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Expose

An Overview of Modeling Guidelines for SysML v2

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1 Expose

The development of modern Cyber-Physical Systems (CPS) is characterized by immense complexity, a challenge managed by Model-Based Systems Engineering (MBSE). [1–3]

This approach relies on standardized frameworks like Systems Modeling Language (SysML) to model discipline-specific subsystems in a central model. [1, 3–9] However, the flexibility of SysML leads to inconsistencies, non-reusable models, making modeling guidelines essential for ensuring quality, consistency, and reusability in MBSE practices. [1, 4–6]

The introduction of SysML v2 is intended to enhance MBSE adoption over its predecessor. [7] SysML v2's new features - particularly its textual syntax, formal metamodel, and standardized API - aim at improving precision, expressiveness, usability, interoperability, and extensibility. [1, 4, 5, 7, 8]

This paper investigates the following question: *How does the introduction of SysML v2 fundamentally change the landscape of modeling guidelines in MBSE, particularly regarding their formalization, validation, and enforcement?* It will explore the new opportunities for precise, automated guidelines and the new challenges that arise from SysML v2's design and adoption.

- **Hypothesis 1 (Opportunity - Formalization):** SysML's formal metamodel and textual notation enable a new class of precise, verifiable guidelines that were not possible in SysML v1. [3]
- **Hypothesis 2 (Opportunity - Validation):** The v2 metamodel allows for automated semantic and syntactic consistency checking, moving guidelines from passive documents to active, verifiable parts of the model. [5]
- **Hypothesis 3 (Challenge - Complexity):** The language design of SysML v2 itself presents challenges to maintainability and portability, which complicates the development and adaptation of guideline sets. [8]

The methodology will be an exploratory literature review. The primary sources will be recent (2022-2025) academic papers from IEEE, INCOSE, and relevant journals that specifically address the implementation, validation, and methodology of SysML v2.

Bibliography

- [1] BOELSEN, K. ; MAY, M. ; JACOBS, G. ; AL. et: SysML v2 based modelling guidelines for mechanical system elements. In: *Forsch Ingenieurwes* 89 (2025), No. 60. <http://dx.doi.org/10.1007/s10010-025-00827-w>. – DOI 10.1007/s10010-025-00827-w. – This paper argues that SysML v2's abstract, general-purpose nature creates a high risk of inconsistent modeling, making reuse impossible . It proposes a new, formal set of guidelines using SysML v2's native action, part, and metadata features. This source is a cornerstone as it provides a direct example of new formal guidelines and structures.
- [2] BERGEMANN, Sebastian: Challenges in Multi-View Model Consistency Management for Systems Engineering. Version:2022. <http://dx.doi.org/10.18420/modellierung2022ws-009>. In: *Modellierung 2022 Satellite Events*. Bonn : Gesellschaft für Informatik e.V., 2022. – DOI 10.18420/modellierung2022ws-009, p. 77–89. – This paper investigates the critical challenge of managing model consistency across multiple, heterogeneous viewpoints in MBSE. It analyzes existing approaches against a set of industrial requirements, identifying significant gaps in current methods. This work is essential as it defines the problem of inconsistency that new, formalized SysML v2 guidelines are intended to solve, thereby motivating Hypotheses 1 and 2.
- [3] DEHN, Simon ; JACOBS, Georg ; HÖCK, Philipp ; HÖPFNER, Gregor: Enhancing model-based development with formalized requirements: integrating temporal logic and SysML v2 for comprehensive state and transition modeling. In: *Forschung im Ingenieurwesen* 89 (2025), No. 1, p. 53
- [4] LI, Zirui ; FAHEEM, Faizan ; HUSUNG, Stephan: Collaborative Model-Based Systems Engineering Using Dataspaces and SysML v2. In: *Systems* 12 (2024), No. 1. <http://dx.doi.org/10.3390/systems12010018>. – DOI 10.3390/systems12010018. – ISSN 2079–8954. – This paper explores how to enable collaborative, multi-company MBSE by combining SysML v2 modeling with a secure framework for data exchange. The proposed solution relies on a modeling guideline to maintain consistency and interoperability, which is why its relevant as it justifies why standardized guidelines are essential for leveraging SysML v2's new features in a collaborative, multi-tool environment.
- [5] CIBRIÁN, Eduardo ; OLIVERT-ISERTE, Jose ; DÍEZ-FENOY, Carlos ; MENDIETA, Roy ; LLORENS, Juan ; RODRÍGUEZ, José M.: Ensuring Semantic Consistency in SysML v2 Models Through Metamodel-Driven Validation. In: *IEEE Access* 13 (2025), p. 121444–121457. <http://dx.doi.org/10.1109/ACCESS.2025.3587786>. – DOI 10.1109/ACCESS.2025.3587786. – This paper presents an automated method for ensuring semantic consistency in SysML v2 models. The method programmatically deri-

ves validation rules directly from metamodels to automatically detect both syntactic and semantic inconsistencies. This work is essential as it provides direct proof for the hypothesis.

- [6] YILDIRIM, Unal ; CAMPEAN, Felician ; KORSUNOV, Aleksandr ; DOIKIN, Aleksandr: Flow heuristics for functional modelling in model-based systems engineering. In: *Proceedings of the Design Society 3* (2023), p. 1895–1904
- [7] FRIEDENTHAL, Sanford: Future Directions for MBSE with SysML v2. In: *MODELS-WARD*, 2023, p. 5–9
- [8] JANSEN, Nico ; PFEIFFER, Jerome ; RUMPE, Bernhard ; SCHMALZING, David ; WORTMANN, Andreas: The Language of SysML v2 under the Magnifying Glass. In: *J. Object Technol.* 21 (2022), No. 3, p. 3–1
- [9] BEERS, Lasse ; NABIZADA, Hamied ; WEIGAND, Maximilian ; GEHLHOFF, Felix ; FAY, Alexander: A SysML Profile for the Standardized Description of Processes during System Development. In: *2024 IEEE International Systems Conference (SysCon)* IEEE, 2024, p. 1–8