Governance of a Common Working Environment for System Engineering and Model Based System Engineering within a PLM Context

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Résumé

1 Introduction: Interoperability issues when deploying SE and MBSE

System Engineering (SE) and Model Based System Engineering (MBSE) are increasingly seen as essential for addressing the complexities of modern products and associated processes (design, production, support, exploitation, upgrade, renewal, recycling) in a volatile environment with many economic, political, regulation and environmental issues. Their aim is to enhance understanding of system architectures, requirements, and interdependencies, facilitating informed decision-making and collaboration among multidisciplinary teams. SE and MBSE also help to reduce costs and risks by identifying issues early in development, promoting agility through the exploration of alternative solutions, and ensuring compliance with industry standards. However, deploying SE and MBSE faces challenges similar to those encountered with computer-aided design and Product Lifecycle Management (PLM) two decades ago, including processes, applications, and technological heterogeneity. Many organizations have developed their own MBSE frameworks, languages, and tools, preventing usage of external open standards shared by a community of practice. Critics argue that existing languages and tools are too complex and time-consuming, leading to calls for new standards. This further complicates the implementation of digital continuity in an increasingly complex and digitally connected environment. Additionally, the rise of cloud technology, data-related paradigms, and emerging Artificial Intelligence (AI) technologies add to the complexity of decision-making in this context. This paper presents a holistic approach for preparing and building the continuous operational interoperability required in a Common Working Environment (CWE) for SE and MBSE in a PLM context.

2 Proposed approach for addressing Interoperability Issues

2.1 Relying on the Federated Interoperability Framework

To address the issue, the presented research relies on the approach defined with the Federated Interoperability Framework (FIF) (1), which has been continuously developed through a

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cycle of research activities, standardization, and operationalization. The FIF focuses on the preparation (governance) and construction (architecture) of continuous operational interoperability within and between enterprises, holistically and over an extended period, adopting an approach to manage its continuous evolution to adapt to changes in business practices and technologies. To achieve this, it aims to define, test, deploy and monitor modular and reconfigurable working environments while addressing barriers to interoperability implementation and leveraging a number of facilitators: ontologies, model-driven application architecture, enterprise architecture representations for continuous transformation, and service-oriented platforms. The work presented here relates to a new methodological iteration of the FIF, addressing specific needs related to SE and MBSE in the current context. The last but not least enablers are standards and the maturity of the addressed community in terms of defining the governance of the relevant standards to be used in order to prepare and build the desired interoperability for the Common Working Environments (CWE). While reusing and adapting what has been defined in the past years, the goal is also to identify new or unresolved actual scientific gaps which prevent the establishment of the targeted continuous operational interoperability at an acceptable cost.

2.2 A new iteration for the FIF: Common Working Environment for SE and MBSE in the extended enterprise

Continuing to rely on the ASD Strategic Standardization Group (www.asd-ssg.org) in the past for end-to-end PLM interoperability, the governance aspect of the targeted new iteration of the FIF will rely on the AFIS Working Group named "System Engineering & Digital Transformation", which will federate industries and research institutes through partnership with GIFAS and AFNET. The point of view of the industry has been captured through the CRISEE Model (Framework for System Engineering in the Extended Enterprise) (2), which results from the work of about twenty companies, members of GIFAS, working in the Aeronautic, Space and Defence field. It responds to the recommendation regarding the deployment of SE. GIFAS highlighted through the analysis of the standards currently applied by companies (e.g., ISO 15288 or NASA Handbook 2016 rev 2) the need to define a generic reference framework allowing collaborative SE deployment. CRISEE is the generic solution allowing all industrial players to understand the constraints of SE deployment, validated by GIFAS and currently applied by industrial players. It defines processes allowing to govern the collaboration for a Program running System Engineering within the Extended Enterprise. At this stage, the guideline is not yet model based, as much of the considered standardized specifications which are not yet Machine Applicable, Readable and Transferable (3). In addition, standards which are more related to MBSE, such as System Modeling languages (e.g., SysML at www.omgsysml.org, Modelica at Modelica.org, etc.), MBSE frameworks (e.g., Unified Architecture Framework at www.omg.org/uaf, Arcadia at mbse-capella.org/arcadia) or Modeling Platforms which can be considered as de facto standards fully implementing the identified open standards in alignment with the practices to put in place, are not yet part of CRISEE. Finally, CRISEE doesn't propose standards for CWE infrastructure realization part, on top of which applications will be deployed, connected and enacted as service. It also doesn't propose standardized candidate solutions to manage data with appropriate controlled access, governance, security and quality, in alignment with the various regulations and required sovereignty. From the FIF, it will be possible to specify, simulate and test such a common environment, with different alternatives, in order to guide and share REX on the best practices for setting up such an environment, taking also into consideration the end-to-end PLM interoperability simultaneously at business, applicative and technology level.

2.3 Scientific issues which will be addressed

Each iteration of the FIF targets some specific issues and scientific gaps related to the main focus of the iteration. Some topics for this iteration dedicated to MBSE have been identified:

1) SysMLV2 is not based on UML2 anymore, as judged as too complex by the users. But is UML actually too complex and are the proposed simplification really appropriate when having to deal with modelling of complex systems of systems? And how will it be possible to related SysML V2 models to the rest of the digital environment providing other representations of the product and of their environments? In particular, how modular and multimodal representations of composite systems will be managed and aggregated in the future, ensuring effective digital threads for validation of architecture through simulation, detailed design, production, support or operational environments?

2) Hypermodels for Interoperability (H4I) are to be extended to modular models of composite systems. Previously assessed for ArchiMate, H4I are now to be assessed for system modelling languages, making the link to various technical environment such as a) Graph (as defined by graph theory) database supporting usage of graph based problem solving algorithms b) Semantic web and linked data technologies c) Text processing platforms encompassing Natural Language Processing, Large Language Models, Deep Learning and many other AI related technologies, with AI for MBSE and MBSE for AI innovative solutions d) Knowledge databases capturing the MBSE and SE practices and representations e) Process execution platforms based on rules based engines and agent based smart workflow systems f) Sovereign data platforms with data as products, as specified by GayaX (at gaia-x.eu) g) Interactive semantic visualization platform enhancing visual navigation and exploratory systems.

3) More generally, complexity of systems of systems with emerging and adaptative behaviours are still an area to explore, in order to identify proper approaches for dealing with holons. Holons

are things
which are at the same time a whole and a part, a product and a component of an upper-level system not
necessarily known in advance before its production (4). This is the core concept behind "Standard Parts"
within an industrial context. Aggregating digital representations of a product as a part of digital
representation of an upper system is one of the most challenging issue in terms of interoperability for
heterogeneous modelling environments, considering Product & Process data management It strongly
impacts the setup of digital collaborations when considering multiscale systems development by
multiscale networked dynamic and adaptative organizations. New software and hardware proposed by
Information and Communication technologies should enable the digitalisation of such collaboration,
relying on the appropriate paradigms. This is currently far from being the case if considering the
extensive usage of tables and flat graphs when dealing with data management.

3 Conclusions and perspectives

As for computer-aided design and PLM two decades ago, deploying System Engineering and Model
Based System Engineering within the extended enterprise is quite challenging when considering
preparing and building holistically the required continuous operational interoperability for end to end
secured digital collaboration within a heterogeneous, volatile, ambiguous and uncertain environment.
This paper proposes an approach based on the Federated Interoperability Framework, with a new
iteration focussing on some specific actual interoperability issues related to SE and MBSE. This
approach combines research, standardization and governance activities in order to make emerge
effective digital collaboration environments with interoperable Common Working Environments.

References

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