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Systems and Software engineering — Methods and tools for model-based systems and software engineering

Ingénierie du logiciel et des systèmes — Méthodes et outils pour l'ingénierie du logiciel et des systèmes basée sur des modèles

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Contents

Page

Foreword ... **vi**

Introduction ... **vii**

1 Scope ... **1**

2 Normative references ... **1**

3 Terms, definitions, and abbreviated terms ... **1**
3.1 Terms and definitions ... 1
3.2 Abbreviated terms ... 8

4 Conformance ... **9**
4.1 Intended usage ... 9
4.2 Full conformance ... 10
4.2.1 Full conformance to outcomes ... 10
4.2.2 Full conformance to tasks ... 10
4.3 Tailored conformance ... 10

5 MBSSE reference model ... **10**
5.1 Overview ... 10
5.2 Build models processes and data-information-knowledge-wisdom (DIKW) ... 13

6 Plan MBSSE ... **13**
6.1 General ... 13
6.2 Define the scope and objectives of MBSSE ... 14
6.2.1 Principal constituents ... 14
6.2.2 Establish MBSSE goals and measures ... 15
6.2.3 Specify the key elements of the MBSSE approach ... 15
6.3 Plan model development and governance ... 16
6.3.1 Principal constituents ... 16
6.3.2 Define MBSSE deployment procedure ... 18
6.3.3 Define the MBSSE life cycle flow ... 18
6.3.4 Define the MBSSE methodology ... 19
6.3.5 Specify how to manage and control the modelling life cycle process ... 19
6.3.6 Document the MBSSE management plan ... 20
6.3.7 Improve model development and governance process continuously ... 21
6.4 Plan resources and assets ... 21
6.4.1 Principal constituents ... 21
6.4.2 Define the MBSSE roles, responsibilities, knowledge, skills and abilities (KSA) ... 22
6.4.3 Identify resources ... 23
6.4.4 Manage modelling assets ... 23
6.5 Manage knowledge reuse ... 23
6.5.1 Principal constituents ... 23
6.5.2 Identify model patterns and define meta-models for patterns ... 24
6.5.3 Perform commonality and variability analysis ... 25
6.5.4 Manage the model repository ... 25
6.5.5 Manage knowledge reuse on methods ... 26
6.5.6 Manage knowledge reuse on tool extensions ... 26

7 Build models ... **26**
7.1 General ... 26
7.2 Produce system models ... 27
7.2.1 Principal constituents ... 27
7.2.2 Collect engineering data ... 29
7.2.3 Build descriptive models ... 29
7.2.4 Build analytical models ... 30
7.3 Produce discipline-specific models ... 31
7.3.1 Principal constituents ... 31

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7.3.2 Collect engineering data ... 32
7.3.3 Build discipline-specific models ... 33
7.3.4 Develop the interfaces between the system models and existing discipline-specific tools and models ... 33
7.4 Verify models ... 34
7.4.1 Principal constituents ... 34
7.4.2 Verify models ... 34
7.5 Validate models ... 35
7.5.1 Principal constituents ... 35
7.5.2 Validate models ... 36
7.6 Simulate systems using models ... 36
7.6.1 Principal constituents ... 36
7.6.2 Prepare simulation environment with required data and models ... 38
7.6.3 Simulate systems using models ... 38
7.6.4 Analyse results and validate behaviours ... 39
7.7 Make decisions using models ... 40
7.7.1 Principal constituents ... 40
7.7.2 Capture decision criteria within the model ... 40
7.7.3 Generate decision reports ... 41
7.7.4 Build a rationale ... 41

8 Support models ... 41
8.1 General ... 41
8.2 Manage technical quality ... 42
8.2.1 Principal constituents ... 42
8.2.2 Perform technical review ... 42
8.2.3 Perform quality assurance ... 43
8.3 Manage configuration ... 43
8.3.1 Principal constituents ... 43
8.3.2 Manage modelling assets and configuration items ... 45
8.3.3 Manage changes to models ... 45
8.4 Manage data and models ... 46
8.4.1 Principal constituents ... 46
8.4.2 Define the data and models management policy ... 47
8.4.3 Define infrastructure needs to support data and model management ... 47
8.5 Share models for collaboration ... 48
8.5.1 Principal constituents ... 48
8.5.2 Define collaborative modelling guidelines and environment ... 49
8.5.3 Define model sharing and authoring rules ... 49
8.5.4 Maintain the consistency of models ... 49

9 Perform MBSSE ... 49
9.1 General ... 49
9.2 Perform business and mission analysis ... 50
9.2.1 Principal constituents ... 50
9.2.2 Describe high-level target enterprise architectures using models ... 51
9.2.3 Evaluate candidate architectures and analyse gaps using models ... 52
9.2.4 Establish capability roadmaps ... 52
9.2.5 Define business and mission requirements ... 52
9.2.6 Generate ConOps ... 53
9.3 Perform operational analysis ... 53
9.3.1 Principal constituents ... 53
9.3.2 Identify system life cycle, boundary and context ... 54
9.3.3 Identify stakeholders ... 54
9.3.4 Identify use cases and develop use case scenarios, validation scenarios ... 54
9.3.5 Identify operational modes ... 55
9.3.6 Capture stakeholder requirements and measures of effectiveness (MOEs) ... 55
9.4 Perform function analysis ... 56
9.4.1 Principal constituents ... 56

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9.4.2 Realize functional analysis and decomposition 57
9.4.3 Detect or identify possible dysfunctions 57
9.4.4 Develop functional flows and system states 57
9.4.5 Capture system requirements, constraints and measure of performance (MOPs) 58
9.4.6 Realize and manage traceability 58
9.5 Perform system structure design 58
9.5.1 Principal constituents 58
9.5.2 Realize system logical structure 59
9.5.3 Realize system physical structure 60
9.5.4 Realize and manage traceability 60
9.6 Perform system analysis 61
9.6.1 Principal constituents 61
9.6.2 Perform safety or reliability analysis 61
9.6.3 Perform security analysis 62
9.6.4 Perform resilience analysis 63
9.7 Perform domain design integration 63
9.7.1 Principal constituents 63
9.7.2 Perform system design modelling 65
9.7.3 Support system integration with the use of models 65
9.8 Perform system verification and validation 66
9.8.1 Principal constituents 66
9.8.2 Prepare model-based verification and validation 67
9.8.3 Perform model-based verification and validation 68
9.8.4 Manage results 68

Annex A (informative) **Instantiation and customization of an MBSSE reference framework** **69**

Annex B (informative) **MBSSE dimensions of a system model** **76**

Annex C (informative) **Models classification and relationships in MBSSE** **78**

Annex D (informative) **Example of MBSSE roles** **80**

Annex E (informative) **Relationships between ISO/IEC/IEEE 24641 and other International Standards** **82**

Bibliography **84**

IEEE notices and abstract **86**

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Foreword

ISO (the International Organization for Standardization) and IEC (the International Electrotechnical Commission) form the specialized system for worldwide standardization. National bodies that are members of ISO or IEC participate in the development of International Standards through technical committees established by the respective organization to deal with particular fields of technical activity. ISO and IEC technical committees collaborate in fields of mutual interest. Other international organizations, governmental and non-governmental, in liaison with ISO and IEC, also take part in the work.

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For an explanation of the voluntary nature of standards, the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the World Trade Organization (WTO) principles in the Technical Barriers to Trade (TBT), see www.iso.org/iso/foreword.html. In the IEC, see www.iec.ch/understanding-standards.

ISO/IEC/IEEE 24641 was prepared by Joint Technical Committee ISO/IEC JTC 1, *Information technology,* Subcommittee SC 7, *Software and systems engineering,* in cooperation with the IEEE Computer Society Systems and Software Engineering Standards Committee, under the Partner Standards Development Organization cooperation agreement between ISO and IEEE.

Any feedback or questions on this document should be directed to the user's national standards body. A complete listing of these bodies can be found at www.iso.org/members.html and www.iec.ch/national-committees.

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Introduction

As systems grow in scale and complexity, some in the systems engineering community turn to model-based systems and software engineering (MBSSE) to, among other objectives, manage complexity, maintain consistency, and help ensure traceability during system development. With an MBSSE approach, the systems and software engineering activities rely on evolving models that serve as the main or major source of knowledge about the system-of-interest and its life cycle processes, which could be any entity subject to a system model such as a program, project, product, or company.

MBSSE benefits differ significantly from 'engineering with models', which has been a common practice among the engineering disciplines for decades and that is mainly based on independent discipline-specific models that, even if very useful for each discipline and system analysis contribution, do not provide an overall understanding of the architecture of the system sharable among stakeholders, e.g. computer-aided design (CAD) for mechanical engineering, aerodynamics models, control loop simulations. In addition, due to the diversity of approaches and terminologies (e.g. model-driven development or MDD), MBSSE usually falls within the context of a specific engineering discipline (e.g. MDD for the software engineering community).

MBSSE is the formalized application of modelling to support systems engineering or software engineering activities. Faced with the issues and challenges linked to the growing complexity of the systems to be developed, document-centric approaches are less and less suitable. The MBSSE approach makes it possible to develop logically consistent multi-view architecture description. These serve as a bridge to enable the traceable, verifiable and dynamic correlation of the system-of-interest and/or software-of-interest models cross multidiscipline and throughout its entire life cycle, and to drive the system and software engineering processes, activities and tasks at all levels of its hierarchy from system-of-systems to system element across multiple engineering disciplines and throughout all stages of its life cycle

From MBSSE perspective, other engineering disciplines (mechanical, thermal, electronic, electrical, etc.) are also considered.

Thus, a need exists to specify the considerations necessary for undertaking the application of MBSSE within an organization. An organization needs to address the considerations necessary for supporting the establishment of each project environment within its overall ecosystem, and the exchange of models between stakeholder organizations.

This document addresses MBSSE-related processes by categorizing them into four process groups:

— Plan MBSSE

— Build models

— Perform MBSSE

— Support models

Each process is defined in terms of purpose, inputs, outcomes, and supporting tasks. The task descriptions include tool and method guidance and the recommended capabilities needed to successfully implement them. The relationships among the four process groups in this document, the four process groups in ISO/IEC/IEEE 15288 and ISO/IEC/IEEE 12207, and the life cycle model and stages in ISO/IEC/IEEE 24748-1 are described in Annex A.

This document is intended to benefit those who acquire, supply, develop, operate, and maintain MBSSE tools and methods. It can be used by:

a) organizations that need to implement or build models – to understand, adopt, and enact the MBSSE processes, tools, and methods (it also helps to evaluate and select relevant tools and methods based on business- and user-related criteria);

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b) tool vendors who facilitate or leverage MBSSE practices – to provide a set of recommended tool capabilities for planning MBSSE, building models, MBSSE performance, and support.

Systems of systems are considered in this document to benefit from the same processes, methods and tool capabilities as any system.

The relationships between this document and other standards are described in Annex E.

NOTE 1 This document prescribes a way to engineer systems and software based on models thanks to a reference model and four process groups; however, other particular uses of models which are out of the scope of this document are used in "model engineering" in other ways: For example, in model-driven modernization [also called architecture-driven modernization (ADM) in object management group (OMG) terms], models are (automatically) generated from the existing code and artefacts of a running system in order to represent it and then build a new system in a different platform. Another usage scenario of models occurs in what is called "models@runtime" whereby the models are used to change the system and evolve with it; these are normally used in self-adaptive systems to achieve the required system self-adaptation features.

NOTE 2 The reference model does not take into account the system evolution (and that of its related models) as a fundamental phase of systems or software engineering in the maintenance and evolution of the system and its models.

NOTE 3 The design within the different domains, for example, mechanical, hydraulics, electrical, electronics, control algorithms, and software, has been performed using model-based techniques for decades. However, each domain uses specialized languages and tool chains for its modelling activities. The guideline to propose how the methods, modelling languages and tools apply in these domains is outside of the scope of this document. However, the interfaces of the engineering models and the system models are crucial and essential for applying MBSSE.

In this document, the following verbal forms are used:

— "shall" indicates a requirement;

— "should" indicates a recommendation;

— "may" indicates a permission;

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Systems and Software engineering — Methods and tools for model-based systems and software engineering

1 Scope

This document deals with the tool capabilities and methods for model-based systems and software engineering (MBSSE). This document:

— specifies a reference model for the overall structure and processes of MBSSE-specific processes, and describes how the components of the reference model fit together;

— specifies interrelationships between the components of the reference model;

— specifies MBSSE-specific processes for model-based systems and software engineering; the processes are described in terms of purpose, inputs, outcomes and tasks;

— specifies methods to support the defined tasks of each process;

— specifies tool capabilities to automate or semi-automate tasks or methods.

This document does not bring any additional life cycle processes for system and software but specifies an MBSSE reference model considered as activities, not only from the life cycle perspectives of systems engineering problem solving and the system-of-interest evolution, but also from the cognitive perspectives of modelling and model management, which can sustain and facilitate the system and software life cycle processes during digital transformation and in the digital age.

The processes defined in this document are applicable for a single project, as well as for an organization performing multiple projects or an enterprise. These processes are applicable for managing and performing the systems and software engineering activities based on models within any stage in the life cycle of a system-of-interest.

2 Normative references

There are no normative references in this document.

3 Terms, definitions, and abbreviated terms

3.1 Terms and definitions

For the purposes of this document, the following terms and definitions apply.

ISO, IEC, and IEEE maintain terminology databases for use in standardization at the following addresses:

— ISO Online browsing platform: available at https://www.iso.org/obp

— IEC Electropedia: available at http://www.electropedia.org

— IEEE Standards Dictionary Online: available at http://dictionary.ieee.org

NOTE For additional terms and definitions in the field of systems and software engineering, see ISO/IEC/IEEE 24765, which is published periodically as a “snapshot” of the SEVOCAB (Systems and Software Engineering Vocabulary) database and is publicly accessible at computer.org/sevocab.

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