

# *Standardization Bodies and Standards Relevant for Uncertainty Modelling*

Tao Yue, Shaukat Ali, Man Zhang and Dipesh Pradhan

Simula Research Laboratory

{tao, shaukat, manzhang, dipesh}@simula.no

## **Introduction**

This technical report aims to identify standardization bodies such as European Telecommunications Standards Institute (ETSI)<sup>1</sup> and Object Management Group (OMG)<sup>2</sup> and standards that are relevant to modelling and testing Cyber-Physical Systems (CPSs) under uncertainty. The work is done in the context of the U-Test project (<http://www.u-test.eu>). The corresponding deliverable is D6.2: Report on Selection of Standardization Bodies. In this technical report, we first provide an overview of relevant standards and standardization bodies. Second, we summarize the procedure of selecting standardization bodies. Finally, we present a list of the selected standardization bodies. The abbreviation reference of this deliverable is provided in Table 1.

**Table 1 Description of Abbreviations**

<b>Abbreviation</b>	<b>Description</b>
ETSI	European Telecommunications Standards Institute
ICT	Information and Communications Technology
IEC	International Electrotechnical Commission
IEEE	Institute of Electrical and Electronics Engineers
ISO	International Organization for Standardization
ITU	International Telecommunication Union
JCGM	Joint Committee for Guides in Metrology
MBE	Model-Based Engineering
MBT	Model-Based Testing
NIST	The National Institute of Standards and Technology
OASIS	Advancing Open Standards for the Information Society
OMG	Object Management Group
OMA	Open Mobile Alliance
OSI	Open Systems Interconnection
UMF	Uncertainty Modelling Framework
UTF	Uncertainty Testing Framework
RTF	Revision Task Force
RFP	Request For Proposal
SACM	Structured Assurance Case Metamodel
TDL	Test Description Language

## **Context**

<sup>1</sup> ETSI, <http://www.etsi.org/>

<sup>2</sup> OMG, <http://www.omg.org/>

Standardization bodies are commonly classified, according to their geographical designation, into three types: international, regional and national standardization bodies [1]. International standardization bodies develop international standards. There are four most well-known and well-established international standardization bodies: the International Organization for Standardization<sup>3</sup> (ISO), the International Electrotechnical Commission<sup>4</sup> (IEC), the International Telecommunication Union<sup>5</sup> (ITU), and the IEEE Standards Association<sup>6</sup>. Under these three standardization bodies, a large number of standards have been defined. For the regional level standardization bodies, we only consider EU standards, among which the European Telecommunications Standards Institute (ETSI) produces a lot of standards in ICT. We do not include any national standardization body into the consideration, as standards produced by national level standardization bodies inherently have limited application scopes, in comparison to international and EU standards.

We aim to define methodologies to test Cyber-Physical Systems (CPSs) under uncertainty. One important mean to achieve this objective is that the project relies on Model-Based Engineering (MBE) technologies. Therefore, the first criterion of selecting relevant standardization bodies is to include standards in MBE field such as the Object Management Group (OMG) (C1). As the project aims to devise testing methodologies, the second selection criterion is to include standardization bodies and standards that are relevant to the testing field (C2). For example, one of the highly relevant standard is the OMG's UML Testing Profile (UTP) 2 [2]. The third selection criterion is to select standardization bodies and standards that are relevant to software-intensive systems, particularly CPSs (C3).

### **Relevant Standardization Bodies and Standards**

Based on the selection criteria C1-C4, presented above, we started from screening through the standards of the standardization bodies: ISO, IEEE, IEC, JCGM, OMG, ETSI and OASIS from two perspectives: modelling uncertainty and CPS, and testing uncertainty and CPS. As the results of the first step, we pre-selected a set of standardization bodies and standards as shown in first column of Table 2. In the second column of Table 2, we indicate whether a standard is for modelling, testing, Model-based Testing (MBT), or others. In the fourth column of Table 2, we indicate whether a specific standard explicitly define or describe Uncertainty (including Probability) and Uncertainty Measurement.

As one can see from Table 2, in terms of modelling, OMG defines standards on system and software modelling: UML [3], SysML [4], MARTE [5], OCL [6] and MOF [7]. ISO/IEC defines UML [8], OCL [9] and KDM [10] modelling notations, which are also defined and maintained by OMG. In addition ISO/IEC also defines RM-ODP [11] for enabling conceptual modelling of complex systems such as CPSs.

In terms of testing and MBT, OMG defines UTP. ETSI also defines standards on model-based testing: ETSI TR 102 840 VI.2.1 [5], ETSI ES 202 951 VI.1.1 (2011-07) [12] and ETSI EG 201 015 V2.1.1 (2012-02) [13] as shown in Table 2. ISO/IEC/IEEE 29119 [14] is a widely recognized standard on testing. In addition, ISO/IEC joined the effort to define the ISO/IEC 9646 series [15] for supporting conformance testing of OSI. As shown in Table 2, a number of standards have been also defined in IEEE from the aspects of system and software verification and validation [16], test documentation [17], unit testing [18] and classification of Software Anomalies [19].

In Table 2, we also include standards (from ISO, IEC and/or IEEE under Other) that are relevant to various aspects of system and software engineering, including vocabulary, architecture description, development lifecycle, risk management and assessment, and quality assurance. Particularly, we collected standards that are relevant to Uncertainty and Uncertainty Measurement, as indicated in the column "Uncertainty" of the table. ISO 61508 [20], OMG SysML [4] and MARTE [5] define concept Probability, which is one type of uncertainty measures. OMG SACM defines Evidence, Confidence and Confidence Level, which are all relevant to uncertainty and several concepts defined in U-Taxonomy. ISO/IEC and JCGM defined few standards on Uncertainty Measurement. The concept of Uncertainty and few relevant concepts are explicitly defined in ISO 31000.

<sup>3</sup> ISO, <http://www.iso.org/iso/home.html>

<sup>4</sup> IEC, <http://www.iec.ch/>

<sup>5</sup> ITU, <https://www.itu.int/en/Pages/default.aspx>

<sup>6</sup> IEEE, <http://standards.ieee.org/>

Table 2 A Pre-selected List of Standardization Bodies and Standards

Body	Modeling/Testing/MBT/Other	Standard	Uncertainty
OMG	Modeling	Unified Modeling Language (UML) [3]	No
		UML Profile for MARTE: Modeling and Analysis of Real-Time and Embedded Systems [5]	Yes (Probability)
		Systems Modeling Language (SysML) [4]	Yes (Probability)
		Object Constraint Language (OCL) [6]	No
		MetaObject Facility (MOF) [7]	No
		Structured Assurance Case Metamodel (SACM) [21]	Yes (Evidence, Confidence, Confidence Level)
	MBT	UML Testing Profile (UTP) [2]	No
ISO, IEC and IEEE	Modeling	ISO/IEC 10746 series – Reference model of Open Distributed Processing (RM-ODP) [11]	No
		ISO/IEC 19505 series – OMG UML 2.4.1 [8]	No
		ISO/IEC 19507:2012 – OMG OCL 2.3.1 [9]	No
		ISO/IEC 19506:2012 – OMG Architecture-Driven Modernization (ADM) — Knowledge Discovery Meta-Model (KDM) [10]	No
	Testing	ISO/IEC/IEEE 29119 series – Software Testing Standard [14]	No
		ISO/IEC 9646 series – Open Systems Interconnection (OSI) - Conformance testing methodology and framework [15]	No
		IEEE 1012-2012 – System and Software Verification and Validation [16]	No
		IEEE 829-2008 – Software and System Test Documentation [17]	No
		IEEE SA - 1008-1987 – IEEE Standard for Software Unit Testing [18]	No
		IEEE 1044-2009 – Classification for Software Anomalies [19]	No
	Other	ISO/IEC/IEEE 24765:2010 – Systems and software Engineering – Vocabulary [22]	No
		ISO/IEC/IEEE 42010:2011 – Systems and software Engineering - Architecture description [23]	No
		ISO/IEC/IEEE 15288:2015 – Systems and software engineering- System life cycle processes [24]	No
		ISO/IEC 16085:2006 – Systems and software Engineering - Life cycle processes - Risk management [25]	No
		ISO/IEC 25010:2011 – Systems and software Quality Requirements and Evaluation (SQuaRE) — System and software quality models [26]	No
		ISO/IEC 15026 series – Systems and software assurance [27]	No
		ISO/IEC 12207:2008 – Systems and software engineering - Software life cycle processes [28]	No
		ISO/IEC Guide 98 series – Uncertainty of Measurement [29]	Yes
		ISO/IEC 10165-7:1996 – Open Systems Interconnection (OSI) - Structure of management information: General relationship model [30]	No
		IEC Guide 115:2007 – Application of uncertainty of measurement to conformity assessment activities in the electrotechnical sector [31]	Yes
IEC 61508:2010 – Functional safety of electrical/electronic/programmable electronic safety-related systems [20]		Yes (Probability)	
IEC 31010:2009 – Risk Assessment Techniques [32]		No	
IEEE 730-2014 – Software Quality Assurance Processes [33]		No	
IEEE 1061-1998 – Software Quality Metrics Methodology [34]		No	
IEEE P2413 – Standard for an Architectural Framework for the Internet of Things (IoT) [35]	No		

Body	Modeling/Testing/MBT/Other	Standard	Uncertainty
		ISO 9000 series – Quality Management [36]	No
		ISO 31000 – Risk Management [37]	<b>Yes (Risk, Uncertainty, Effect, Likelihood)</b>
		ISO 3534-1:2006 – General statistical terms and terms used in probability [38]	<b>Yes</b>
		ISO 21748:2010 – Guidance for the use of repeatability, reproducibility and trueness estimates in measurement uncertainty estimation [39]	<b>Yes</b>
		ISO/TR 13587:2012 – Three statistical approaches for the assessment and interpretation of measurement uncertainty [40]	<b>Yes</b>
		ISO/TS 17503:2015 – Guidance on evaluation of uncertainty using two-factor crossed designs [41]	<b>Yes</b>
		ISO 9241 series – Ergonomics of human-system interaction [42]	No
JCGM	Other	JCGM 200:2012 – International vocabulary of metrology- Basic and general concepts and associated terms (VIM) [43]	<b>Yes</b>
ETSI	Testing	ETSI TR 102 422 V1.1.1 (2005-04) – IMS Network Integration Testing Infrastructure Testing Methodology [44]	No
		ETSI EG 203 130 V1.1.1 (2013-04) – Methodology for standardized test specification development [45]	No
		ETSI TR 101 583 V1.1.1 (2015-03) – Security Testing; Basic Terminology [46]	No
		ETSI ES 201 873 series on TTCN-3 [47]	No
		ETSI ES 203 119 series on Test Description Language (TDL) [48]	No
	Testing, MBT	ETSI TR 102 840 V1.2.1 (2011-02) – Methods for Testing and Specifications (MTS); Model-based testing in standardization [49]	No
		ETSI ES 202 951 V1.1.1 (2011-07) – Methods for Testing and Specification (MTS); Model-Based Testing (MBT); Requirements for Modeling Notations [12]	No
		ETSI EG 201 015 V2.1.1 (2012-02) – Methods for Testing and Specification (MTS); Standards engineering process; A Handbook of validation methods [13]	No
OASIS	Other	Open Services for Lifecycle Collaboration (OSLC) [50]	No

**Acknowledgment**

This work is funded by EU Horizon2020 project U-Test (Testing Cyber-Physical Systems under Uncertainty).

**Reference**

- [1] NIST. "National Standards Bodies," 2015; <http://www.nist.gov/iaao/std-orm>.
- [2] OMG, "UML Testing Profile," April, 2013.
- [3] OMG, "Unified Modeling Language (UML)," June 2015.
- [4] OMG, "System Modeling Language," June, 2014.
- [5] OMG, "UML Profile For MARTE: Modeling And Analysis Of Real-Time Embedded Systems," June, 2011.
- [6] OMG, "Object Constraint Language (OCL)," February 2014.
- [7] OMG, "Meta Object Facility (MOF) Core Specification (Version 2.4.2)," 2014.
- [8] ISO/IEC, "ISO/IEC 19505-x: Information technology - Object Management Group Unified Modeling Language (OMG UML)," 2012.
- [9] ISO/IEC, "ISO/IEC 19507: Information technology - Object Management Group Object Constraint Language (OCL)," 2012.
- [10] ISO/IEC, "ISO/IEC 19506:2012 Information technology – Object Management Group Architecture-Driven Modernization (ADM) – Knowledge Discovery Meta-Model (KDM)," 2012.
- [11] ISO/IEC, "ISO/IEC 10746-x: Information technology - Open Distributed Processing," 2009.
- [12] ETSI, "ETSI ES 202 951 Methods for Testing and Specification (MTS); Model-Based Testing (MBT); Requirements for Modelling Notations (v1,1,1)," 2011.
- [13] ETSI, "ETSI EG 201 015 Methods for Testing and Specification (MTS); Standards engineering process; A Handbook of validation methods (v1.2.1)," 2012.
- [14] ISO/IEC/IEEE, "ISO/IEC/IEEE 29119-x: Software Testing," 2013.
- [15] ISO/IEC, "ISO/IEC 9646-x: Information technology – Open Systems Interconnection – Conformance testing methodology and framework," 1994.
- [16] IEEE, "IEEE Standard for System and Software Verification and Validation," IEEE Std 1012-2012 (Revision of IEEE Std 1012-2004), 2012, pp. 1-223.
- [17] IEEE, "IEEE Standard for Software and System Test Documentation - Redline," IEEE Std 829-2008 (Revision of IEEE Std 829-1998) - Redline, 2008, pp. 1-161.
- [18] IEEE, "IEEE Standard for Software Unit Testing," ANSI/IEEE Std 1008-1987, 1986, p. 0\_1.
- [19] IEEE, "IEEE Standard Classification for Software Anomalies," IEEE Std 1044-2009 (Revision of IEEE Std 1044-1993), 2010, pp. 1-23.
- [20] IEC, "IEC 61508: Commented version, Functional safety of electrical/electronic/programmable electronic safety-related systems," 2010.
- [21] OMG, "Structured Assurance Case Metamodel," 2015.
- [22] ISO/IEC/IEEE, "ISO/IEC/IEEE 24765: Systems and software engineering – Vocabulary," 2010.
- [23] ISO/IEC/IEEE, "ISO/IEC/IEEE Systems and software engineering – Architecture description," ISO/IEC/IEEE 42010:2011(E) (Revision of ISO/IEC 42010:2007 and IEEE Std 1471-2000), 2011, pp. 1-46.
- [24] ISO/IEC/IEEE, "ISO/IEC/IEEE 15288: Systems and software engineering - System life cycle processes," 2015.
- [25] ISO/IEC, "ISO/IEC 16085: Systems and software engineering - Life cycle processes - Risk management," 2006.
- [26] ISO/IEC, "ISO/IEC 25010: Systems and software engineering - Systems and software Quality Requirements and Evaluation (SQuaRE) - System and software quality models," 2011.
- [27] ISO/IEC, "ISO/IEC 15026-x: Systems and software engineering – Systems and software assurance," 2013.
- [28] ISO/IEC, "ISO/IEC 12207: Systems and software engineering - Software life cycle processes," 2008.
- [29] ISO/IEC, "ISO/IEC Guide 98: Uncertainty of measurement," 2009.
- [30] ISO/IEC, "ISO/IEC 10165-7: Information technology - Open Systems Interconnection - Structure of management information: General relationship model," 1997.
- [31] IEC, "IEC Guide 115: Application of uncertainty of measurement to conformity assessment activities in the electrotechnical sector," 2007.

- 
- [32] IEC, "IEC 31010: Risk management - Risk assessment techniques," 2009.
- [33] IEEE, "IEEE Standard for Software Quality Assurance Processes," IEEE Std 730-2014 (Revision of IEEE Std 730-2002), 2014, pp. 1-138.
- [34] IEEE, "IEEE Standard for a Software Quality Metrics Methodology," IEEE Std 1061-1998, 1998, p. i.
- [35] IEEE, "IEEE P2413: Standard for an Architectural Framework for the Internet of Things (IoT)."
- [36] ISO, "ISO 9000: Quality management systems - Fundamentals and vocabulary," 2015.
- [37] ISO, "ISO 31000: Risk management," 2009.
- [38] ISO, "ISO 3534-1: Statistics – Vocabulary and symbols – Part 1: General statistical terms and terms used in probability," 2006.
- [39] ISO, "ISO 21748: Guidance for the use of repeatability, reproducibility and trueness estimates in measurement uncertainty estimation," 2010.
- [40] ISO/TR, "ISO/TR 13587: Three statistical approaches for the assessment and interpretation of measurement uncertainty," 2012.
- [41] ISO/TS, "ISO/TS 17503: Statistical methods of uncertainty evaluation - Guidance on evaluation of uncertainty using two-factor crossed designs," 2015.
- [42] ISO, "ISO 9241-x: Ergonomics of human-system interaction," 2010.
- [43] JCGM, "JCGM 200: International vocabulary of metrology - Basic and general concepts and associated terms," 2012.
- [44] ETSI, "TR 102 422 Methods for Testing and Specification (MTS) IMS Network Integration Testing Infrastructure Testing Methodology (v1.1.1)," 2005.
- [45] ETSI, "ETSI EG 203 120 Methods for Testing and Specification (MTS); Model-Based Testing (MBT); Methodology for standardized test specification development (v1.1.1)," 2013.
- [46] ETSI, "ETSI TR 101 583 Methods for Testing and Specification (MTS); Security Testing; Basic Terminology (v1.1.1)," 2015.
- [47] ETSI, "ETSI TR 102 873-x TTCN-3 Specification."
- [48] ETSI, "ETSI ES 203 119-x Methods for Testing and Specification (MTS); The Test Description Language (TDL); ."
- [49] ETSI, "ETSI TR 102 840 Methods for Testing and Specifications (MTS); Model-based testing in standardisation (v1.2.1)," 2011.
- [50] OASIS, "Open Services for Lifecycle Collaboration Core Specifications Version 3.0," 2013.
- [51] OMG, "System Modeling Assessment and Roadmap Working Group."
- [52] OMA, "FI-WARE NGSI-9 Open RESTful API Specification."