Model-Based Standards Authoring

This research is supported by EU FP7 VISIONAIR - A World-class infrastructure for Advanced 3D visualization-based research

Alex Blekhman
Technion, Israel Institute of Technology, Haifa, Israel
Email: blekhman@tx.technion.ac.il

Dov Dori
Technion, Israel Institute of Technology, Haifa, Israel
Massachusetts Institute of Technology, Cambridge, Massachusetts, USA
Email: dori@ie.technion.ac.il

Richard Martin
International Organization for Standardization (ISO)
Tinwisle Corporation, Bloomington, Indiana, USA
Email: richardm@tinwisle.com

Abstract. We present a methodology for model-based authoring of standards based on Object-Process Methodology (OPM). This general systems-engineering approach to authoring of specifications is supported by an OPM framework and a procedure for model-to-text translation. This methodology, developed as part of the ISO TC 184/SC 5 OPM Study Group activities, is expected to become the basis of an emerging ISO Standard for Model-Based Standards Authoring.

Introduction

Standards in general and enterprise-related standards in particular are supposed to be a solid source of authority and must therefore be explicit, reliable, and easy to read and implement. However, the ability of the standard authors to coherently convey the subject matter is often problematic, as the development of standards involves creating complex and detailed descriptions. It is therefore not surprising that in spite of the best efforts of technical editors, the completeness, coverage and consistency of standards are often criticized.

A primary source of these problems is the fact that standards are authored mostly using free text, which is generally difficult to verify for consistency with other sections of the standard, with other standards, or with reference works. Further, the text is often accompanied by graphical annotations, illustrations, figures or diagrams, which frequently do not match the text or conflict with other figures and tables in the same document [Dori et al, 2010].

Given the variety of authors and relationships to other domain standards, managing the quality of a technical document such as an ISO standard is a daunting task, especially as currently there is no underlying analytical process that provides some sense of technical document verification and validation.

A desirable solution, or procedure for coping with the difficulties stated above should address the following major parameters:

<u>Inter- and intra-standard consistency:</u> Checking for mentions in the standard and with reference to other standards in the same domain should be made easy. It should be made

straightforward eliminating duplicate objects, symbols or phrases, regardless of terminology or author's style. A set of common phrase snippets and standard building blocks should be used while laying out document's outline and as a reference for change validation.

Traceability: The elements defined and referenced in a document should fit into a network of relations. These relations should be re-checked on insertion, removal or change of an element. Relevant adjustments to fill missing details or modifying existing properties should be made as required.

Accessibility: The content of the standard should be made navigable with comfort. It should be easy to look for an item through a common tree of domain terms. The definition of this catalogue should be widely known and new definitions and directives should be weaved in it for future reference.

Clarity: Definitions should be bound to a set of rules, allowing on the one hand for expressiveness, and providing on the other hand strict and clear formalism. As opposed to ambiguity, clauses should be certain and use terms that are defined to one exact meaning.

In our solution we present a complete Model-Based Standards Authoring (MBSA) methodology. It is a process that assures a significant reduction of content inconsistencies in standards through a concurrent textual and graphical presentation. This bimodal approach enables deep cognitive analysis of the standard’s technical content. Relying on general model-based systems engineering principles, the MBSA process provides the necessary reference for the production of concise and complete documents.

The cornerstone of this approach is moving modeling to the early stage of standard formulating rather than as a post-processing step. This has the major advantage of basing the specification on more solid foundations than free text, which is notoriously susceptible to ambiguities, discrepancies, and incompleteness. Text is, and will remain, the primary means of communications amongst humans, many of whom are non-technical stakeholders. With this in mind, we integrate a human-readable text that is derived from the model, and hence compatible with it. This way we achieve the best of both worlds, i.e., a model, which provides rigor and formality, along with text, which is easy to read, making it accessible to non-technical stakeholders.

The rest of the paper is organized as follows. The Choice of Underlying Formalism for MBSA section describes the relevant modeling approaches for MBSA. ISO Model-Based Standards Authoring Activity section presents the ISO study group activity that guides our view of Model-Based Standards Authoring (MBSA). In Object-Process Methodology (OPM) Overview section we review Object-Process Methodology (OPM), as the preferred modeling language that accompanies MBSA. In MBSA Standard and Tesperanto section we specify the details of the MBSA process, accompanied with parts of the emerging Standard Draft. Conclusion section contains a sum-up discussion of the merits and challenges of the proposed methodology, along with possible applications and extensions.

The Choice of Underlying Formalism for MBSA

Since a major Model-Based Standards Authoring (MBSA) challenge is unifying data through a systematic model-based approach, the selection of the supporting underlying model notation must be intuitive and formal at the same time. Among the notations examined were UML, SysML, Modelica, and Object-Process Methodology (OPM). The characteristics of the modeling notation we looked for included:

- Simple and intuitive notation, yet expressive enough for defining common MBSA conceptual meta-models,
- Ability to represent data in hierarchically organized diagrams,

- Rigor and formalism, and
- Clear semantics for model simulation.

UML was discarded as being software-oriented and not quite appropriate for modeling systems. SysML was designed for modeling general systems, but like UML, the SysML notation is comprised of multiple diagram types that provide mainly aspect decomposition. The multiple multiple-view model of SysML makes it difficult to get a good grasp of the complete system, one of the major tenets of conceptual design. Modelica most fit for the detailed design phase but is too technical for the conceptual modeling phase and for use by a wide user community.

We use, therefore, Object-Process Methodology (OPM) [Dori 2002] as the underlying formalism for MBSA. OPM offers a holistic approach, backed by a formal yet intuitive graphic and textual language that can be used for modeling enterprise-related standards and technical standards in general. Building on this model-based approach, we specify a method that significantly reduces inconsistencies through a bimodal model representation. The dual graphics-text equivalence, which constitutes the basis of the method, enables deep cognitive analysis of the standard's technical content, thereby providing for a holistic and consistent standard [Blekhman et al, 2010].

This text-graphics bimodal approach has several important advantages with standards such as the IEC 62264 [Johnsson 2009], that occasionally present models (mostly UML) to support the their text-based contents. In this model-supported approach, UML diagrams embedded in the standard do not stem from an underlying foundational model. Rather, they are provided on an ad-hoc manner to go with nearby text, with no guarantee of conformance between the two or among UML diagrams in the standard.

ISO Model-Based Standards Authoring Activity

The International Organization for Standardization (ISO) is the world's largest developer and publisher of International Standards. As such, one of its major concerns is the quality of the standards and other technical documents it issues.

ISO Technical Committee 184 Sub-Committee 5 (TC 184/SC 5) is tasked with developing and overseeing standards related to enterprise systems and automation applications. At its Plenary Meeting in Paris on April 23-24, 2009, ISO/TC 184/SC 5, in Resolution 611 (Paris 21) unanimously resolved to establish the Object Process Methodology Study Group (OPM SG), which was tasked with investigating the usefulness of Object-Process Methodology for creating, designing, analyzing, and simulating models of its standards to improve the development, communication and understanding of these standards.

A group of 27 experts from 12 countries expressed interest in participating in this effort. They conducted online sessions and frequent electronic exchange of documents and models. The actions included investigating the viability of using OPM as a methodology and modeling language for the purpose of streamlining, formalizing, and explicating the standard ontology and glossary, and making enterprise-related standards more comprehensive, accessible, usable, and consistent both internally and across standards.

In an interim report (N1070) submitted by the authors participating in OPM SG to the ISO TC 184/SC5 Plenary Meeting on March 25-26, 2010 in Tokyo, the IEC 62264 standard (Enterprise-Control System Integration) was used as a case in point to demonstrate the value of switching from text-based or model-accompanying standards to model-based standards and to discuss the merits of OPM as the modeling language and methodology for this purpose. Our methodology for producing a model-based document has been shown to be capable of identifying inconsistencies, assuring content correctness and aid in producing a clearer, more concise clause statement than that achieved using a text-based approach.

Following the acceptance of Resolution 624 (Tokyo 9), SC 5 requested the OPM Study Group to produce a normative document that specifies a generic approach to standards authoring using OPM. The essence of this approach is presented in the following sections, based on lessons learned while modeling and adjusting existing documents, such as the IEC 62264 standard.

Object-Process Methodology (OPM) Overview

As its name suggests, the two basic building blocks in Object-Process Methodology (OPM) are objects—things that exist (at some state), and processes—things that transform objects by creating or destroying them, or by changing their state.

OPM elements are entities and links. The three entity types are objects and processes, collectively referred to as "things", and object states. Objects are things that exist, and they can be stateful (i.e., have states). Processes transform objects: they generate and consume objects, or affect stateful objects by changing their states. Objects and processes are of equal importance, as they complement each other in the single-model specification of the system. Links, which are the OPM elements that connect entities, are of two types: structural and procedural.

OPM consists of two semantically equivalent modalities of the same model: graphical and textual. A set of interrelated Object-Process-Diagrams (OPDs) constitute the graphical model, and a set of automatically-generated sentences in a subset of English constitute the Object-Process Language (OPL). In the graphical-visual model, each OPD consists of OPM elements depicted as graphic symbols, while the OPD syntax specifies the consistent and correct ways by which those elements can be managed. Since the corresponding textual model is generated in a subset of English, it is immediately understood by domain experts, who need not learn any special language nor decipher cryptic code.

OPM notation supports conceptual modeling of systems. Its top-down approach includes refinement mechanisms of in-zooming and unfolding. OPM uses a single type of diagram to describe the functional, structural and behavioral aspects of the system. OPCAT [Dori et al, 2003], an OPM-based conceptual modeling software environment, features an accessible API, a basic animated class-level execution module, and integration with files of various formats, e.g., XML and CSV, reducing the development effort.

OPM objects relate to each other via structural relations, expressed graphically as structural links. Structural relations can specify time-independent relations between any two objects. The four fundamental structural relations are aggregation-participation, generalization-specialization, exhibition-characterization, and classification-instantiation. Objects can also be structurally related to each other by unidirectional or bidirectional user-tagged relations, similar to association links in UML class diagrams. Due to the object-process symmetry, structural relations can also specify relations between any two processes.

Procedural links connect a process with an object, or an object's state, to specify the dynamics of the system. Procedural links include (1) transforming links: effect link, consumption link, result link, and the pair of input-output links, (2) enabling links, which are the agent and instrument links, and (3) control links: event, condition, invocation, and time exception links.

An OPM model consists of a set of hierarchically organized Object-Process Diagrams (OPDs). This hierarchical organization alleviates the system model's complexity. Each OPD is obtained by in-zooming or unfolding of a thing (object or process) in its ancestor OPD. Copies of an existing thing can be placed in any diagram, where some or all the details, such as object states or links to other things, which are unimportant in the context of the diagram, can be hidden. It is sufficient for some detail to appear once in some OPD for it to be true for the system in general even though it is not shown in any other OPD.

The choice of OPM for modeling enterprise-related standards in particular and standards in general is straightforward since OPM is the only conceptual modeling language that exhibits built-in dual graphics-text model representation, with automatic generation of constrained English (OPL sentences). This, along with its single-model view and compact, generic ontology of stateful objects and processes that transform them, provides for quick learning, making OPM a natural choice for model-based enterprise standards authoring. Not only is OPM a simple language to learn; as a methodology, OPM advocated top-down refinement of the major function of the system, which is its central process in the System Diagram. This is perfectly aligned with the way enterprise standards are structured. OPM can serve as the modeling language and methodology for authoring and evolving model-based enterprise standards. Due to its bimodal graphic-text capabilities, OPM provides a means for validating the standard's clauses and producing ontology that encompasses the document content, which significantly enhances the document's testability and validability. These capabilities, described using clauses from IEC 62264 [Blekhman et al, 2010], demonstrate identification of several inconsistencies in the standard. The ontology model can provide reference to other standards in the same domain and a basis for integrating standards across domains.

MBSA Standard and Tesperanto

The details of the MBSA process will be presented using the OPM model in graphics (OPDs) and text. These sentences are elaborations of OPL sentences, which are embryonic sentences in *Tesperanto*. Tesperanto is the future language we are currently designing as a natural language layer above OPL. As the sentences show, Tesperanto is less mechanical and feels more like it was written by a person rather than a machine. The MBSA process is presented using the directives it ascribes, forming a reflective model-based meta-standard—a model-based standard for authoring model-based standards.

In the text that follows, names of OPM things (objects or processes) are in **Capitalized Arial Font Bold Phrases** as they appear in the accompanying model OPDs. Similarly, **lower-case Arial font bold phrases** are names of states (or tags in tagged structural relations). The part of the model presented below is accompanied by a Tesperanto excerpt from the proposed Model-Based Enterprise Standards Authoring Meta-Standard.

The first stage in the MBSA process is an extended statement of the main function or purpose of the standard being authored. The main function of the ISO standard which specifies how to develop a standard in the MBSA approach is called **Model-Based ISO Standards Developing** (Figure 1). Once this function is specified in a short phrase, we define the standard's stakeholder groups, expected benefit or value for each relevant stakeholder group, the standard's scope, goal, objectives, interfaces, and possibly reference to relevant prior material. The main function is the top-level process of the OPM model which is constructed gradually in a top-down fashion.

Model-Based ISO Standards Developing is the process of creating a **Published International Standard**. It is performed by a **Project Leader** along with a **Contributing Expert, ISO Secretariat, Committee Secretariat**, and **Nominated Expert**. The **Project Leader** coordinates the **Nominated Expert**.

Model-Based ISO Standards Developing is performed while a **Working Group** is **active** with the aid of **Authoring Support Set** and **Related Subject Material**.

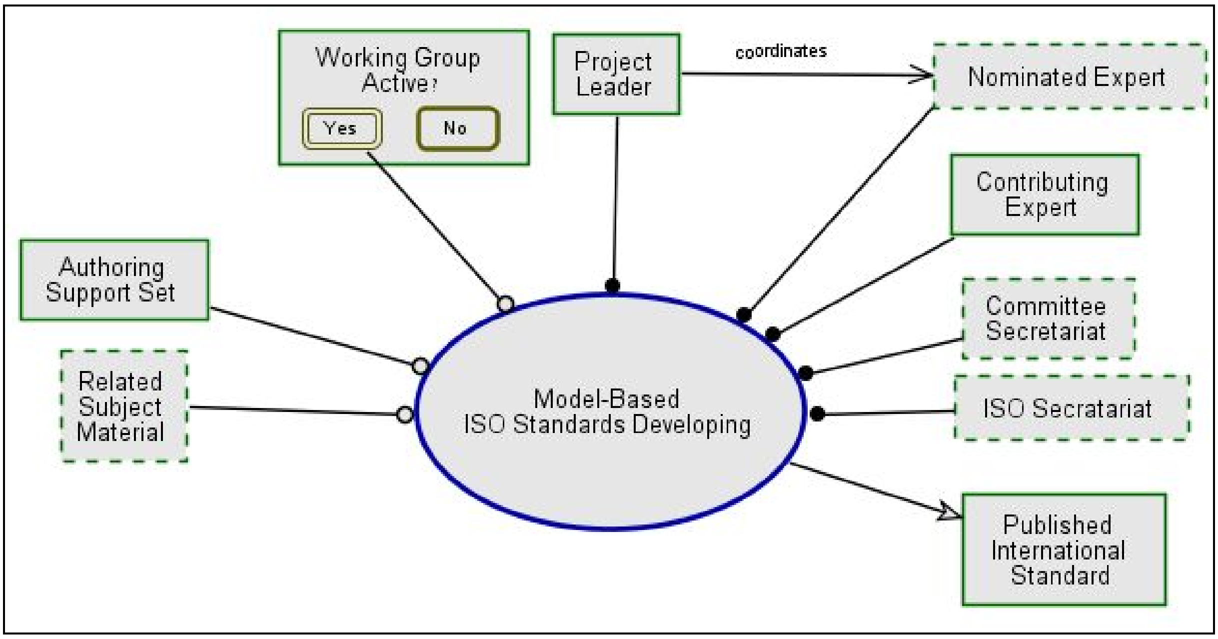

Figure 1: OPD of Model-Based ISO Standards Developing process – System Diagram (the top level)

Next, details of the top-level process—the main function identified earlier, are specified by successively delving into subordinate processes (sub-functions), their input objects, resulting objects, the enablers—agents (human enablers) and instruments (non-human enablers) —along with the attributes relevant to each of these objects.

The OPD in which **Model-Based ISO Standards Developing** is zoomed into contains two main processes: **Model-Based Standard Authoring** and **ISO Balloting.** For the sake of simplicity, we will skip the (mostly procedural) details of **ISO Balloting** and related objects and activities (e.g., **Balloted Circulation Document**, **ISO Phase**, etc.), and move on directly to **Model-Based Standard Authoring** in Figure 2.

Model-Based Standard Authoring is the process of creating a **Model-Based Standard**. The process consists of three stages: **Input Document Preparing**, **Proposed Standard Revising**, and **Proposed Standard Managing**.

Input Document Preparing occurs if **Standard** does not exist. This process yields a **New Standard Document**, which is then used in the **Proposed Standard Revising** process. If **Standard** exists already, **Proposed Standard Revising** is entered directly.

Proposed Standard Revising is the process of creating **Proposed Standard Draft**. A revised version of **Proposed Standard Draft** is then used as a condition to start **Proposed Standard Managing**.

Proposed Standard Managing is the process of creating **Model-Based Standard**, which can be one of the following: **working draft**, **committee draft**, **draft international standard**, **final draft international standard** or **published international standard**.

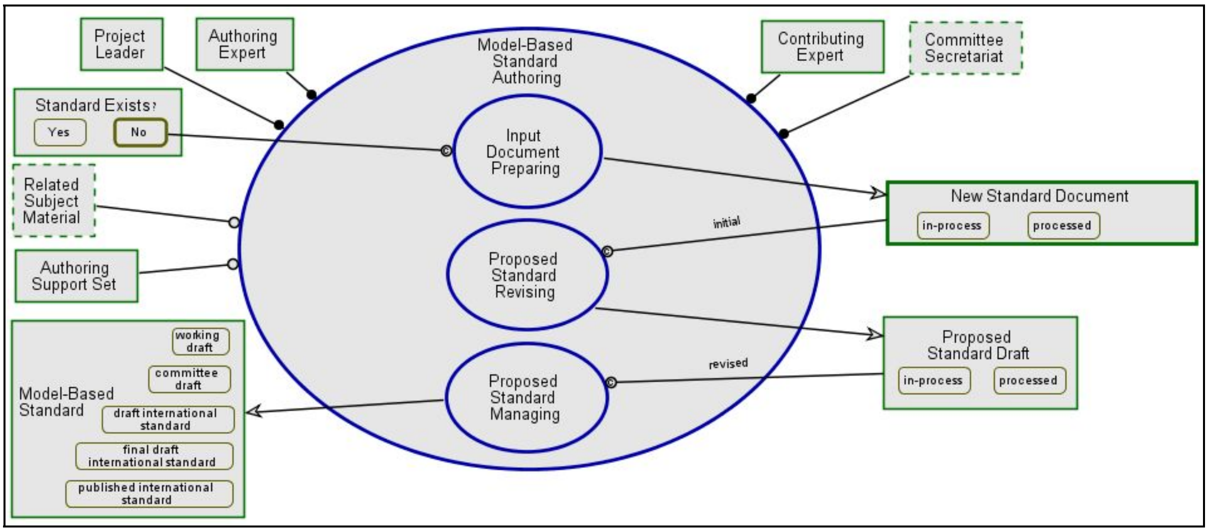

Figure 2: Model-Based Standard Authoring in-zoomed

The subprocesses of **Model-Based Standard Authoring** are further detailed through in-zooming (of processes) and unfolding (of objects). For example, the **Input Document Preparing** process consists of **Initial Content Identifying**, **Standard Forming** and **First Draft Preparing** processes. Some of the more detailed diagrams for **Initial Content Identifying** and its sub-processes are presented in Figure 3. Figures 4 and 5 similarly show in-zoomed views of **Standard Foundation Laying** and **Standard Foundation Modeling**, respectively.

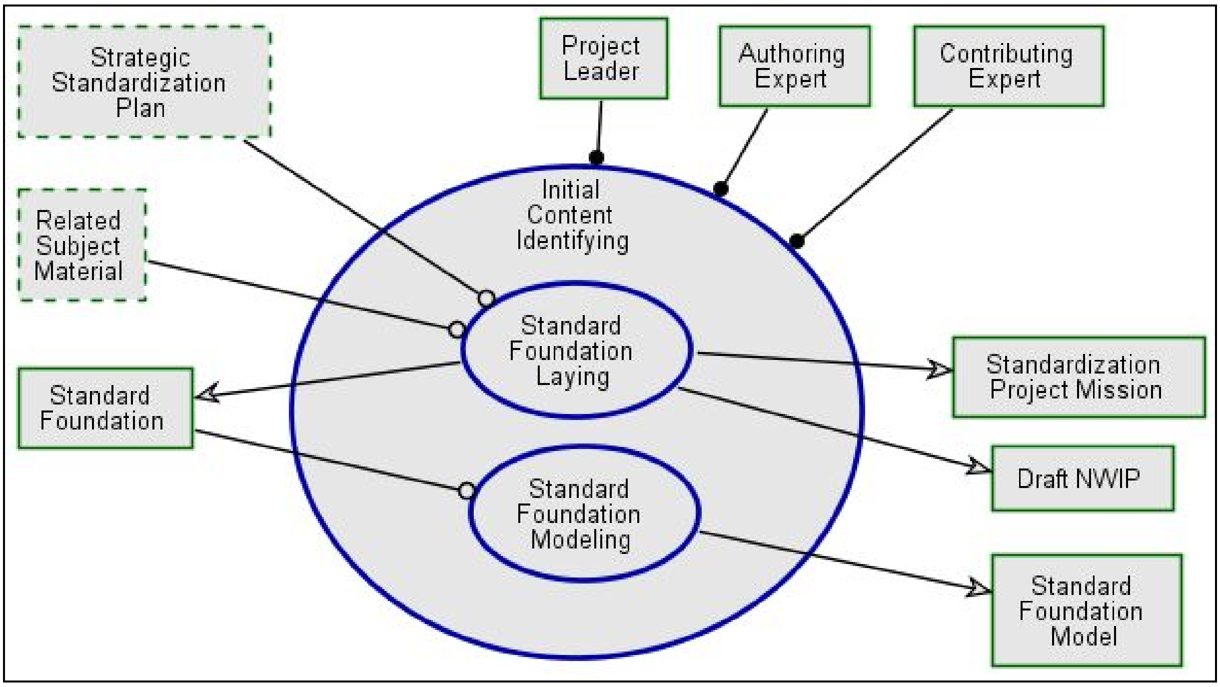

Figure 3: Initial Content Identifying in-zoomed

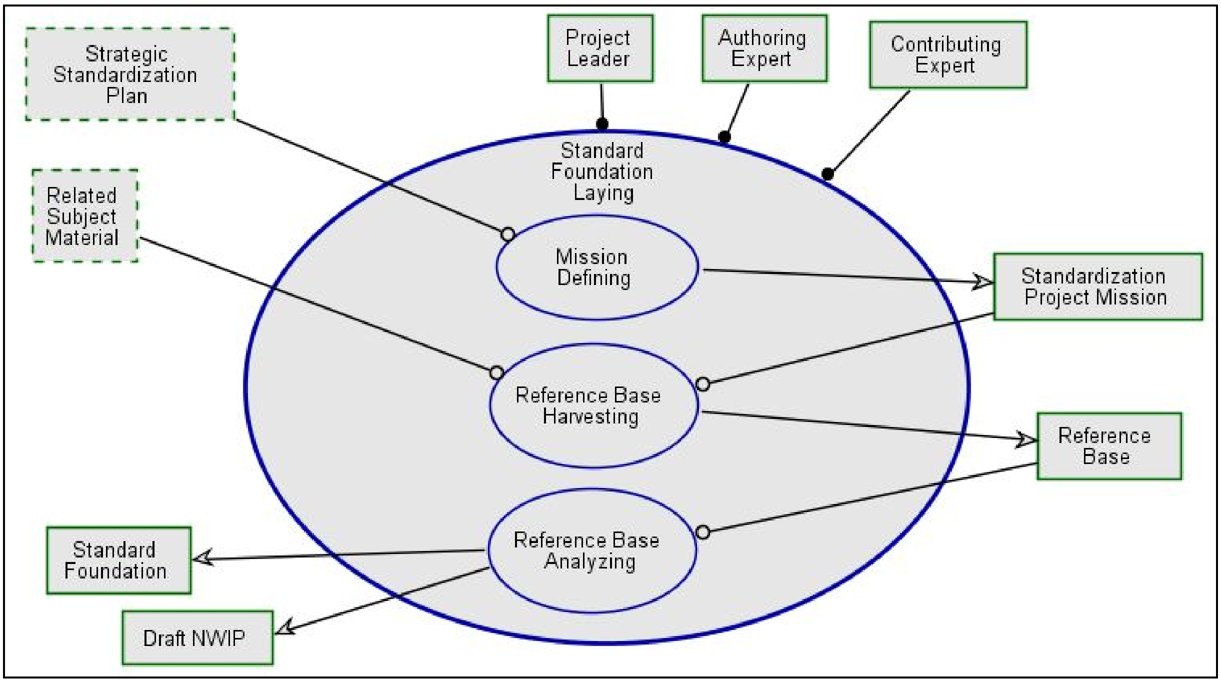

Figure 4: Standard Foundation Laying in-zoomed

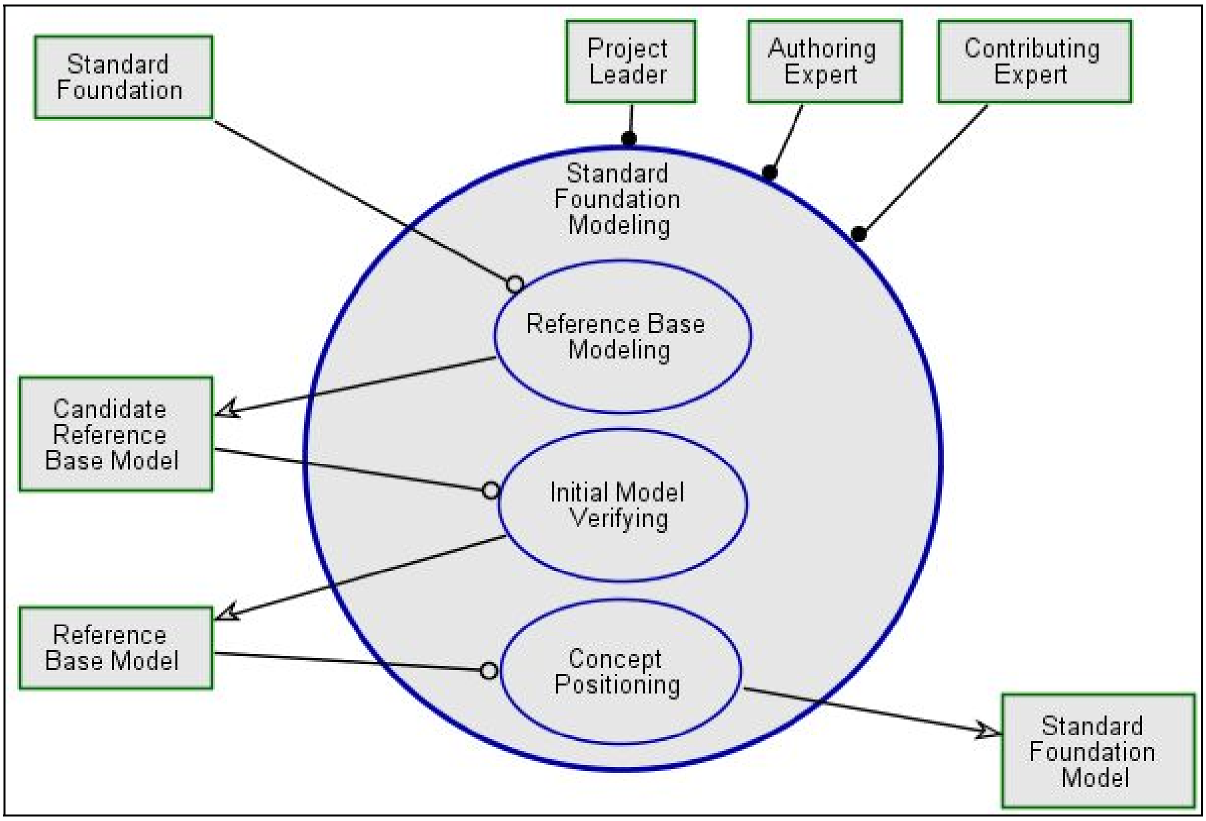

Figure 5: Standard Foundation Modeling in-zoomed

The outcome of the process is a model and its corresponding model-based text. During later stages of the model-based document life cycle, the model backbone helps maintain the document completeness and consistency through changes it would inevitably need to undergo. Using the model, it is possible to validate and adjust the text to the ever-emerging changes of operational environment requirements, stakeholder needs, and technological advances.

Conclusion

The work of OPM SG has demonstrated the viability and benefits of using a modeling language in general and OPM in particular to significantly improve the quality and consequently the value of standards by aligning the text with an underlying coherent model that drastically reduces inconsistencies and ambiguities while increasing clarity and completeness.

This paper presents a structured procedure for authoring model-based standards and technical specifications in general through internal and external verification and validation processes, according to the guidelines requested by OPM SG. Documents created by following this procedure are based on an underlying unified formal OPM model that jointly and concurrently represents the structure and behavior of the standard's technical content. Following this approach, standard specifications are bound to be significantly more complete, consistent, unambiguous, and exact than their un-modeled text-based counterparts.

Our model-based approach derives the standard's content from an underlying model rather than a model-supported approach. This methodology is designed to be backed up by Tesperanto text generation capabilities, so that both the model and the text convey complete information in a consistent form as the Tesperanto text is fully aligned with the graphical model. Tesperanto is composed of simple, light, unambiguous sentences that, in addition to its simplicity and explicit nature, are also likely to significantly facilitate automated, yet reliable, translations to natural languages other than English. Further detailed information, which causes confusion in the original specification, is deferred to be exposed in lower-level views of the system, again, both graphically and textually.

The model-based standards authoring approach we have presented can be applied not only to standards, but to a wide variety of technical and scientific documents with declarative or procedural content. These include requirements specifications, safety procedures and regulations, medical protocols, manuals, and scientific publications. We plan to augment the model-based approach to handle a variety of such documents.

References

Blekhman, A., Howes, D. B. and D. Dori. 2010 Model-Based Verification and Validation of a Manufacturing and Control Standard, *MSOM (Manufacturing and Service Operations Management Society) International Conference*, Haifa, Israel, June 27-29, 2010.

Dori, D. 2002. Object-Process Methodology - A Holistic Systems Paradigm. Berlin: Springer Verlag.

———, Reinhartz-Berger, I. and Sturm, A. 2003. Developing Complex Systems with Object-Process Methodology using OPCAT, *LNCS* 2813, pp. 570-572.

———, N. Korda, A. Soffer, and S. Cohen. 2004. SMART: System Model Acquisition from Requirements Text. *LNCS* 3080, pp. 179-194.

———, R. Martin, and A. Blekhman, 2010. Model-Based Meta-Standardization: Modeling Enterprise Standards with OPM. *IEEE International Systems Conference*, San Diego, CA, USA, April 5-8.

Johnsson C. 2003. An introduction to IEC 62264. `http://isotc.iso.org/livelink/livelink/fetch/2000/2489/Ittf_Home/MoU-MG/Moumg159.pdf`, Accessed Nov. 12 2009.

Biography

Alex Blekhman is a Ph. D. student at William Davidson Faculty of Industrial Engineering and Management at the Technion, Israel Institute of Technology, Haifa, Israel under the supervision of prof. Dov Dori.

Dov Dori is a professor in the William Davidson Faculty of Industrial Engineering and Management at the Technion, Israel Institute of Technology, Haifa, Israel, and a research affiliate at MIT, Cambridge, MA.

Richard Martin is the President of Tinwisle Corporation, Convener of ISO WG1 and USTAG of ISO TC184/SC5.