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# An ontology for ISO software engineering standards: 1) Creating the infrastructure

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ABSTRACT

Software engineering standards developed under the auspices of ISO/IEC JTC1's SC7 have been identified as employing terms whose definitions vary significantly between standards. This led to a request in 2012 to investigate the creation of an ontological infrastructure that aims to be a single coherent underpinning for *all* SC7 standards, present and future. Here, we develop that necessary infrastructure prior to its adoption by SC7 and its implementation (likely 2014). The proposal described here requires, firstly, the identification of a single comprehensive set of definitions, the definitional elements ontology (DEO). For the scope of an individual standard, only a subset of these definitional elements will be needed. Once configured, this definitional subset creates a configured definitional ontology or CDO. Both the DEO and the CDO are essentially foundational ontologies from which a domain-specific ontology known as a SDO or standard domain ontology can be created. Consequently, all such SDOs are conformant to a CDO and hence to the single DEO thus ensuring that all standards use the same ontological base. Standards developed in this fashion will therefore be not only of a higher quality but also, importantly, interoperable.



## 1. Introduction

The International Organization for Standardization (ISO), based in Geneva, is responsible for the creation and maintenance of a large suite of international standards (IS) and technical reports (TR) for software engineering (SE). However, the semantics of the terms used in these various SE standards can often be contradictory, or at best misaligned, across pairs of similarly-focussed standards. For example, within the SC7 (the sub-committee responsible for software engineering standards) community, Rout [1] analyzed a number of standards, term by term, identifying by number the standards in which these terms appear together with their (disparate) definitions. Other ISO work, outside of SC7, has led to the publication of ISO 704,[1] currently in its third edition (2009): "Terminology work — principles and methods".

The early 2000s saw SC7 standards being developed increasingly in 'stovepipes', leading to the realization that these various standards need to be consistent with each other in terms of terminology, structure and semantics, resulting in significant discussions between working groups (WG) within SC7 to resolve terminology differences e.g. WG6 and WG13 needed to resolve 'metric' and 'measure' e.g. see discussion in [2]. On a larger scale, initial conceptual differences, possibly among other things, led to quite different process standards for software (ISO/IEC 12207) and systems (ISO/IEC 15288). More recently, SC7 (notably WG7) has attempted to reconcile definitions within a harmonization project to align ISO/IEC 12207 and ISO/IEC 15288, requiring considerable effort (see also [3]). Also over the last several years, a new International Standard (ISO/IEC 24744) has been created specifically to create a set of definitions of process-focussed terms and their interrelationships, effectively creating a foundational ontology [4].

At the beginning of 2012, McBride et al. [5] produced a document for the 2012 SC7 Plenary meeting (Korea) entitled "The growing need for alignment" (also as a PowerPoint™ presentation to the Strategic Planning meeting of SC7 on 19–20 May 2012). The themes presented there included:

- Increasing recognition that standards are becoming multi-disciplinary and that there is no guidance for a new team when building a standard to ensure it is compatible with other SC7 standards. They need guidance for "What kind of standard do you want to develop", especially, guidance about the type, purpose and applicability.
- Clashes of terminology and subtle clashes in semantics observed in current standards.
- The recent impacts on software engineering standards due to the enactment of external legislation such as Sarbanes–Oxley Act [6].

These factors suggest that:

- There is a need to move from serendipitous knowledge of such problems to organizational (SC7-level) solutions.

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[1] All ISO standards cited are listed separately at the end of the paper.

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- Each standard should be tightly focussed e.g. requirement standards are different from guidance standards.
- An ontology/taxonomy should be produced, in particular using ISO 704:2009 — Terminology work — principles and methods.

Resulting from the discussion of these proposals at the May 2012 meeting of SC7, a study group was created, chaired by the first author of this paper and charged with investigating the potential utility of ontologies for rationalizing SC7's suite of software engineering International Standards.

SC7 is not alone in addressing concerns on non-interoperability [7]. Almost any successful organization will gradually introduce more products and eventually face the need to rationalize them in order to present potential customers with a suite of products that can work together and that do not contradict or compete with each other unnecessarily. Organizations also find it necessary to rationalize their production methods in order to avoid supporting unique development and production methods, tools and infrastructure. For SC7, a rationalized product set is more important than rationalized production methods. Even so, JTC1 (Joint Technical Committee 1) has found it necessary to impose a template standard, a standard form for ballot comments and a uniform balloting system.

Like all products, standards are frequently used in combinations. Organizations want to use high level standards for systems development, for example, along with standards that expand on specific processes such as software maintenance or risk management. Organizations also want to combine standards from different sources; quality management with software development or CoBIT with software development and related processes. Harmonious combination of standards is aided when the standards start with consistent concepts and terms. This is not significantly different from organizations sourcing product components from different suppliers. They too need agreements on the basics like voltages, measurement scales, thread types and screw sizes.

Muddling through, resolving conceptual differences as they are noticed will not suffice in a future where standards are used in combinations, sometimes from disparate sources.

Software, systems, IT Service management, and IT governance are all sufficiently different domain that considerable effort is needed to avoid mutual misunderstanding of fundamental concepts. That there is now considerable effort being made to split the "management" related standards off into another JTC1 committee argues that this effort was either not made or was insufficient. Splitting into another JTC1 committee will not solve the problem of mutual misunderstanding but will increase the difficulty of developing standards that can work together.

SC7 needs to manage its strategic direction, as does any organization. The clarity and effectiveness of that strategy depends, in part, on how clearly the conceptual foundations of the different families of standards are articulated, how well the relationships are understood between those families to other standards within SC7 and standards external to SC7. This is much easier to achieve when the concepts and terminology are universally agreed.

In this paper, which offers a significant extension to the ideas proffered in [8], we present the research-oriented results of the material evaluated by the members of this study group and the proposal that was made to the SC7 overseeing committee (SWG5) at the SC7 Plenary meeting in Montréal in May 2013 and the subsequent revisions to create its "Second Report" (circulated to committee members July 2013). At that May 2013 plenary meeting, further work was also commissioned by SWG5 in order to create a work plan prior to the development of the first report into a new work item proposal (NWIP) at the next international SC7 meeting.

Our overall hypothesis is simply that SC7 standards, as an interdependent suite of artifacts, could benefit by the application of conceptual modeling and ontological organization.

In summary, the problems to be addressed in this paper and the proposed solutions adopted by the study group and SWG5 are:

(i) construction of clear, unambiguous and comprehensive definitions of all SC7 terminology;
(ii) conformance of existing and new standards to this agreed ontological description of terminology;
(iii) categorization of existing standards and their relationship to (i) and (ii).

The approach taken is that of a combination of conceptual modeling e.g. [9] and ontology engineering e.g. [10]. In Section 2 of this paper, we first identify from the research literature five possible flavors of 'ontology' that might be usefully transformed into SC7 standards i.e. research-underpinned technology transfer (each of these five being discussed in detail in five subsections). Section 3 discusses how these ideas might be implemented in the context of ISO's SC7 committee and its request in May 2013 for a detailed work plan. Section 4 discusses how this proposal can be maintained in future years and its influence on how new standards will need to be developed; while Section 4 gives both our recommendations (made to SC7) together with our overall conclusions.

### 1.1. Current situation for SC7 standards

SC7 already has a vocabulary (ISO/IEC 24765 SEVOCAB), a definition of process (TR 24774), several process reference models (ISO 12207, ISO 15288, ISO 19770-1, ISO 29119-2, ISO 20000-4) and several detailed processes (ISO 14764, ISO 16085, ISO 15939, etc.). In the example shown in Fig. 1, TR 24774 is specified using terms defined in the ISO vocabulary. SC7 process reference model standards, e.g. ISO 12207, ISO 15288, and ISO 19770-1, define or describe processes using the terms and structure defined in TR 24774 and there are several standards, of which ISO 15939 is an example, that are an expanded description of a process used in or referenced in SC7 process reference models, e.g. ISO/IEC 15939. This structure has simply emerged, illustrating that a hierarchy of concepts, configured concepts, standards based on those definitions and instantiations of those defined processes seems a natural thing to do.

ISO 24765 (SEVOCAB) was not intended to be a collection of precise definitions, simply a collecting together of existing definitions. Yet SC7 needs to know which definitions should apply in its domain. Additionally, SC7 needs a way to adopt a precise definition to the particular circumstances. For example, a process may be defined as "set of interrelated or interacting activities that transforms inputs into outputs" but that definition needs to extend to other attributes of processes in order to accommodate the interests of process assessment.

TR 24774 has guidelines for process descriptions that do not try to include every conceivable interest in processes. So far, TR 24774 accommodates process performance (e.g. ISO 15288) and process assessment (ISO 15504/33002) but not process governance. Nor should it. These divergent needs will come with time and might extend TR 24774 or might result in another set of guidelines for process description. In either case, there needs to be consensus about just what a process is, and precisely what the different attributes of a process are.

The hierarchy exists but the problems described earlier attest to its limitations.

Secondly, SC7 is increasingly being presented with PASs (publicly accepted standards), many from the object management group (OMG). Yet, there is no guarantee that the vocabulary (and ontology) utilized in a PAS will be consistent with that of SC7. For example, Fig. 2 contrasts the implicit definitions of terms in OMG's SPEM standard (Software Process Engineering Metamodel: [11]) and similarly focussed standards of SC7 (see also discussion of this diagram in [12]). It is clearly seen that these are different across both SPEM and the process-focussed standards of SC7.