Tesperanto – A Model-Based System Specification Methodology and Language

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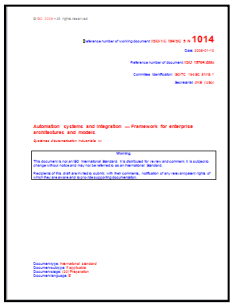
Introduction

- Systems engineering (SE)
  - is an interdisciplinary approach and means to enable the realization of successful systems.
- Successful systems
  - must satisfy the needs of its customers, users and other stakeholders.
- Technical specifications
  - are a central part of a systems engineer's work.
  - shall contain a clear presentation of the function and characteristics required from some system, product, or service in demand.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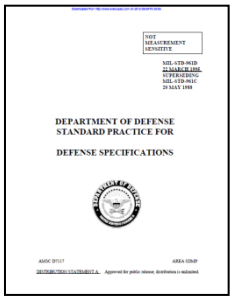
Automation systems and integration — Framework for enterprise architectures and models


Manufacturing Software Interoperability Services which ISO 16100 brings about


NOT MEASUREMENT SENSITIVE

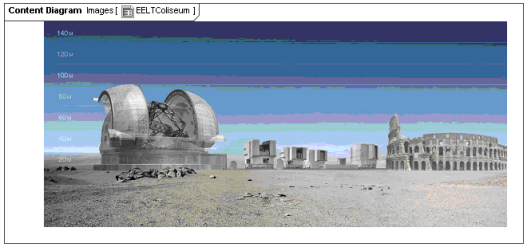
MIL-STD-961D
31 MARCH 1995
SUPERSEDING
MIL-STD-961C
31 MAY 1988

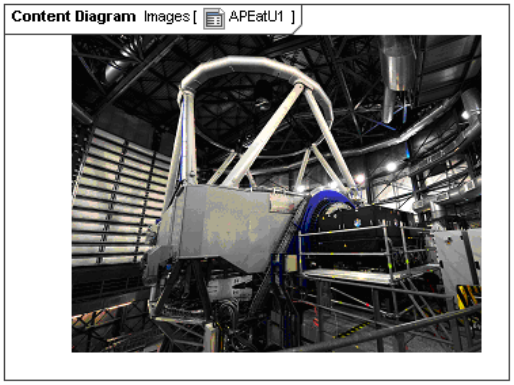
DEPARTMENT OF DEFENSE
STANDARD PRACTICE FOR

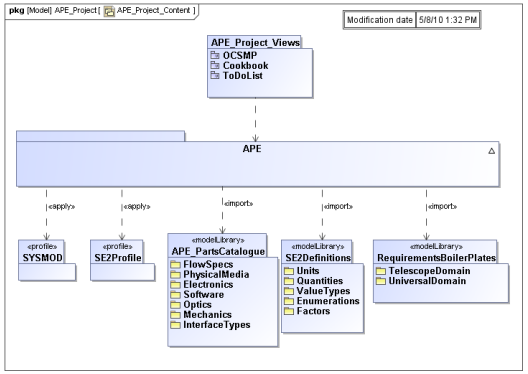
DEFENSE SPECIFICATIONS

Challenges

- Specifications that convey structured technical information
  - are supposed to be a solid source of authority.
- Must be
  - explicit, clear.
  - consistent, complete.
  - accessible, comprehensible.
- Currently, many, if not most, are
  - ambiguous.
  - difficult to use and trace.
  - at times inconsistent internally and externally. [ISO TC184/SC5 2009]

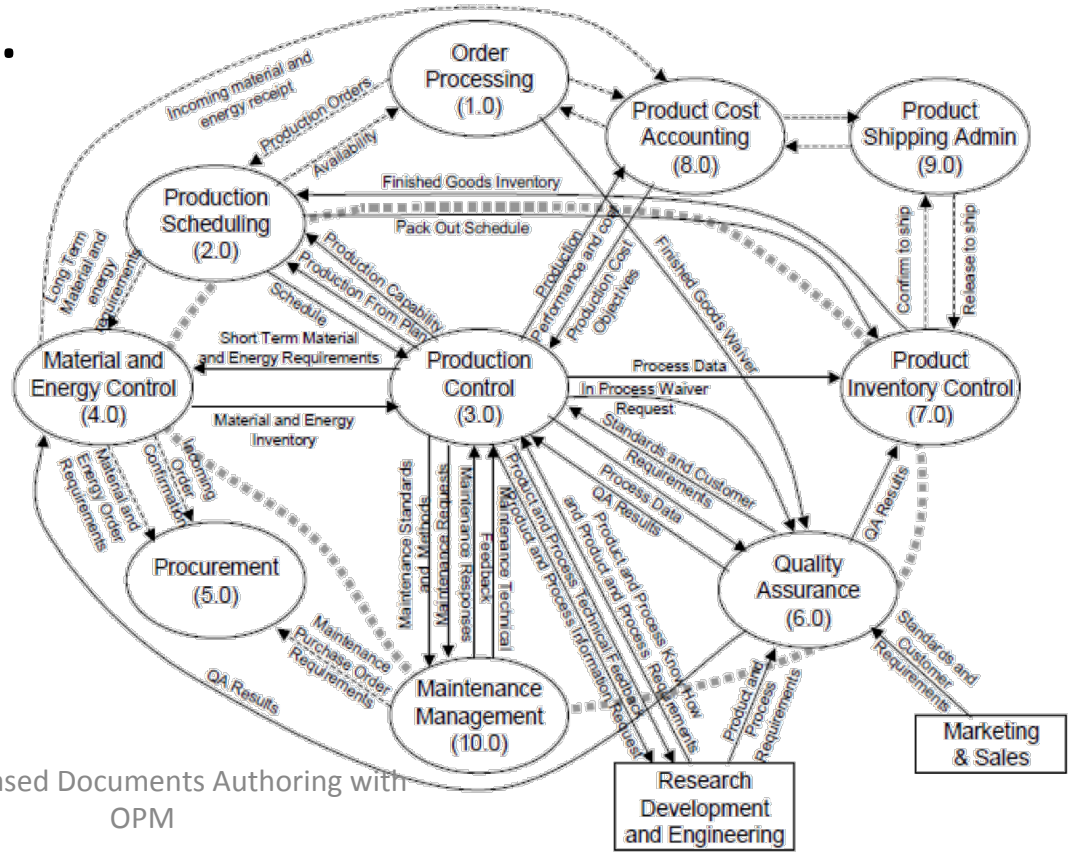






System and document complexity example

- ISO 62264-1 paragraph 6.3, figure 5: Functional enterprise-control interface and relevant functions.
- Overall: 143pp.
- Directly related to Figure 5: 12pp.



Examples for inconsistencies in ISO standards (62264-1)

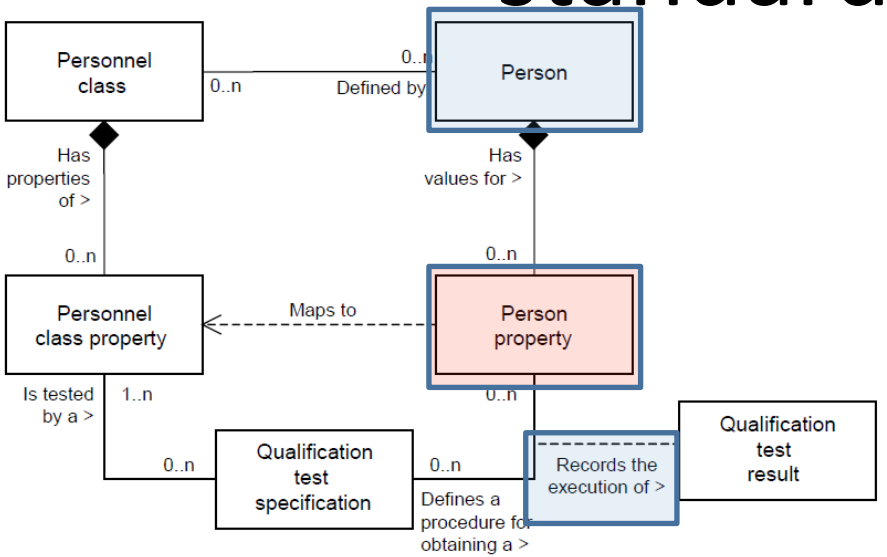


Figure 14 – Personnel model

7.5.1.1 – Personnel Model

The personnel model contains the information about specific personnel, classes of personnel, and qualifications of personnel. Figure 14 illustrates the personnel model. This corresponds to a resource model for personnel, as given in ISO 15704 and ISO 15531-1

Incomplete text	• The relation "records the execution of" between Qualification test result and Person property.
Incomplete figure	• Correspondence to ISO 15704 and ISO 15531-1.
Inconsistency between figure and text	• Specific personnel vs. Person • Qualifications of personnel vs. Person property.

Analysis

- Technical documents
  - are built with no comprehensive base reference with which to measure the coherence of technical statements they convey.
- The practical length and complexity of a comprehensible document
  - Is limited by the lack of an underlying analytical process that would accompany the creation and maintenance of technical documents.
- The main modality
  - should remain textual, possibly accompanied by matching figures.

The underlying structure of text

- Technical specifications
  - aim to convey structured, exact, and well-defined information.
  - commonly describe in text an underlying scheme, be it a block diagram, a flow chart, a state machine, or some informal, ad-hoc schema.
- In many cases, this hidden structure bears the true value of sometimes wordy and confusing specifications.
  - accompanying figures, diagrams, schemes, or drawings illustrate and complement the text, providing a visual reference for the textual content.

The rationale for Model-Based Documents Authoring

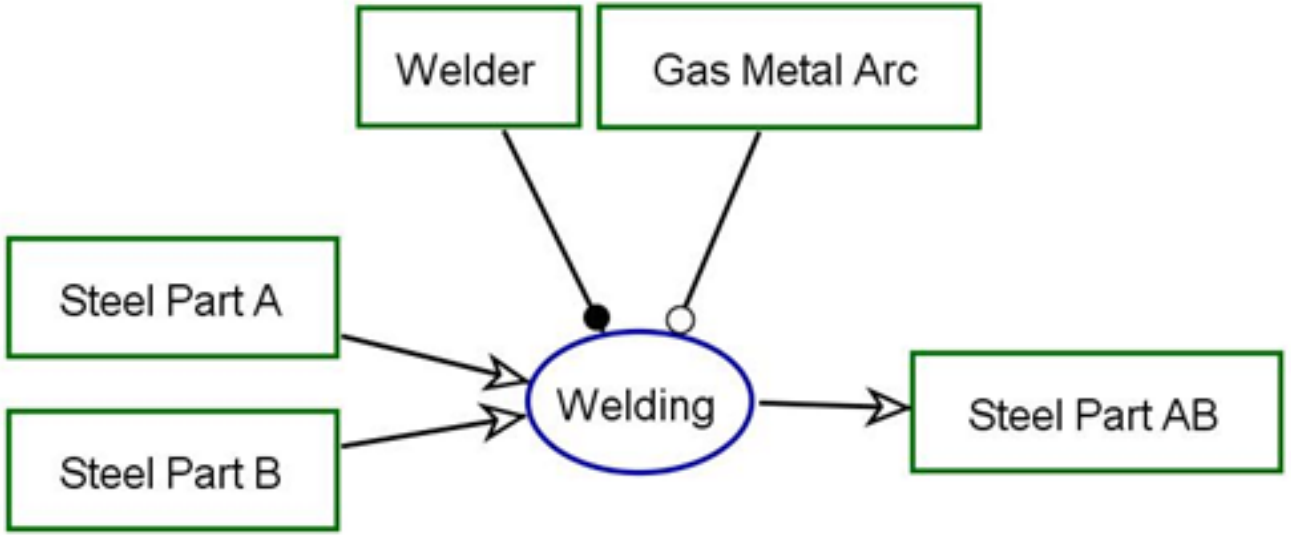
- We wish to uncover, rely on, and work with
  - the actual scheme underlying the technical document text,
  - rather than interpret the free text with its accompanying disparate figures and mostly informal diagrams.
- The combination of underlying model and text that relies on that model
  - Is an analytical representation of the authors' intent.
- The model can serve as a solid, consistent and unambiguous basis for analyzing the system
  - unequivocal throughout the document.
  - comparable to models of other systems.
  - implementation and code-generation ready.

Model-Based Documents Authoring principle

- Model-Based Documents Authoring with OPM
  - is a process that is aimed at the significant reduction of internal and external inconsistencies in technical documents,
  - through the introduction of graphical model presentation that is concurrent with the textual content.
- The model provides the necessary reference for the authoring and managing of consistent specifications.

Text-model correspondence example

Welding is the process of creating a **Steel Part AB**, with the aid of a **Gas Metal Arc**. This process is performed by a **Welder**, consuming a **Steel Part A** and a **Steel Part B**.



Choosing OPM as the MBDA Underlying Formalism

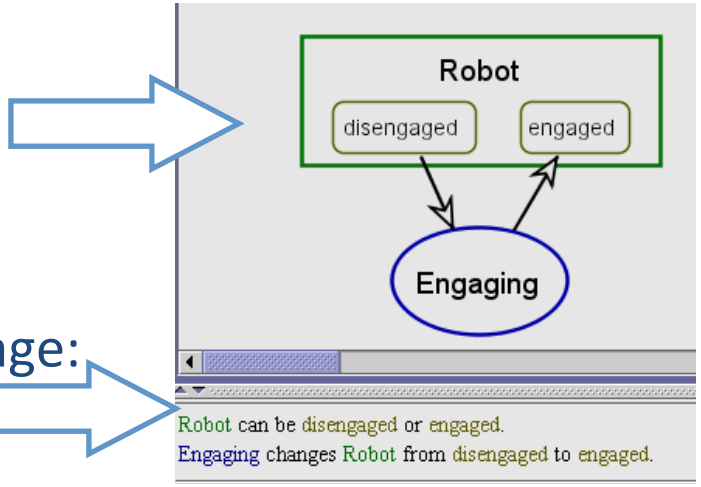
- OPM is a visual methodology that
  - incorporates the functional, static-structural and dynamic-procedural aspects of a system into a unifying model.
  - includes concurrent textual representation.

A single diagramming tool:

Object-Process Diagram (OPD)

A corresponding subset of language:

Object-Process Language (OPL)



OPM as a basis for language

- Objects, processes, states.

- Procedural links: agent, instrument, consumption, result, effect.

- Structural links: aggregation, generalization, exhibition, instantiation, tagged.

- Dynamics: condition, event, invocation.
- Complexity management: in-zooming, un-folding.

Tesperanto Ontology and Language

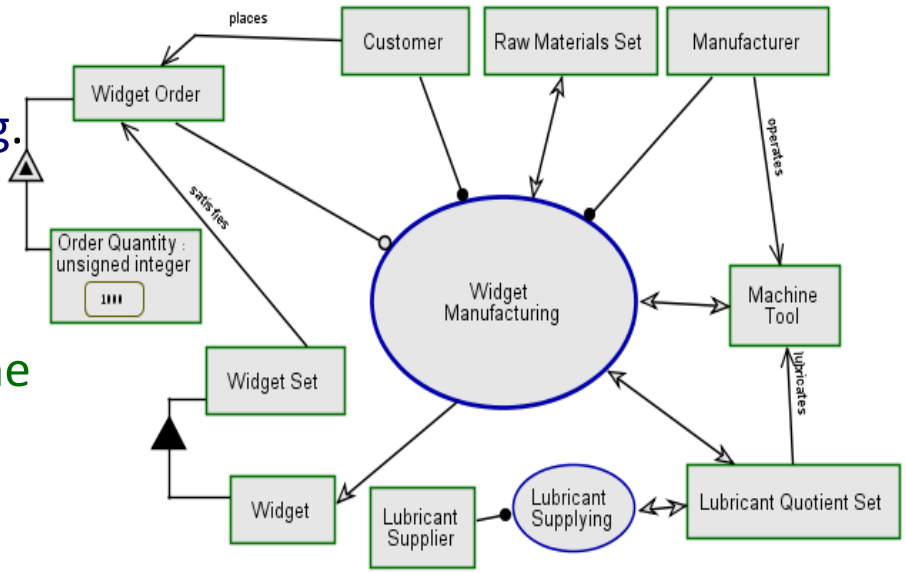
- A mapping from text to concrete concepts and relations.
- Practical guidance following OPM principles that suit the need for consistent system presentation and gradual details exposure.

OPM symbol	Meaning	Example	Text
	Aggregation-Participation	Car includes an engine	Include, comprise, consist, contain

Tesperanto vs. OPL

OPL:

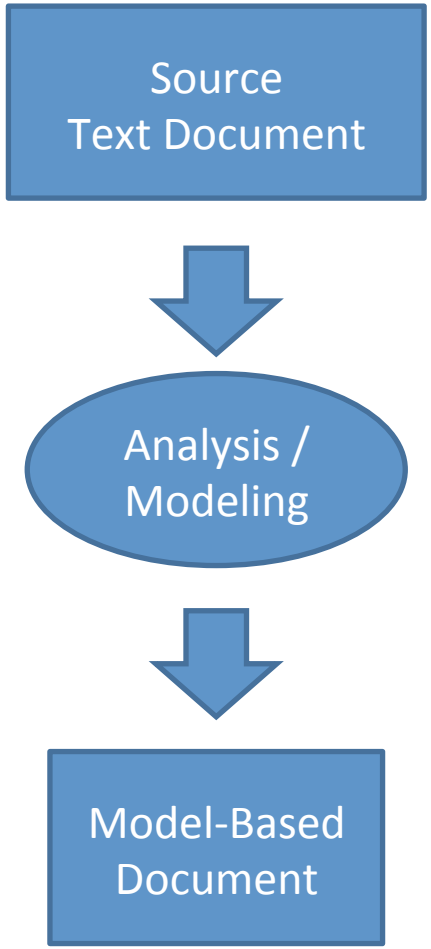
Customer places Widget Order.
Customer handles Widget Manufacturing.
Manufacturer operates Machine Tool.
Manufacturer handles Widget Manufacturing.
Lubricant Quotient Set lubricates Machine Tool.
Lubricant Supplier handles Lubricant Supplying. […]



Tesperanto:

Widget Manufacturing is a process of manufacturing **Widgets** according to **Widget Order** that is placed by a **Customer**. It is performed using **Raw Materials Set** by a **Manufacturer** that operates **Machine Tool**. […]

From text-only to model-based specifications



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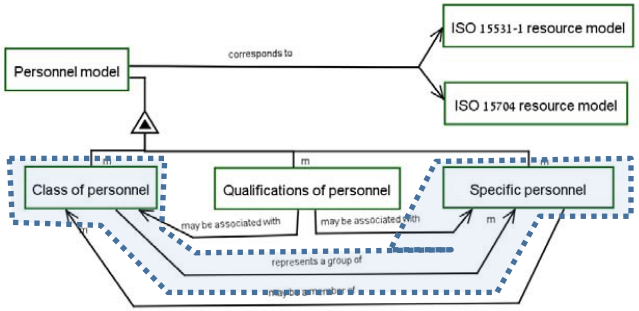
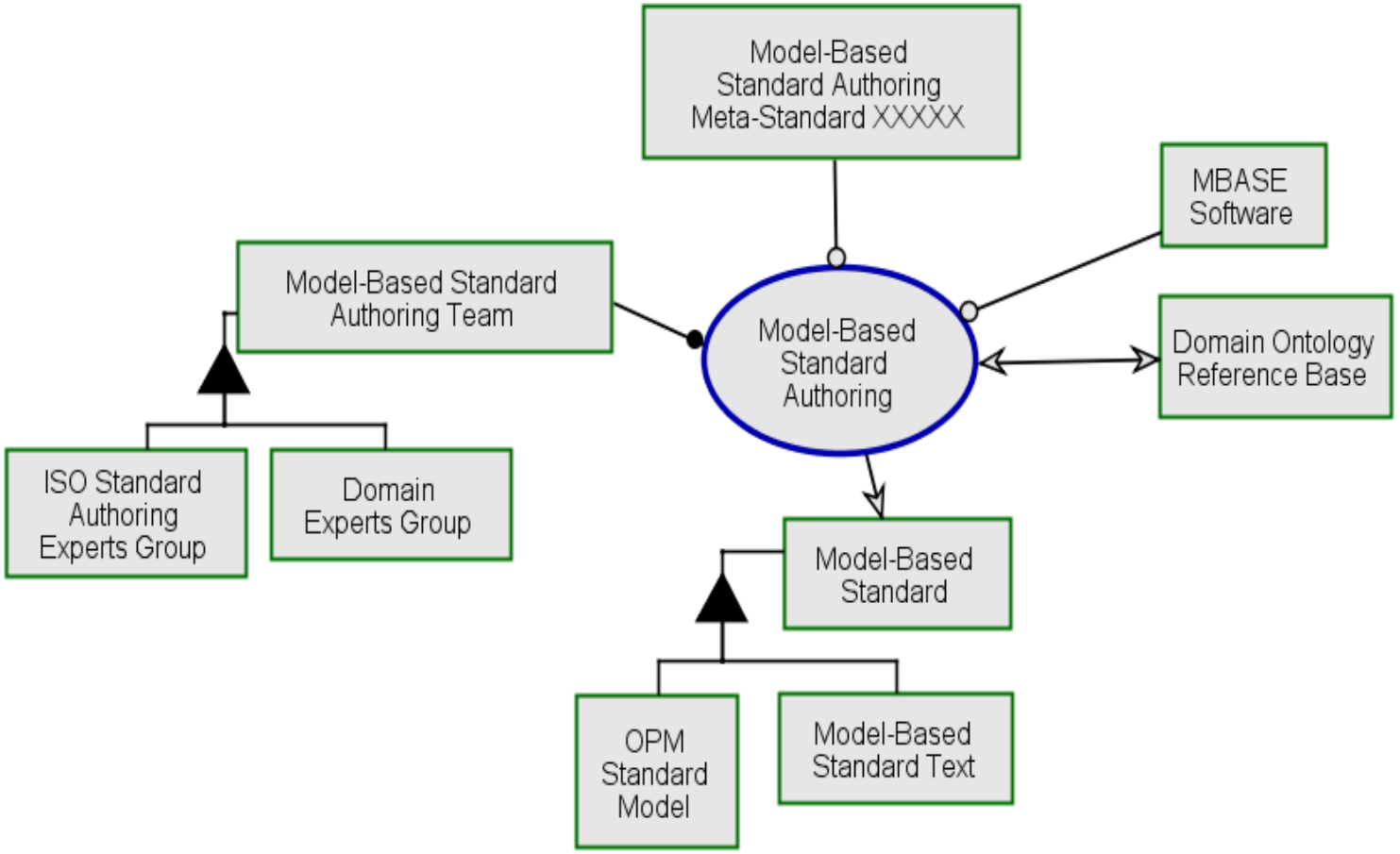


- Personnel model corresponds to ISO 15704 and ISO 15531-1 resource models and contains the information about Specific personnel, Qualifications of personnel and Classes of personnel:
  - Class of personnel represents a group of many Specific personnel.
  - Specific personnel may be a member of many Classes of personnel.
- Qualifications of personnel may be associated with Class of personnel and/or with Specific personnel.

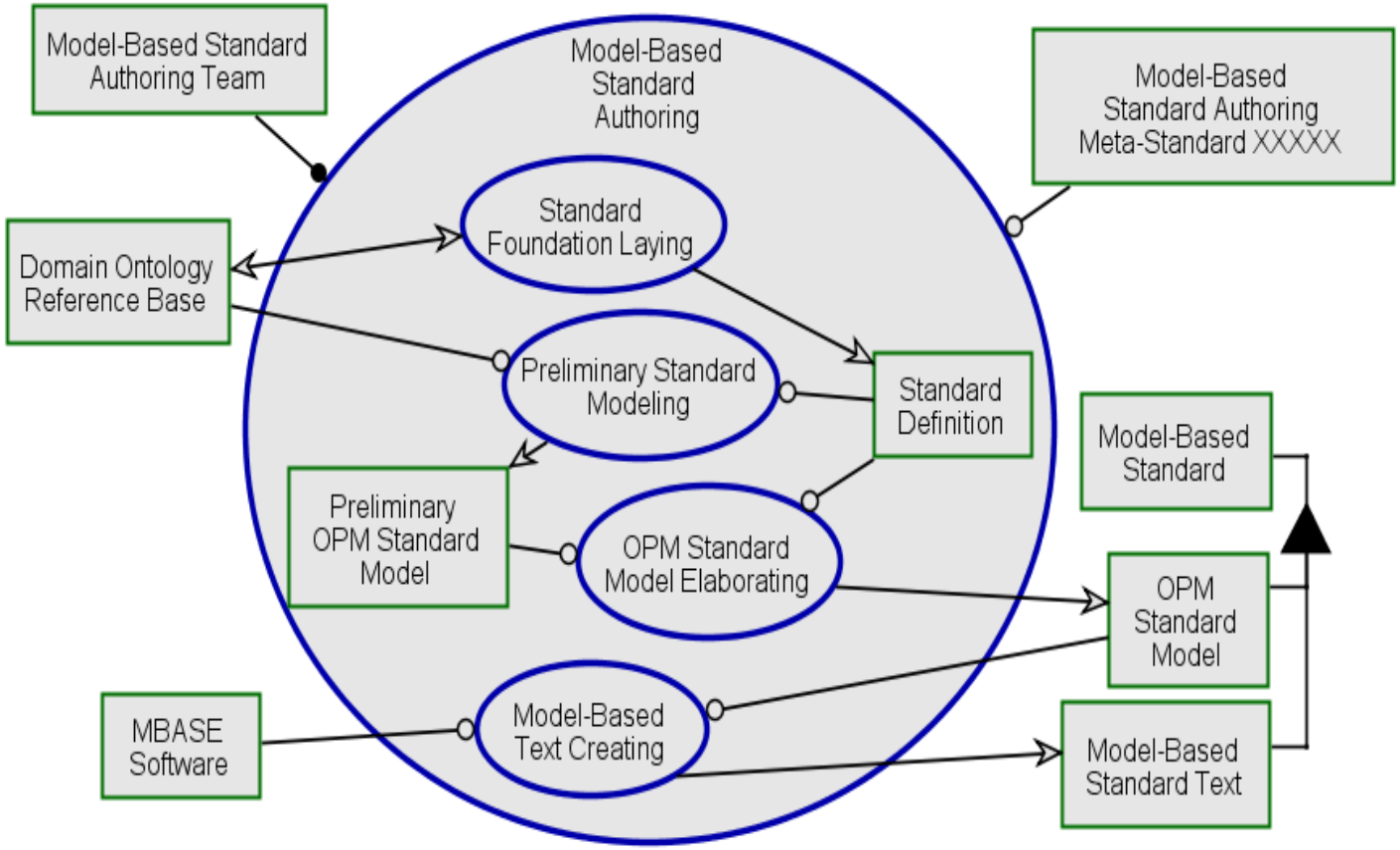
Methodology Application to ISO/IEC 62264

- Identify OPM objects and processes in the text.
- Create a snippet
  - a small OPM model that represents the text element (sentence or paragraph).
- Integrate the snippet with existing snippets
  - gradually building a consolidated model.
- Restate the snippet
  - based upon the consolidated model.
- Form the structured text associated with the snippet.

Model-Based Standards Authoring (MBSA)

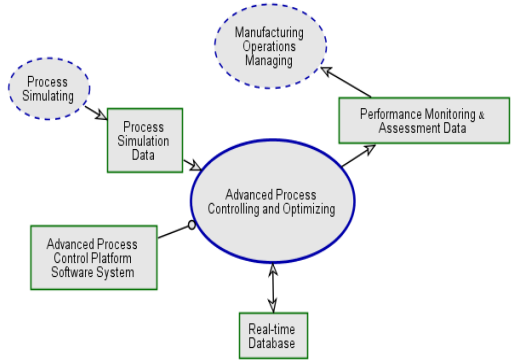


Model-Based Standards Authoring (MBSA) cont.

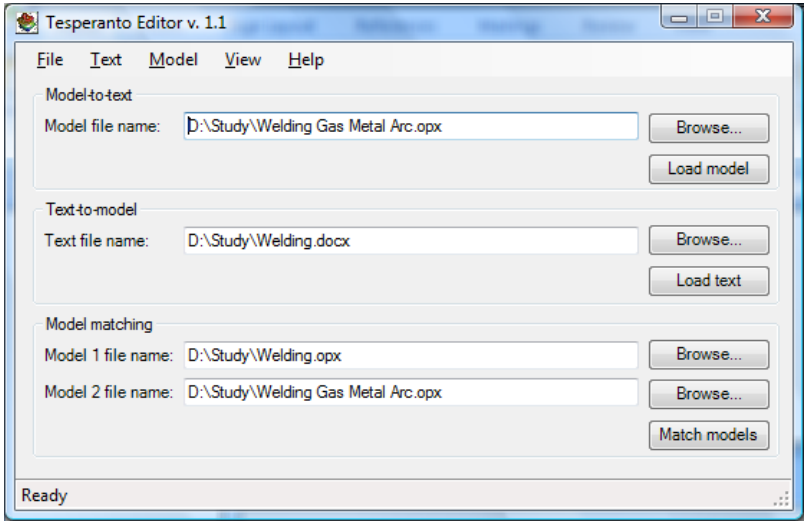


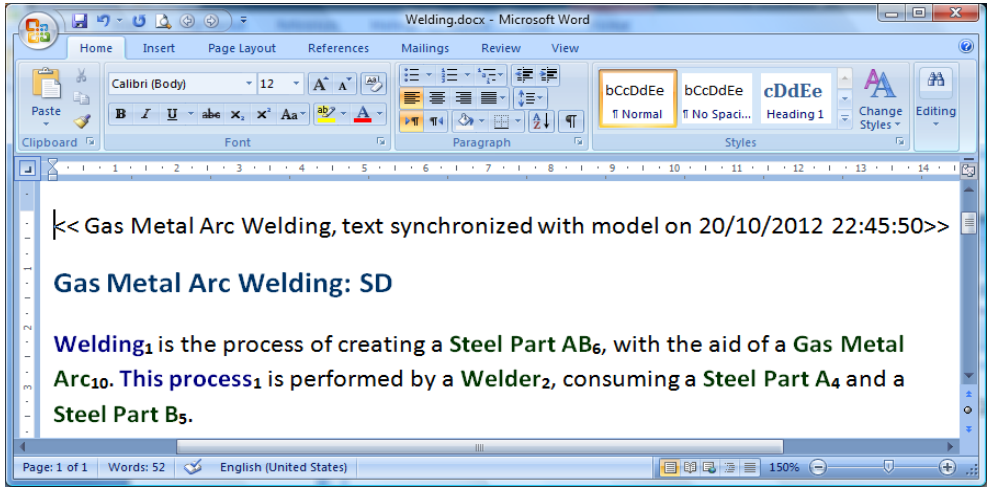
Model-Based Authoring of Specifications Environment (MBASE)

- OPM-to-text translation



Advanced Process Controlling and Optimizing is the process of creating **Performance Monitoring & Assessment Data**, to be used in **Manufacturing Operations Managing**. **This process** is performed with the aid of an **Advanced Process Control Platform Software System**, affecting a **Real-time Database**. **Advanced Process Controlling and Optimizing** consumes **Process Simulation Data**, that is created through **Process Simulating**.





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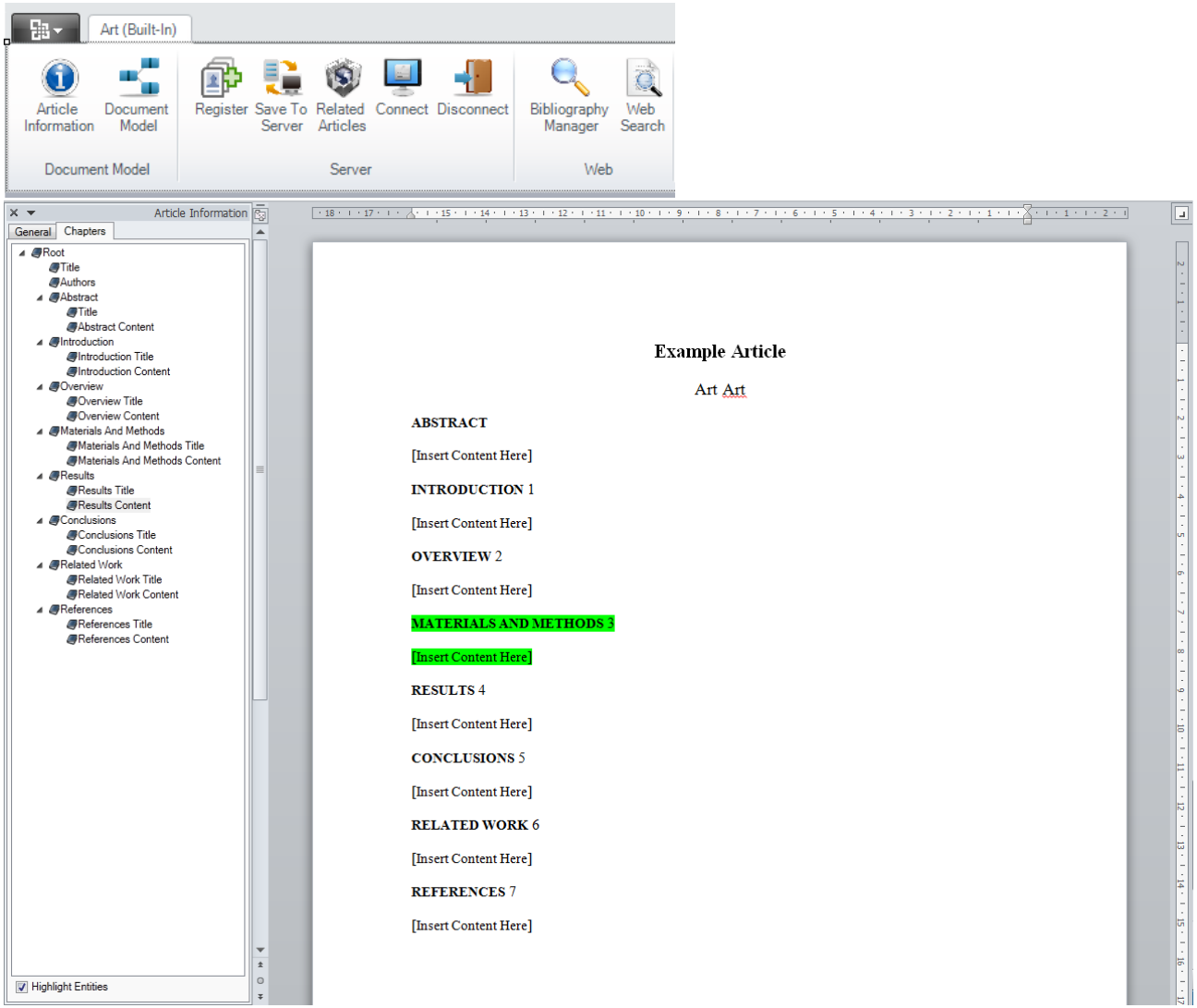
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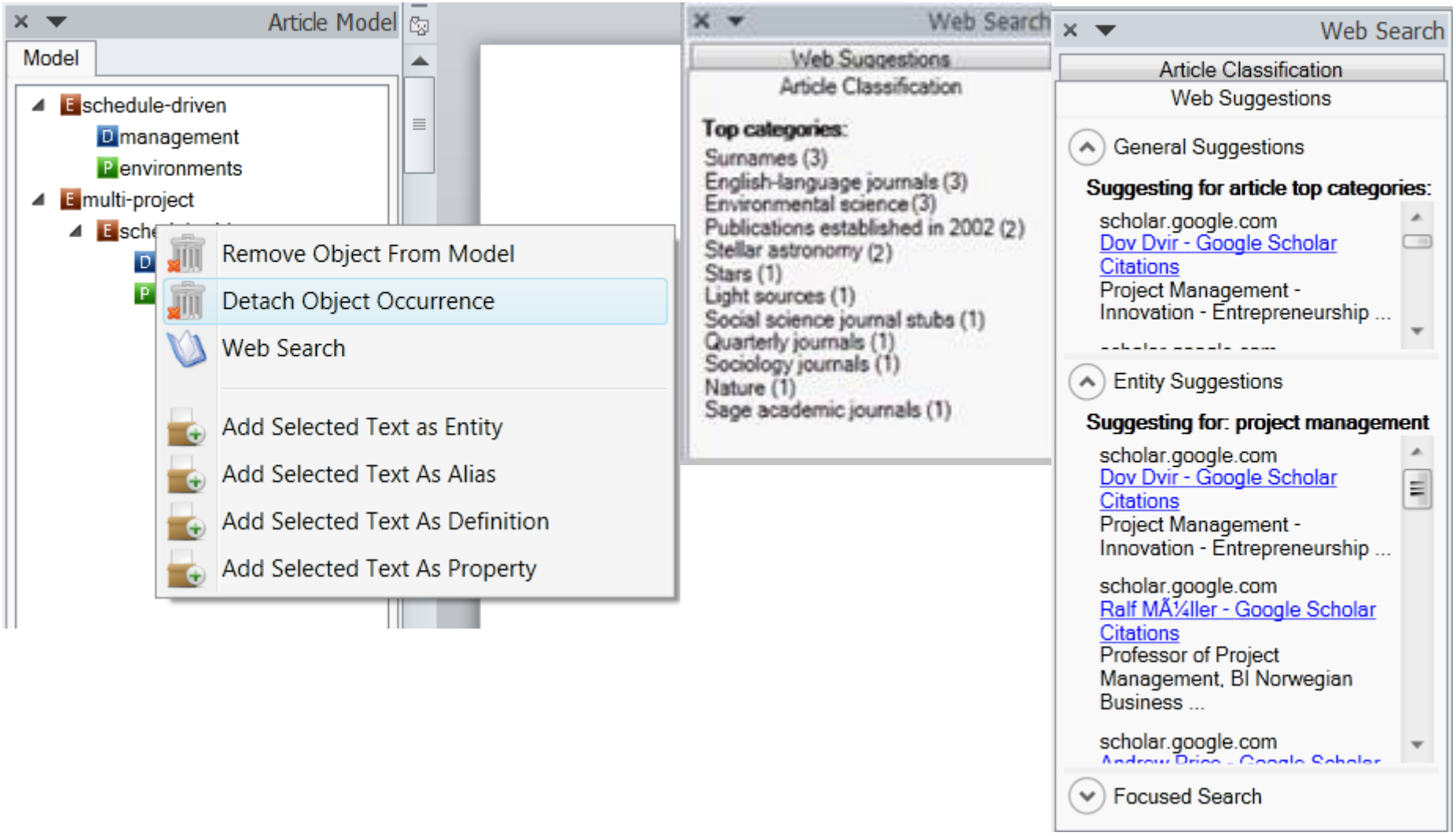

ISO case study as a primary evaluation avenue

- A group of 27 experts from 12 countries, who had expressed interest in participating in OPM SG, took part in online sessions and electronic exchange of documents and models over a period of more than two years.
- During this period, this methodology was applied to several manufacturing, control and enterprise standards, including:
  - IEC 62264,
  - ISO 19440,
  - ISO/IEC 15416,
  - and others

ISO SG experts (partial list)

Country	Name	Organization
Canada	Michael Gruninger	University of Toronto
China	Liu Wenyin	City University of Hong Kong
China	Qing Li	City University of Hong Kong
Great Britain	David Short	IT Focus; Convenor of CEN TC310 WG1
Italy	James Brucato	Palermo shipyard
Sweden	Charlotta Johnsson	Lund University
USA, Israel	Dov Dori**	MIT and Technion
USA	Dave Howes	Silver Bullet Solutions, Inc. San Diego, CA (ret.)
USA	Richard Martin**	Tinwisle Corporation

Evaluation – ISO 15746-1

Advanced Process Controlling and Optimizing is the process of creating **Performance Monitoring & Assessment Data**, to be used in **Manufacturing Operations Managing**.

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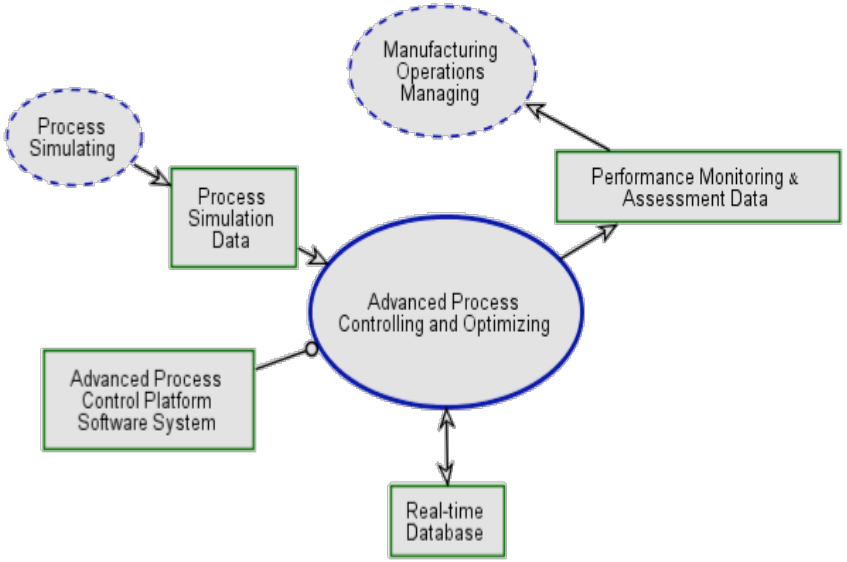
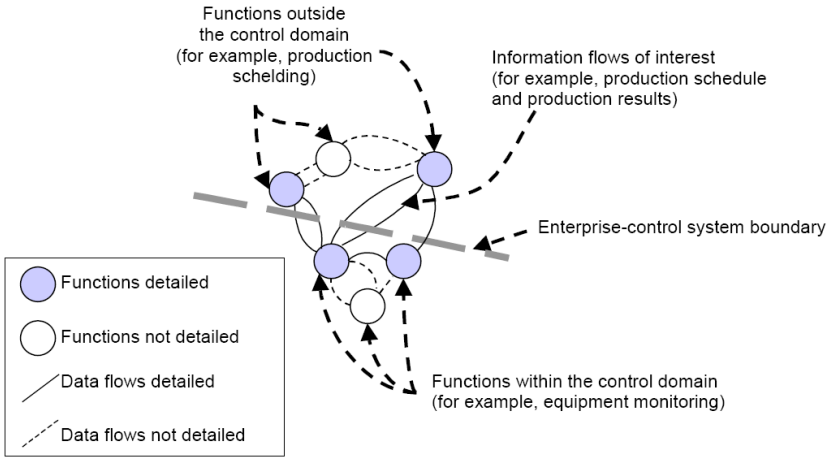


Questions discovered by modeling ISO/IEC 62264 - example

Clause 4, Section 4.1, p. 13:

- "identifying the boundary between the enterprise and the manufacturing operations and control domains (MO&C)"
- The definitions (Clause 3) do not contain the term "*enterprise domain*", only "*enterprise*". Hence the sentence should read:
- "identifying the boundary between the enterprise and the manufacturing operations and control (MO&C) domain"



62264-1/FDIS © IEC(E) – 15 –

Figure 2 – Enterprise-control system interface

ISO TC184/SC5: Case study conclusions

- OPM offers a modeling methodology that can be applied to a wide variety of ISO TC184/SC5 and other ISO and IEC standards.
- OPM advocates top-down refinement beginning at the System Diagram and aligns well with the way standards are structured beginning with a statement of scope.
- OPM models of specific clauses assist in identifying inconsistencies within or between standards.
- Using a modeling language in general and OPM in particular significantly improves the quality and the value of standards.

ISO TC184/SC5: Method limitations

- Learning OPM is not difficult: there is a minimal set of concepts and just one type of diagram that integrates function, structure, and behavior. However, the power of the set of simple concepts means using them well in a wide variety of situations, and this is not a trivial task.
- While OPM models of specific clauses may assist in identifying inconsistencies within or between standards, there seems to be little benefit from the extraordinary amount of effort required to produce OPM models for the entire standard.
- Domain expertise is critical to the preparation of a satisfactory OPM model.
- Domain-specific ontology and practice are implied qualities of a standard that cannot always be overcome without extensive revision.

Summary - novelty and contribution

- MBDA & Tesperanto address the synthesis phase of specification,
  - rather than analyzing existing, possibly confusing statements.
- MBDA uses Object-Process Methodology (OPM) as an underlying formalism
  - capitalizing on the advantage of OPM as a combined method that addresses function, structure and behaviour in a single diagram.
- MBDA contains a procedure for a constrained natural language representation on top of a strict logical backbone
  - as opposed to existing formal notation techniques, that are more mathematics-oriented and less readable by most technical document authors.

Future work & vision

- Model-Based text: underlying formal model
- Text becomes searchable information system
- Semantic web