

# From Machine-Readable to Machine Executable & Verifiable Standards

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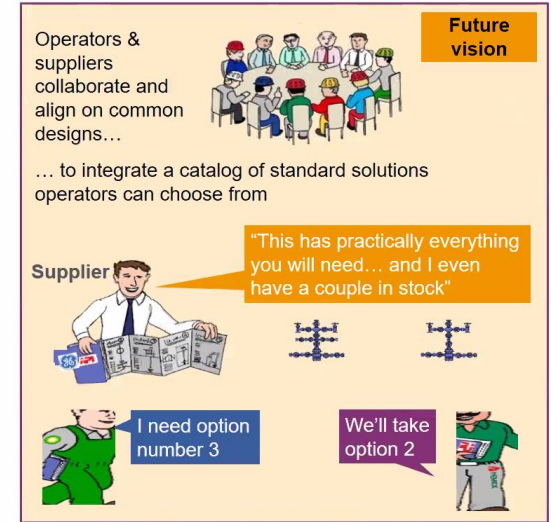


# How to move from here



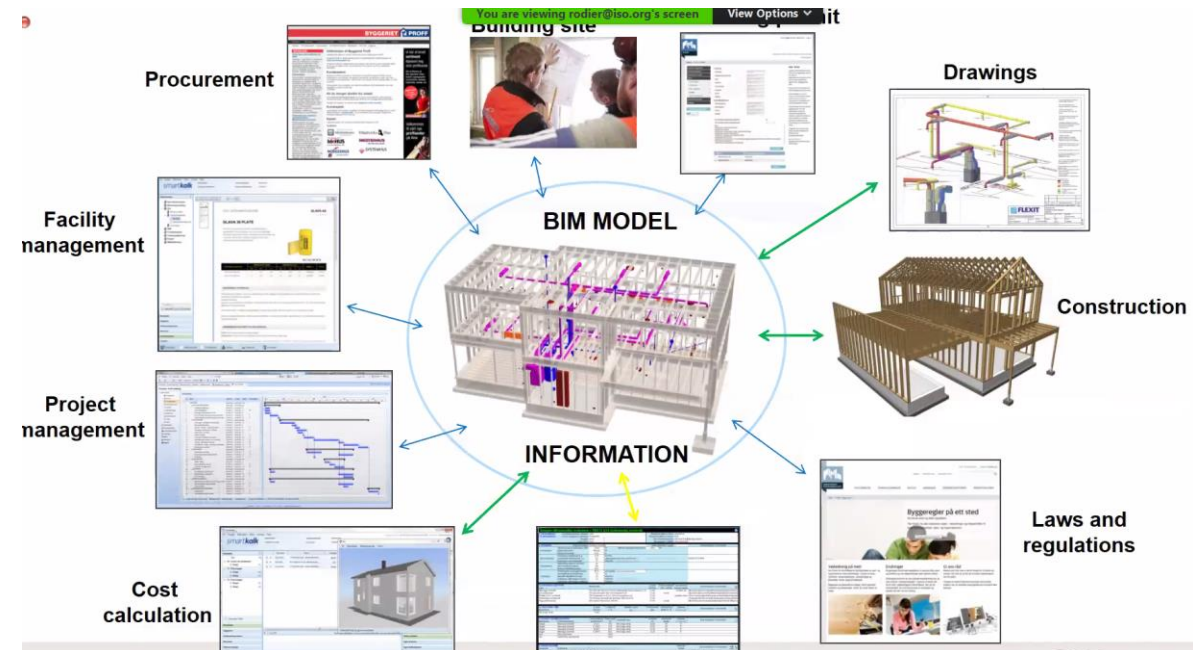
# To here?

## Pre-competitive collaboration



Answer:

- **Model-Based Systems Engineering (MBSE)**
- **Common ontologies**
- **Conceptual modeling**





## **Going from PDF books to data?**

Yes as a first step, but we must go much further:

From






**Text-based documents**

To

**Knowledge-conveying queryable models!**



# Is Step 4 the final one?

Maturity step	Step 0	Step 1	Step 2	Step 3	Step 4
Description	Paper, A4	Open digital format PDF, ODF	Machine readable, as product	Machine readable, as services	Machine interpretable
					
Standards format	Paper	PDF	XML	XML + Business model	Information model

Answer:

- **Not quite; the next ones are**
- **Conceptual & computational model**
  - Bi-modal representation: Graphics and text
  - Execution, automatic verification & validation capabilities



# Principles for producing a new generation of model-based international standards

- 1) Single bimodal graphical & textual model representation
- 2) Tight bidirectional binding between the graphical representations and corresponding textual statements
- 3) Text based on a structured subset of natural language defined via a formal language foundation (EBNF)
- 4) Language substitutability as automatic translations for any natural language using the same universal graphical notation set



# Principles for producing a new generation of model-based international standards (cont.)

- 5) Based on a minimal universal, domain-agnostic ontology, which captures the function structure and behavior of any system, product or service
- 5) Amenable to combined qualitative and quantitative execution and simulations for verification and validation
- 6) Execution in a production environment with end-to-end integration using application extensions.

# Technologies involved in Industry 4.0



**Models must include physical artifacts and their digital twins!**

## SOFTWARE

Smart **Robotics**

Smart **Manufacturing**

**Data Capture (sensors) and analytics**

**Digital Fabrication (3D Printing...)**

**Cloud Computing in Computer Farms**

**Location & navigation services**

**Smart Phones**

**Internet of Things**

**Physical and Digital Twins**

**Autonomous Transportation**

## HARDWARE

**Are we daydreaming?**

**Is this a pie in the sky?**

No! Quite the opposite!

OPM, using ISO 19450, complies with these principles of executable design

N1112 document as an example.



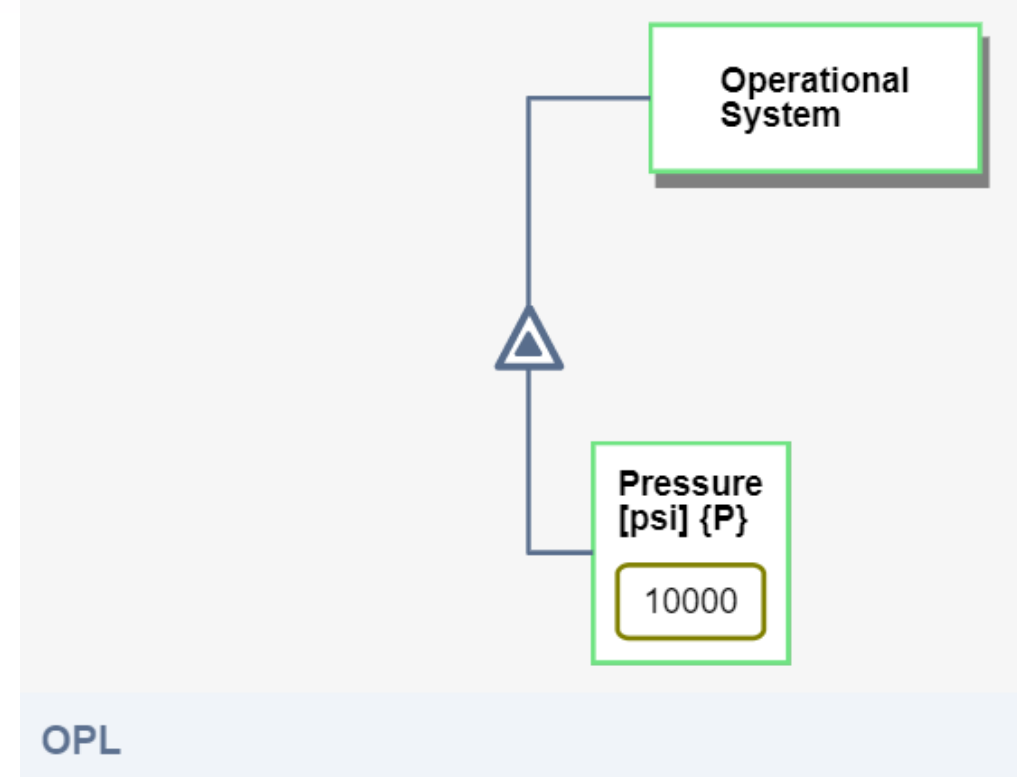


# Requirements are the Key

#	Subject	Verb	Requirement	Condition(s)
1.	The system	shall	contain a pressure of 10,000psi	when installed in the operating environment

**OPM OPCloud model  
with  
auto-generated text**

***Sentence-from-model centric***



Pressure, P, of Operational System is 10000 psi.  
Operational System exhibits Pressure, P,.



# Problematics of Text-Based Documentation

- Currently, standards are based primarily on free **natural language**
- Relying on natural language is inherently problematic:
  - it is a source of ambiguities, omissions, lack of consistency, and possible contradictions both within the text and between the text and the graphics.
- These problems grow with the size of the document and are difficult to track
  - due to the **informal nature of natural languages**,
  - hindering automated verification and validation.



# Model-Based System Specification With Tesperanto: Readable Text From Formal Graphics

Alex Blekhman, Juan P. Wachs, and Dov Dori, *Senior Member, IEEE*

[Alex Blekhman, Juan P. Wach  
Dov Dori, Model-Based System  
Specification with Tesperanto  
Readable Text from Formal  
Graphics. IEEE SMC, 45\(11\)  
pp. 1448-1458, 2015.](#)

- Text is generated ***automatically*** from a ***formal graphical model***.
- Caters to humans' ***dual channel processing*** cognitive assumption (Meyer 2009)

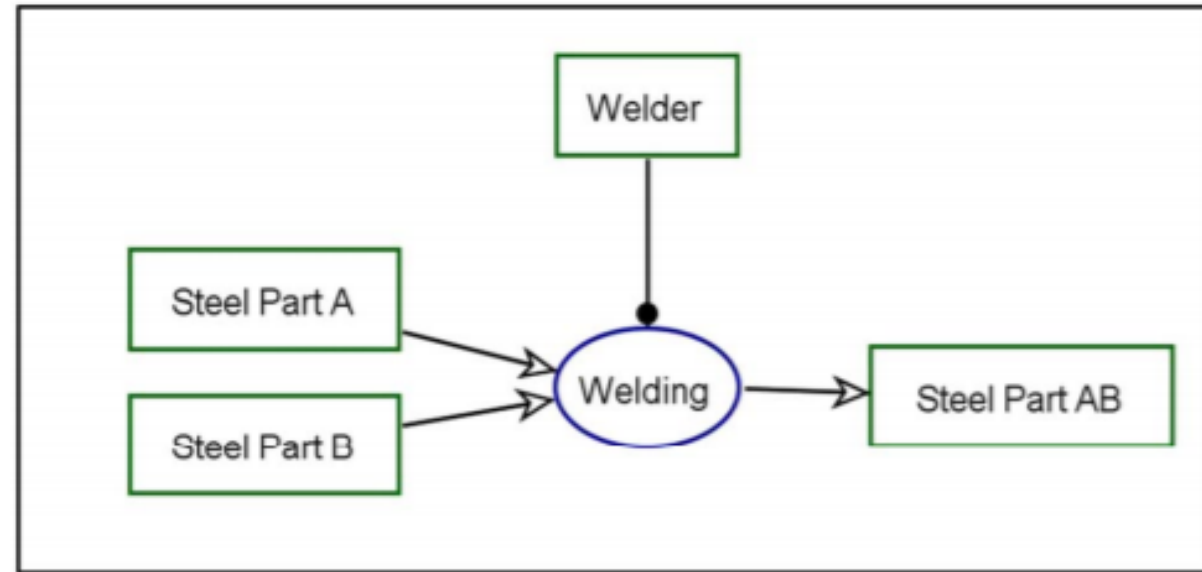


Fig. 7. OPD for a basic welding process.

**Welding** is the process of creating a **Steel Part AB** by a **Welder**. This process consumes a **Steel Part A** and a **Steel Part B**.

Fig. 8. Tesperanto paragraph for a basic welding process.

# Model-Based System Specification With Tesperanto: Readable Text From Formal Graphics

Alex Blekhman, Juan P. Wachs, and Dov Dori, *Senior Member, IEEE*

- Humans need both **text** and **graphics** – they complement each other!
- Text derived from a **formal verified executable** model is **complete, consistent, reliable, queryable ...**

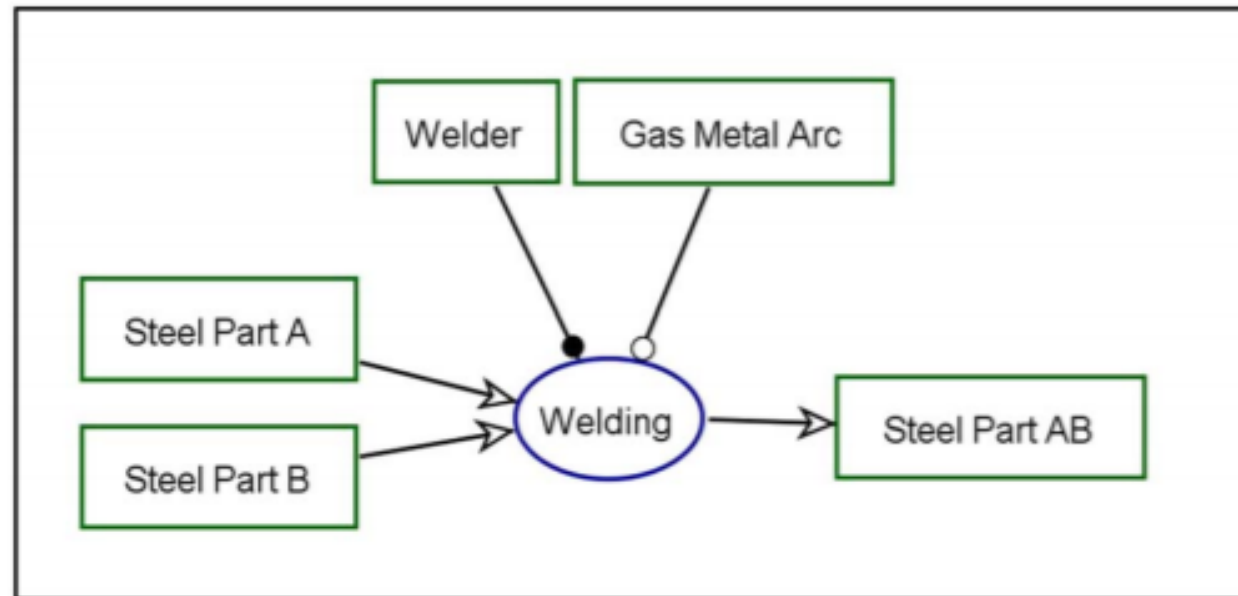


Fig. 9. OPM diagram for welding with a gas metal arc process.

**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**.

Fig. 10. Tesperanto paragraph for welding with a gas metal arc process.



# ISO TC 184 SC5 WG14 Objective

Using **ISO PAS 19450:2015 Object-Process Methodology – OPM** modeling language as a basis for

- Producing **executable standard specifications**

for

- new standards

and

- revision of existing standards



ISO/PAS 19450:2015(en)

# ISO/PAS 19450:2015(en) Automation systems and integration — Object-Process Methodology

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## Foreword

ISO (the International Organization for Standardization) standards bodies (ISO member bodies). The work of pre normally carried out through ISO technical committees.

# OPM – Highlights

- ❑ **Bi-modal visual-textual presentation:**
  - ❖ **OPD – Object-Process Diagram**
  - ❖ **OPL – Object-Process Language**
- ❑ **Complexity management:**
  - ❖ **Things – objects and processes – can be refined to any desired level of detail**
  - ❖ **Via refinement-abstraction mechanisms:**
    - In-zooming – Out-zooming (primarily for processes)
    - Unfolding – Folding (primarily for objects)
    - Expressing – Suppressing (for states)



# ISO TC184 / SC 5 / WG 14

- Formed in June 2019 (in Indiana SC5 Annual Meeting)
- Goal: develop a model-based standard, or ISO directive, for model-based and machine-readable & executable standards authoring,
  - which specifies how to create standards using ISO 19450 OPM model that is translated automatically to a subset of natural language text and provides for execution & validation
- This transformative approach streamlines, formalizes, and explicates the formation of new and existing standards,
  - making them more comprehensive, accessible, usable, and consistent both internally and across each other.





# ISO TC184 /SC 5/SG 5 Presentation

- To accomplish this goal, **ISO TC184 /SC 5/WG 14**
- pursues the following objectives:
  - Prepare a draft of a model-based standard or ISO directive for model-based standards authoring.
  - Itself being the first model-based standard or ISO directive, this model-based document demonstrates, instructs, and directs how to create model-based standards.
  - Work out an example of a standard, currently under preparation, which applies the model-based standard or ISO directive developed in (1), in order to demonstrate the viability and value of the proposed modeling framework and identify problems with the process of preparing model-based standards.



# SG5 document N1112 & Participants

We have prepared WD N1112

WORKING

INTERNATIONAL

TC184/SC5

DRAFT

STANDARD

N1112

## ISO SG5 members

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**Meta-model for model-based standards authoring**

- ISO 19450 Object-Process Methodology (OPM) offers
  - a holistic approach
  - backed by a formal yet intuitive graphic and textual language
  - provides a solid formal foundation for modeling technical standards
- N1112 is a WD for a standard that specifies a method for a Model-Based Standards Authoring
  - significantly reducing inconsistencies
  - a bimodal graphical-textual model representation

## Model-Based Standards Authoring Methodology

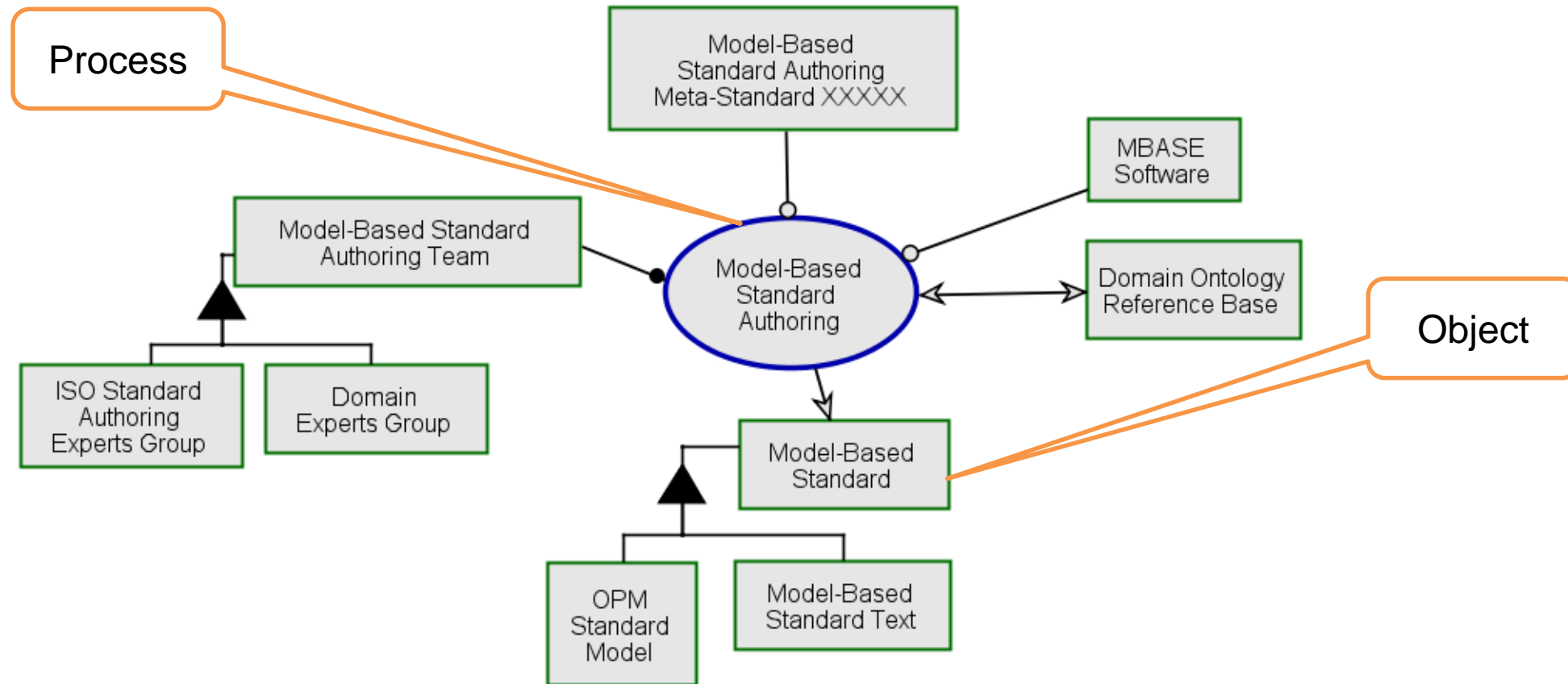


Figure 1. Model-Based Standards Authoring System Diagram (SD)



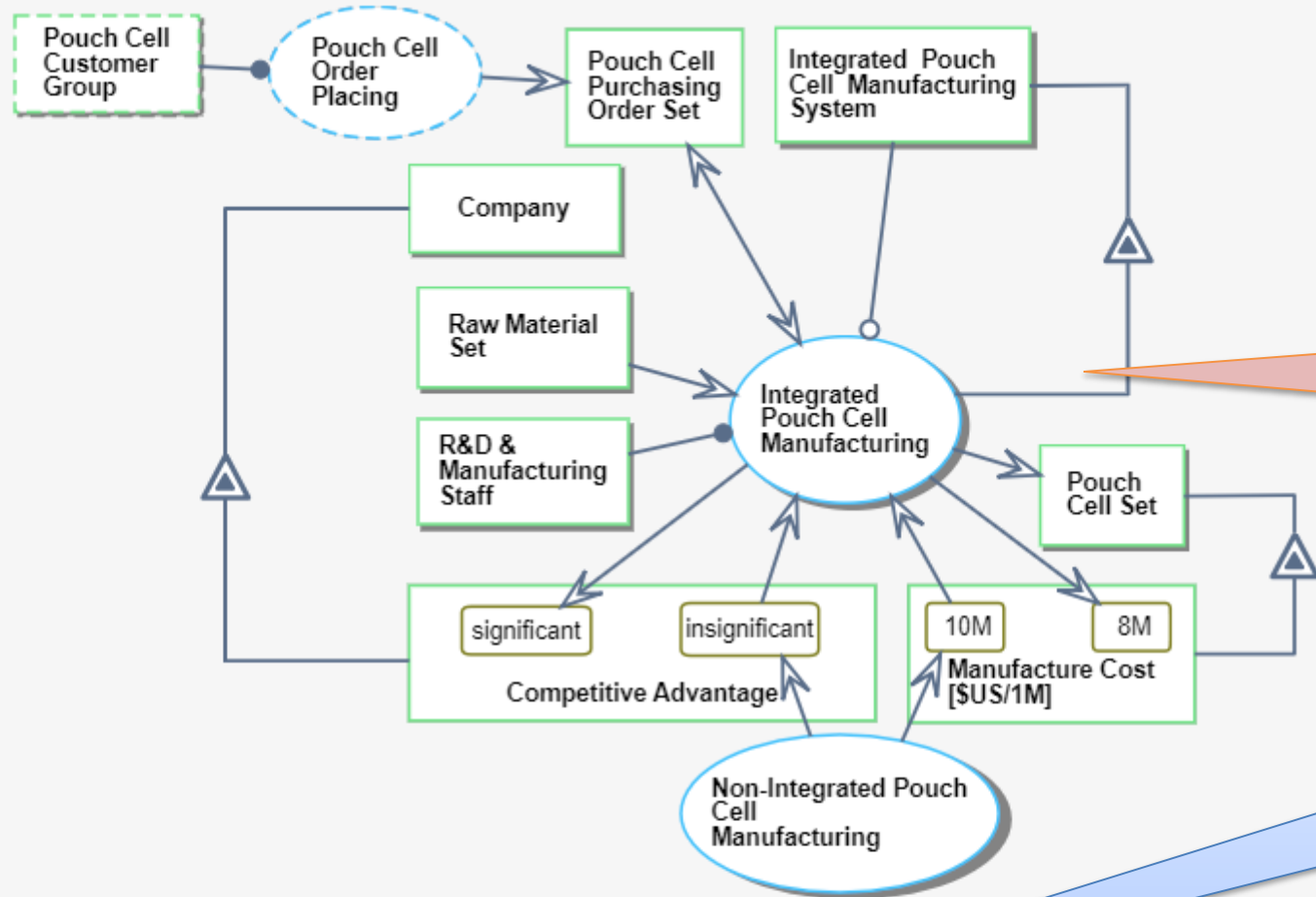
# OPCloud Screenshot

<https://www.opcloud.tech/>

The screenshot displays the OPCloud web interface. At the top, there is a dark blue navigation bar with a hamburger menu icon, the "OPM" logo, and two icons: a green square and a blue circle. Below this is a light blue header area with the text "Model (Not Saved...)" and a settings gear icon. The main workspace is divided into two sections: "SD" on the left and "OPL" on the right. In the "SD" section, a diagram shows a blue oval labeled "Model-Based Standard Authoring" with an arrow pointing to a green rectangle labeled "Model-Based Standard". Below the "OPL" section, a text box states "Model-Based Standard Authoring yields Model-Based Standard." At the bottom, a panel titled "Draggable OPM Things" contains a search bar and two items: "Model-Based Standard" with a green square icon and "Model-Based Standard Authoring" with a blue circle icon.



OPM  
=  
OPD  
+  
OPL



OPD -  
Object  
Process  
Diagram

OPL -  
Object  
Process  
Language

OPL

- Competitive Advantage is informational.
- Competitive Advantage of Company can be significant or insignificant.
- Manufacture Cost [SUS/1M] is informational.
- Manufacture Cost [SUS/1M] of Pouch Cell Set can be 8M or 10M.
- Pouch Cell Customer Group is environmental.
- Pouch Cell Purchasing Order Set is informational.
- Company exhibits Competitive Advantage.
- Pouch Cell Set exhibits Manufacture Cost [SUS/1M].
- Integrated Pouch Cell Manufacturing System exhibits Integrated Pouch Cell Manufacturing.
- Pouch Cell Order Placing is informational and environmental.
- Pouch Cell Customer Group handles Pouch Cell Order Placing.

**Bimodal graphics-text  
representation  
caters to dual channel  
processing**



# In-Zooming – an OPM Refinement Mechanism

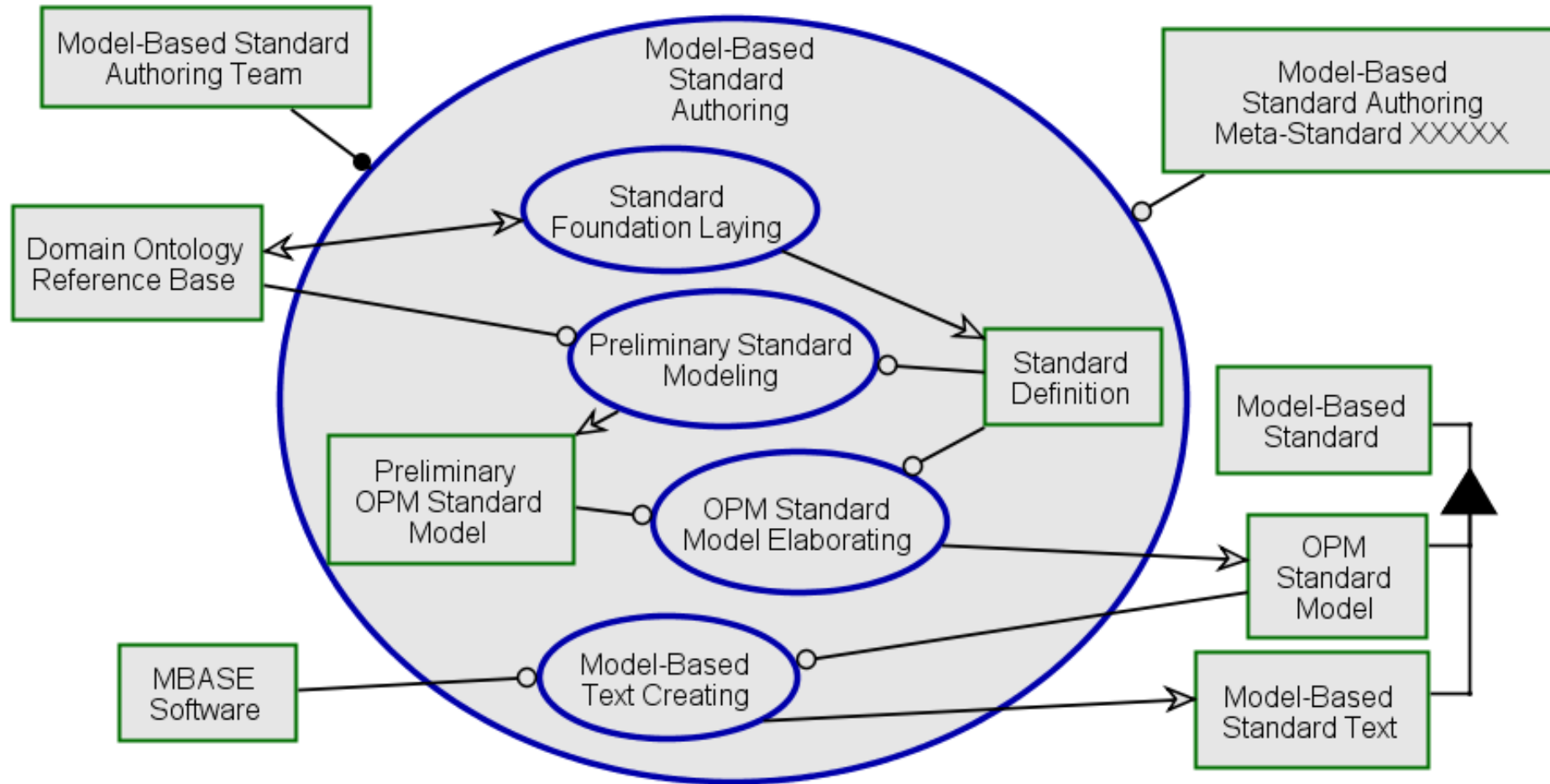


Figure 2. The Model-Based Standards Authoring process in-zoomed



# ISO TC184 /SC 5/SG 5 Presentation

- N1112 contains over 10 additional OPDs specifying the details of the ISO standard creation and approval process.
- The objective of N1112 is two-fold:
  - Specify in a model-based approach how to author and prepare a model-based ISO standard including formalization of pertinent ISO Directives concerning form and format of documents.
  - Constitute a prime example for how the next generation of ISO standards might appear and function.





# Value Proposition to the SAG

Adopt N1112 as a starting point for developing a Machine Readable & Executable ISO standard (or directive)