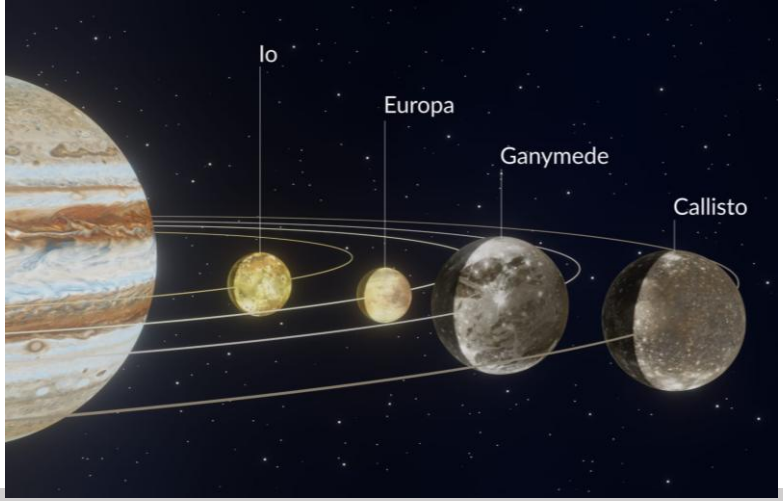
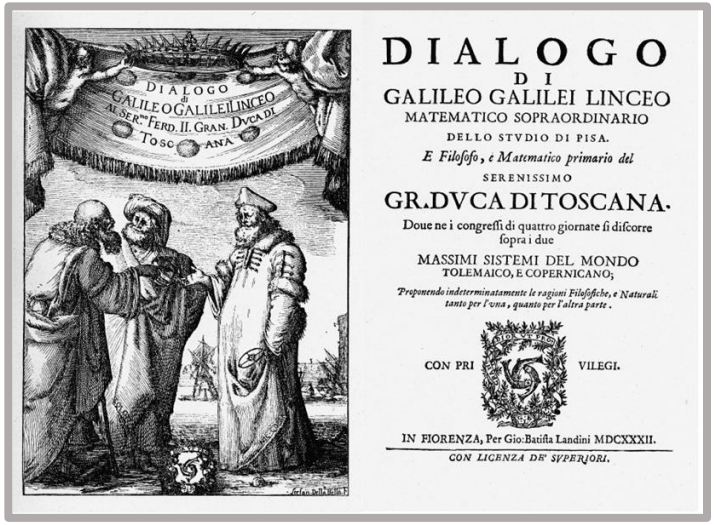


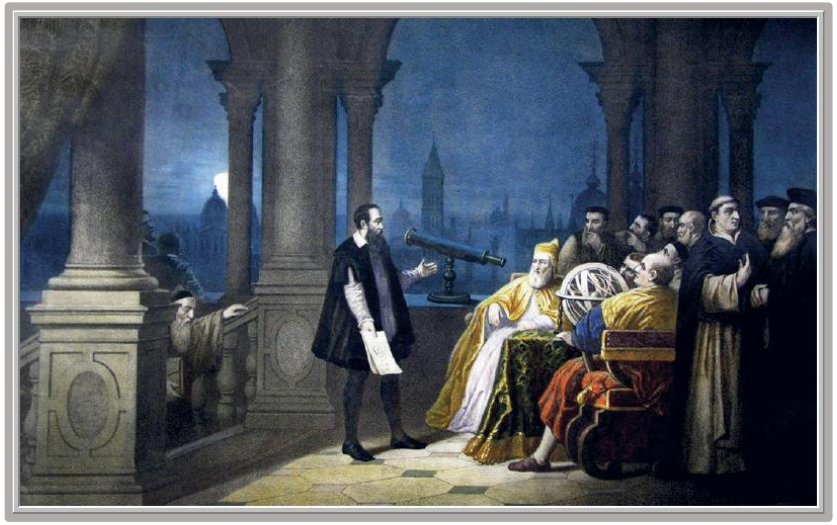


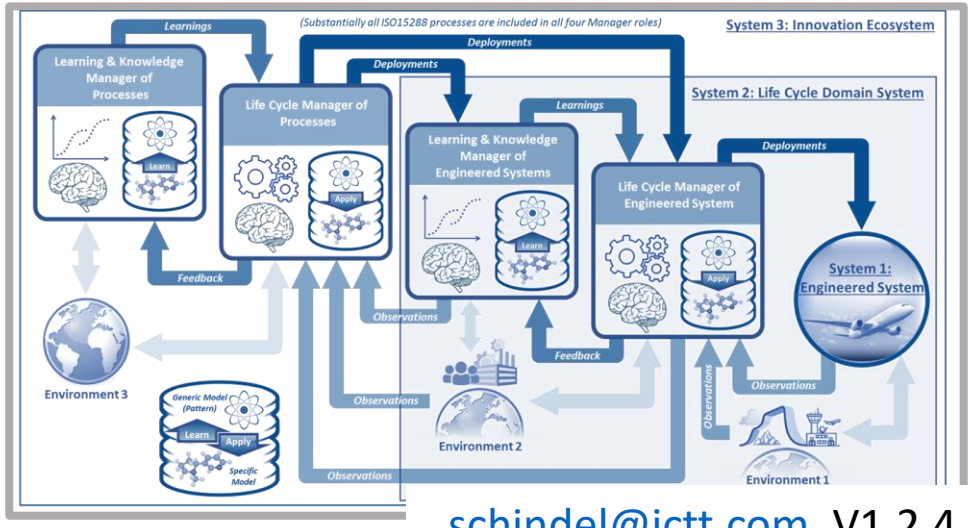


Four Consistencies:

What History and the Consistency Paradigm Tell Us About Planning INCOSE's MBSE Standards Involvement







schindel@ictt.com V1.2.4

Contents

- Purpose and scope
- Currently perceived INCOSE intentions and activities
- Key roles in the “model relationship”
- The Consistencies Paradigm in Systems of Innovation
- Opportunities and risks for INCOSE, the systems community, and stakeholders
- Recommendations
- Questions and discussion

- References

Purpose and scope

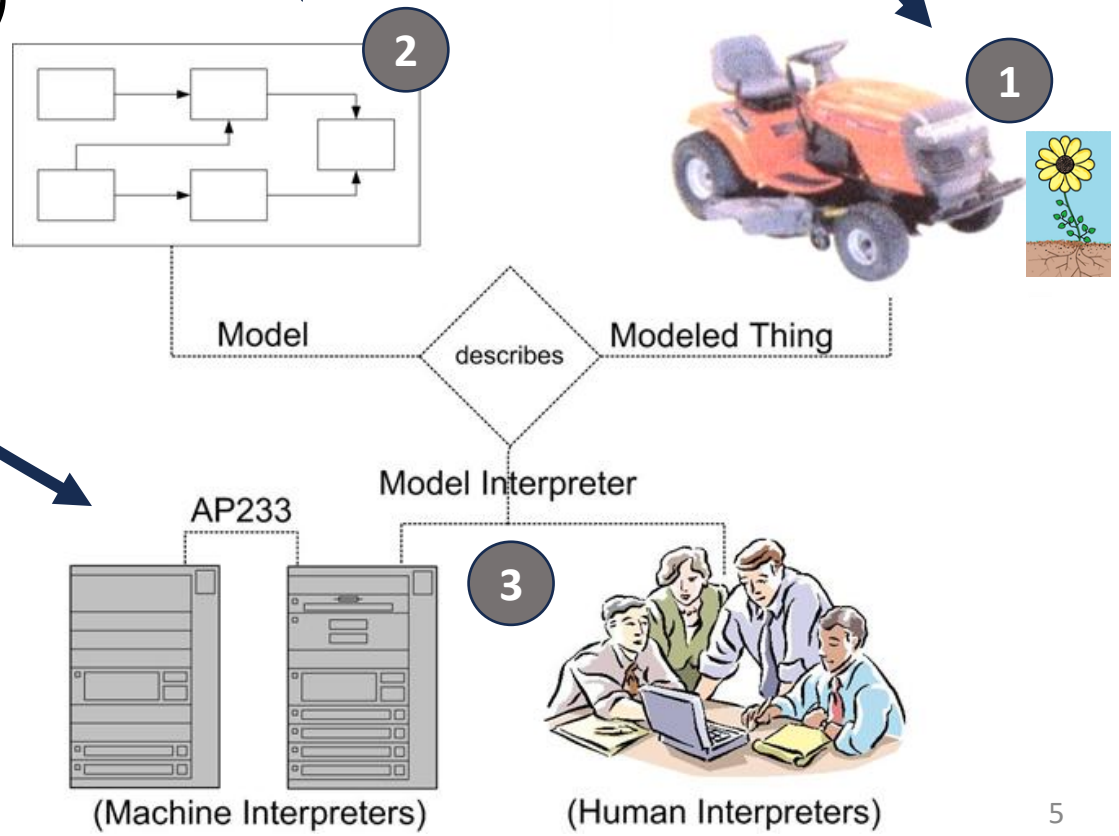
- This material briefly summarizes some *respectfully offered cautionary advice* about INCOSE's current planning for additional strategic involvement in standards related to Model-Based Systems Engineering (MBSE).
- Overall, the advice offered is intended to *encourage, not discourage*, strengthened positioning of INCOSE in this space; however, . . .
  - It includes a few cautions on certain "details" that seem to the author to put INCOSE, the systems community, and our stakeholders at risk of negative strategic outcomes--if the issues noted are not addressed.
- Detailed expertise in MBSE is not essential to understand the thrust of the following material.
- References also cited to historical and technical resources. "[ ]"

Currently perceived INCOSE intentions and activities

- Perceived INCOSE intentions:
  - At the parent society level, there is a strategic intention and evolving plan for INCOSE to take a larger and recognized role in SE related standards, including those applicable to MBSE. [1]
  - We think this is a good idea.
- Perceived current activities:
  - Some INCOSE working groups and industry players are in early efforts working toward Digital Engineering/MBSE related standards frameworks. [2]
  - This includes connection to / building on existing and emerging resources. [3]
  - We think such “getting organized and underway” can be a good thing, but are concerned about some implications described in the following . . .

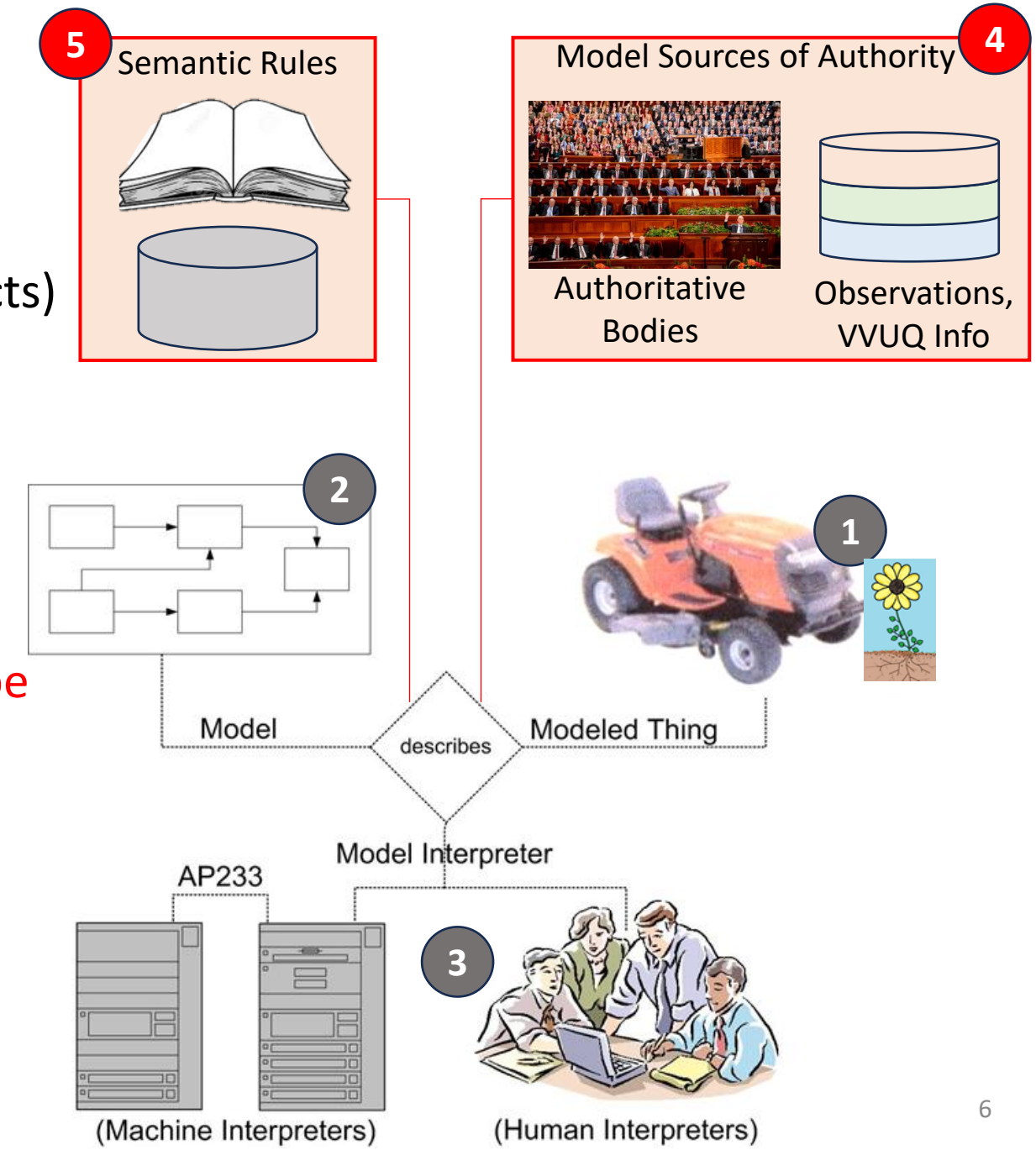
Key roles in the “model relationship”

1. The *Modeled Thing* (AKA the System of Interest)
2. The *Model* (describe some Modeled Thing aspects)
3. The *Model Interpreter* (human, machine, both)



There are also *two other roles:*

1. The *Modeled Thing* (AKA the System of Interest)
2. The *Model* (describes some Modeled Thing aspects)
3. The *Model Interpreter* (human, machine, both)
4. The *Model Sources of Authority* (why, and with what certainty, is the Model to be believed, as representative of the Modeled Thing?)
5. The *Model Semantic Rules* (how is the model to be interpreted, by people and machines? *meaning*)



The Consistencies Paradigm in Systems of Innovation

- *At the heart of engineering and innovation* are both formal and informal efforts to "align" needs, opportunities, requirements, designs, conceptual frameworks, standards, methods, tooling, etc.
- Efforts to "manage the consistency" of these help us steer efforts, manage risk, and award confidence in new learning. [4]

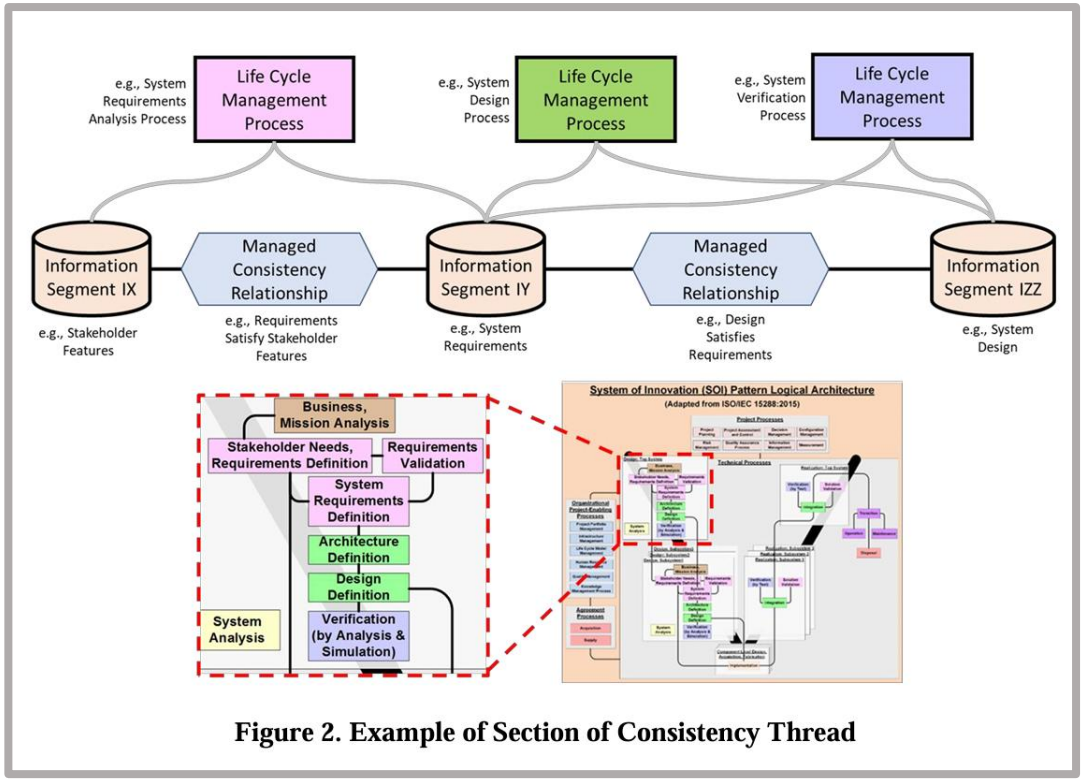
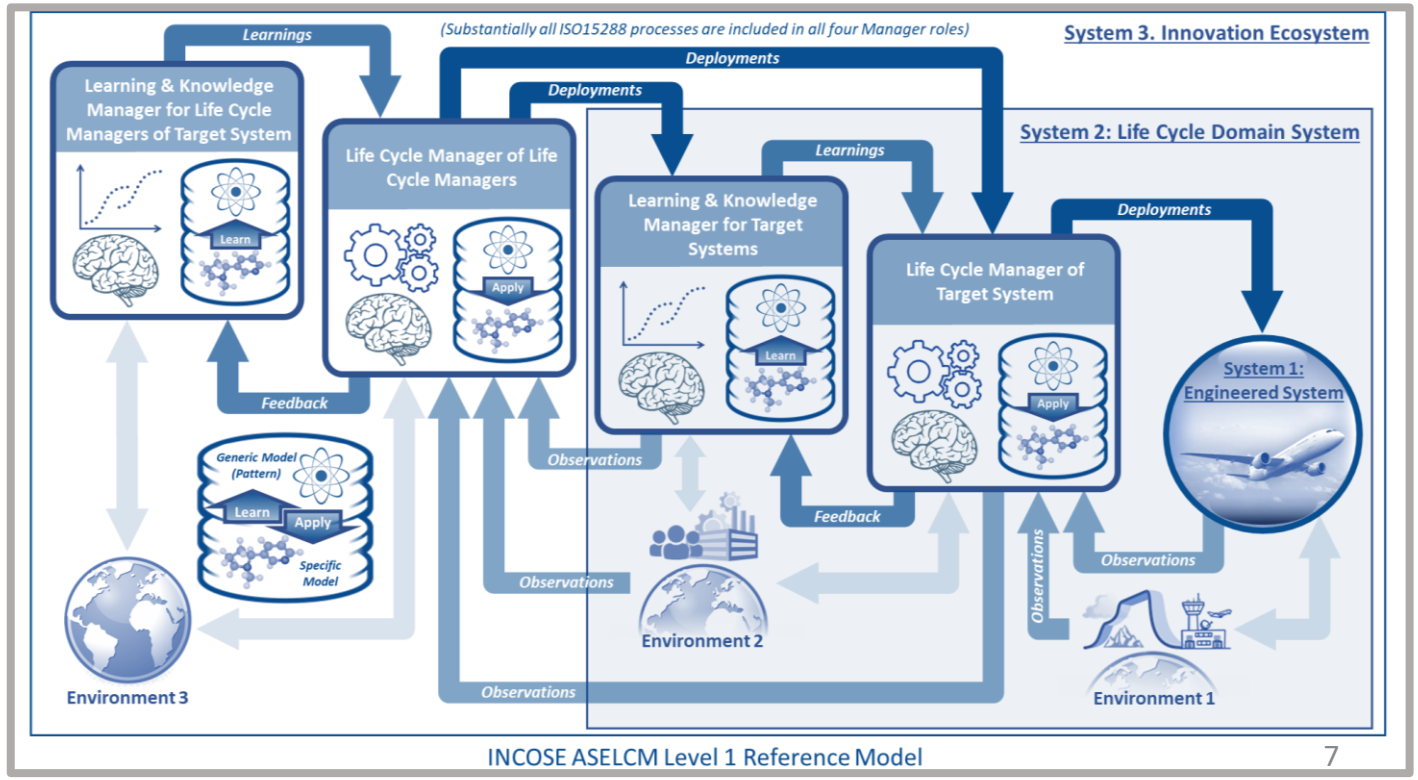
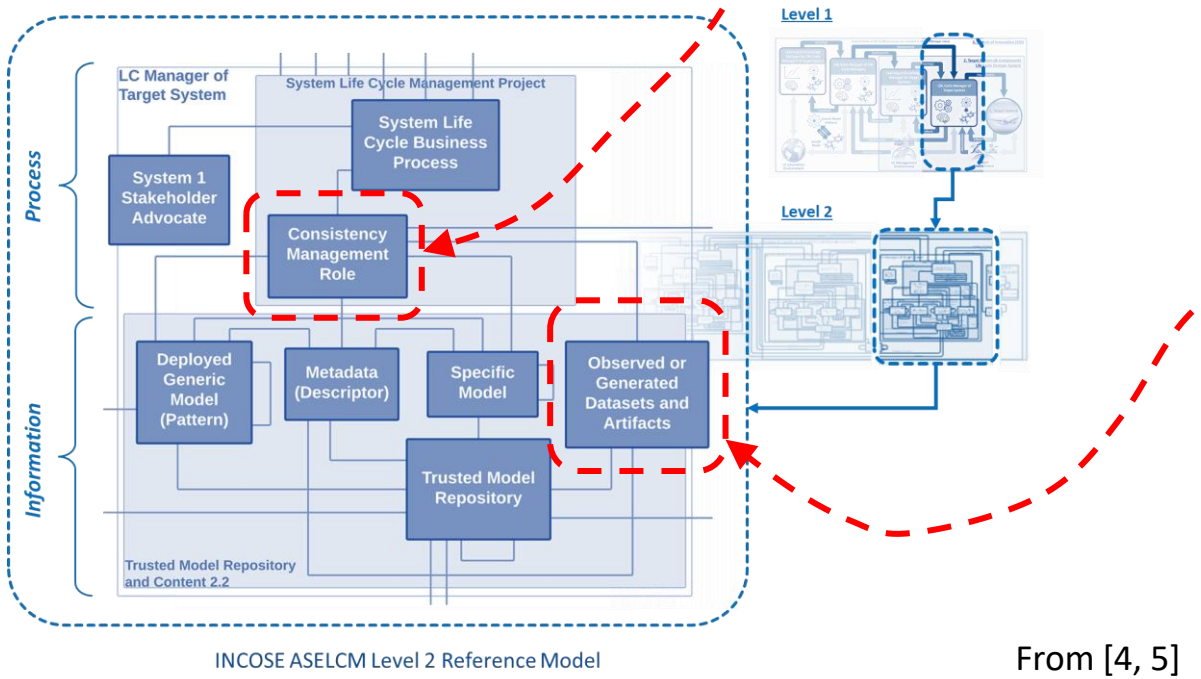


Figure 2. Example of Section of Consistency Thread



INCOSE ASELCM Level 1 Reference Model

The Consistencies Paradigm in Systems of Innovation



INCOSE ASELCM Level 2 Reference Model

From [4, 5]

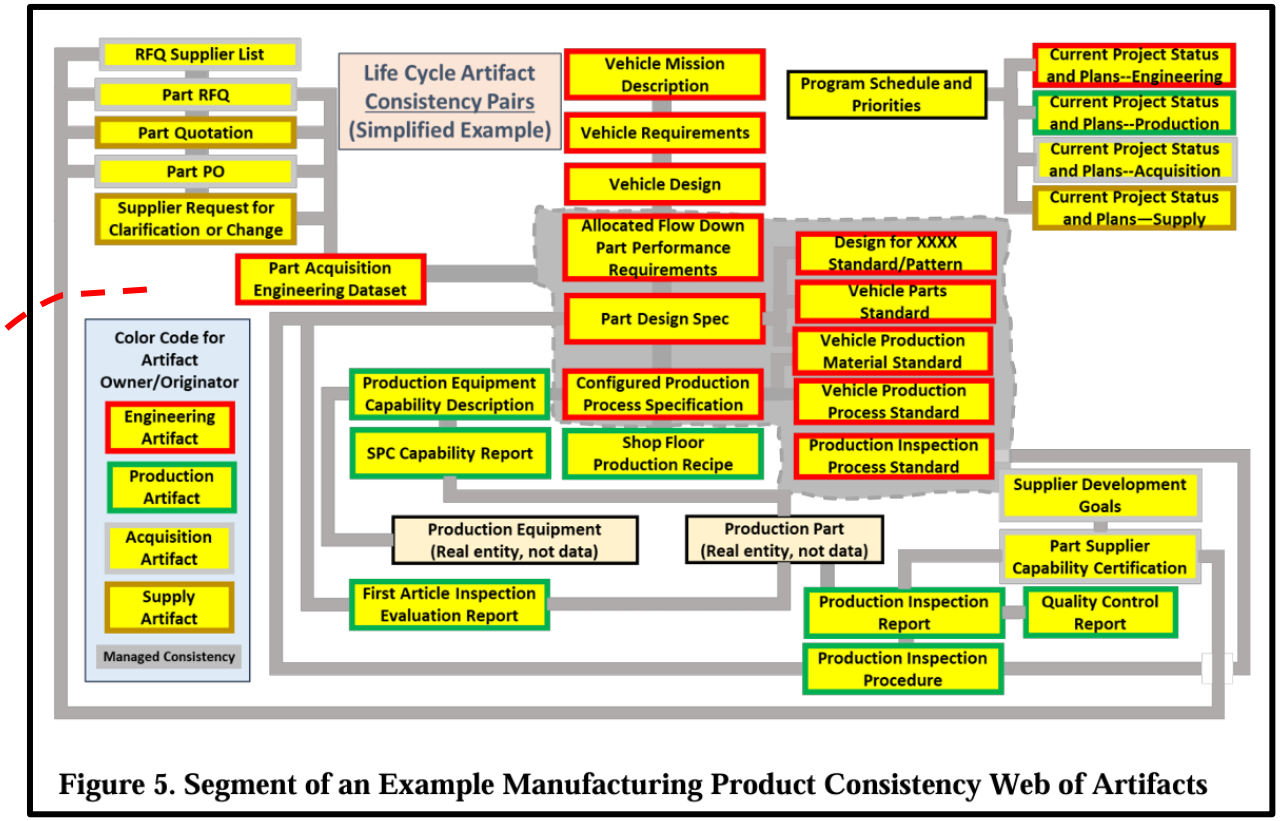


Figure 5. Segment of an Example Manufacturing Product Consistency Web of Artifacts

Innovation Ecosystem Dynamics, Value, Learning II: Can V&V Frameworks Tell Us More?

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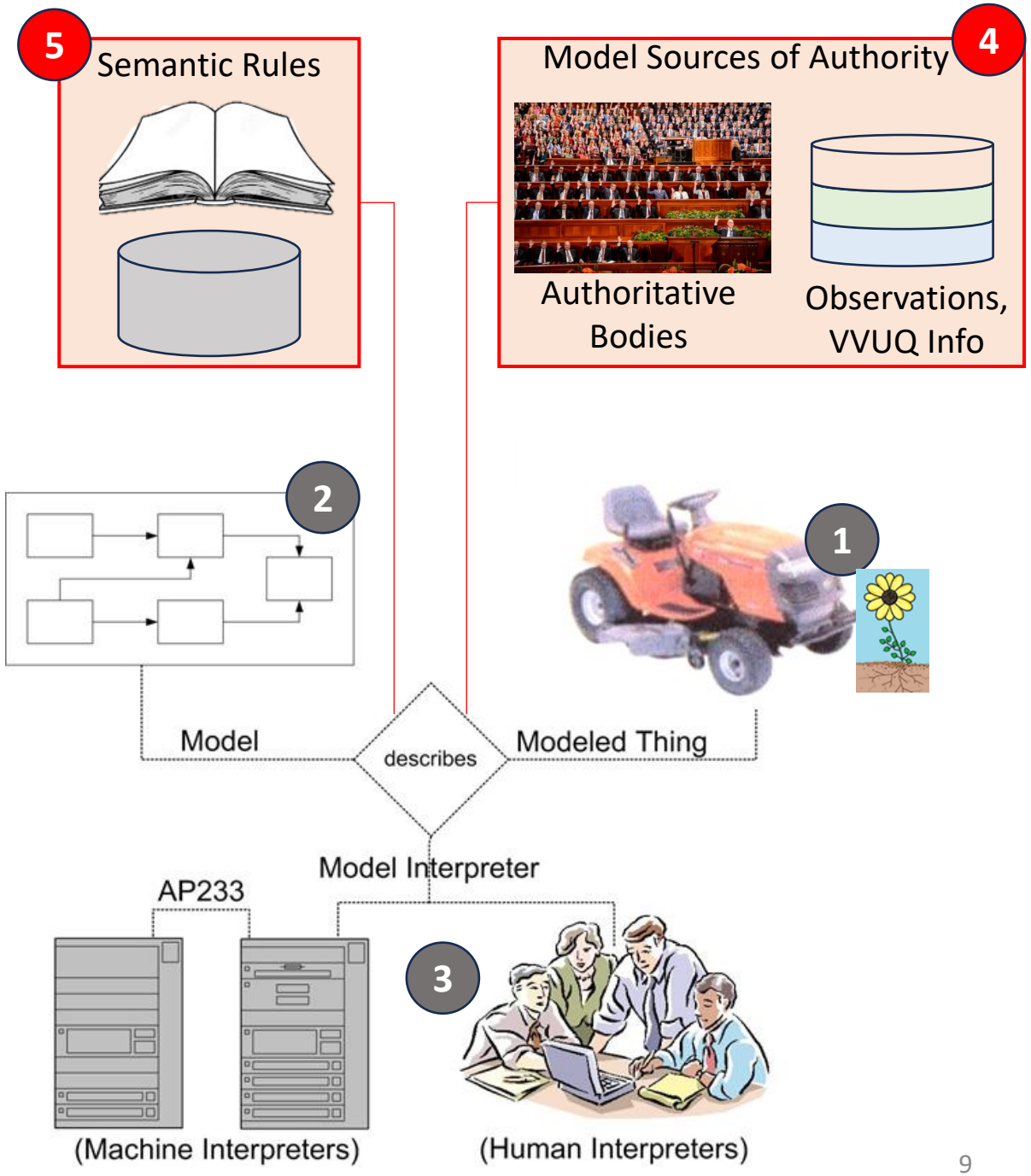
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Abstract. Can innovative system projects deliver faster, while also increasing earned confidence in the face of risk? This is not only a question of organizational paradigms, methods, and management—if we "push the envelope" far enough, it also begs the question of foundational limitations on underlying

Of particular concern are risks related to certain types of "managed consistencies":

4. The *Model Sources of Authority* (why, and with what certainty, is the Model to be believed, as representative of the Modeled Thing?)

5. The *Model Semantic Rules* (how is the model to be interpreted, by people and machines? *meaning*)

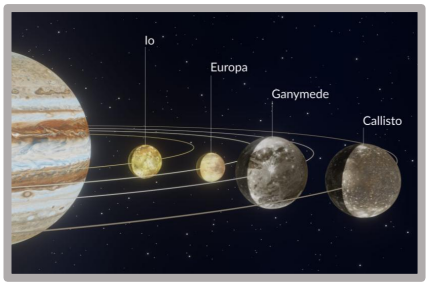


Opportunities and risks for INCOSE, the systems community, and its stakeholders:

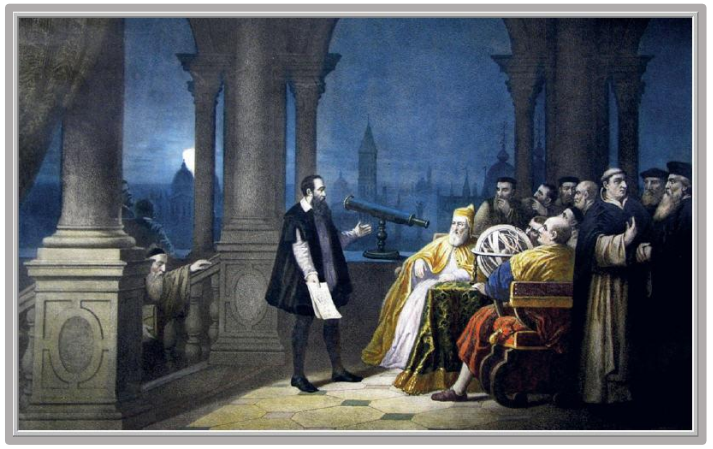
Focused on four consistencies:

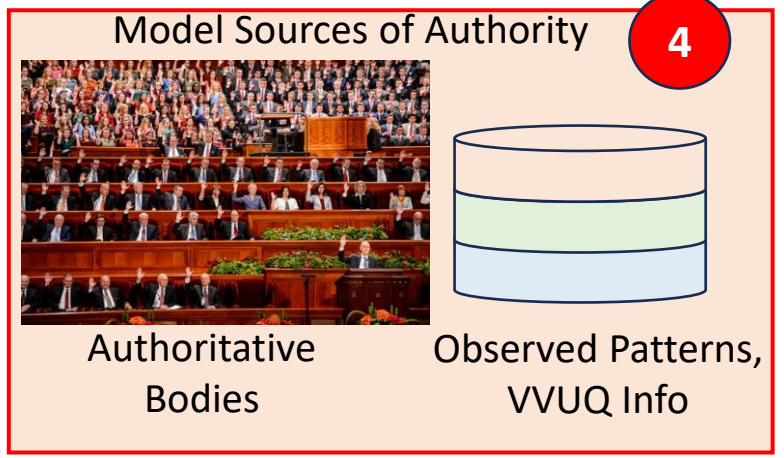
- Sources of authority:
  1. Consistency of models with human authoritative bodies
  2. Consistency of models with STEM observable / extracted patterns, VVUQ [6]
- Conceptual semantic frameworks:
  3. Consistency of models with static ontological frameworks at levels below the phenomena they describe.
  4. Consistency of models with dynamically evolving ontological frameworks, based on new phenomena arising from larger scale interactions.

Risk 1: Unbalanced emphasis on the model sources of authority









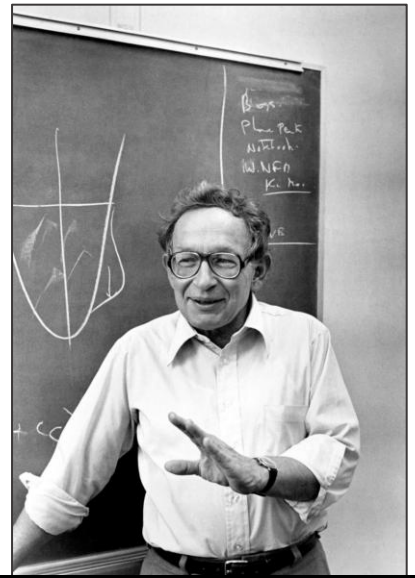
- After thousands of years of slower progress, the STEM Revolution of 1700 - 2000 dramatically advanced the experience and possibilities of human life on Earth, at a greatly accelerated rate not previously encountered.
- Central to this acceleration was STEM's rebalancing of Sources of Authority, from authoritative human entities to increased observation of the natural world and extracting the STEM patterns of natural sciences—the physical laws. [7]
- A worrisome sign is heavy INCOSE emphasis on jockeying for position across working groups, external bodies, etc., characteristic of Authoritative Bodies, . . .
- . . . instead of balance with emphasis on STEM-oriented observation and pattern-extraction as the basis for VVUQ-supported trust.
- Historical reference on this struggle: Galileo--"Dialogue On Two World Systems" [8]
- This is also represented in the present "non-STEMy" state of practice of many MBSE models.

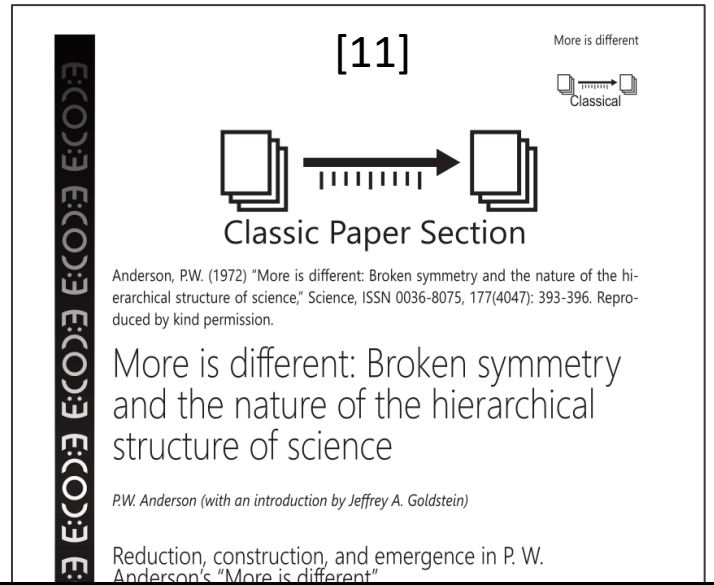
When have authoritative bodies worked well?

- Information system standards for engineered network protocols and database structures, agreed upon across cooperating user entities or set by government:
  - TCP/IP for underlying internet layers
  - HL7 application protocol in health care
  - New Distribution Capability (NDC), by International Air Transport Association (IATA)
  - Providing persistent memory of physical sciences discoveries (e.g., periodic table)
- When were authoritative bodies incorrect or troubled?
  - Copernican Revolution (observation eventually overcame authority)
  - Recognition that COVID-19 can be airborne transmitted (eventually by observed experiment)
  - When the public comes to distrust warring scientific establishments (e.g., climate sciences) [9]
- Notice that a balanced combination of both can be more powerful:
  - Bayesian methods "optimally" mix [what we have newly observed] + [earlier knowledge].
  - However, a STEM basis for socio-technical systems is in its earliest days. [10]

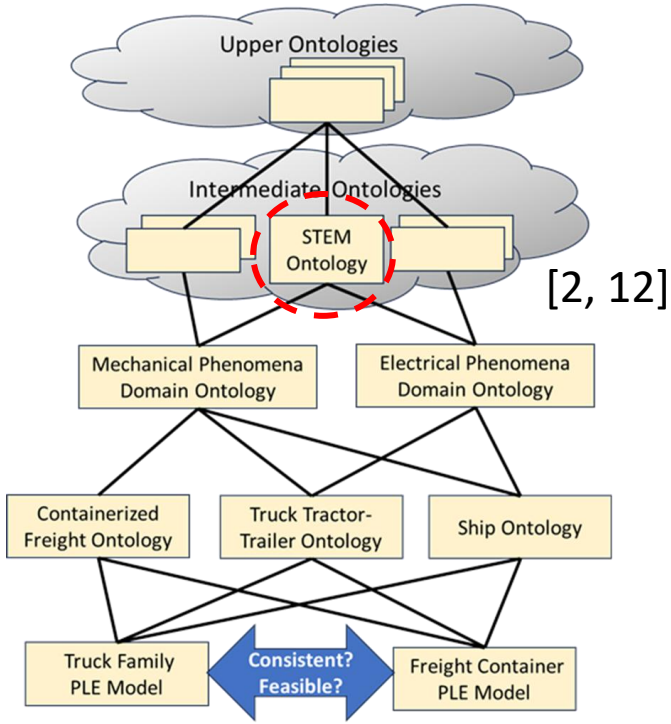
Risk 2: Partial understanding of the model semantics challenge

- Interoperability of tools across the work of multiple people/organizations is not simply achieved by use of a shared ontology—witness two teams working on interacting subsystems.
- Feasibility of modeled systems is not promised by representing them in a consistent ontology.
- Ontologies shift at the rate of introduction of newly emergent interactions, causing new phenomena: Historical reference: P.W. Anderson--“More Is Different” [11]
- The semantics of a model are not the same as the semantics of the ontological framework in which it is encoded.
- Not including a STEM Ontology diminishes/abandons STEM in SE.









- Nobel Laureate P. W. Anderson's "More Is Different" [11] pushed back in 1972, when the trend across fundamental particle physicists suggested that learning the fundamental phenomena would be sufficient to explain the higher-scale emergent phenomena (e.g., chemistry, biology, ecology, weather).
- Anderson explained that emergent phenomena (arising from interactions at lower levels) can be combinatorially new and unique, delivering unexpected phenomenological behaviors.
- Such emergent phenomena bring with them emergent ontological frames, so that in the same way we cannot predict future ontologies from those we know now—we can only get more practiced at adapting dynamically to the adoption of new phenomena/ontologies, as agile learners.
- As our engineered systems' scope increases, new interactions surface and new ontologies are needed.
- And, more basically, even ontological agreement does not prevent subsystem modelers from creating incompatibilities between their subsystem models that use the same ontology.

Recommendations

1. Goal: Correct the observed imbalance of emphasis in current INCOSE planning:
   a) Over-emphasis on organizational sources of model authority: Jockeying for organizational position with other external bodies as well as INCOSE internal bodies, versus . . .
   b) Lack of emphasis on STEM sources of model authority; lack of inclusion of a standard STEM-based ontology; lack of emphasis on consistent standards of VVUQ of models.
2. Goal: Improve level of understanding of the model ontologies setting in current INCOSE planning:
   a) Nature of interoperability issues and the levels of ontology specificity
   b) Inherently dynamic evolutionary nature of ontologies in STEM.
3. Task: Plan tactical actions necessary to accomplish the above goals.

Questions and discussion

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