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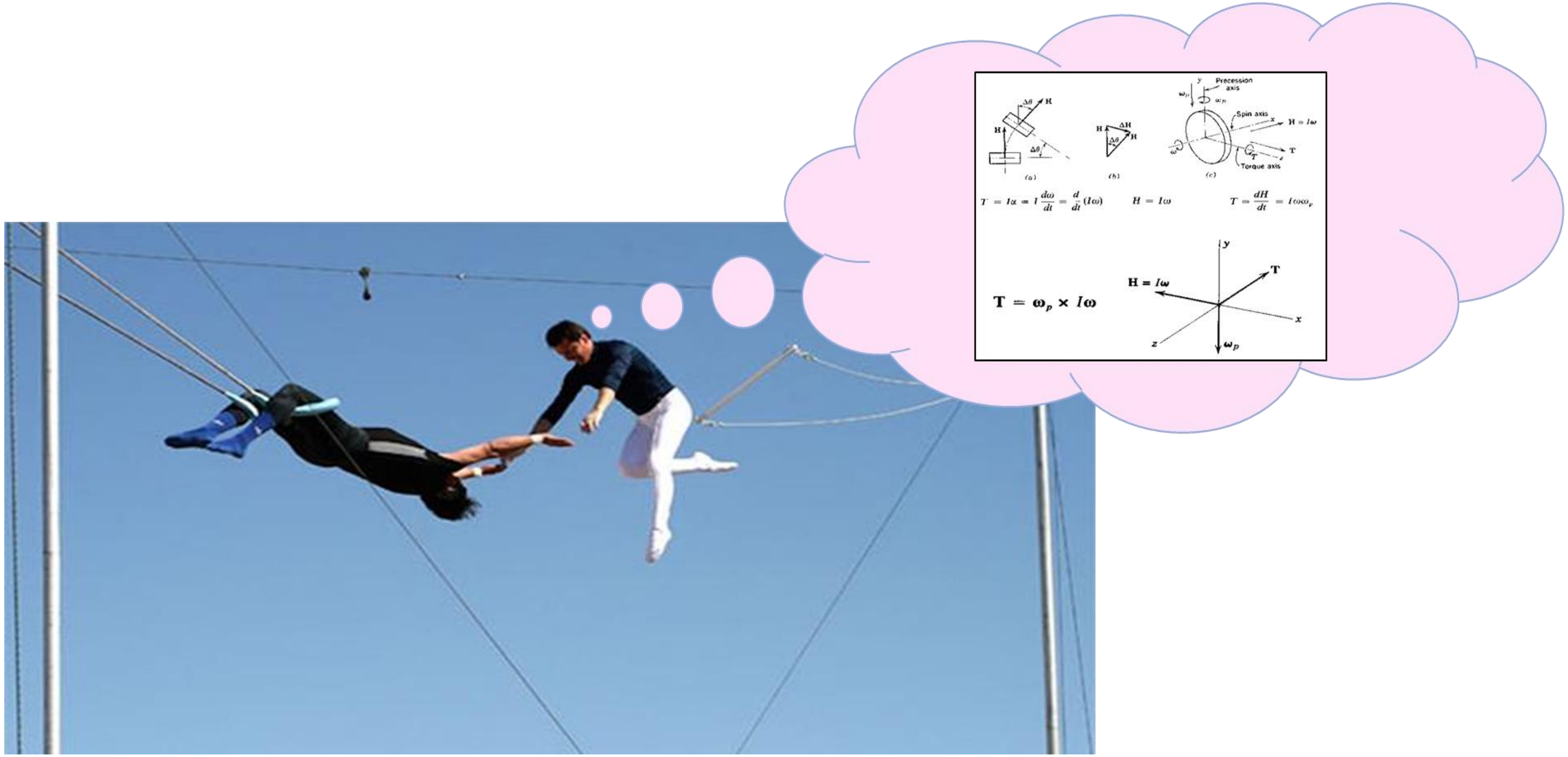

Managing Trust in Models

ICTT System Sciences®
Understand your systems.

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V1.2.2

Contents

- What brought me to this subject
- The growing importance of model credibility
- V&V of Models vs. V&V of Systems
- Pressure toward a framework for learning
- An INCOSE beta product: Model Features Planning and Packaging Framework
- What you can do

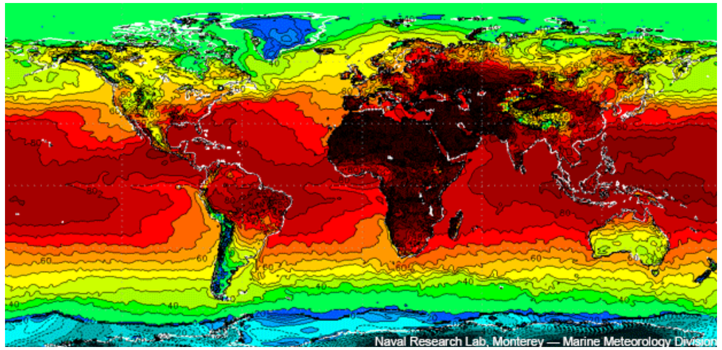
- References and backup material

What brought me to this subject

- Uncertainty about Uncertainty
- Kalman Filters
- INCOSE
- Systems Physics
- ASME
- MBSE & Computational Models

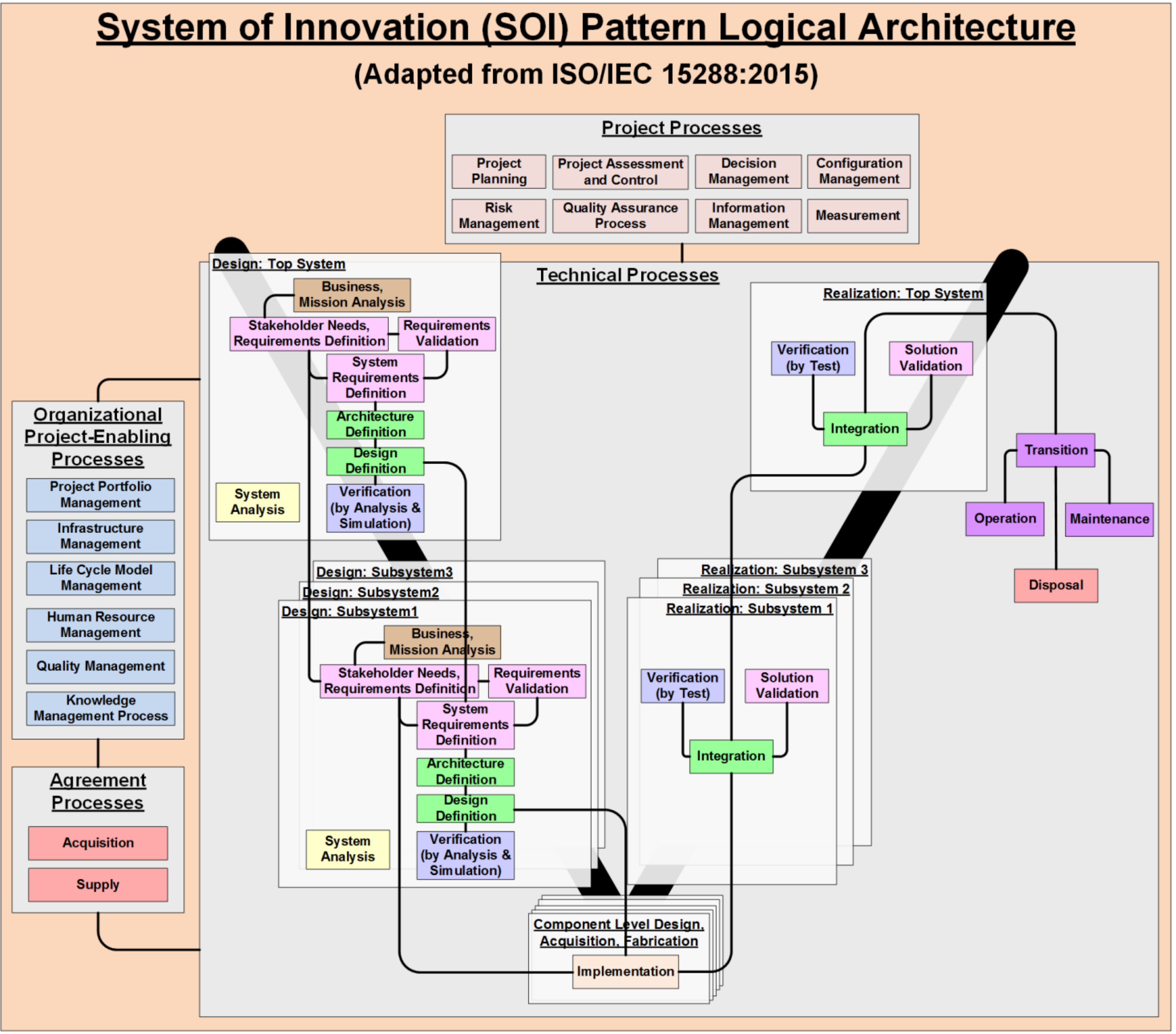
If we expect to use models to support critical decisions, then we are placing *increased trust in models*:

– Critical financial, other business decisions
– Human life safety
– Societal impacts
– Extending human capability



- MBSE Maturity requires that we characterize the structure of that trust and manage it:
  - The Validation, Verification, and Uncertainty Quantification (VVUQ) *of the models themselves*.

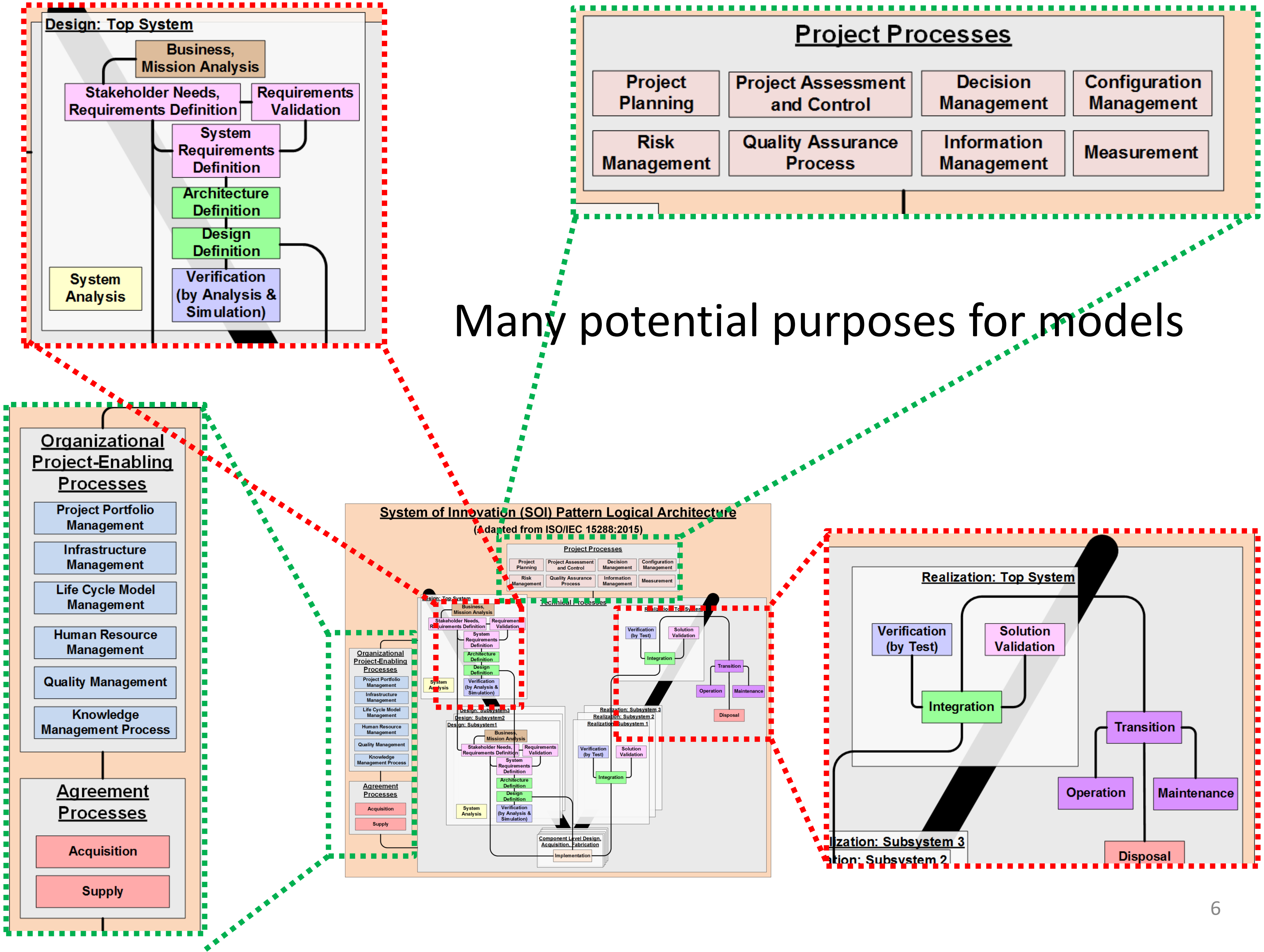
Models for what purposes?



Potentially for any ISO 15288 processes:

- If there is a net benefit . . .
- Some more obvious than others.
- The INCOSE MB Transformation is using ISO 15288 framework as an aid to migration planning and assessment.

Many potential purposes for models

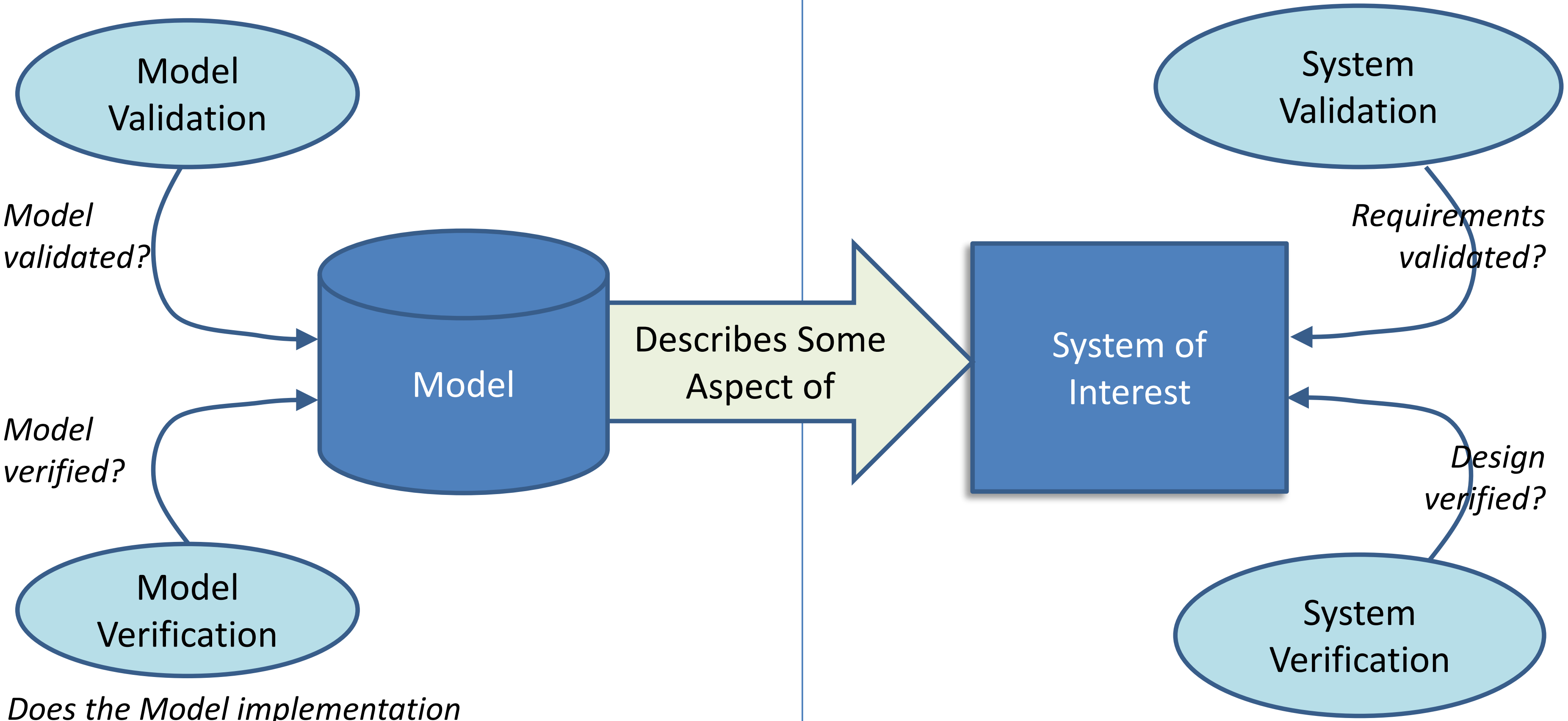


V&V of *Models*, Per Emerging ASME Model V&V Standards

Does the Model adequately describe what it is intended to describe?

V&V of *Systems*, Per ISO 15288 & INCOSE Handbook

Do the System Requirements describe what stakeholders need?

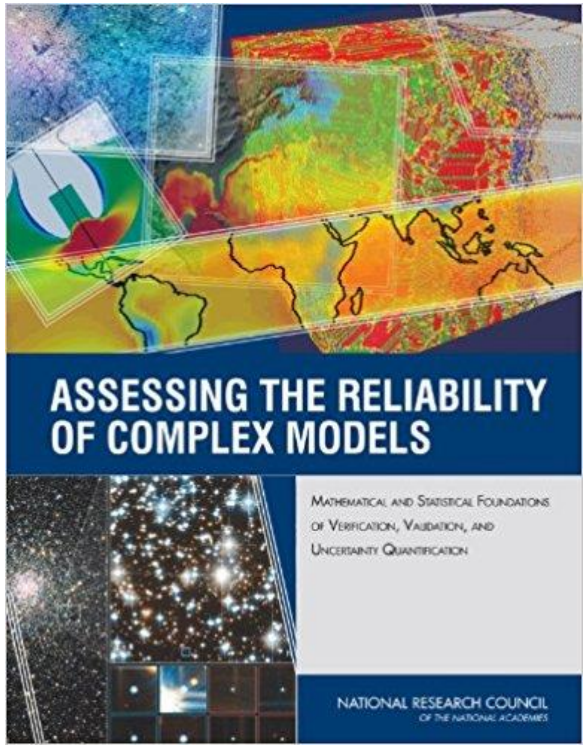


Does the Model implementation adequately represent what the Model says?

Does the System Design define a solution meeting the System Requirements?

Don't forget: A model (on the left) <u>may</u> be used for system verification or validation (on the right!)

Quantitative Fidelity, including Uncertainty Quantification (UQ)



- There is a large body of literature on a mathematical subset of the UQ problem, in ways viewed as the heart of this work.
- But, some additional systems work is needed, and in progress, as to the more general VVUQ framework, suitable for general standards or guidelines.

General structure of uncertainty / confidence tracing:

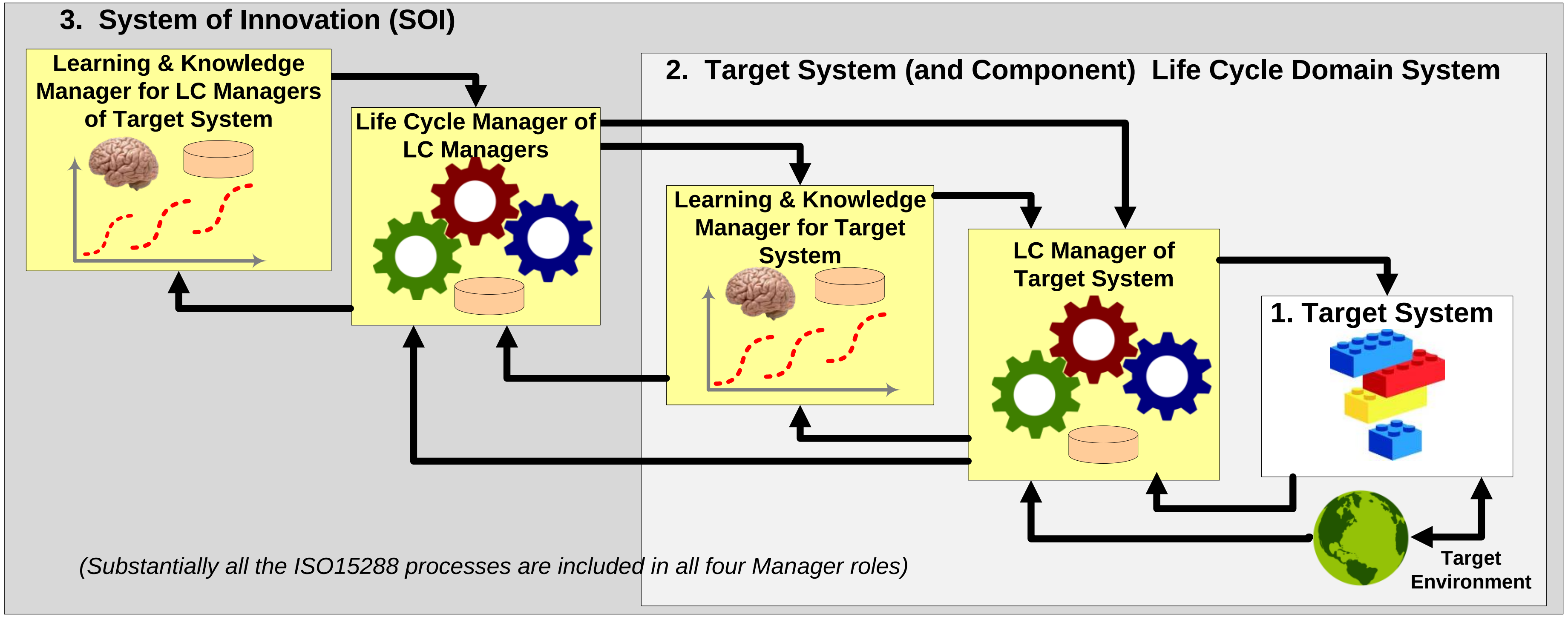
- Do the modeled external Interactions qualitatively cover the modeled Stakeholder Features over the range of intended subject system situations of interest?
- Quantify confidence / uncertainty that the modeled Stakeholder Feature Attributes quantitatively represent the real system concerns of the subject system Stakeholders with sufficient accuracy over the range of intended situation envelopes.
- Quantify confidence / uncertainty that the modeled Technical Performance Attributes quantitatively represent the real system external behavior of the subject system with sufficient accuracy over the range of intended situation envelopes.

Related ASME activities and resources

- ASME, has an active set of teams writing guidelines and standards on the Verification and Validation of Computational Models.
  - Inspired by the proliferation of computational models (FEA, CFD, Thermal, Stress/Strain, etc.)
  - It could fairly be said that this historical background means that effort was not focused on what most systems engineers would call “system models”
- Also conducts annual Symposium on Validation and Verification of Computational Models, in May.
- To participate in this work, in 2016 the speaker joined the ASME VV50 Committee on behalf of INCOSE:
  - With the idea that the framework ASME set as foundation could apply well to systems level models; and . . .
  - with a pre-existing belief that system level models are not as different from discipline-specific physics models as believed by systems community.
- Also invited sub-team leader Joe Hightower (Boeing) to address the INCOSE IW2017 MBSE Workshop, on our related ASME activity.

Increased Cost of Credibility of a Model: Creates Pressure for a Framework for Learning

ASELCM Pattern

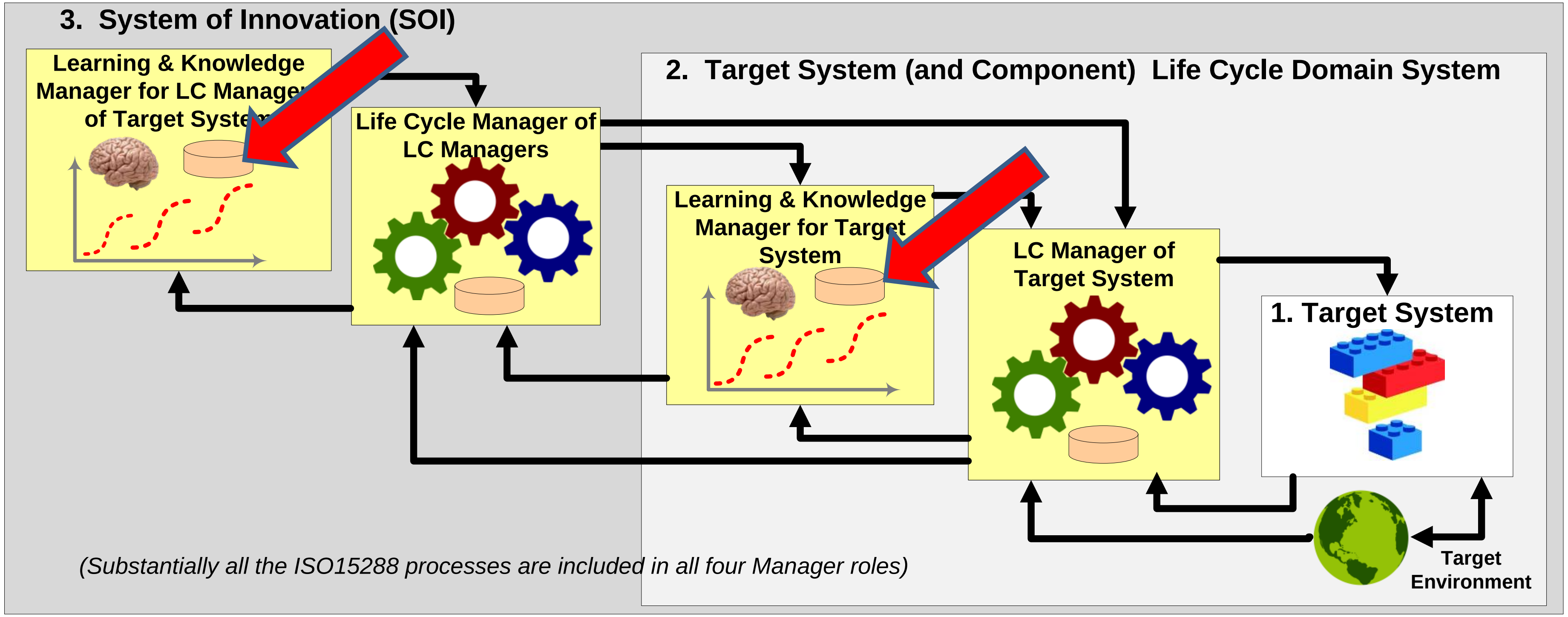


System 1: The target system of interest (e.g., a product system)

System 2: The (ISO 15288) life cycle management systems for System 1, along with the rest of System 1's target environment

System 3: The life cycle management systems for System 2

An emerging special case: Regulated markets

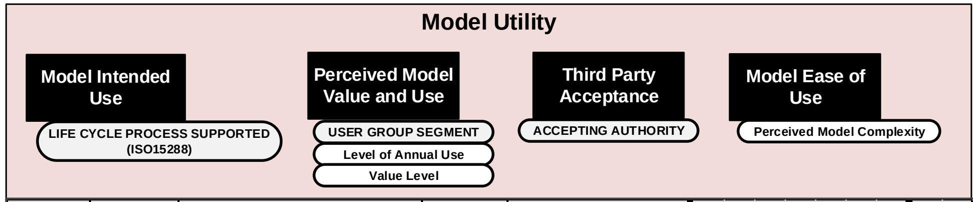


- Trusted shared MBSE Patterns for classes of systems
- Configurable for vendor-specific products
- With Model VVUQ frameworks lowering the cost of model trust for regulatory submissions

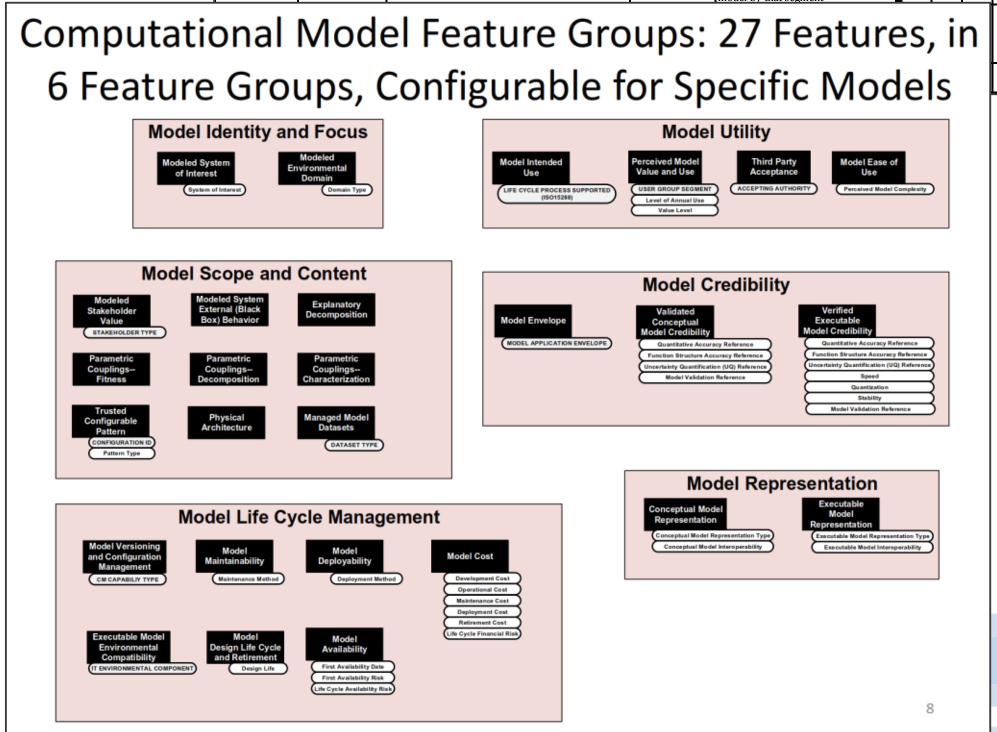
INCOSE Transformation Product, for Beta Test Use:

Model Features Planning and Packaging Framework

- **Product Concept:** What are the stakeholder features of the model we are planning, the model we are building, the model we are using? Is it fit for its intended use?
- A more detailed, but entirely stakeholder-level, framework for describing the full spectrum of stakeholder issues, expectations, and outcomes for the full life cycle (development through use, maintenance, retirement) of any type of model.
- Explicitly connected to the ISO15288 process areas, but drills further into what stakeholders expect and actually receive.
- Tied to the joint effort with ASME on Computational Model Credibility (Model VVUQ) guidelines and standards, supported by INCOSE.
- Tied to (separate tool) Model Requirements to follow separately, as the basis for determining the credibility of models.
- Resulting data is suitable for creating views bridging from business stakeholders to technical practitioners.
- For use by:
  - An enterprise
  - A project
  - An individual person
  - A multi-company team
  - A trade group
  - And especially by . . . INCOSE members!



Feature Group	Feature Name	Feature Definition	Feature Attribute	Attribute Definition	Feature Stakeholder: Model User	Model Developer	Model Maintainer	Mdl Deployer-Distributor	Model Use Supporter	Regulatory Authority	Mdl Investor-Owner	Model Type: Physics Based	Data Driven
Describes the intended use, utility, and value of the model													
Model Utility	Model Intended Use	The intended purpose(s) or use(s) of the model.	Life Cycle Process Supported	The intended life cycle management process to be supported by the model, from the ISO15288 process list. More than one value may be listed.	X					X	X	X	X
	Perceived Model Value and Use	The relative level of value ascribed to the model, by those who use it for its stated purpose.	User Group Segment	The identify of using group segment (multiple)	X					X	X	X	X
			Level of Annual Use	The relative level of annual use by the segment	X					X	X	X	X
			Value Level	The value class associated with the model by that segment	X					X	X	X	X
										X	X	X	X
										X		X	X



Opportunities--what you can do

- Think larger about <u>intended uses and users of MBSE</u>, and judge its maturity in that light.
- Include how well MBSE enables group learning.
- Include the full breadth of model types in your thinking.
- Consider why you think a model should be trusted.
- Join the INCOSE MBSE Patterns Working Group, to advance practice.
- Join the ASME Computational VVUQ effort, to advance model trust.
- Exercise the emerging MBSE Planning and Assessment Framework, in your own company and work, and provide feedback.

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Speaker

Bill Schindel chairs the MBSE Patterns Working Group of the INCOSE/OMG MBSE Initiative. He is president of ICTT System Sciences, and has practiced systems engineering for over thirty years, across multiple industry domains. Bill serves as president of the INCOSE Crossroads of America Chapter, and is an INCOSE Fellow and Certified Systems Engineering Professional. An ASME member, he is part of the ASME VV50 standards team's effort to describe the verification, validation, and uncertainty quantification of models.

V4 Institute

- Virtual Validation, Verification, and Visualization Institute
- Member consortium
- Established 2016 by Indiana Private and Public Sectors, Academia, ASME, and INCOSE CoA Chapter + Patterns WG
- Management partner: NCDMM
- http://v4i.us/

ASME Verification & Validation Standards Committee

- V&V 10: Verification & Validation in Computational Solid Dynamics
- V&V20: Verification & Validation in Computational Fluid Dynamics and Heat Transfer
- V&V 30: Verification and Validation in Computational Simulation of Nuclear System Thermal Fluids Behavior
- V&V 40: Verification and Validation in Computational Modeling of Medical Devices
- V&V 50: Verification & Validation of Computational Modeling for Advanced Manufacturing
- V&V 60: Verification and Validation in Modeling and Simulation in Energy Systems and Applications

ASME SETTING THE STANDARD

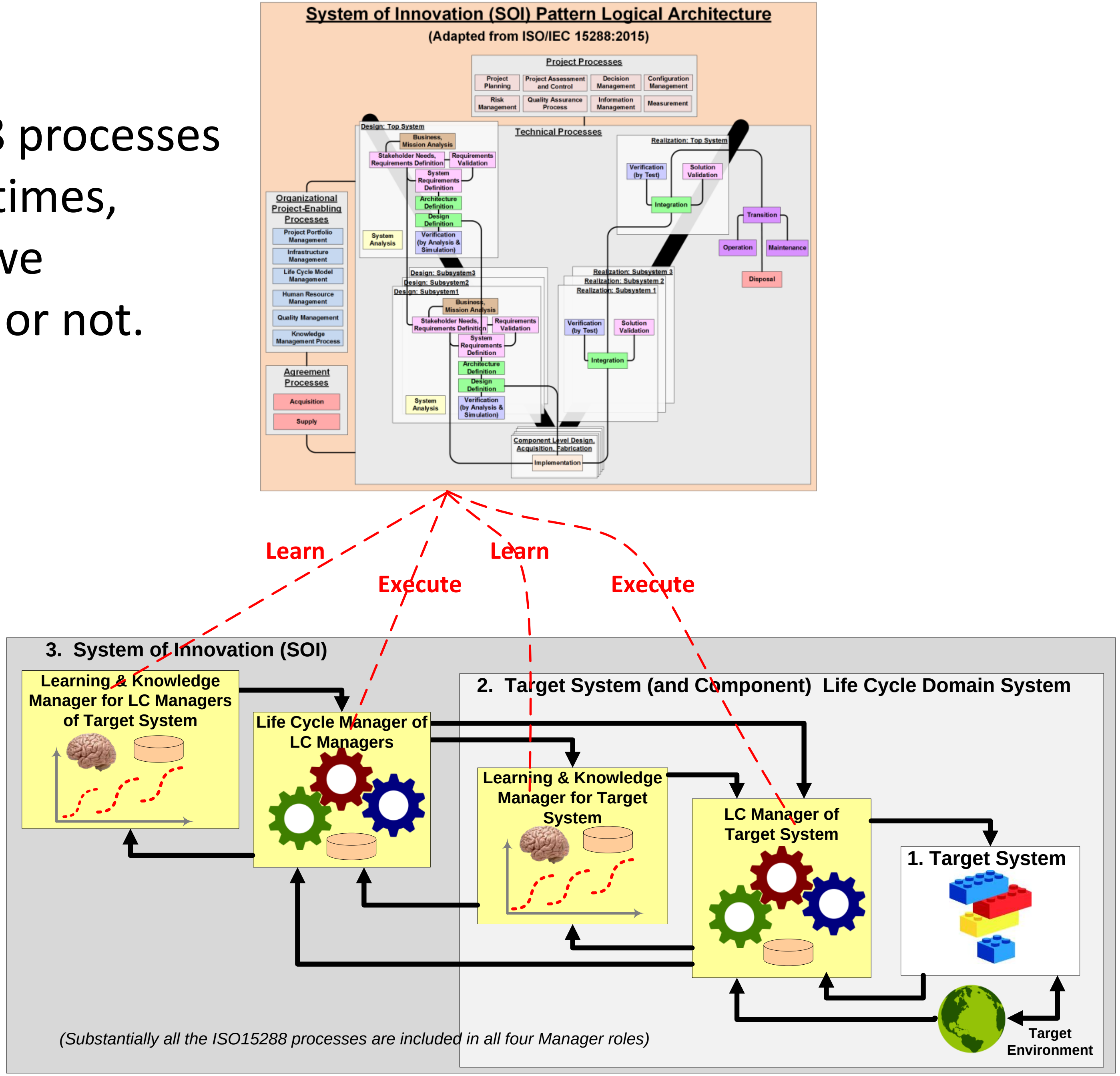
https://cstools.asme.org/csconnect/CommitteePages.cfm?Committee=100003367

Related INCOSE, ASME communities

- **INCOSE:**
  - Model-Based Engineering Transformation Initiative
  - INCOSE-NAFEMS Joint Working Group on Simulation
  - MBSE Patterns Working Group
  - Agile Systems & Systems Engineering Working Group
  - Tools Interoperability and Model Life Cycle Management Group
  - INCOSE-OMG MBSE Initiative: Challenge Teams, Activity Teams

- **ASME Computational Model V&V Committee / Working Groups:**
  - V&V 10: Verification & Validation in Computational Solid Dynamics
  - V&V20: Verification & Validation in Computational Fluid Dynamics and Heat Transfer
  - V&V 30: Verification and Validation in Computational Simulation of Nuclear System Thermal Fluids Behavior
  - V&V 40: Verification and Validation in Computational Modeling of Medical Devices
  - V&V 50: Verification & Validation of Computational Modeling for Advanced Manufacturing
  - V&V 60: Verification and Validation in Modeling and Simulation in Energy Systems and Applications

ISO 15288 processes appear 4 times, whether we recognize or not.



An emerging special case: Regulated markets

- Increasing use of computational models in safety-critical, other regulated markets is driving development of methodology for Model VVUQ:
  - See, for example, ASME V&V 10, 20, 30, 40, 50, 60.
- Models have economic advantages, but the above can add new costs to development of models for regulatory submission of credible evidence:
  - Cost of evidentiary submissions to FDA, FAA, NRC, NTSB, EPA, OSHA, when supported by models—includes VVUQ of those models.
- This suggests a vision of collaborative roles for engineering professional societies, along with regulators, and enterprises:
  - Trusted shared MBSE Patterns for classes of systems
  - Configurable for vendor-specific products
  - With Model VVUQ frameworks lowering the cost of model trust for regulatory submissions
- Further emphasizes the issue of trust in models . . .