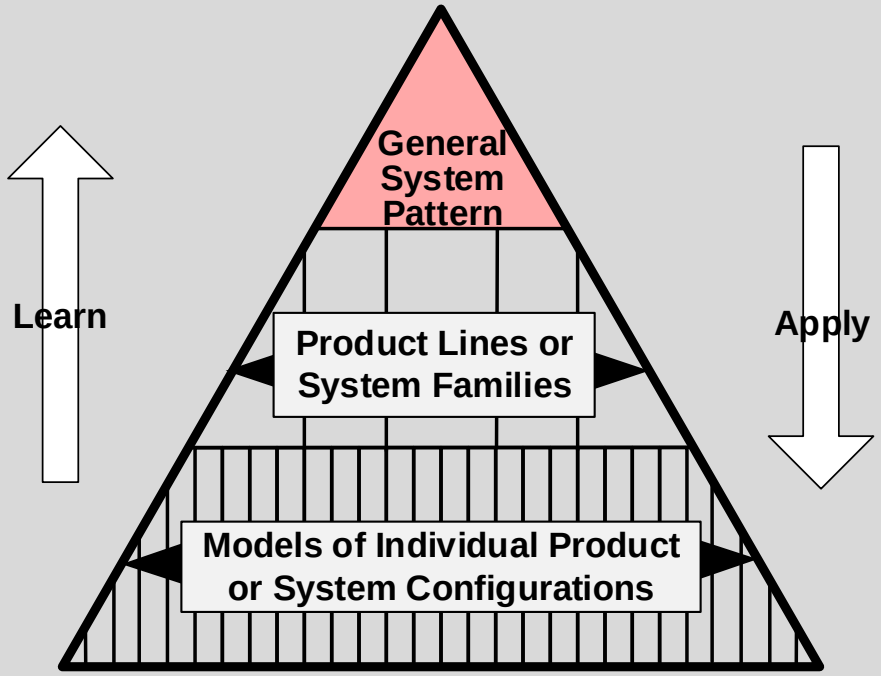
2018 Annual INCOSE
Great Lakes Regional Conference
SYSTEMS AT THE CROSSROADS
17 - 20 October 2018 | Indianapolis, Indiana



System Pattern
Class Hierarchy

Patterns In the Public Square:
Sharing Model Patterns to Optimize Innovation

Panel Moderator: Bill Schindel
ICTT System Sciences
schindel@ictt.com

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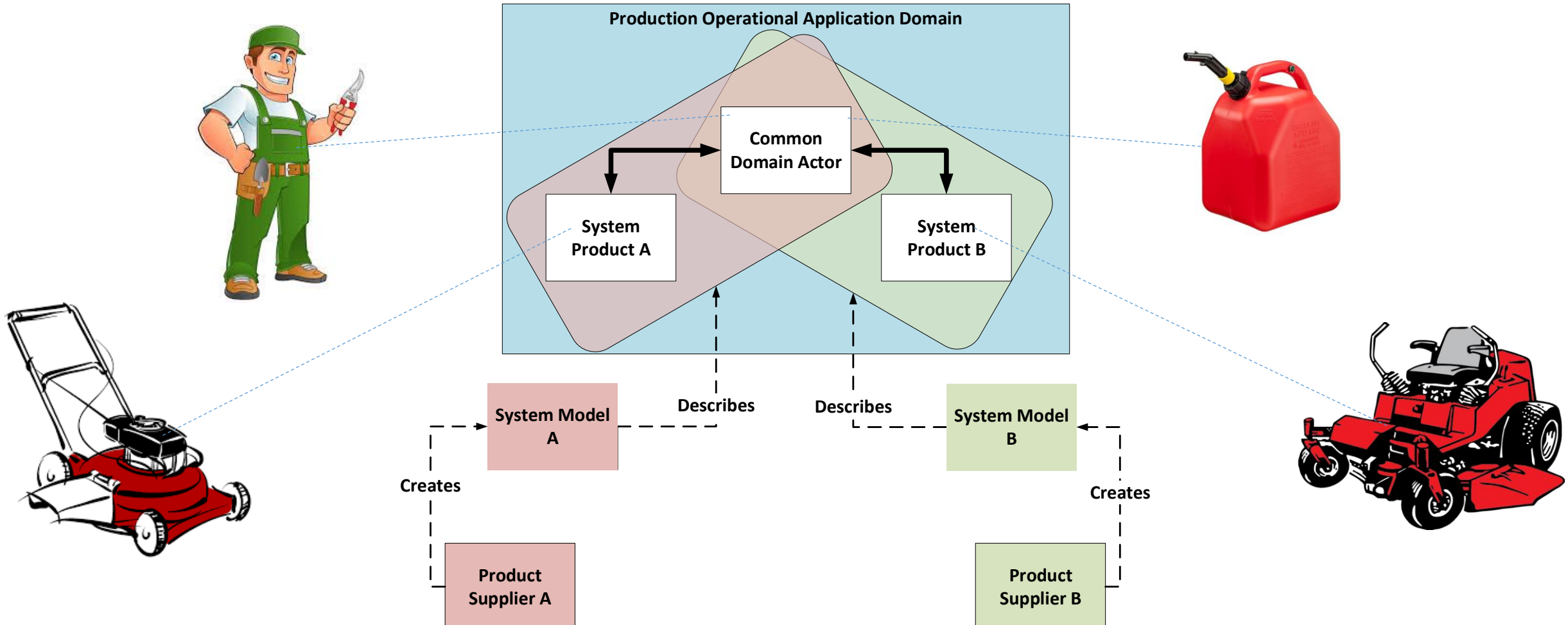
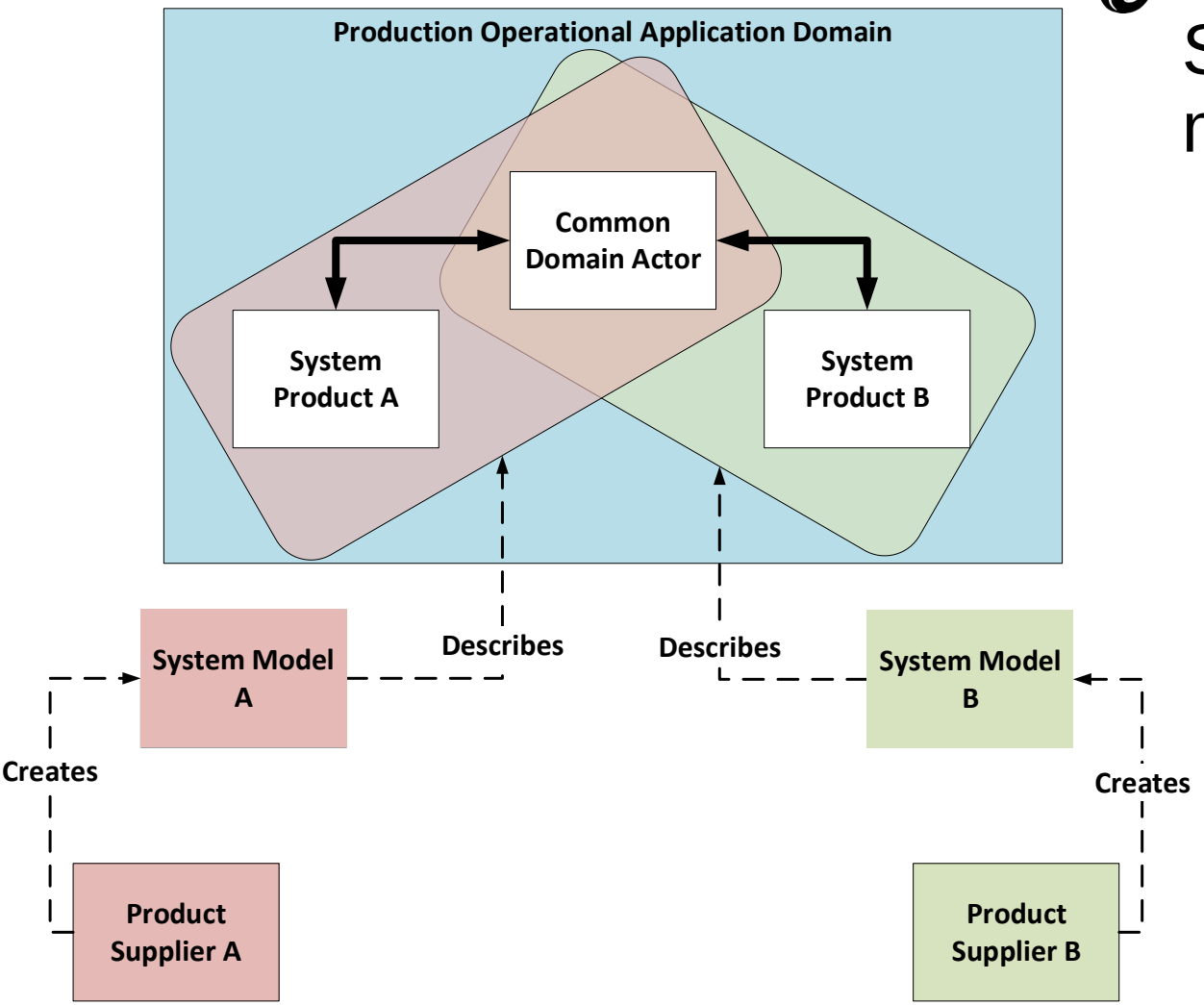
- **Abstract**: Society benefits from innovation across the dimensions of life, including advancements in aviation and ground transportation, medicine and health care, production of food, energy, communication, and information systems, distribution of products and services, and other evolving systems. In many of these areas, society also depends upon effective regulation to protect us from undue risks involving safety, credibility, and other aspects.
- Sometimes we hear questions of whether the systems of regulation are effective in their balance of reward and risk to society. Not so well known are the collaborative efforts by regulators and technical professional societies (ASME, INCOSE, others) to advance new frameworks in which the expectations of regulators and innovators are recognized on behalf of the society both serve.
- This panel will discuss some contemporary efforts, beyond traditional standards-making of earlier generations, including the perspectives of engineering societies, regulators, and enterprises. The discussion will include consideration of how computational models are changing this environment, and ask questions about the implications for future innovation, and the practical issues of sharing regulatory and industry models and patterns. Part of a continuing conversation intended to engage more of our communities in these efforts.

Protecting and Sharing IP in S*Pattern Families

Consider an innovative, competitive, and possibly regulated, market, where competitive product suppliers A and B create model-described products:



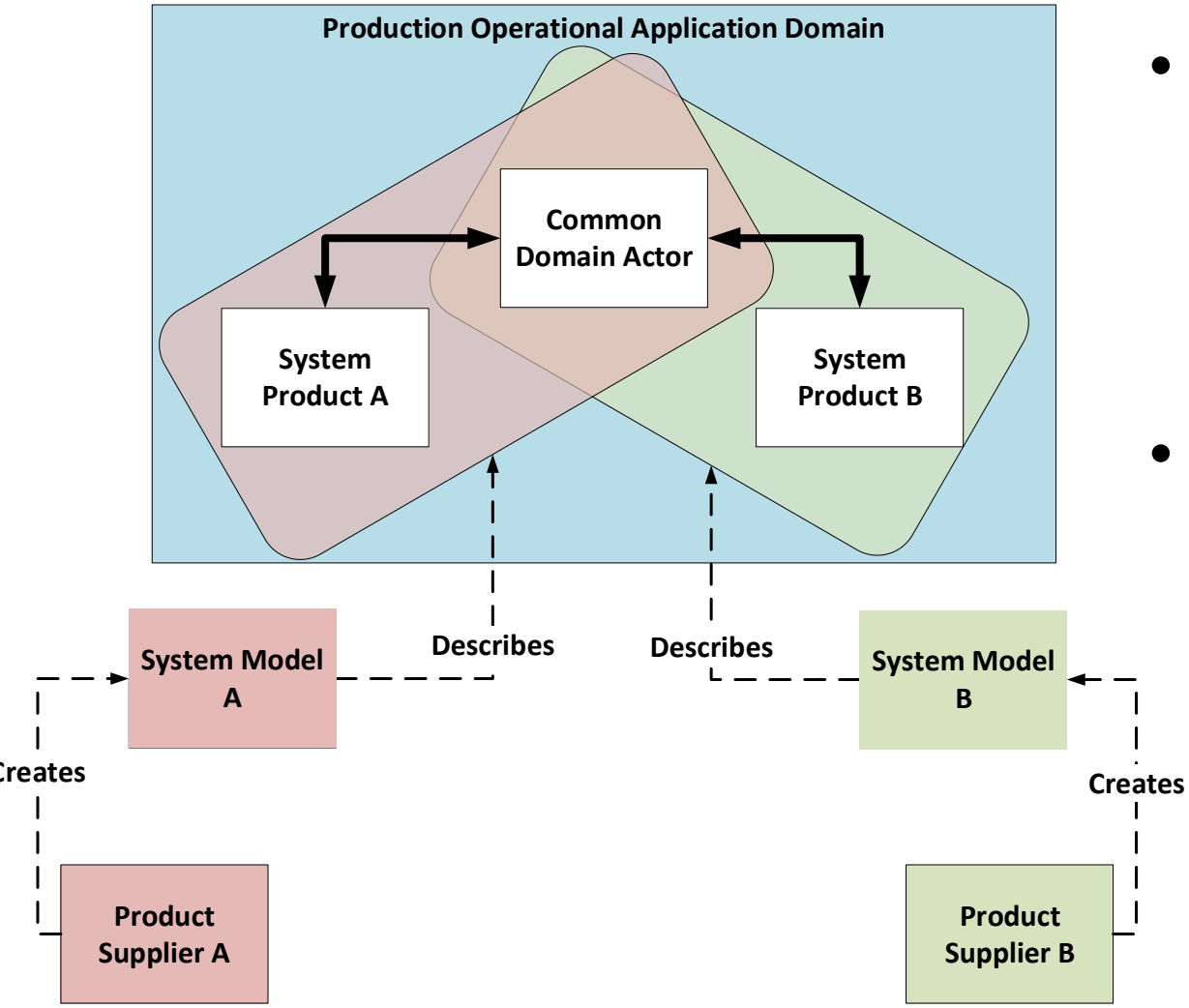
Protecting and Sharing IP in S*Pattern Families



Speed and effectiveness of innovation may be enhanced by sharing; e.g.:

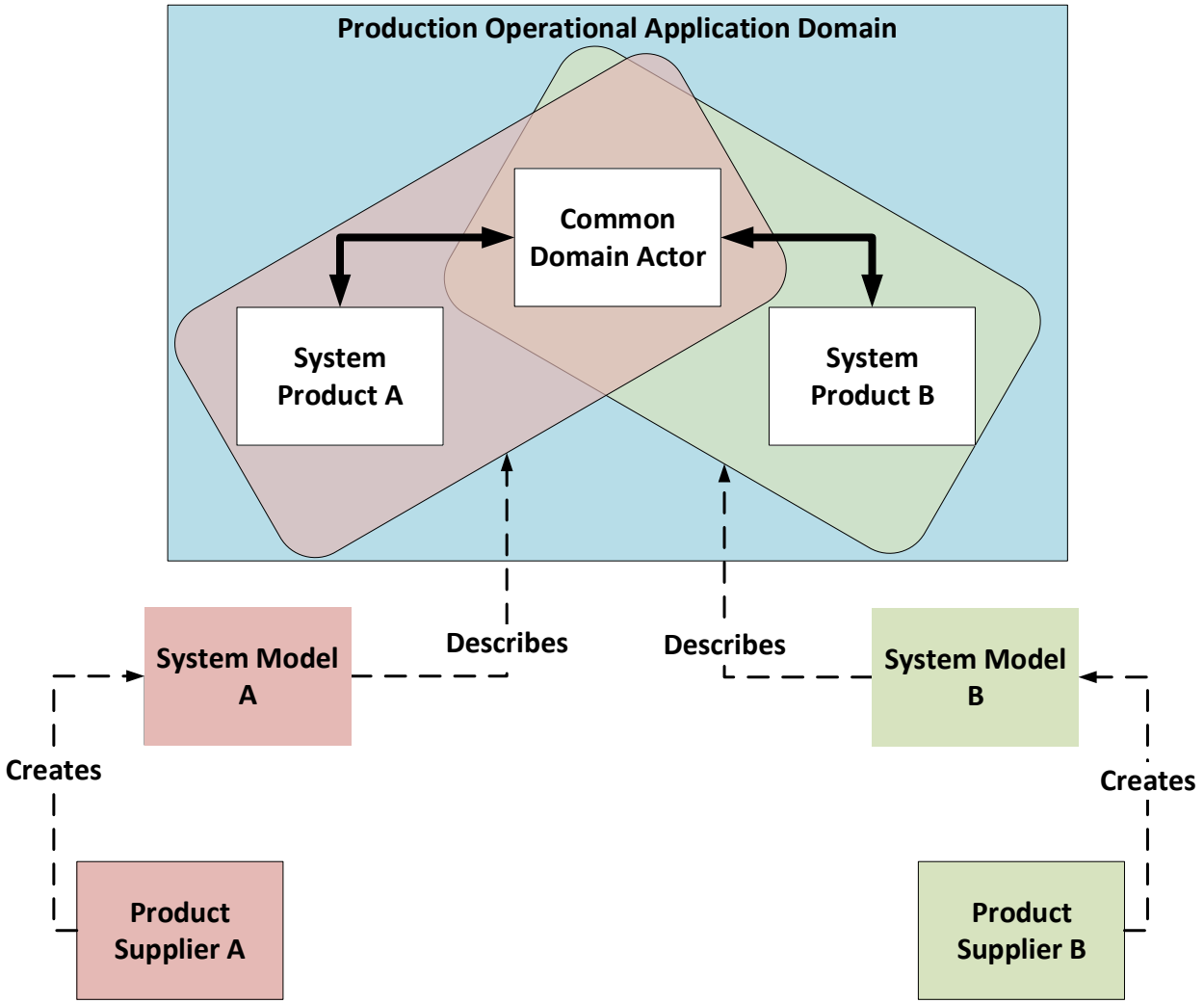
- Descriptions of interfaces that appear on competitive systems but must interact with each other or with other common actors
- Descriptions of regulatory expectations as to safety, and evidence of its achievement
- Guidelines or standards as to credibility of model-based descriptions of the above

Protecting and Sharing IP in S*Pattern Families



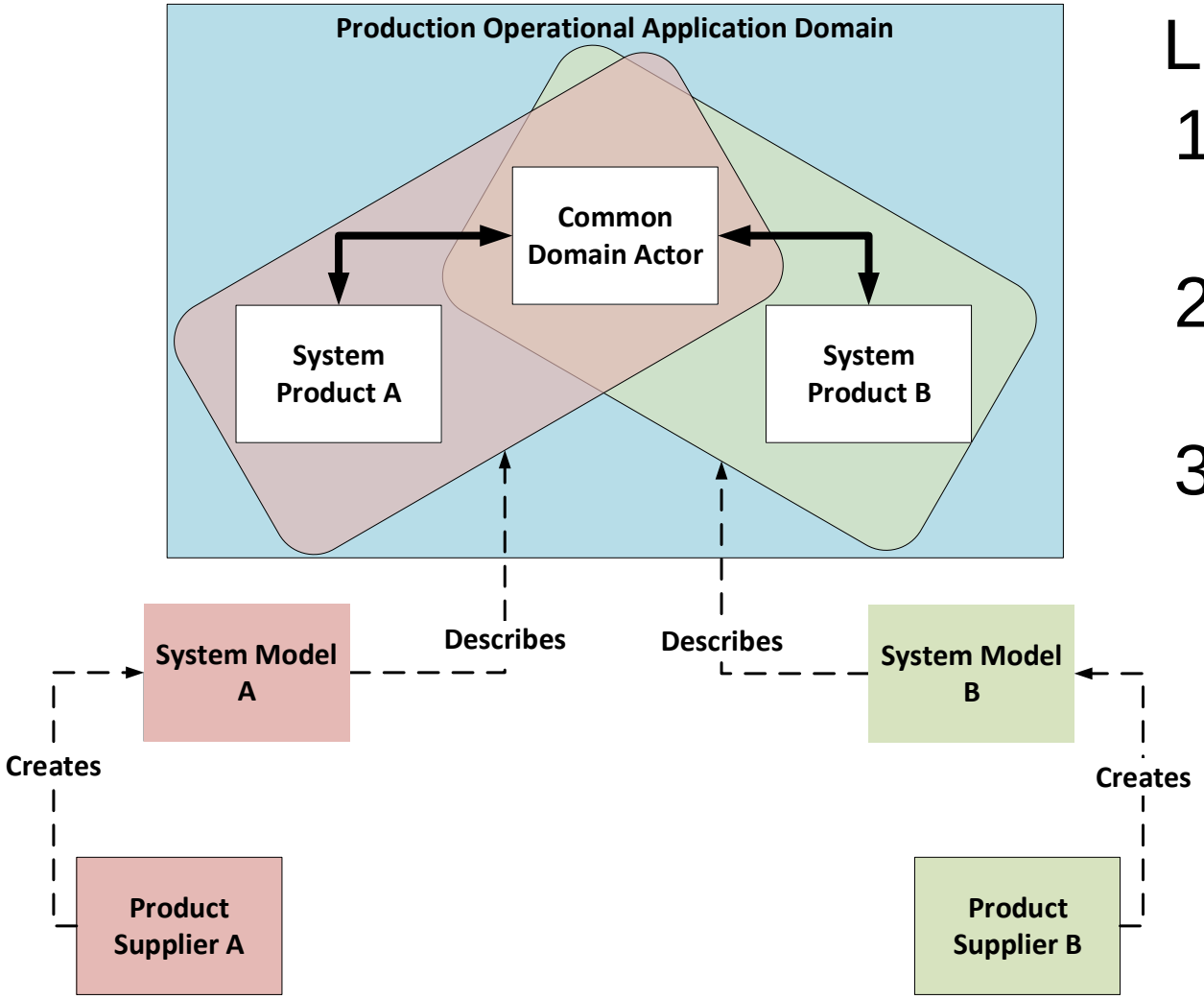
- But some aspects of the competitive systems will involve market-differentiating proprietary IP, that the competitors want to keep confidential.
- So, how do we:
  1. Share some content, while . . .
  2. Keeping other content confidential, but . . .
  3. Making sure the integrated system described works as expected (that is, the two partitions of data are not in conflict)?

Protecting and Sharing IP in S*Pattern Families



- The work load on the regulatory process, and ability of regulators and businesses to avoid getting bogged down, depend on whether submissions arrive looking very unique, versus very related.
- Can the regulator and submitter establish common expectations about overall regulated parameters and credibility of related evidence?

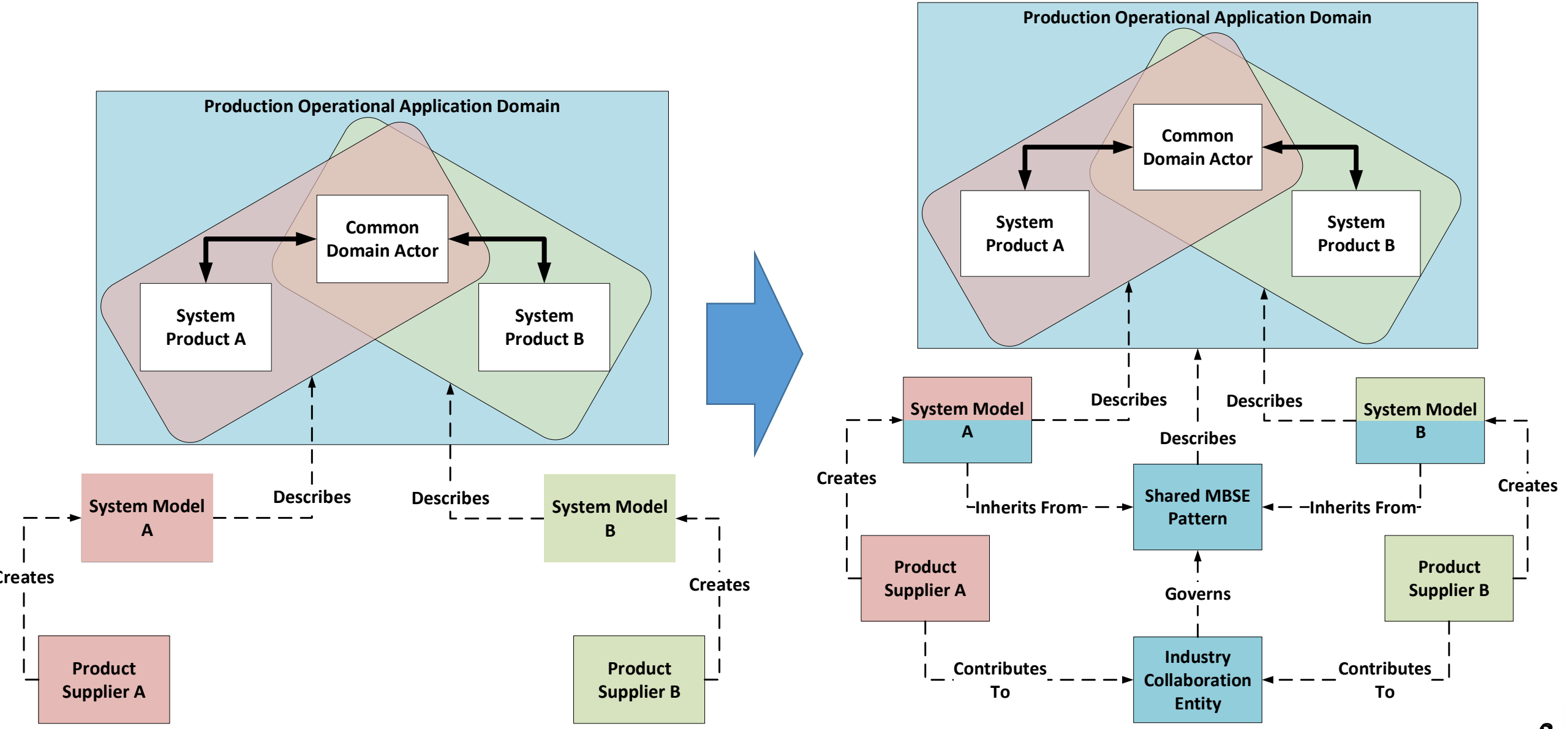
Protecting and Sharing IP in S*Pattern Families



Larger questions: How do we--

1. Create innovative market differentiating content, while . . .
2. Describing it in a regulatory context of what is still fixed, and . . .
3. Create sufficient confidence in related models (at low enough model VVUQ cost) to trust them for evidence of that performance?

Answer: Hybrid Patterns in the Public Square



Panel Session: Segments

- Introduction of the session topic and panelists (20 minutes)
- Position discussion from each panelist (40 minutes total)
- Attendee & panel discussion of this subject (30 minutes)

Topics and References

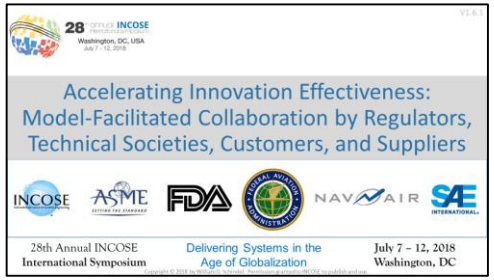
- Arc of this public conversation
- Innovation, regulation, vision for a collaboration
- Historical and continuing interest in the “Commons”
- Collaborating on use of computational models
- Initial questions for our panelists
- Panelists—introductions and position statements
- Panel and audience discussion
- References

Arc of this public conversation

Today

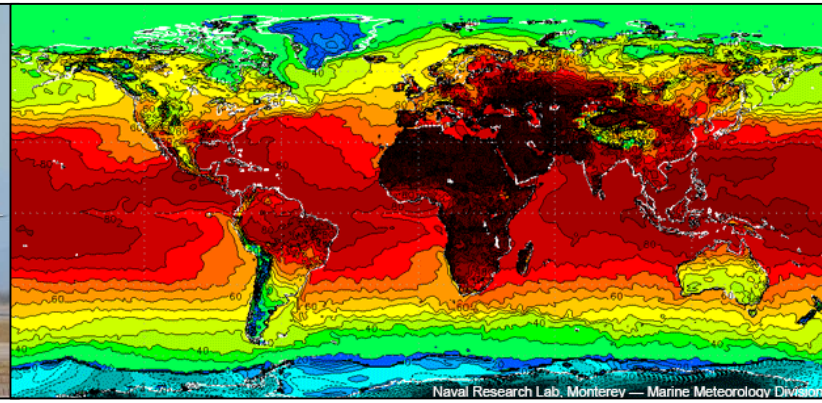
GLRC2017 Panel 1	IS2018 Panel 2	GLRC2018 Panel 3	V4 Institute Launch Projects
Focus: Technical Societies	Focus: Regulators, Certifiers	Focus: Enterprises	Focus: Community Collaboration

ASME, INCOSE, SAE, AIAA . . . . . FAA, FDA, DoD . . . . . V4I Member Enterprises, Academia, Regulators



Innovation, Regulation, Vision for a Collaboration

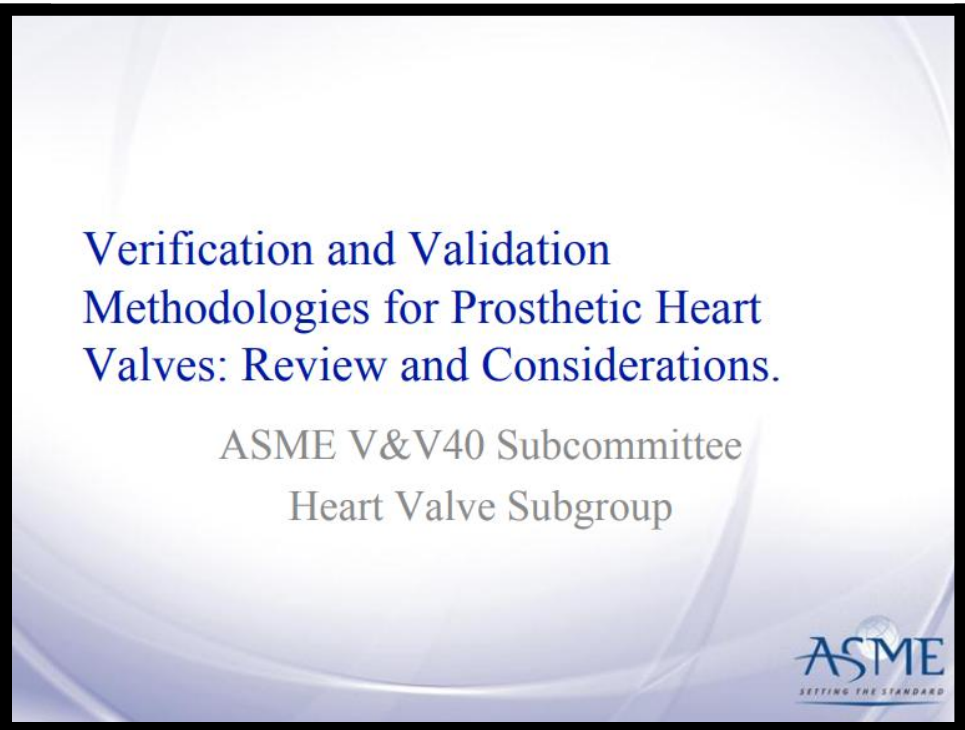
- Society benefits from innovation across the dimensions of life, including advancements in aviation and ground transport, medicine and health care, production of food, energy, communication, and information systems, distribution of products and services, and other evolving systems.

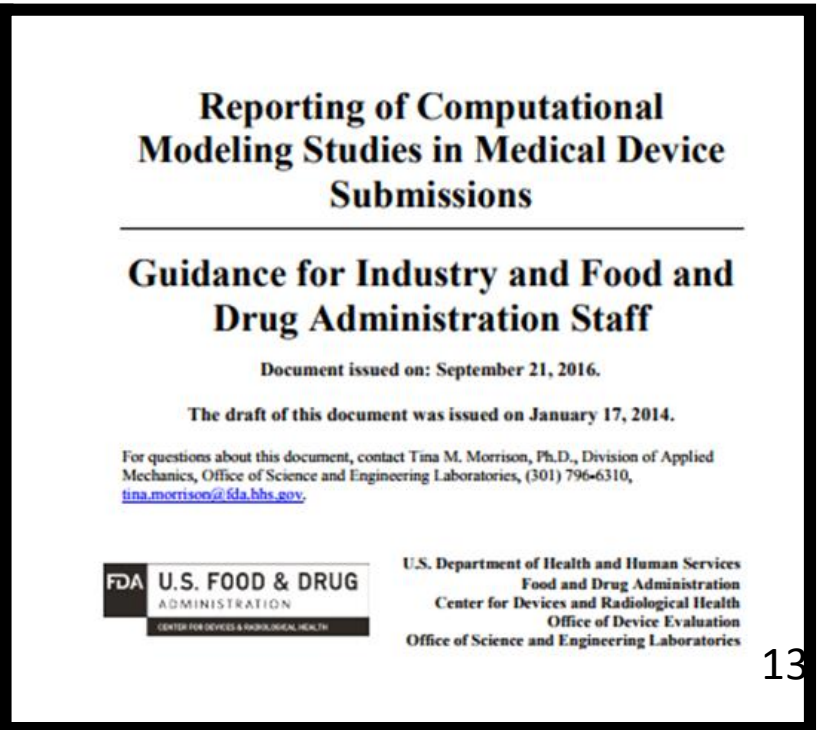


- In many of these areas, society also depends upon effective regulation to protect us from undue risks involving safety, credibility, and other aspects.

Innovation, Regulation, Vision for a Collaboration

- Sometimes we hear questions of whether the systems of regulation are effective in their balance of reward and risk to society.
- Not so well known are the collaborative efforts by regulators and technical professional societies (ASME, INCOSE, others) to advance new frameworks in which the expectations of regulators and innovators are recognized on behalf of the society both serve.





Innovation, Regulation, Vision for a Collaboration

- This panel will discuss some contemporary efforts, beyond traditional standards-making of earlier generations, including the perspectives of engineering societies, regulators, and enterprises.
- The discussion will include consideration of how computational models are changing this environment, and ask questions about the implications for future innovation, and the practical issues of sharing regulatory and industry models and patterns.

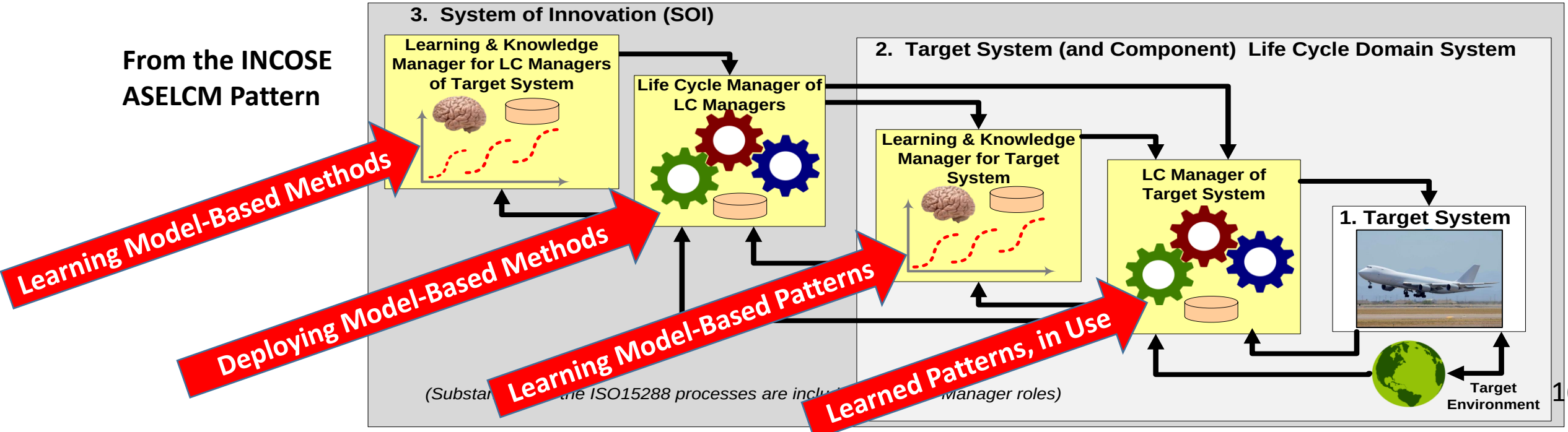
Innovation, Regulation, Vision for a Collaboration

- **The Setting**: Innovation, particularly in regulated domains
- **The Need**: Streamline the innovation cycle while still achieving regulatory goals
- **The Domains**: Aerospace, medicine, electrical grids, automotive, others
- **The Opportunity**: Enhanced trust shared models that society and regulatory authorities can trust during interaction with enterprises and researchers, streamlining joint processes
- **Achieved Example**: Automotive virtual crash testing
- **Engineering Professional Societies**: These System 3 entities occupy a special place in this ecosystem, by virtue of their ethical commitment, combined with technical expertise:
  - Not the same position as the enterprises, or trade groups;
  - Not the same position as the regulators;
  - Not the same position as the academic research community;
  - But a potentially catalytic collaborator with them all, to accelerate the advancement of this vision to reality.

Innovation, Regulation, Vision for a Collaboration

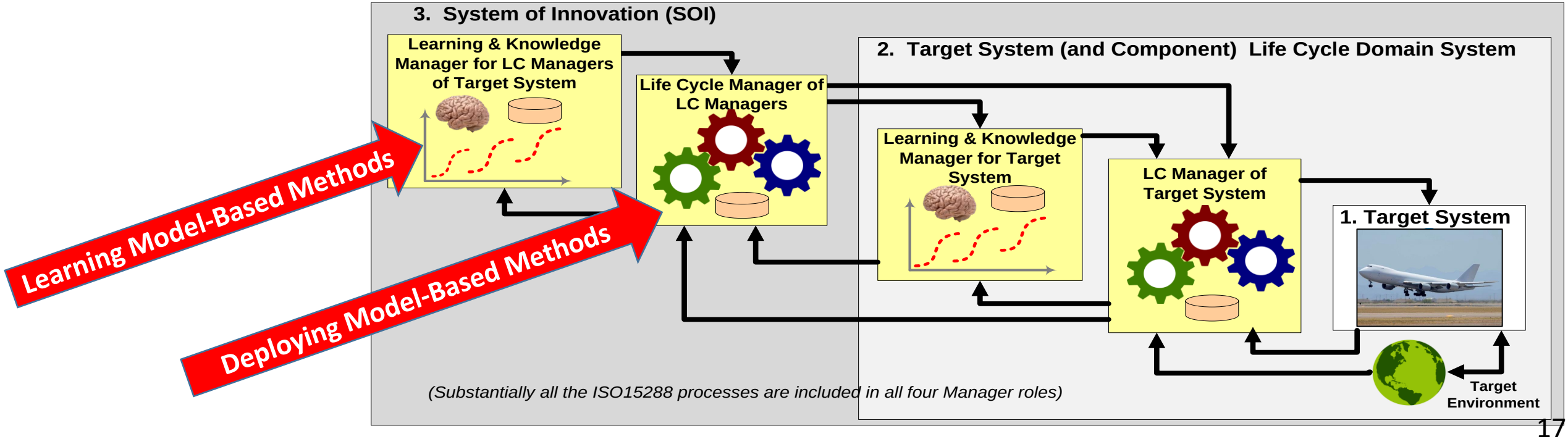
Arguably the most dramatically impactful example of extended group-wide learning process, during the last three centuries, is the edifice of the physical sciences:

- The language of its “lessons learned” repository is that of explicit quantitative models—specifically, recurring patterns expressed as general models;
- The credibility of these models (whether wrong, close, or right) is expressed via Model Validation, Verification, and Uncertainty Quantification (Model VVUQ);
- Described in this way, the System 2 and System 3 portions of ASELCM Pattern are models of Group Learning as well its effective (“muscle memory”) application:



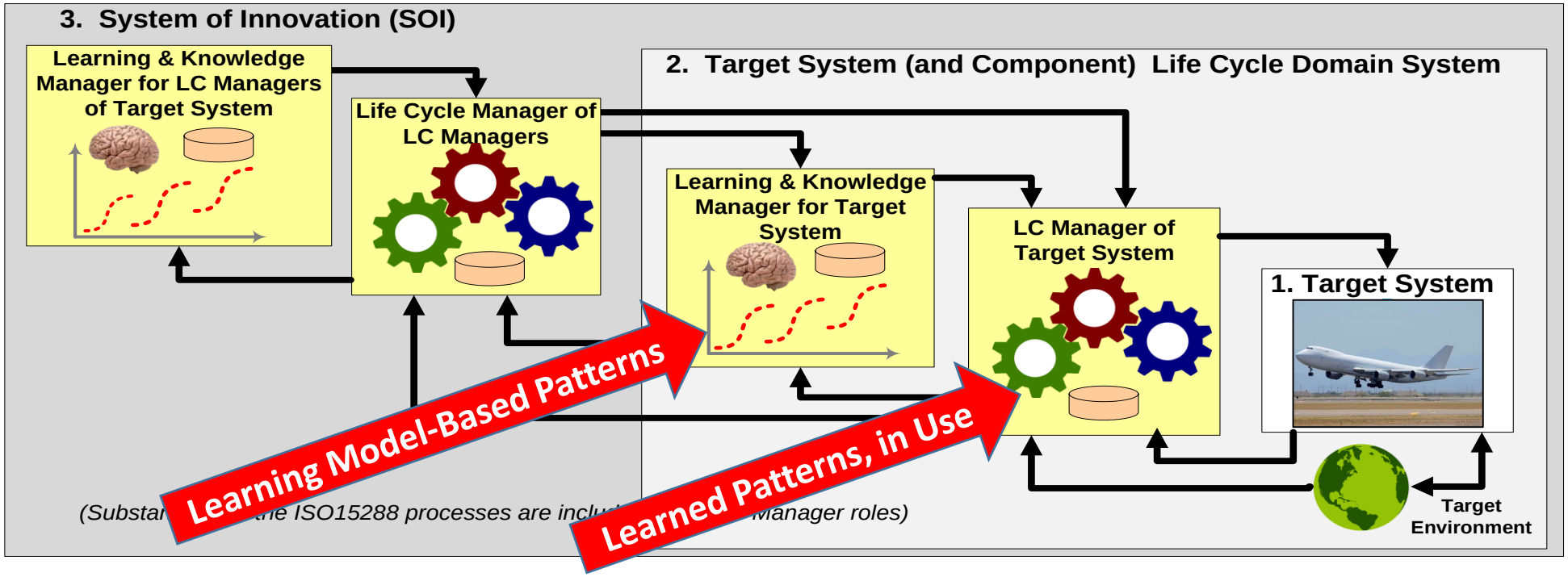
Innovation, Regulation, Vision for a Collaboration

- Collaborative learning new patterns for performing **System 2** (e.g., Engineering) can seem most natural, in sense of sharing:
  - Methods, processes, tools
  - Typified by technical societies: INCOSE, ASME, SAE, et al
  - Organizational change management (OCM) challenges
  - This is part of the scope of this panel



Innovation, Regulation, Vision for a Collaboration

- Collaboration learning new patterns for **System 1** (e.g., Products) may seem more challenging, as to sharing:
  - Pre-competitive versus competitive period
  - Regulatory evidence, including computational model-based evidence
- But, model-based patterns facilitate dividing sensitive vs. shared data.



Innovation, Regulation, Vision for a Collaboration

- **ASME's Model VVUQ Leadership Position**: Attracted participation by INCOSE beginning in 2016, in connection with:
  - ASME's goals and leading position in V&V of Computational Models
  - INCOSE's transformation of SE to a Model-Based Discipline
- Special role played by MBSE Patterns (re-usable, configurable models) in this transformation, and in the tradition of the physical sciences (shared, validated general models, configurable)
- Other engineering professional societies discussing this interest (e.g., SAE)
- Other technical societies and trade groups discussing this interest (e.g., AIAA)
- Public forum discussion and panel interests for:
  - INCOSE Great Lakes Regional Conference 2017 (MN)
  - INCOSE International Symposium 2018 (Washington, DC)
  - INCOSE Great Lakes Regional Conference 2018 (IN)
- Indiana private sector aero/medical team standing up a Virtual Verification Institute (V4I), with ASME collaboration from outset

Historical and continuing interest in the “Commons”

- Shared assets: both tangible (e.g., public infrastructure) or intangible (IP, e.g., physical sciences, engineering standards)
- Interest in the “commons” is not new to the current age:
  - Interest and disagreements as early as Plato & Aristotle.
- Proud Indiana U heritage:
  - Nobel Laureate Dr. Elinor Ostrum, the continuing Ostrum Workshop.
- Emergence of Knowledge Commons:
  - Medicine, other physical sciences,
  - Open software, “free” software movement
  - Public records and databases
  - Historical KM efforts
  - Ontology efforts

Historical and continuing interest in the “Commons”

- Sharing as well as protection mechanisms—legal and business:
  - Patents
  - Copyrights
  - Licenses, advent of CC, GPL, other public licenses
  - Subscriptions
- Intellectual property growth, surpassing annual hard capital investment, FASB recognition of IP as financial asset
- IP as revenue-generating capital, ownership and proprietary rights
- Government, regulatory, societal interest in competition, anti-trust considerations, as well as group advance:
  - “Pre-competitive” collaboration in medical and other markets
- More recent re-connection to older, established technical frameworks:
  - Learning, science, VVUQ, ASME
  - Models
- Optimizing balance between proprietary and shared assets: A true systems opportunity
- Payoff dogged by some nagging human issues of relearning, repeat invention

Collaboration on the use of computational models in innovation

- An Indiana-focused private-public collaboration, formed in 2017:
  - www.v4i.us
  - GLRC 2018 Platinum Sponsor, provided the free GRLC V4 Institute last Wednesday
- An open membership organization of enterprises and academic institutions, focused on raising the productivity of the innovation process, using computational models:
  - Including IP asset leverage of shared model-based patterns in the V4I Framework.
- Managed by NCDMM (the National Center for Defense Manufacturing and Machining), based on their successful experience managing the private-public collaboration America Makes.

Collaboration on the use of computational models in innovation

- Member-created IP assets enhancing model-based innovation competencies, prioritized by and shared with Members, following the V4 Institute Roadmap.
- Currently starting five projects by the membership:
  - Product design regulatory certification enhanced by model-based evidence
  - Product manufacturing process regulatory certification enhanced by model-based evidence
  - Systems-level innovation enhanced by model-based evidence
  - Model verification, validation, and uncertainty quantification (Model VVUQ)
  - Repository Reference Model for model-based supply chains, communities
- Inviting additional collaborating members.

Initial questions for our panelists

1. What are potential gains from group collaborations, as with the V4 Institute members?
2. Can regulated market participants share selective parts of model-based patterns, while keeping other aspects confidential?
3. How can enterprises using recurring patterns for their internal and supply chain innovations minimize the human tendency to re-invent and re-learn?

Invited Panelists--Introductions

Dr. John F. Matlik, Chief of Manufacturing & Service Systems, Rolls-Royce

- Currently leading technical team of cross-functional systems engineers who model service attributes and effectively influence development and in-service designs to deliver safe, reliable, low through-life cost and predictable operation.
- Previously served as the Manager of a Materials & Process Modeling team responsible for delivering advanced manufacturing & material modelling capability in support of new technology programs and cost reduction/avoidance.
- Also currently serves as the Rolls-Royce internal Virtual Verification, Validation & Visualization Institute (V4i) program lead, championing efforts to develop & integrate business critical digital (physics based modeling & simulation) technologies for linking “as built” (Manufacturing) & “as used” (Service/Aftermarket) product variability to performance and cost which will deliver significant cost reduction of legacy products as well as higher performing, lower cost “right first time” solutions for new product development.
- External to Rolls-Royce, Dr. Matlik is working with US federal government leadership, local State of Indiana leadership and professional societies on Advanced Manufacturing Program initiatives aimed at accelerating the integration of Digital Engineering, Manufacturing and Materials & Process Modelling capability into product life cycle development systems for increasing US national security & competitiveness. He is a Purdue Alum 3 times over having received his Ph.D. in Aeronautical and Astronautical Engineering in 2004.

Doug Koeneman, Cofounder and Partner, Adjutant Solutions Group

- Doug serves as the driving force behind Adjutant Solutions Group's mission to help create, commercialize, and realize medical devices.
- With more than 30 years of engineering experience, including global assignments and an MBA in global business management, Doug serves as a proven business and innovation leader with a track record of exceptional results. He reports a long term passion to apply technology in solving difficult business needs, through good process and partnering to reduce risk and secure sustainable sources of innovation and revenue. This passion continues through his current efforts with V4i and the commitment to extend understanding and access to these capabilities.
- Doug earned a BS in Mechanical Engineering from Rose-Hulman Institute of Technology, an MBA from Purdue Krannert School of Management, and an International Business MBA from ESCP Europe.

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Understand your systems.

Bill Schindel, President, ICTT System Sciences

- 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. He leads ICTT System Sciences participation in the V4 Institute.
- Bill served as a Trustee of Rose-Hulman Institute of Technology, chairing its board committee on academics for ten years. His earlier roles included service on the faculty of Rose-Hulman Institute, founding and running a telecom electronics company for two decades, and aerospace engineering methods advancement for the Federal Systems Division of IBM Corporation.

- Panel initial presentations

- Discussion by panel and attendees

Position Statement

Patterns In the Public Square:

Sharing Model Patterns to Optimize Innovation

Dr. John F. Matlik, Chief of Manufacture & Service Systems

19 October 2018

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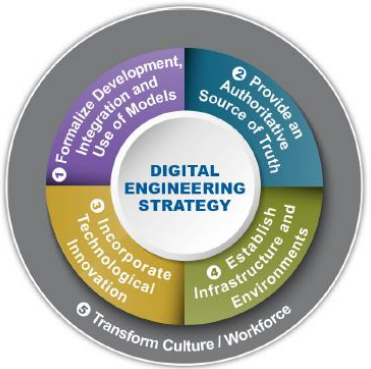
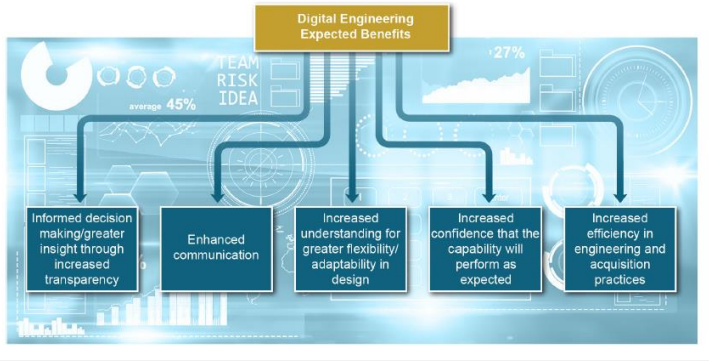
Digital - A Customer Requirement

The Dawn of Digital Engineering





"… a way to achieve greater performance & affordability"

https://www.acq.osd.mil/se/docs/2018-DES.pdf

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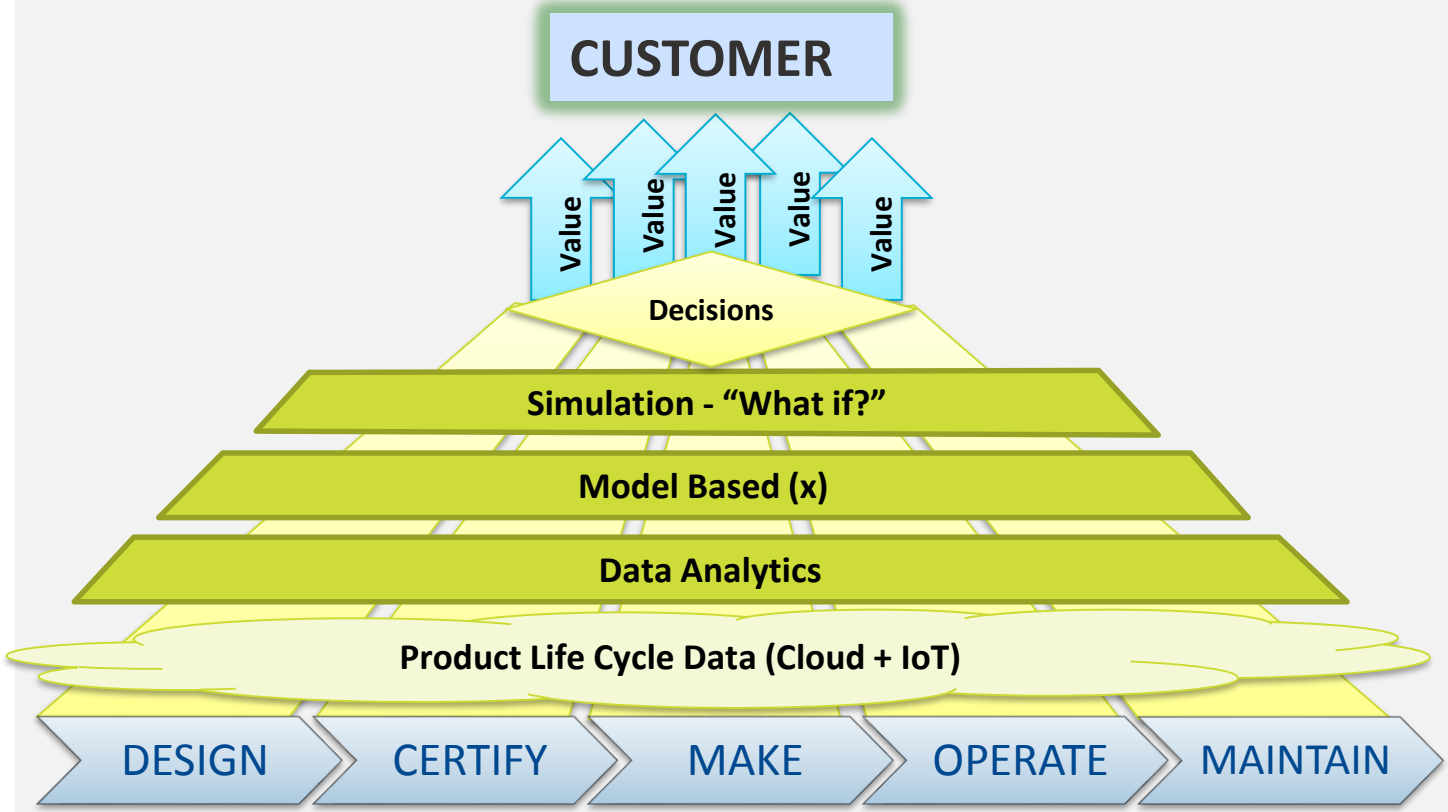
Focus on value … not capability

Customers value ability to make good decisions through digital integration



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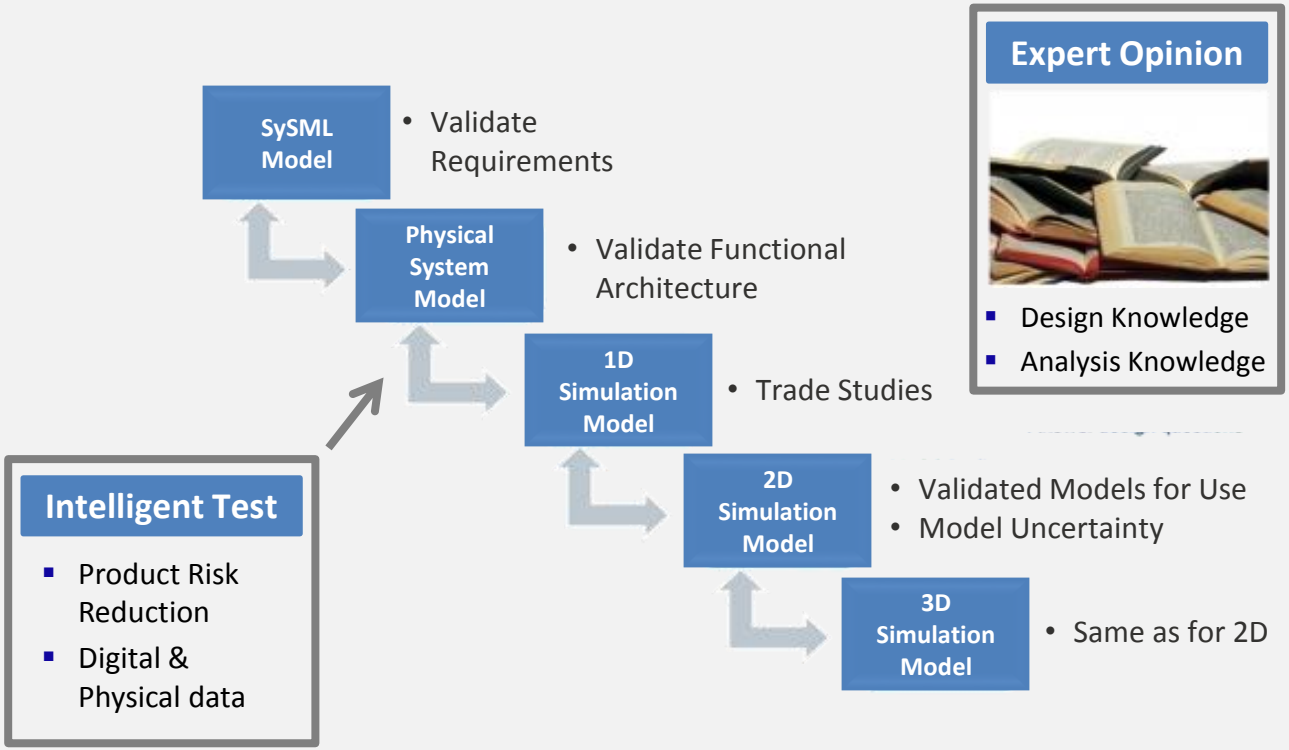
Model Verification, Validation & Uncertainty Quantification (VVUQ)

"No model is right, some models are useful"

Know how much to trust the model …



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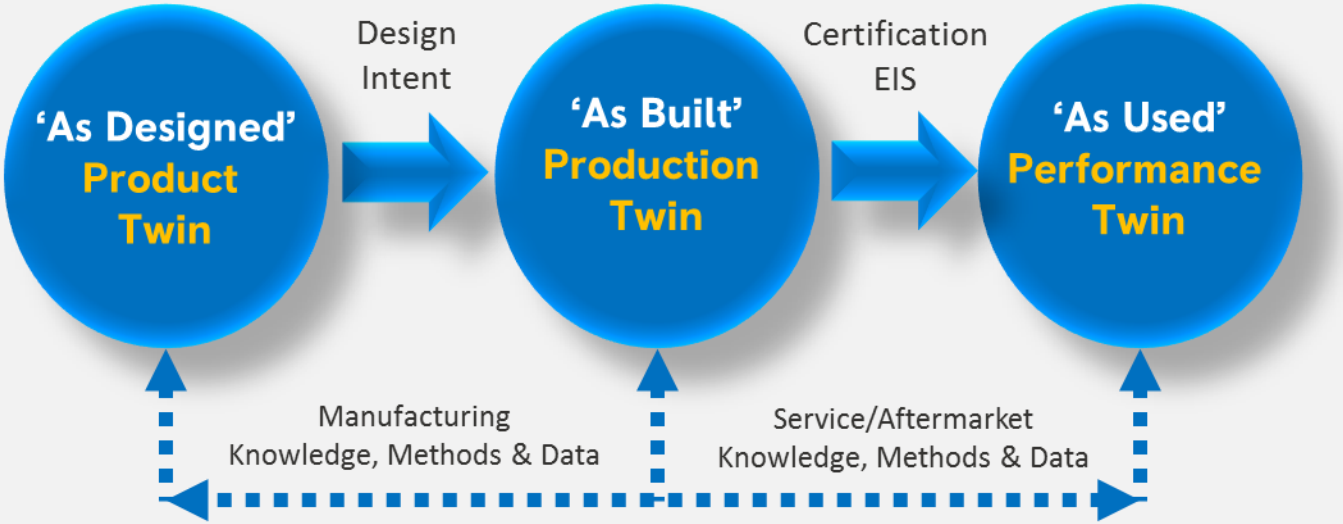
Full lifecycle application of Digital Engineering avoids late defects…

Full realization of value requires a life cycle view … systems, not silos



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Digital Engineering enables rapid platform integration

Model-based engineering and collaboration are re-inventing the way new product systems and services are developed

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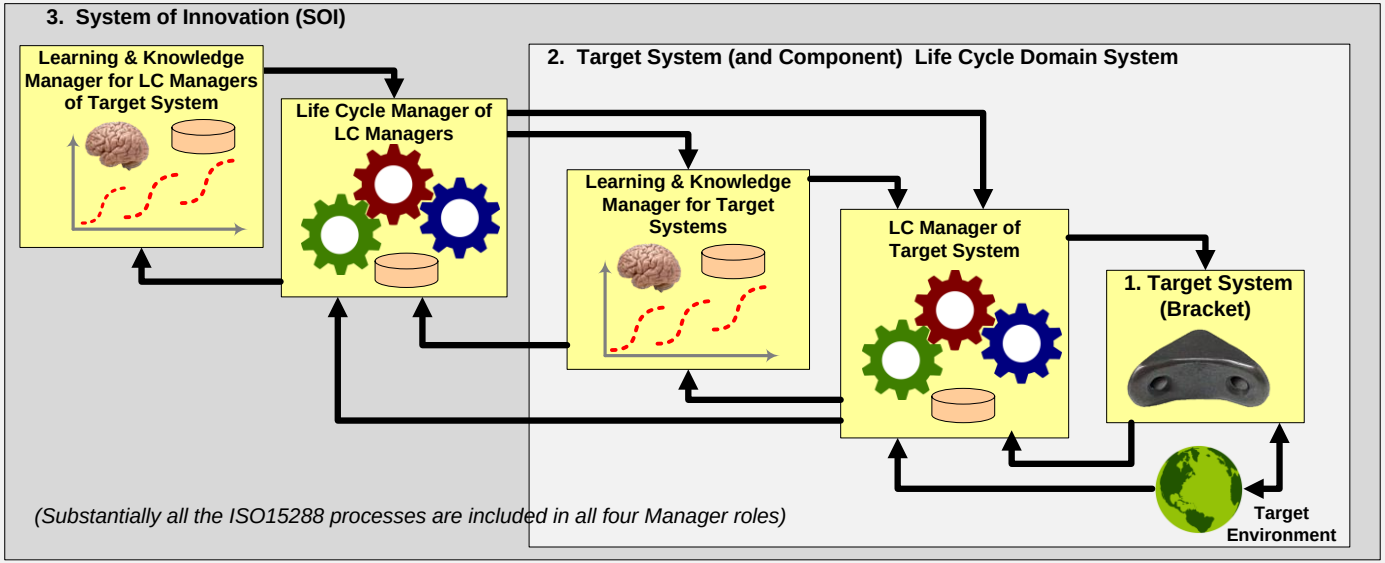
The importance of understanding your system of interest …

Holistic view required to facilitate system integration through context and understanding



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*W. Schindel, System of Innovation S*Pattern, S1-S2-S3 View, ICTT System Sciences, Oct., 2017.*
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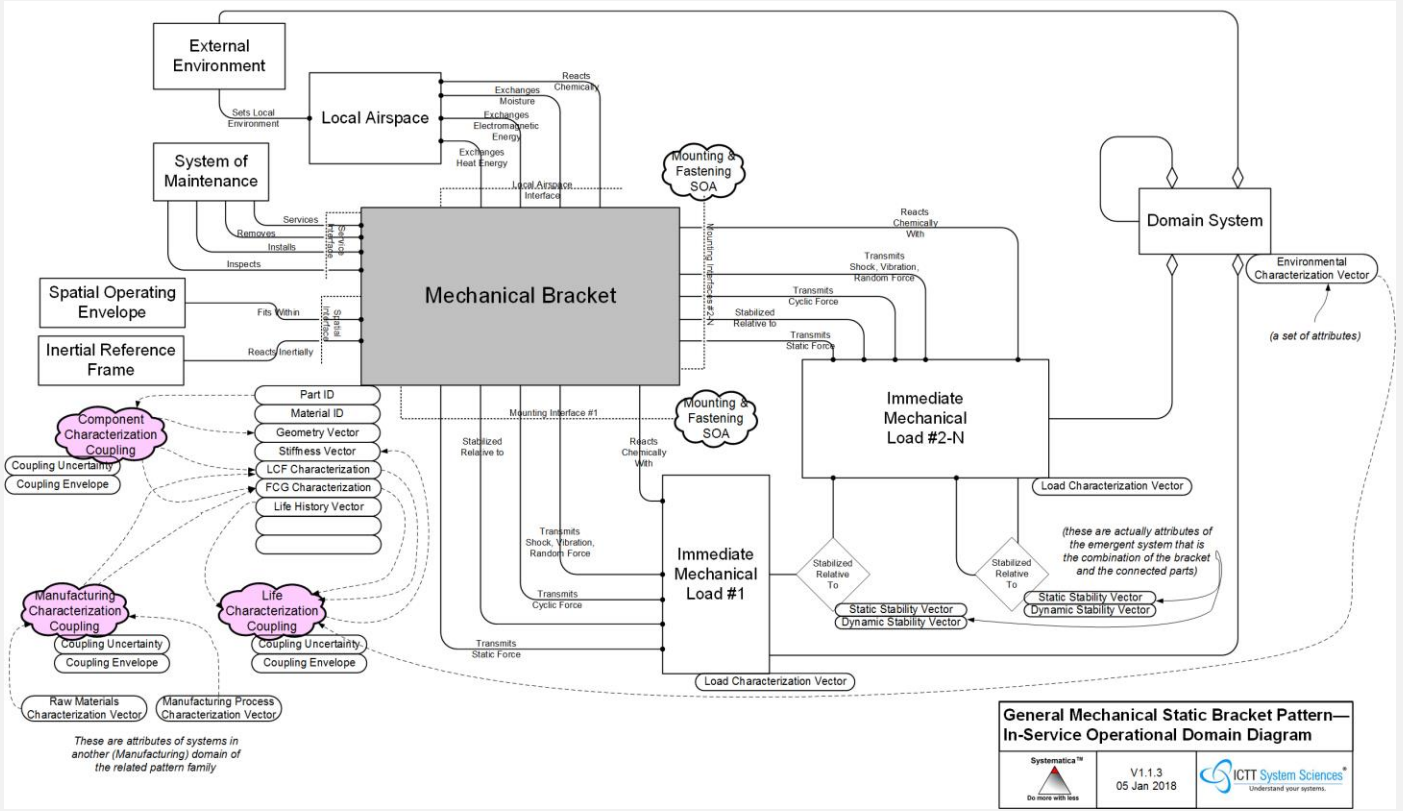
An example …

System patterns enable collaboration, learning and reuse



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*W. Schindel, General Mechanical Static Bracket S*Pattern, In-Service Operational Domain View, ICTT System Sciences, Jan 2018.*
As appeared in INCOSE Interface Patterns Project Meeting (part of INCOSE Patterns Working Group), March 8, 2018.

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Closing Comments

Realizing Value through patterns …

Opportunity: *Enabling digital transformation for* ***business benefit*** *…*

- **Builds Trust** – in models and use of them
- **Facilitates Integration** – with context and understanding
- **Enables Collaboration** – for learning & reuse

Realization challenges: *Need a* ***CULTURE*** *that …*

- **Focuses on Value –** know & validate “why” you are doing it
- **Promotes Systems Thinking –** holistic viewpoint beyond only what is “good for me”
- **Demonstrates Servant Leadership** – willing to walk in another's shoes…

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Patterns in the Public Square: Sharing Model Patterns to Optimize Innovation

Position Statement

Doug Koeneman, Cofounder & Partner, ASG

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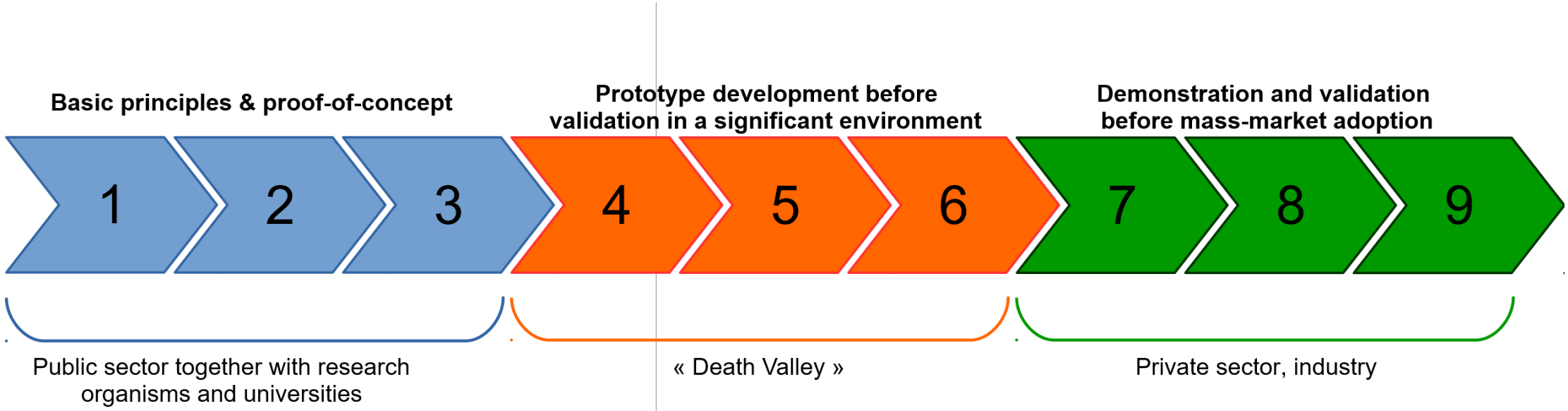
What is the Valley of Death?



Where does innovation start?

Does realizing innovation require us to operate across many phases simultaneously?

How do we systematically advance while reducing risk and accelerating access to value?

What does it take to reduce complexity to concurrency (survival) and concurrency to a strength (to win)?

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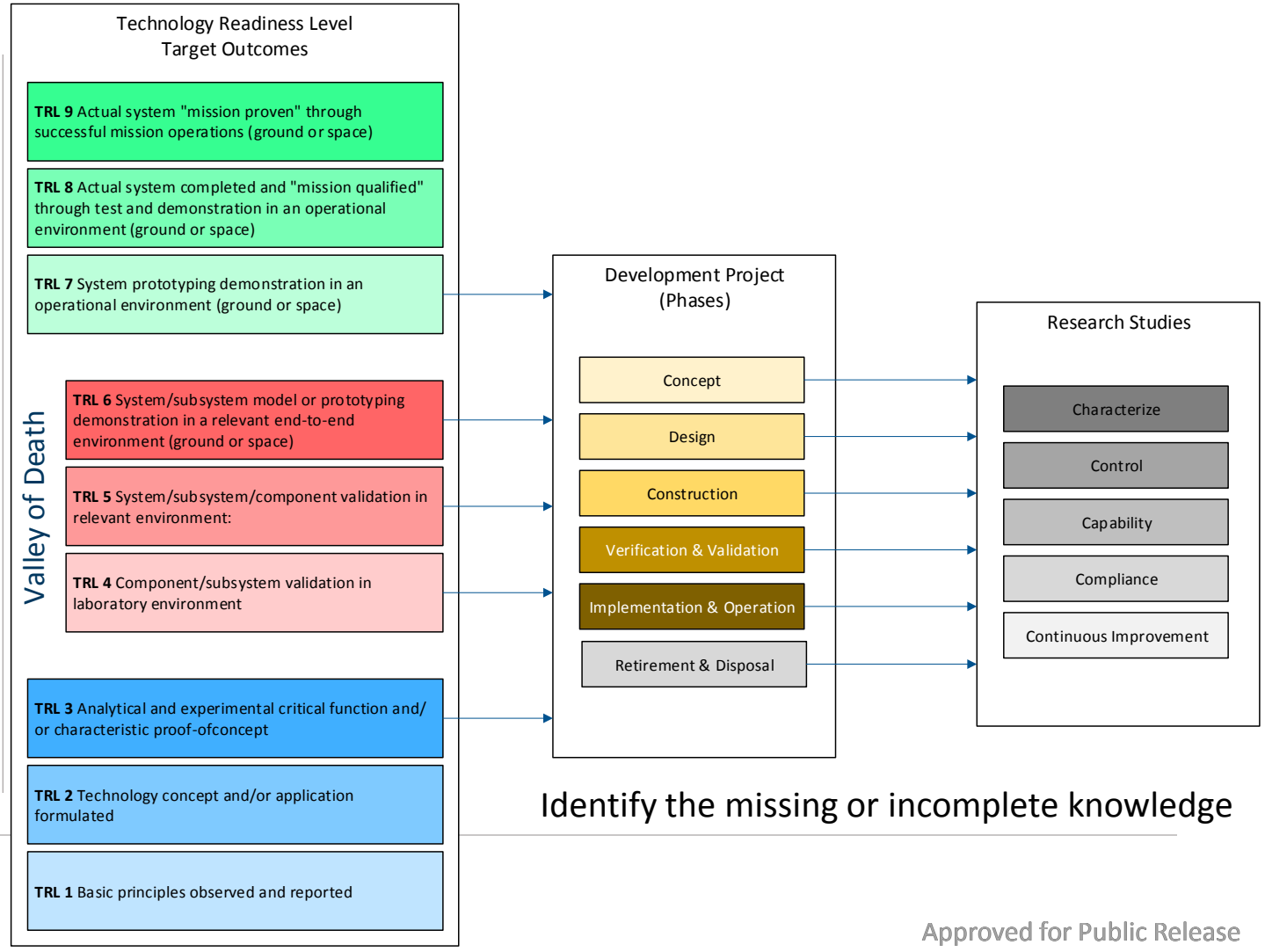
Traversing the Valley of Death

- Pattern based models organize & accumulate knowledge across the life cycle and promote reuse.
- Modeling & Simulation moves research & verification out of the physical into the virtual world…increasing speed & agility.
- Using patterns based models with M&S standardizes the language & unlocks collaboration at a new level.



Identify the missing or incomplete knowledge

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What exactly is the End in Mind?

Moving from a traditional waterfall development to a Lean Innovation process with MVP

…it's a different world.

Most effort (and time) is in aligning risk and risk attitudes to understand what decision is actually being made to advance innovation

… not in the decision itself.

- **Common language** to enable collaboration
- **Aligned process** to set context and expectations for understanding and assessing risk
- Tools for **open sharing of ideas and solutions** while protecting background intellectual property.
- An **accepted measurement** for certainty that both enough is known and the level of confidence what is known is reproducible …as innovation traverses the valley of death.

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The Future … Collaborative Ecosystems

Ecosystems are about about PEOPLE internally and externally who …

- Are focused on a common mission -- value innovation – and common priorities
- Possess a shared understanding and speak a common language
- Fill critical gaps in capability and capacities
- Play well with others
- Embrace change and the spirit of constant innovation

Ecosystems of seamlessly integrated enterprises and contributors who… work together to reduce risk for all in the digital transformation.

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Small, Entrepreneurial Enterprises

A known, accepted process combined with common knowledge captured in patterns enables the small, entrepreneurial business to focus critical resource on the highest priorities.

- Are typically more agile in response because they are less constrained by precedence and structure
- Can be key sources of innovation and ideas… but often lack critical resources, capacities and know-how to realize.
- Are ready to step-up and contribute, but need an accepted process and right opportunity to engage
- Provide alternative perspectives that help in understanding the limits to balance with risk acceptance

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Don’t let the partners in your ecosystem accept risk outside the current boundaries of their understanding.

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Calling out the Business Challenges

Old axiom…

fail early & often

New axiom…

learn early & share openly

- Transforming the people and organizations to create understanding & trust across the ecosystem
- Establishing the Risk- Benefit relationship
- Developing Common Language
- Ability to share openly without compromising the prize (Intellectual Property)
- Building or Accessing …the resources needed to complete the mosaic
- Acceptable Process & Measurement (expectations)
- Finding an agent to integration the ecosystem

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Sharing Model Patterns to Optimize Innovation

Position Statement

Business Opportunity

- Lowering risk for small business
- Shorter time to market
- New sources of competitive advantage

Business Challenges

- Building trust internally (with own staff) and externally (with regulators and customers)
- Developing/acquiring and validating the needed capabilities and capacities
- Systematizing the limits of pattern-based modeling

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References

The first two panels in this series, plus a related presentation, themselves contain considerable background reference bibliographies, resources, and links to standards, on the focus of those panels:

1. Schindel, Heller, Roedler, Johnson, “Accelerating Innovation Effectiveness: New Collaboration Roles for Engineering Societies and Regulators”, in *Proc. of INCOSE 2017 Great Lakes Regional Conference*, Minneapolis, MN, October, 2017; download from http://www.omgwiki.org/MBSE/lib/exe/fetch.php?media=mbse:patterns:panel--accelerating_innovation_effectiveness_societies_regulators_glrc_2017_schindel_v1.3.5.pdf
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Additional references, primarily on The Commons related subjects:

4. Altschuler, J., et al, “Opening Up to Precompetitive Collaboration”, *Science Translational Medicine*, Vol. 2, Issue 52, Oct. 6, 2010, retrieve from http://stm.sciencemag.org/content/2/52/52cm26.full
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12. Ostrom, Elinor, *Governing the Commons: The Evolution of Institutions for Collective Action*. Cambridge, UK: Cambridge University Press. ISBN 9780521405997, 1990.
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14. Hardin, Garrett, “The Tragedy of the Commons”, *Science*, Vol. 162, pp. 1243-1248, Dec, 1968.
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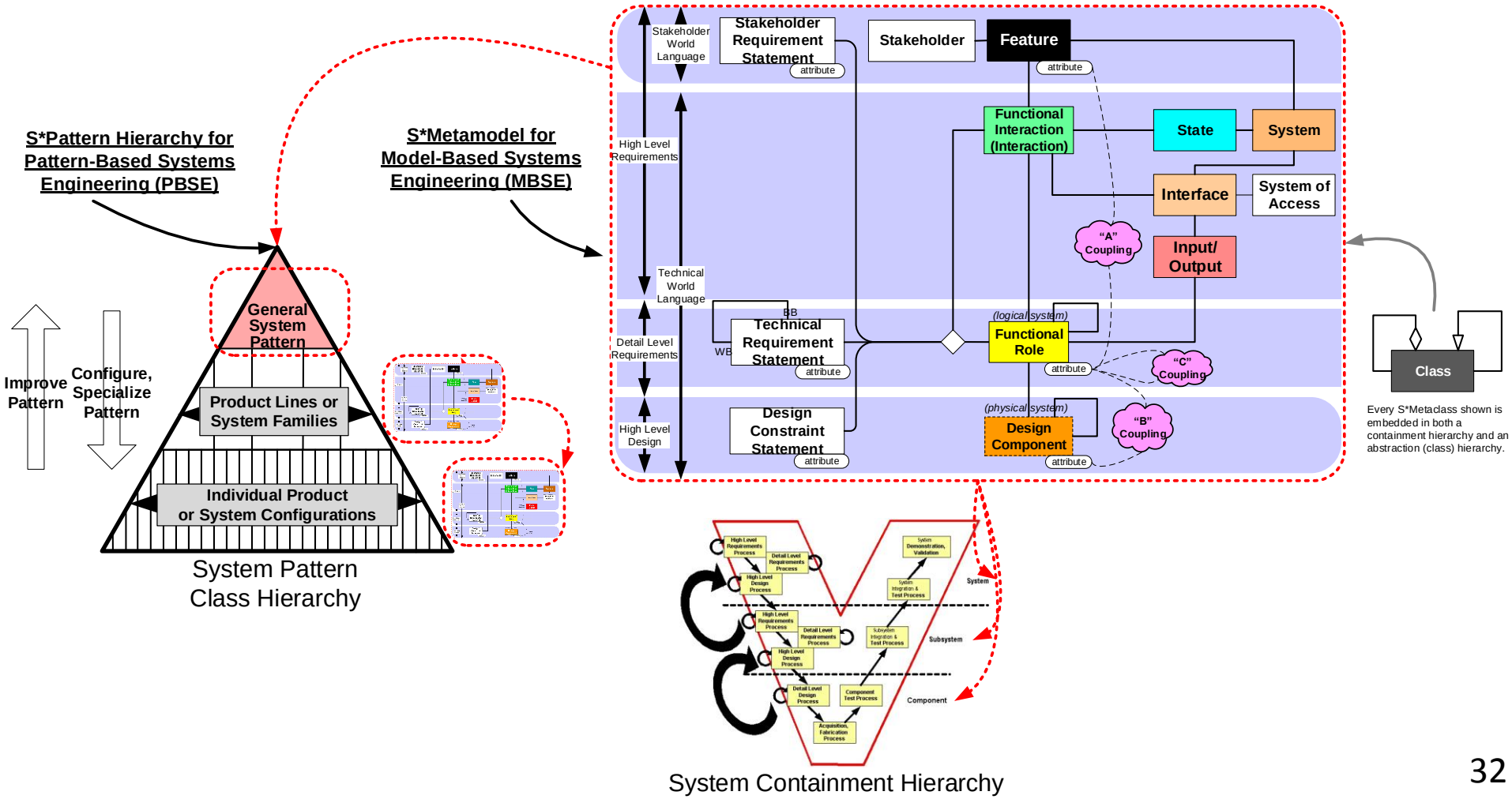
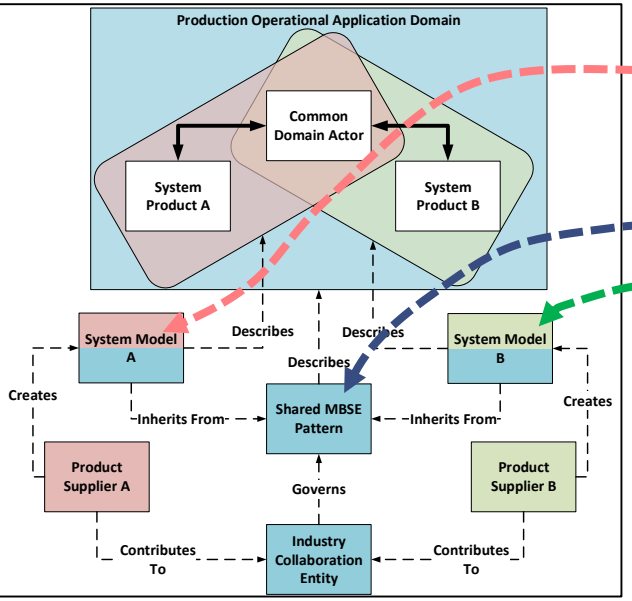
Protected IP, Coordinated with Shared Public IP

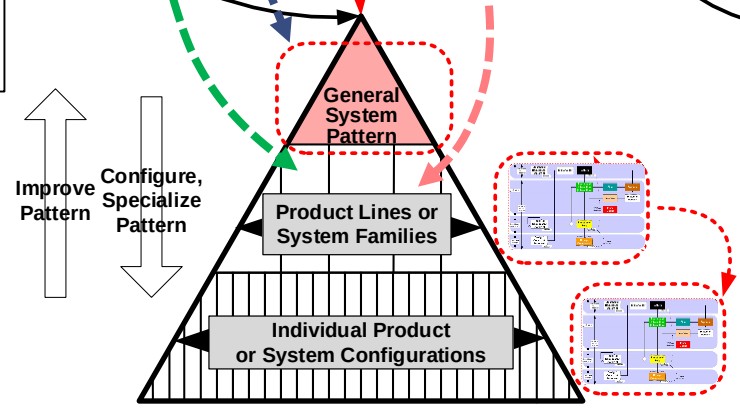


Protected IP, Coordinated with Shared Public IP

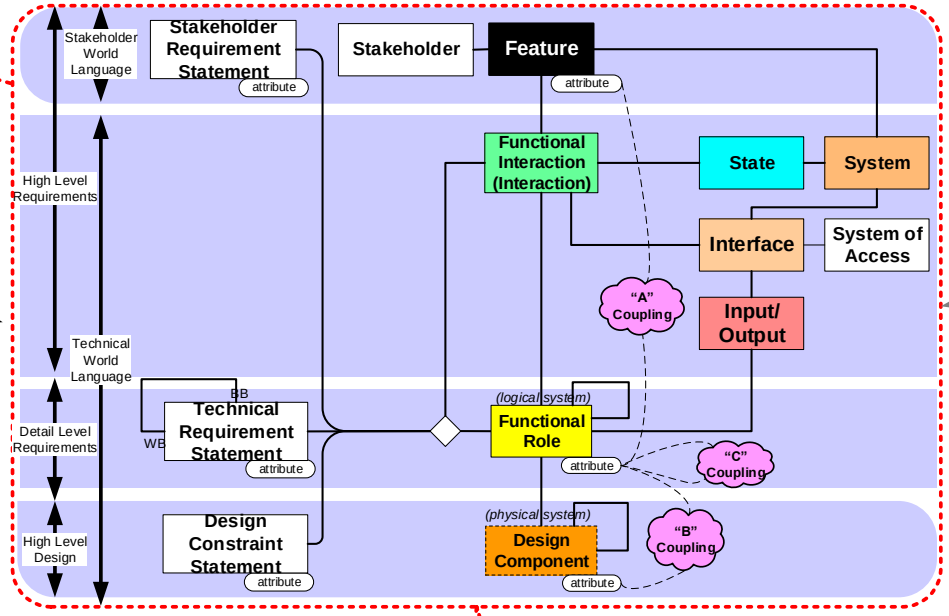


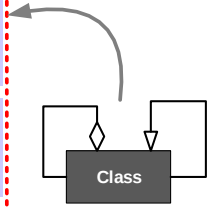
S*Pattern Hierarchy for Pattern-Based Systems Engineering (PBSE)

S*Metamodel for Model-Based Systems Engineering (MBSE)

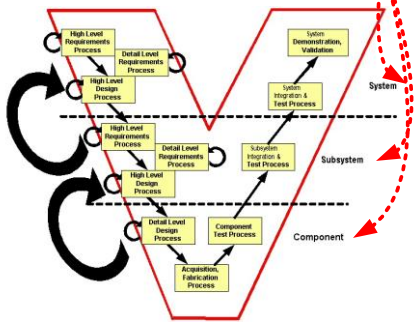


System Pattern Class Hierarchy





Every S*Metaclass shown is embedded in both a containment hierarchy and an abstraction (class) hierarchy.



System Containment Hierarchy

Examples of Public Square Shared Model Activity

- Consortium-generated technical standards, frameworks: Not new.
- But, expressing them as system models emerging more recently.
- Examples of related efforts:
  - Trustable models: ASME Model VVUQ Standards activity
  - Domain specific example: EPRI CIM Electrical Power Industry Model
  - Harvesting patterns from legacy descriptions
  - V4 Institute: expanding capabilities in virtual verification
  - Model-Based Standards Authoring (MBSA)
  - Public licensing and open source movements (e.g., Creative Commons)