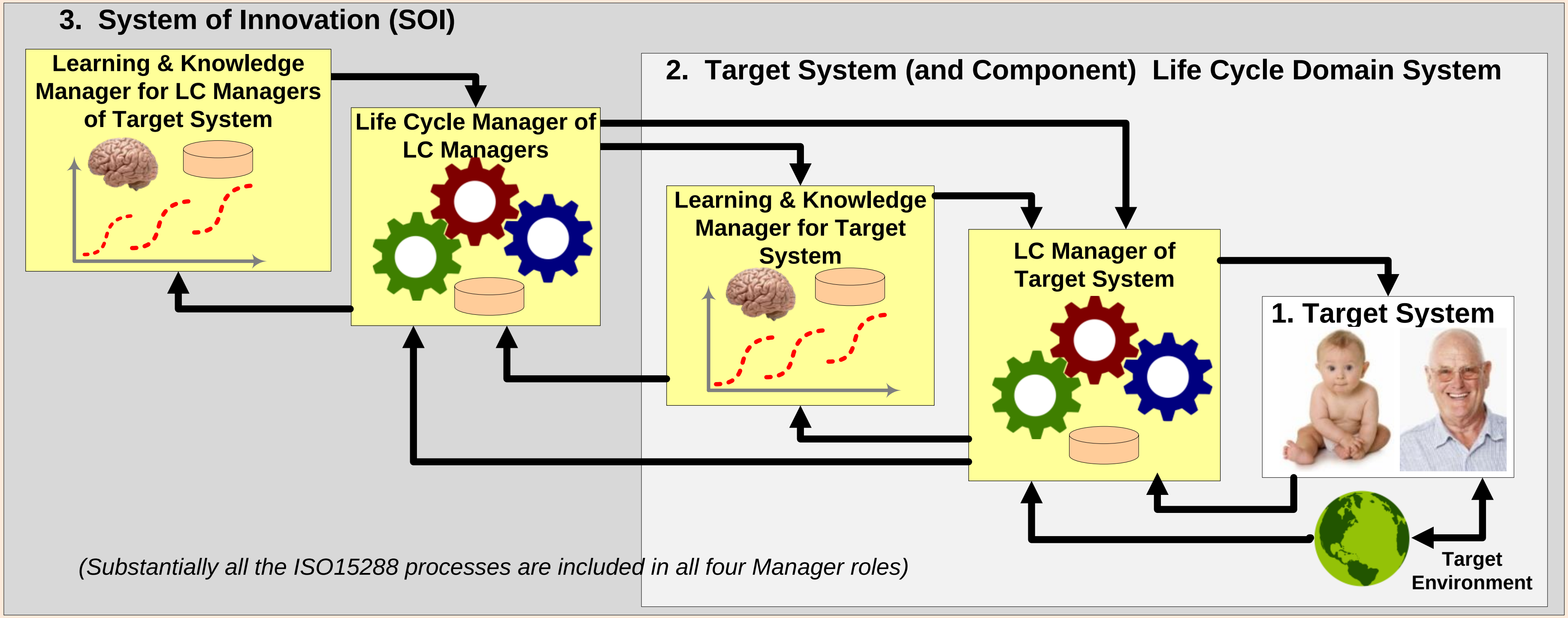
Advancing Agility in Health Care Systems: Applying the INCOSE Agile Systems Engineering Life Cycle Management Pattern



INCOSE Agile Health Care Systems Conference
May 16-17, 2017, Chicago, IL

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Abstract

- During the 2016 Agile Health Care Systems Conference, a break-out group worked on application of the INCOSE Agile Systems Engineering Life Cycle Management (ASELCM) Pattern, applied to the health care domain. This led to identification of perceived priority targets for increased agility in the health care domain.

- This session will briefly review their conclusions, then provide a means for participants to apply the pattern further, along with another INCOSE planning instrument, in the public forum offered by the conference as well as confidentially when they return to their home enterprises.

Contents

- Health care systems and agility
- INCOSE: Agility in general systems engineering
- The emerging connection of agility to models
- INCOSE ASELCM Pattern, applied to Health Care Systems
- INCOSE MBSE Assessment and Planning Pattern
- Agility through shared patterns in regulated domains
- Conclusions from 2016 INCOSE AHCS and ET Conferences

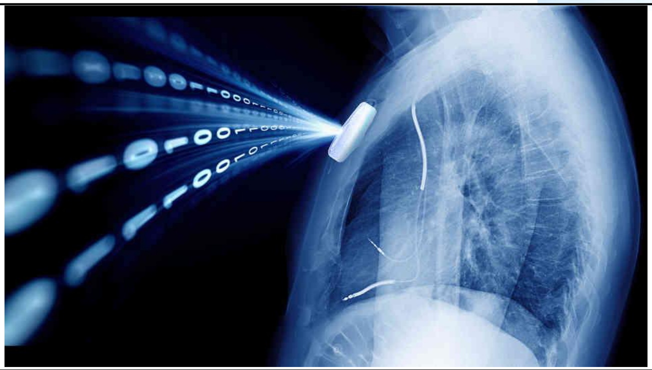
- Break out session: Agile Test Drive, Hot Spot Collection

- References
- Attachment: Break out session materials
- Attachment: Take home beta instruments for your use

Health Care Systems and Agility

- Viewed at almost any level—individuals, products, enterprises, market segments, or society--Health Care appears as a vast and complex system.



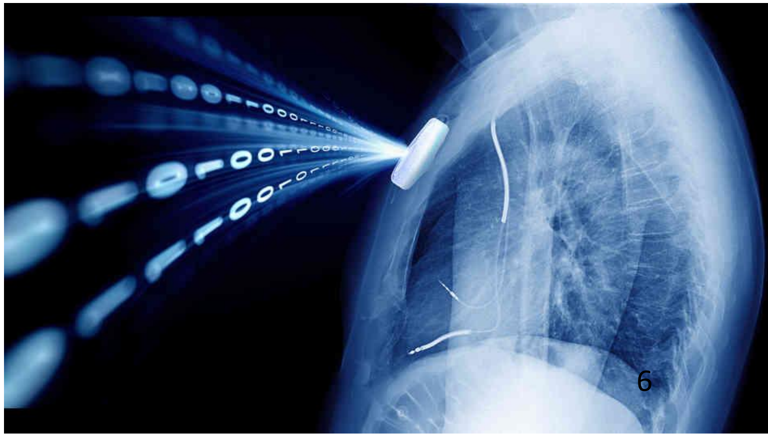


Health Care Systems and Agility

- Since there are countless challenges and opportunities for progress, how can an enterprise, industry, society, or individual systematically plan and manage future progress and innovation?
  - Where can we best apply the principles and lessons of Systems Engineering, deeper Agility, or Lean Methods to make optimal progress today, tomorrow, and in the future?
  - Is there a systemic approach to map-making for planning this progress?

Health Care Systems and Agility

- Roughly speaking, in referring to “agility”, we mean ability to respond effectively to the challenges of uncertainty and rates of change in environment, stakeholders, competition, technologies, capacities, capabilities.
- This includes learning and adjusting.
- Not just “going faster”.



Health Care Systems and Agility

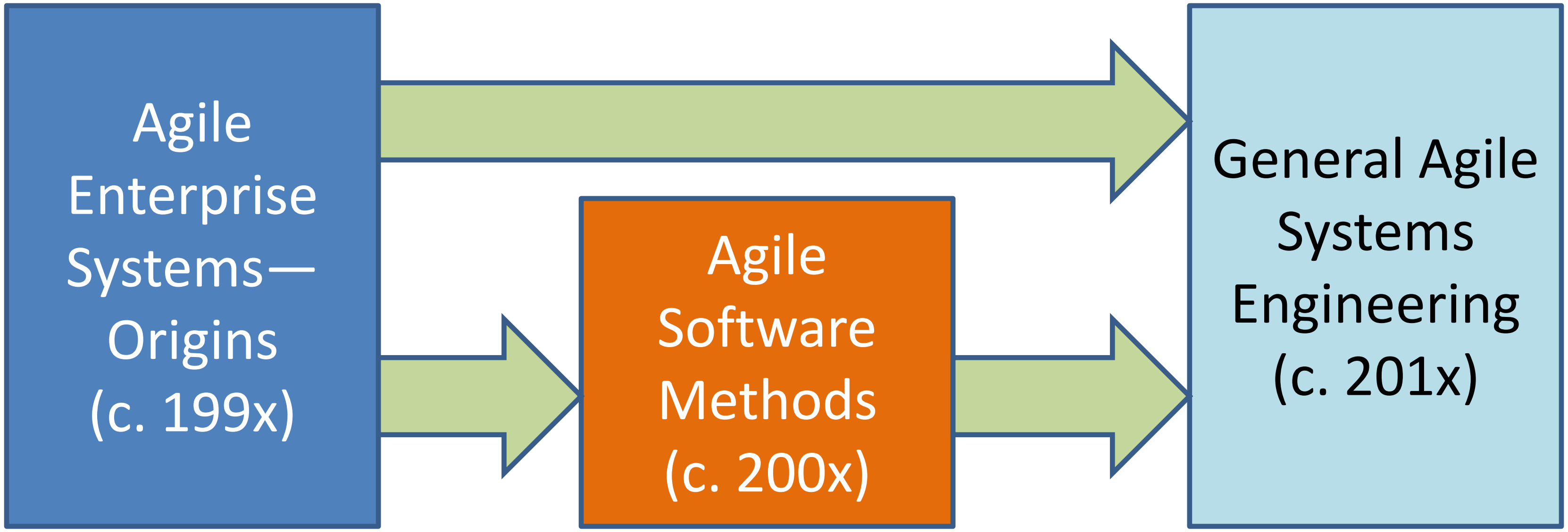
- This session will include brief overviews of the:
  - INCOSE Agile Systems Engineering Life Cycle Management (ASELCM) Pattern being developed by the INCOSE ASELCM Discovery Project,
  - INCOSE MBSE Planning and Assessment Roadmap being developed by the MBSE Transformation Project,
  - INCOSE Model VVUQ Pattern being developed by INCOSE as part of the ASME Model Validation and Verification Project,
- And,
  - Break out: “Test drive” some of these, to map “hot spots” and opportunities for progress
  - Take home: Plus, resources to use privately after the conference.

INCOSE: Agility in General Systems Engineering

- The INCOSE parent society is sponsoring the Agile Systems Engineering Life Cycle Model (ASELCM) Discovery Project:
  - Based on a series of workshop clinics being held at case study discovery host enterprise sites
- This project, now underway, will provide INCOSE inputs to a future version of ISO 15288, to improve explicit understanding of principles and practices of agility as applicable to systems engineering across different domains.
  - So far, three case studies and an overview have been published in INCOSE and IEEE conference proceedings, with continuing work underway
  - Your company can host such an INCOSE discovery workshop
- Support from INCOSE Agile Systems WG and MBSE Patterns WG:
  - Rick Dove, project lead, co-leads Kevin Forsberg, Jack Ring, Garry Roedler, Bill Schindel

INCOSE: Agility in General Systems Engineering

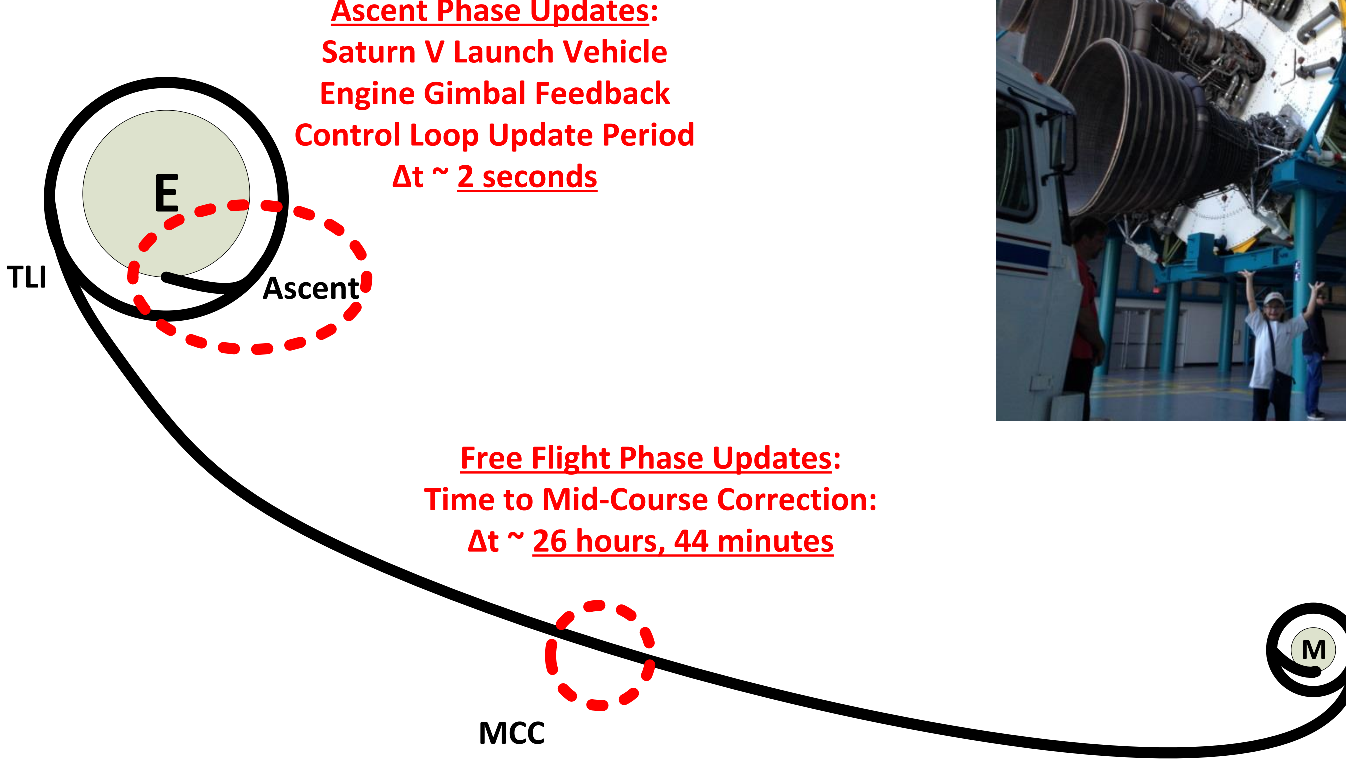
Longer history than just Agile Software Development Methods :



- For history and background, see Dove and LaBarge, 2014
- Agile software methods, by far better known, are related.
- General Agile Systems Engineering is the related broader subject of the INCOSE ASELCM Project.

Optimized Feedback & Correction Cycle Rate: A Hallmark of Agile Methods & Problem Space

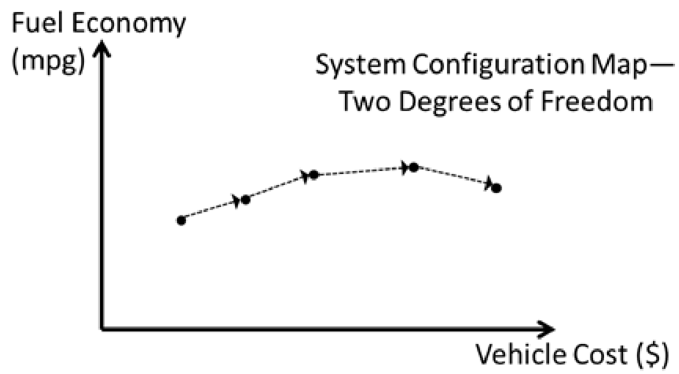
An Apollo 11 Mission Question: Why was the Saturn V rocket engines' directional gimbals update cycle period throughout the Ascent Phase ~ 2 seconds, but the update cycle period of course direction during the Free Flight Phase was ~ 26 hours?



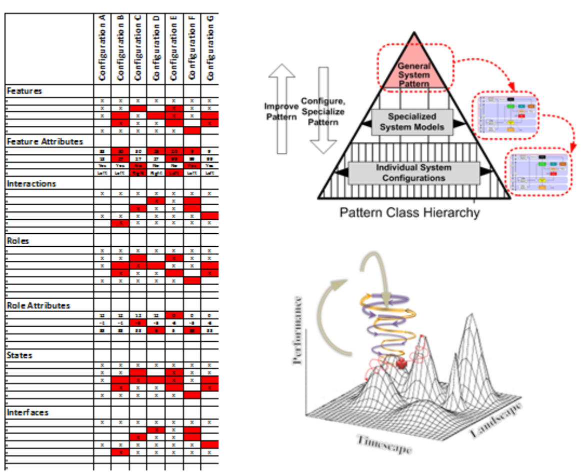
System Life Cycle Trajectories in S*Space

- Configurations change over life cycles, during development and subsequently
- Trajectories (configuration paths) in S*Space
- Effective tracking of trajectories
- History of dynamical paths in science and math
- Differential path representation: compression, equations of motion

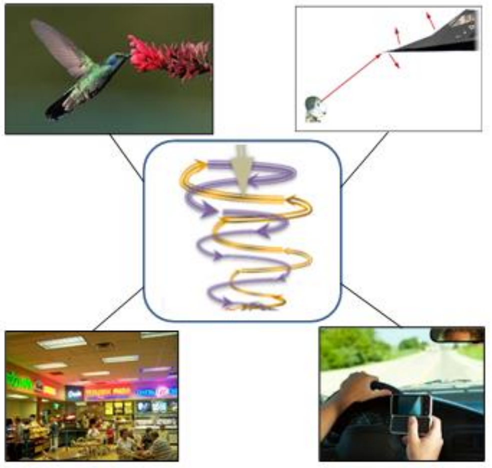
Evolving Systems Over Multiple Life Cycles



Path as a series of system configurations, through iterations of the SE process



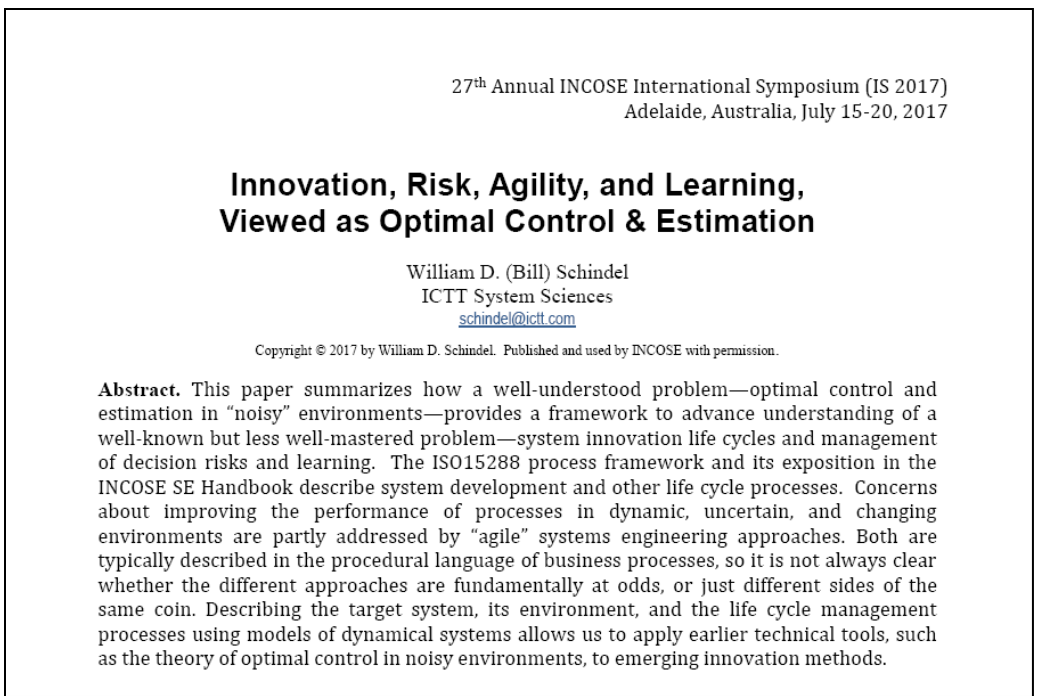
"Delta" Descriptions Further Compress Trajectory Representations



Co-Evolution of Interacting Systems

The Emerging Connection of Agility to Models

"Agility" and "Trajectory" are not just metaphorical terms—there is a further body of applicable historical technical findings, tools:



27th Annual INCOSE International Symposium (IS 2017)
Adelaide, Australia, July 15-20, 2017

Innovation, Risk, Agility, and Learning, Viewed as Optimal Control & Estimation

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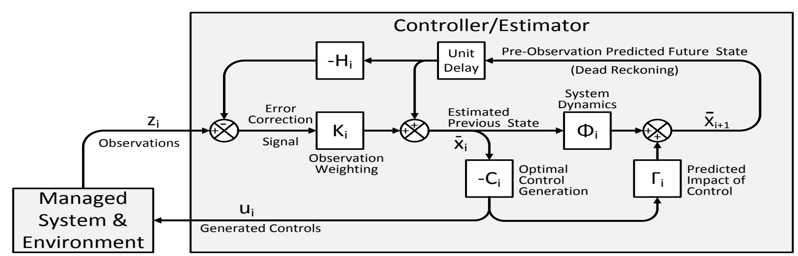
Abstract. This paper summarizes how a well-understood problem—optimal control and estimation in "noisy" environments—provides a framework to advance understanding of a well-known but less well-mastered problem—system innovation life cycles and management of decision risks and learning. The ISO15288 process framework and its exposition in the INCOSE SE Handbook describe system development and other life cycle processes. Concerns about improving the performance of processes in dynamic, uncertain, and changing environments are partly addressed by "agile" systems engineering approaches. Both are typically described in the procedural language of business processes, so it is not always clear whether the different approaches are fundamentally at odds, or just different sides of the same coin. Describing the target system, its environment, and the life cycle management processes using models of dynamical systems allows us to apply earlier technical tools, such as the theory of optimal control in noisy environments, to emerging innovation methods.



How are Agile Systems Related to MBSE?

1. **Basics**: Using explicit models, MBSE/PBSE adds clarity to pre-model descriptions of Agile Systems and Agile SE-- improves understanding of Agile Systems.
2. **More important**: MBSE/PBSE complements and improves the capability of Agile Systems and Agile Systems Engineering—
- Agility requires persistent memory & learning—*being forgetful/not learning impacts agility*.
- Patterns capture & retain learning, as persistent, re-usable, configurable, models, *updated as experience accumulates*.
- S*Patterns are configurable, reusable S*Models.

"*PBSE as Agile MBSE*" emerges as essential when competing on agility becomes reality for competing, competent players:

- Improved: "Where are we?"
- Improved: "Where are we going?"
- Improved: "We've been here before."

Vital for Scrum, other approaches

- Improved: Understanding of response.
- Improved: Understanding of mission envelopes.
- Improved: Ability to assess agility
- Improved: Ability to plan agility

Vital for Response Situation Analysis (RSA, Dove)

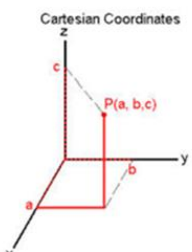
<u>Maps *vs*. Itineraries -- SE Information *vs*. SE Process</u>

Itinerary ≠ Map!

(What am I doing?) *(Where am I?)*

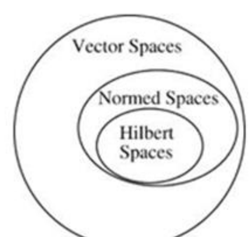
When they eventually did emerge, maps represented a newer idea of the nature of "where".

- The SE Process consumes and produces <u>information</u>.
- But, SE historically emphasizes <u>process</u> over <u>information</u>. (Evidence: Ink & effort spent describing standard process versus standard information.)
- Ever happen?-- Junior staff completes all the process steps, all the boxes are checked, but outcome is not okay.
- Recent discoveries about ancient navigators: Maps <u>*vs*</u>. Itineraries.
- The geometrization of Algebra and Function spaces (Descartes, Hilbert)
- Knowing where you are, not just what you are doing.
- Knowing where you are going, not just what you are doing.
- Distance metrics, inner products, projections, decompositions.



Rene Descartes
1596 - 1650

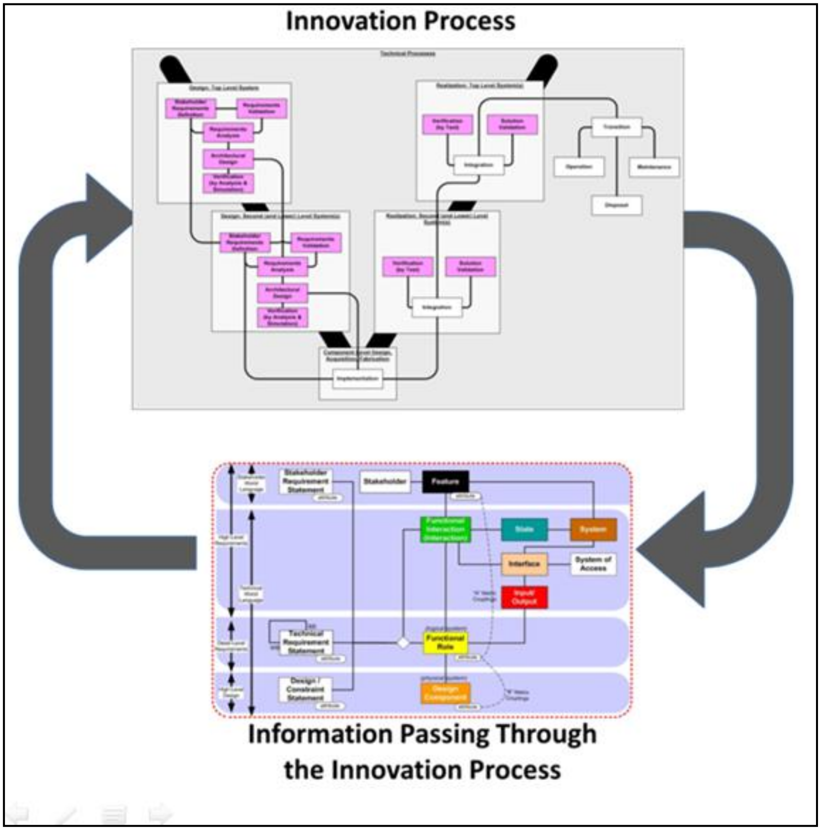
Geometrization of Algebra, by Rene Descartes

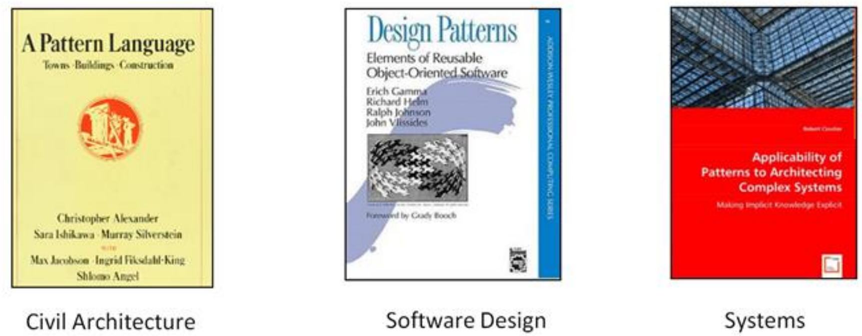


David Hilbert
1862 - 1943

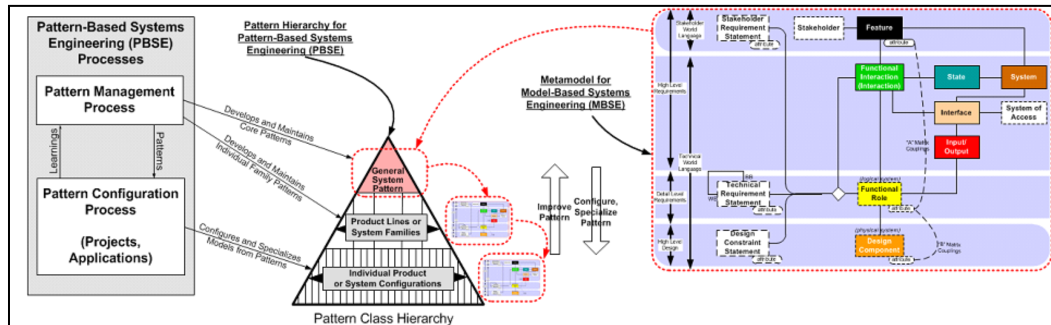
Geometrization of Function Space, by David Hilbert

Maps *vs.* Itineraries -- SE Information *vs.* SE Process





Formal Patterns In Human-Performed Engineering Processes



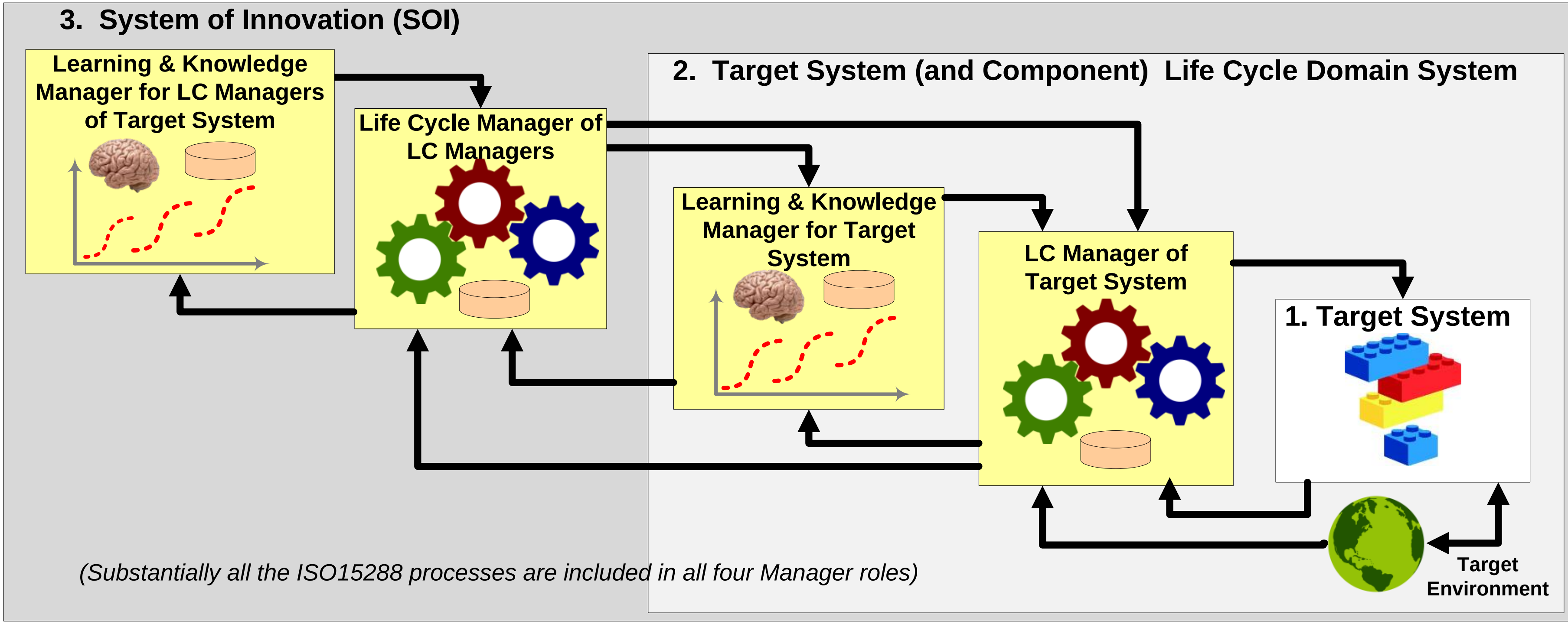
Evolving Families of Systems, Pattern-Based Systems Engineering (PBSE)

- Model-based Patterns in S*Space.
- Interactions as the basis of all laws of physical sciences.
- Relationships, not procedures, are the fruits of science used by engineers: Newton's laws, Maxwell's Equations.
- Immediate connection to Agility: knowing where you are--starting with better definition of what "where" means. There is a minimal "genome" (S*Metamodel) that provides a practical way to capture, record, and understand—the "smallest model of a system".
- Not giving up process: MBSE/PBSE version of ISO/IEC 15288.

The ASELCM Pattern, Applied to Health Care Systems

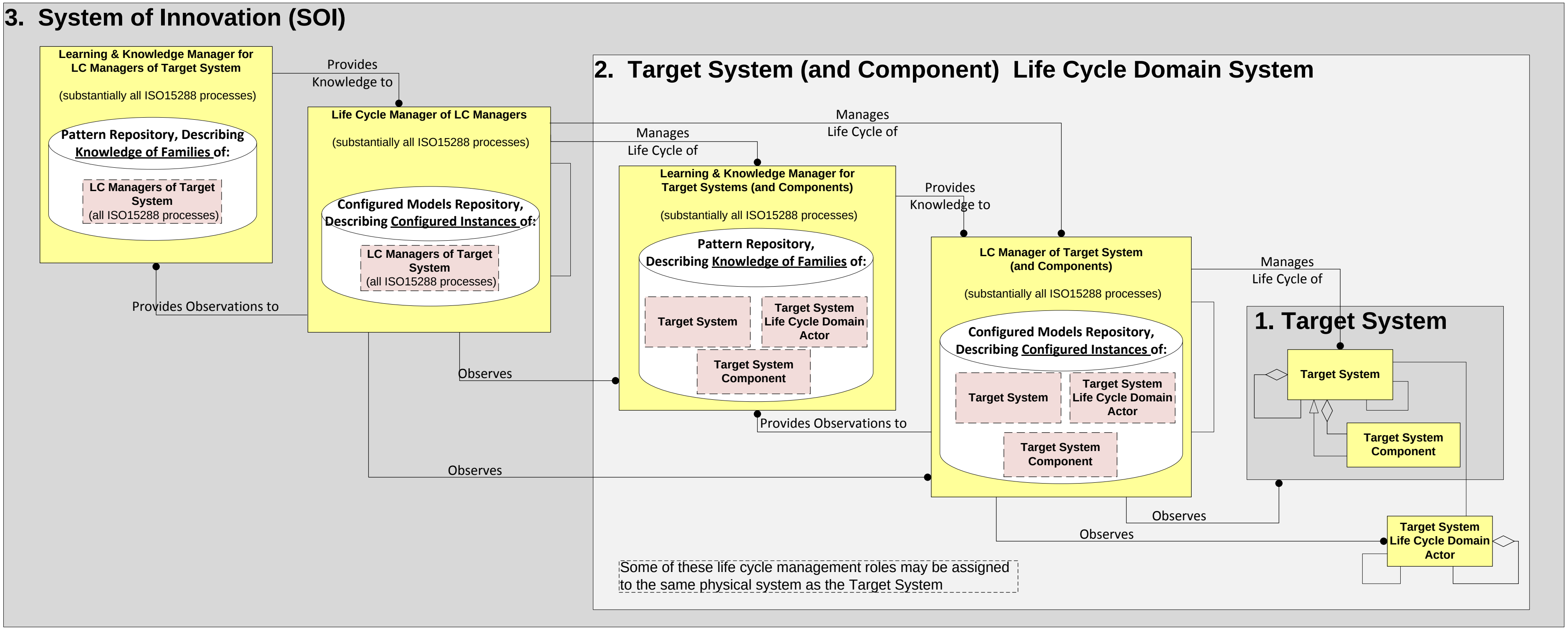
- We will particularly refer to **<u>three major system boundaries</u>**:
  - To avoid a confusion bog of loaded terms, we could have just named them “System 1”, “System 2”, and “System 3” and proceeded to define them behaviorally.
  - The definitions are <u>behavioral</u> because these are <u>logical</u> systems, performing defined <u>roles</u>.
  - However, we will also give them more specific names — but make sure you understand the <u>definitions</u> of these systems, which are more important than their names . . .

The Agile System Life Cycle Management Domain Model



- System 1: Target system of interest, to be engineered or improved.
- System 2: The environment of (interacting with) S1, including all the life cycle management systems of S1, including learning about S1.
- System 3: The life cycle management systems for S2, including learning about S2.

Behind the "iconic" diagram, there is a formal MBSE model that describes the ASELCM Pattern

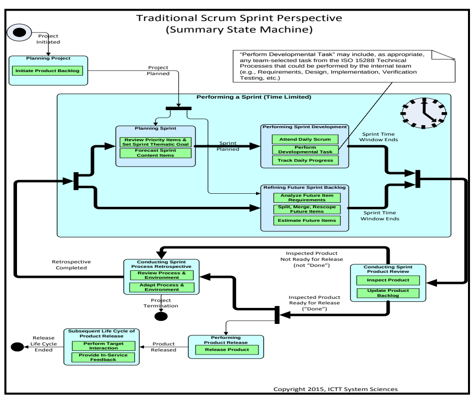


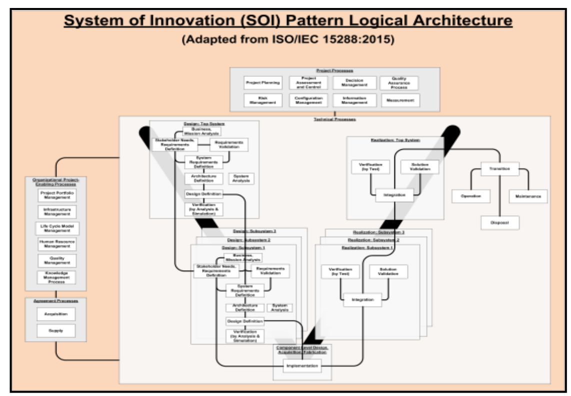
More Than One Representation (Model View) of the Same Underlying Reality

Four different representations of the same underlying reality:

1. The Scrum Pattern: Emphasizes time-bound outputs and feedback, focusing on processes for *learning from produced outputs, and management of risk*
2. The ISO15288 Pattern: Emphasizes types of processes, focusing on *management of processes*
3. The Agile Systems Engineering Life Cycle Pattern : Shows how (1) and (2) above may be seen as one
4. The S*Metamodel: Emphasizes the information flowing through all three of them: (1), (2), and (3)

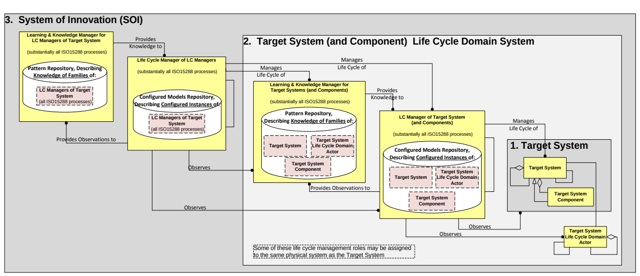
Scrum Pattern

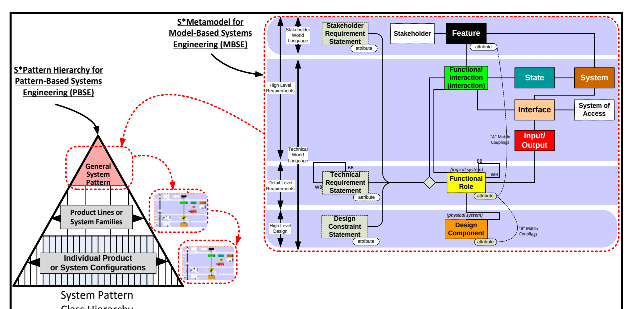




ISO15288 Pattern

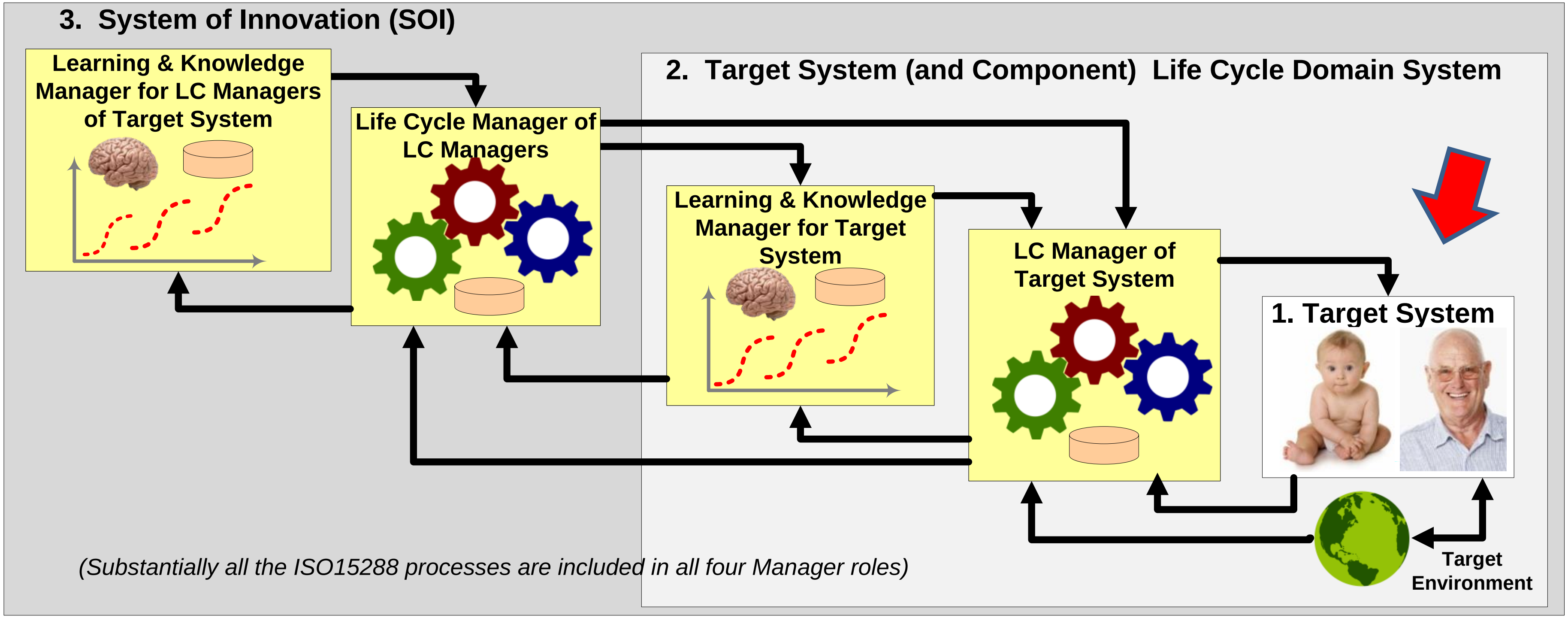
ASELCM Pattern



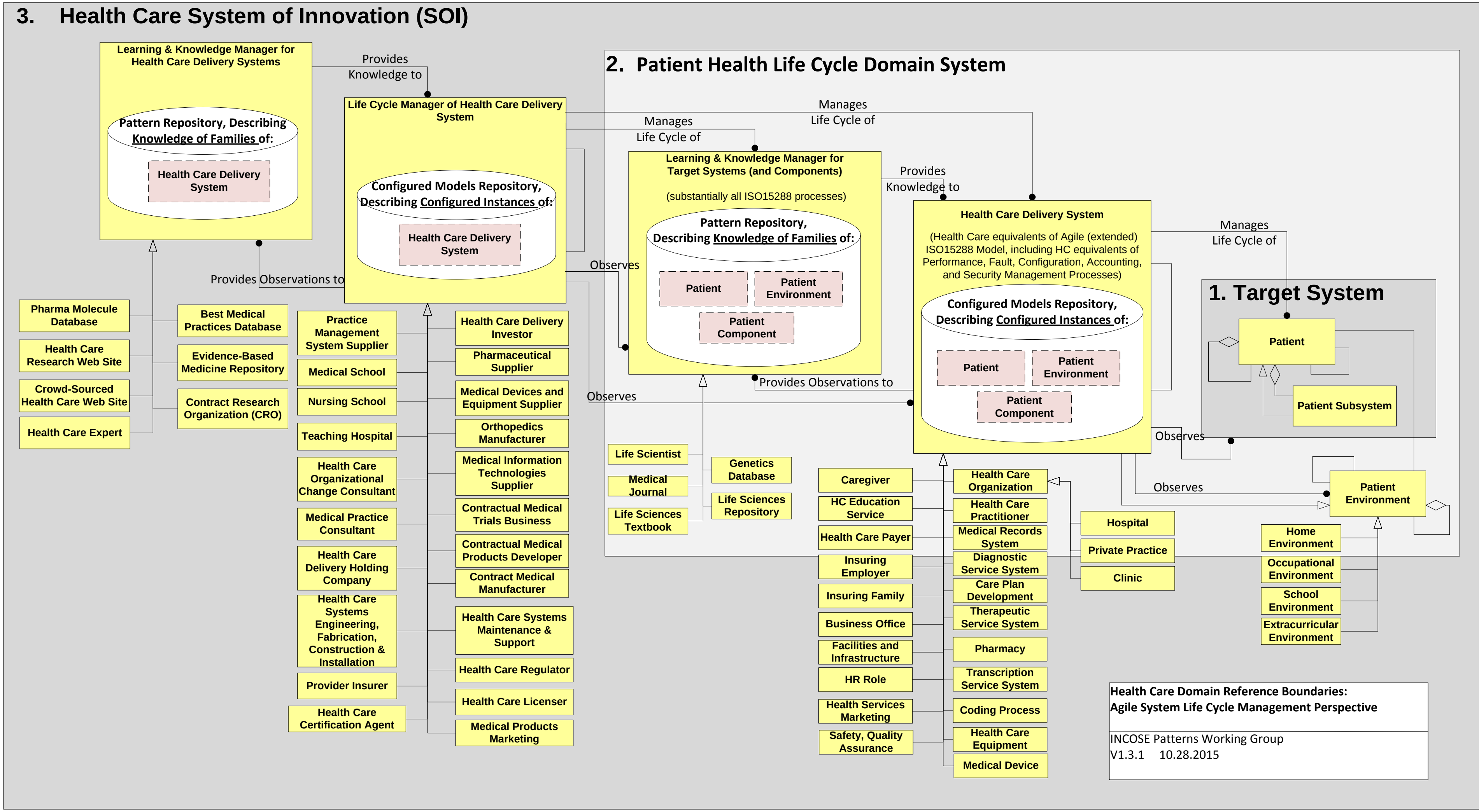


S*Metamodel

Example: Health care domain, top level



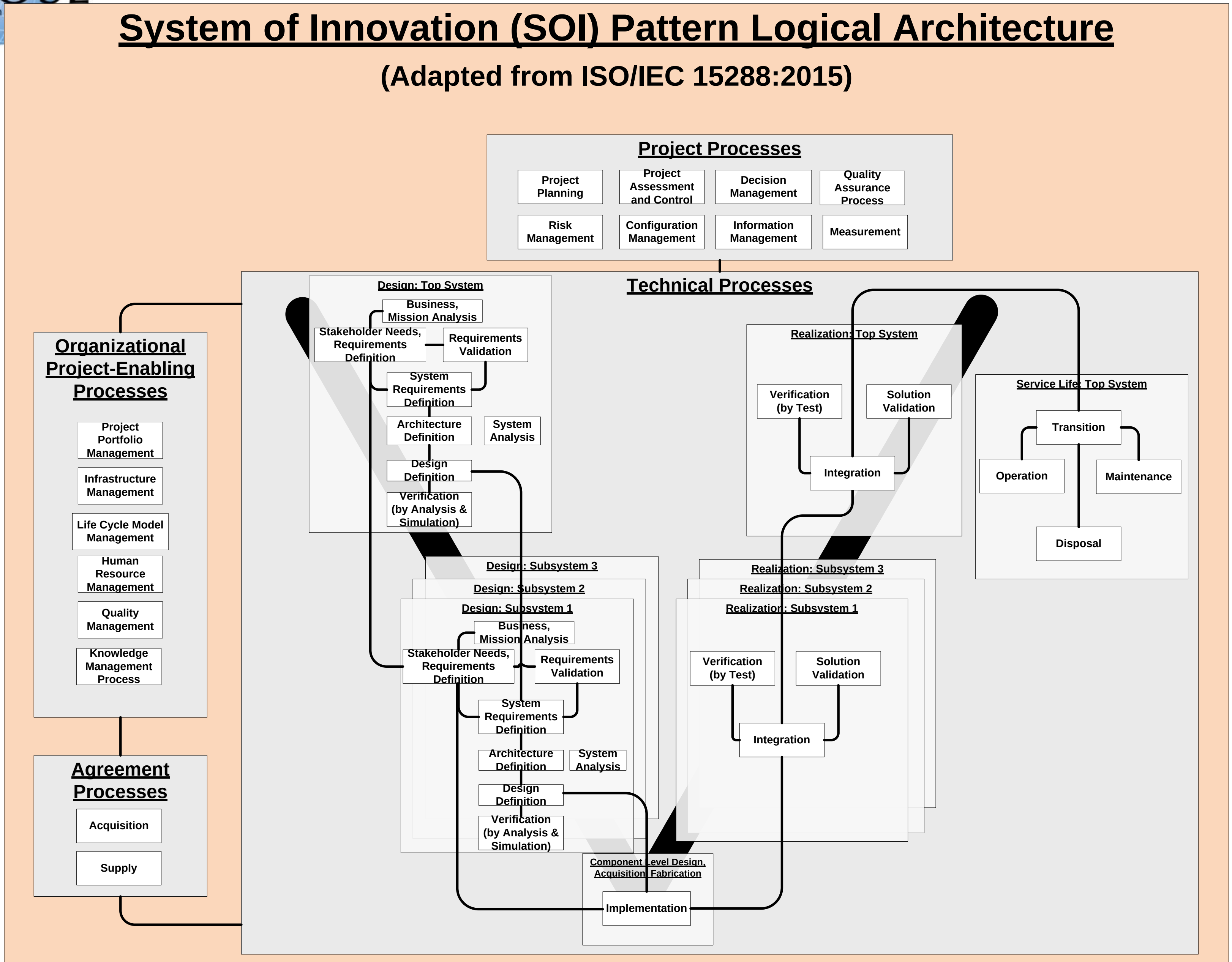
Example: Health care domain, top level



INCOSE MBSE Assessment and Planning Pattern

- The INCOSE parent society Board of Directors made it a strategic objective to support the transformation of SE to a model-based discipline.
- An Assistant Director (Troy Peterson) for this Transformation was appointed, and a plan of actions and deliverables adopted.
  - http://www.incose.org/about/strategicobjectives/transformation
- Among the products: The MBE Transformation Roadmap, a planning and assessment instrument for progress in model-based methods.
- Initial minimal product version was shown and piloted at Agile Health Care Systems 2016, at Energy Tech 2016, at IW2017 MBSE Workshop, and at IW 2017 CAB meeting,
- Initial Model Stakeholder Features being piloted in INCOSE support for the ASME Model VVUQ project.
- What does it mean to become a model-based discipline?
  - The Stakeholder Features of Models, and how they support the overall discipline
- An SE view: Model-based ISO15288 processes and life cycle stages
  - ISO15288 is not agile incompatible and is not waterfall

INCOSE MBSE Assessment and Planning Pattern



INCOSE MBSE Assessment and Planning Pattern

Population <-- Size (Log)	**Stakeholders in A Successful MBSE Transformation (showing their related roles and parent organizations)**	Industry & Gvmt. Initiatives	Organizations Internalizing MBSE, Including Gvmt Contractors & Commercial	Vendors of MBSE Tooling and Services	Academia and Researchers	Technical Societies, Other Non-Technical Organizations
Model Consumers (Model Users):						
****	Non-technical stakeholders in various Systems of Interest, who acquire / make decisions about / make use of those systems, and are informed by models of them. This includes mass market consumers, policy makers, business and other leaders, investors, product users, voters in public or private elections or selection decisions, etc.	X	X			X
**	Technical model users, including designers, project leads, production engineers, system installers, maintainers, and users/operators.	X	X			X
*	Leaders responsible to building their organization's MBSE capabilities and enabling MBSE on their projects	X	X			X
Model Creators (including Model Improvers):						
*	Product visionaries, marketers, and other non-technical leaders of thought and organizations	X	X		X	X
*	System technical specifiers, designers, testers, theoreticians, analysts, scientists	X	X		X	X
*	Students (in school and otherwise) learning to describe and understand systems				X	X
*	Educators, teaching the next generation how to create with models	X	X		X	
*	Researchers who advance the practice		X	X	X	
*	Those who translate information originated by others into models	X	X		X	X
*	Those who manage the life cycle of models	X	X		X	X
Complex Idea Communicators (Model "Distributors"):						
**	Marketing professionals	X	X	X		X
**	Educators, especially in complex systems areas of engineering and science, public policy, other domains, and including curriculum developers as well as teachers	X	X	X	X	
**	Leaders of all kinds	X	X	X	X	X
Model Infrastructure Providers, Including Tooling, Language and Other Standards, Methods:						
*	Suppliers of modeling tools and other information systems and technologies that house or make use of model-based information			X		
*	Methodologists, consultants, others who assist individuals and organizations in being more successful through model-based methods	X	X	X	X	
*	Standards bodies (including those who establish modeling standards as well as others who apply them within other standards)	X				X
INCOSE and other Engineering Professional Societies						
*	As a deliverer of value to its membership					X
*	As seen by other technical societies and by potential members					X
*	As a great organization to be a part of					X
*	As promoter of advance and practice of systems engineering and MBSE					X

INCOSE MBSE Assessment and Planning Pattern

Model Identity and Focus

- **Modeled System of Interest**
  - System of Interest
- **Modeled Environmental Domain**
  - Domain Type

Model Utility

- **Model Intended Use**
  - LIFE CYCLE PROCESS SUPPORTED (ISO15288)
- **Perceived Model Value and Use**
  - USER GROUP SEGMENT
  - Level of Annual Use
  - Value Level
- **Third Party Acceptance**
  - ACCEPTING AUTHORITY
- **Model Ease of Use**
  - Perceived Model Complexity

Model Scope and Content

- **Modeled Stakeholder Value**
  - STAKEHOLDER TYPE
- **Modeled System External (Black Box) Behavior**
- **Explanatory Decomposition**
- **Parametric Couplings--Fitness**
- **Parametric Couplings--Decomposition**
- **Parametric Couplings--Characterization**
- **Trusted Configurable Pattern**
  - CONFIGURATION ID
  - Pattern Type
- **Physical Architecture**
- **Managed Model Datasets**
  - DATASET TYPE

Model Fidelity

- **Model Envelope**
  - MODEL APPLICATION ENVELOPE
- **Validated Conceptual Model Fidelity**
  - Quantitative Accuracy Reference
  - Function Structure Accuracy Reference
  - Uncertainty Quantification (UQ) Reference
  - Model Validation Reference
- **Verified Executable Model Fidelity**
  - Quantitative Accuracy Reference
  - Function Structure Accuracy Reference
  - Uncertainty Quantification (UQ) Reference
  - Speed
  - Quantization
  - Stability
  - Model Validation Reference

Model Representation

- **Conceptual Model Representation**
  - Conceptual Model Representation Type
  - Conceptual Model Interoperability
- **Executable Model Representation**
  - Executable Model Representation Type
  - Executable Model Interoperability

Model Life Cycle Management

- **Model Versioning and Configuration Management**
  - CM CAPABILIY TYPE
- **Model Maintainability**
  - Maintenance Method
- **Model Deployability**
  - Deployment Method
- **Model Cost**
  - Development Cost
  - Operational Cost
  - Maintenance Cost
  - Deployment Cost
  - Retirement Cost
  - Life Cycle Financial Risk
- **Executable Model Environmental Compatibility**
  - IT ENVIRONMENTAL COMPONENT
- **Model Design Life Cycle and Retirement**
  - Design Life
- **Model Availability**
  - First Availability Date
  - First Availability Risk
  - Life Cycle Availability Risk

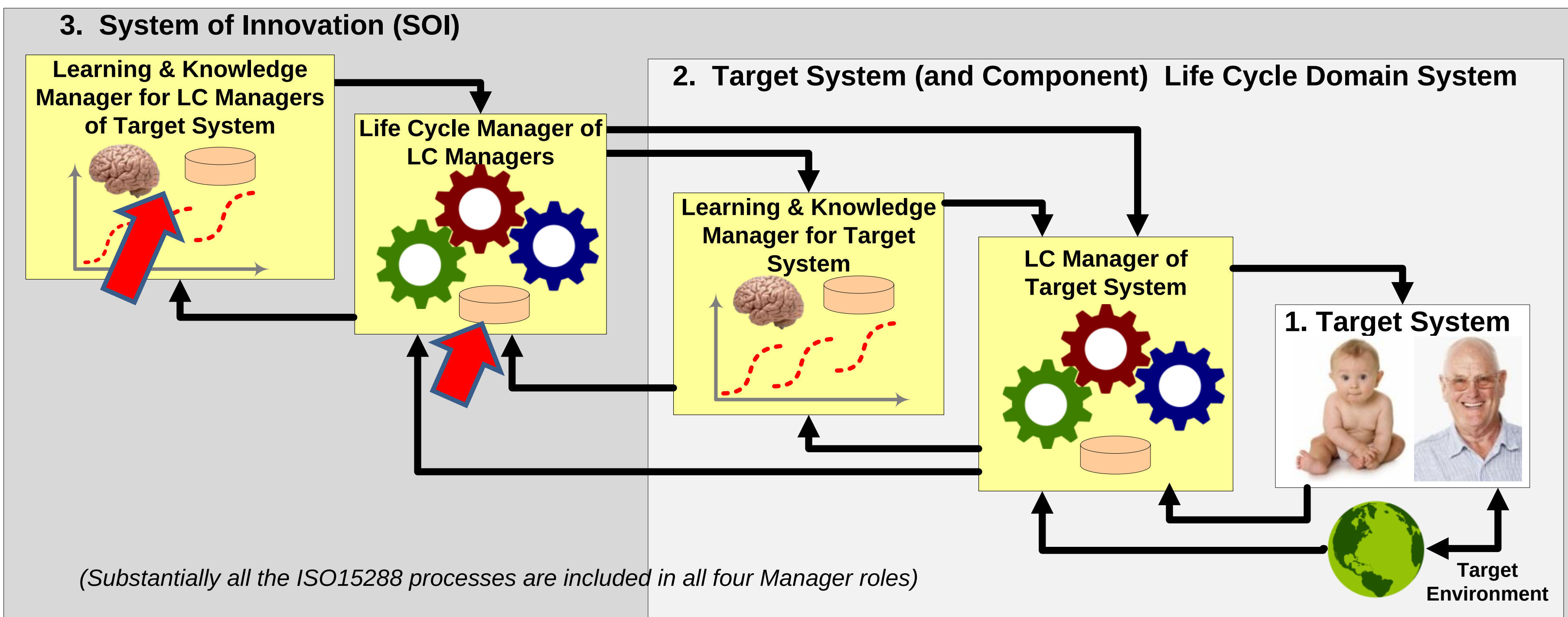
Legend:

- **STAKEHOLDER FEATURE**
  - FEATURE PK ATTRIBUTE
  - Other Feature Attribute
  - Other Feature Attribute

Stakeholder Feature Model for Computational Models		
Version: 1.4.15	Date: 30 Apr 2017	Drawn By: B Schindel

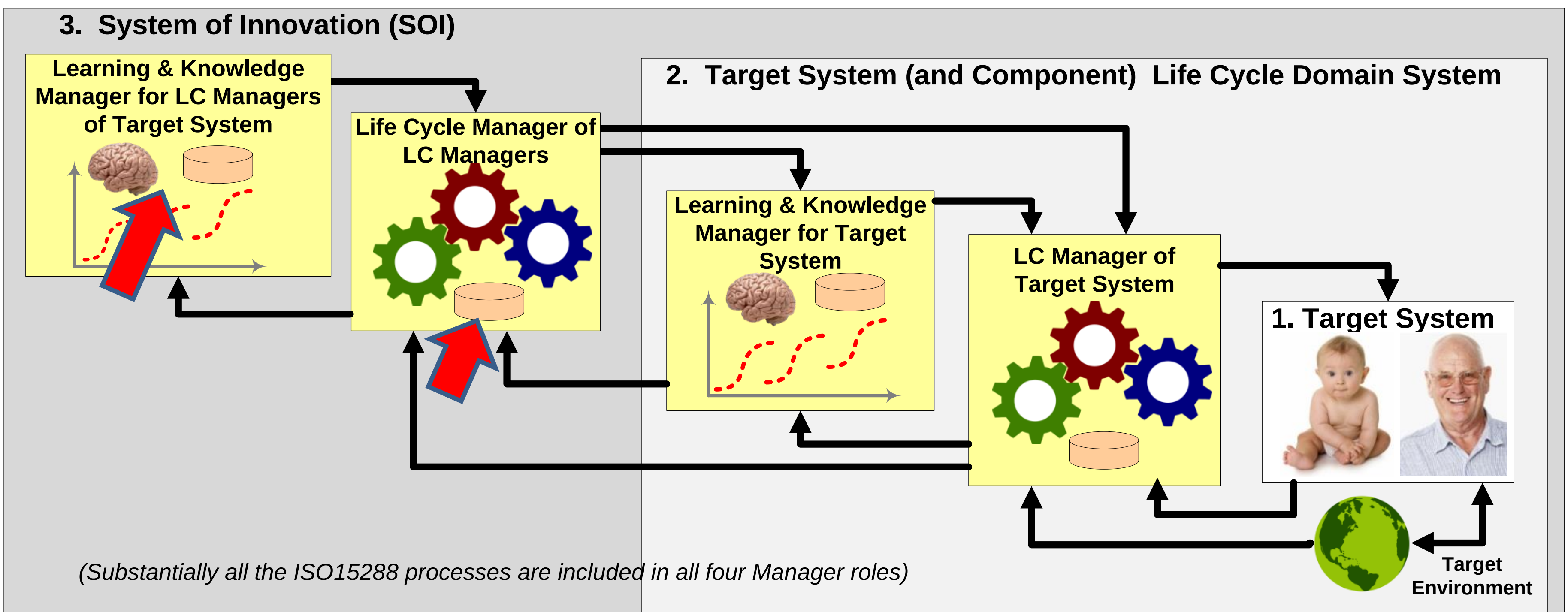
Agility Through Shared Patterns in Regulated Domains

- In domains where innovation is subject to regulation (e.g., Health Care, Aviation, Automotive, etc.), agility may seem to have special challenges:
  - This conference is already aware of efforts to accommodate agile methods while meeting regulatory goals (e.g., safety).
- A powerful way to view efforts to find agreed-upon approaches is to think of them as agreements concerning shared system pattern frameworks:
  - MBSE extension of idea already applied to Devices of limited vs. greater changes



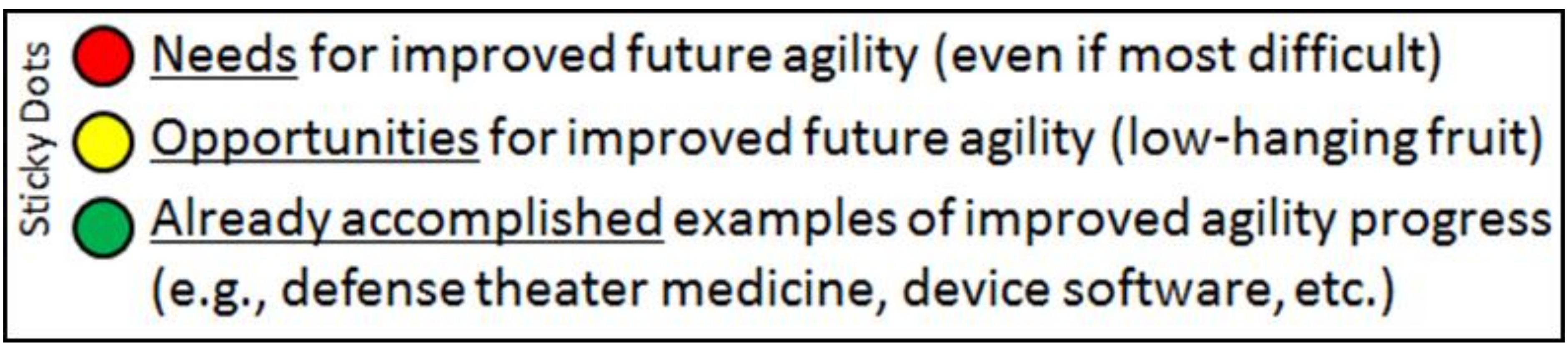
Agility Through Shared Patterns in Regulated Domains

- Example: The Model VVUQ Pattern, being examined in the ASME Model VVUQ standards and guidelines effort:
  - How can evidence be provided to most efficiently demonstrate evidence of model VVUQ?
  - The over effort already includes FDA, FAA, others
- In break-out, we will take the related Model System Features for a test drive



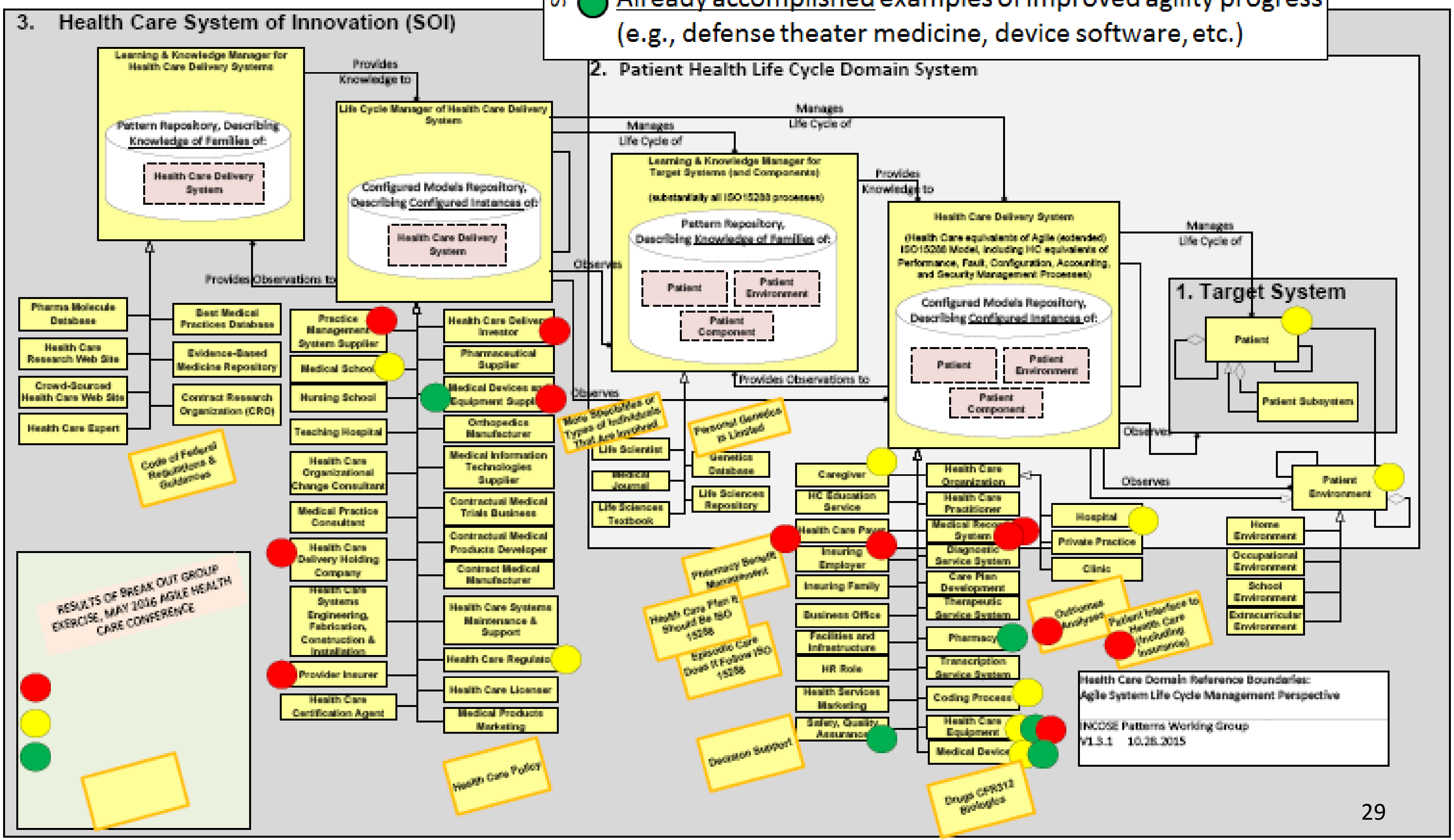
Conclusions from 2016 INCOSE AHCS Conference Break-Out Session

- During the 2016 version of this conference, participants used the ASELCM Pattern to identify Health Care Domain systems that they deemed:



Conclusions from 2016 INCOSE AHCS Conference Break-Out Session

Sticky Dots
- 🔴 Needs for improved future agility (even if most difficult)
- 🟡 Opportunities for improved future agility (low-hanging fruit)
- 🟢 Already accomplished examples of improved agility progress (e.g., defense theater medicine, device software, etc.)



Conclusions from 2016 INCOSE AHCS Conference Break-Out Session

Sticky Dots

- Needs for improved future agility (even if most difficult)
- Opportunities for improved future agility (low-hanging fruit)
- Already accomplished examples of improved agility progress (e.g., defense theater medicine, device software, etc.)

Red:

- Patient Interface to Health Care (Including Insurance)
- Medical Devices and Equipment Supplier
- Health Care Delivery Investor
- Health Care Payer
- Provider Insurer
- Insuring Employer
- Practice Management System Supplier
- Health Care Delivery Holding Company
- Medical Record System
- Health Care Equipment
- Outcomes Analysis

Yellow:

- Caregiver
- Medical School
- Hospital
- Coding Process
- Health Care Equipment
- Medical Devices

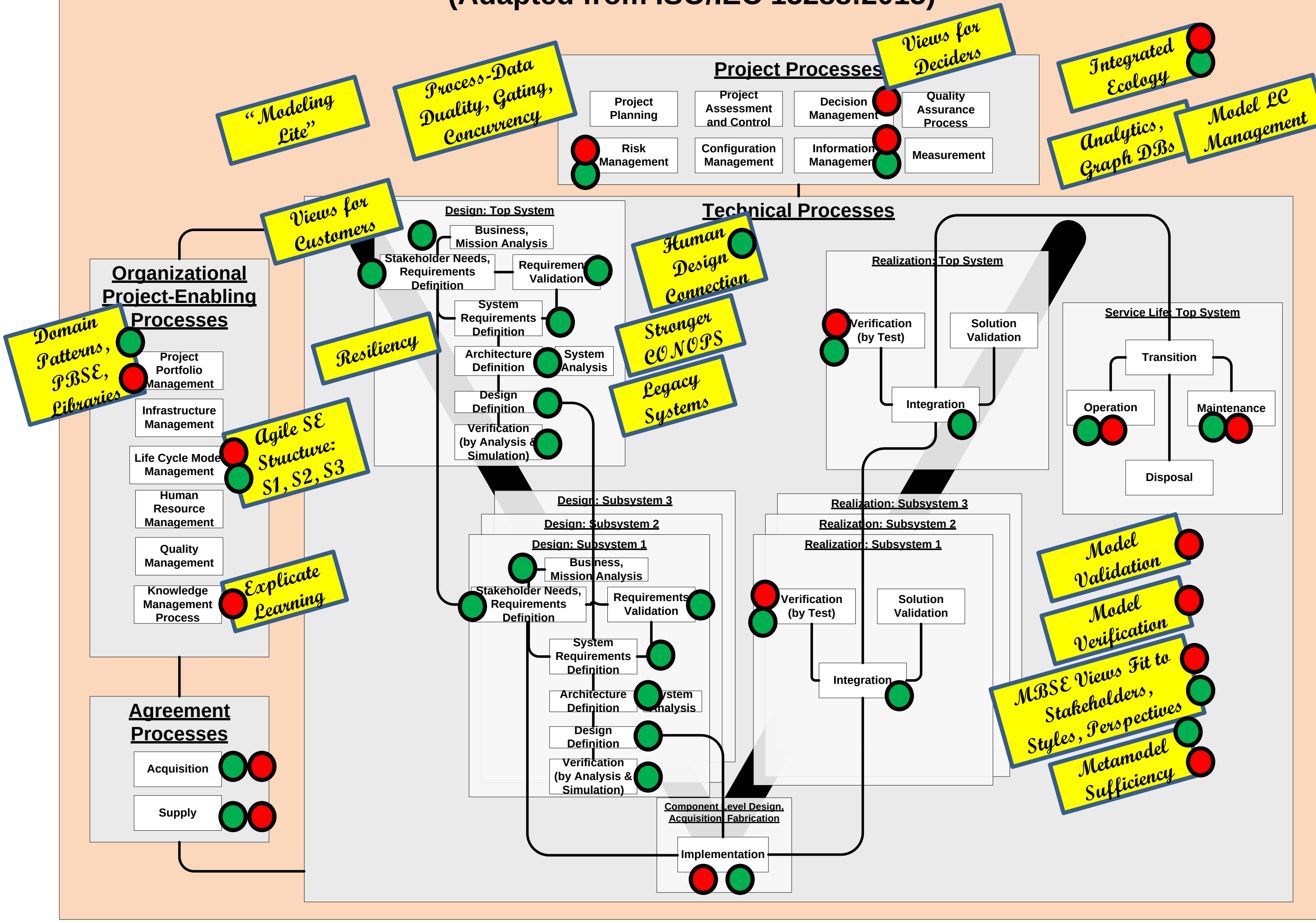
Green:

- Medical Devices and Equipment Supplier
- Safety, Quality Assurance
- Pharmacy
- Health Care Equipment
- Medical Devices

Conclusions from 2016 INCOSE Energy Tech Conference MBSE Break-Out Session

System of Innovation (SOI) Pattern Logical Architecture

(Adapted from ISO/IEC 15288:2015)



Conclusions from 2016 INCOSE Energy Tech Conference MBSE Break-Out Session

Population <-- Size (Log)	Stakeholders in A Successful MBSE Transformation (showing their related roles and parent organizations)	Industry & Gvmt. Initiatives	Organizations Internalizing MBSE, Including Gvmt Contractors & Commercial	Vendors of MBSE Tooling and Services	Academia and Researchers	Technical Societies, Other Non-Technical Organizations
Model Consumers (Model Users):						
****	Non-technical stakeholders in various Systems of Interest, who acquire / make decisions about / make use of those systems, and are informed by models of them. This includes mass market consumers, policy makers, business and other leaders, investors, product users, voters in public or private elections or selection decisions, etc.	X	X			X
**	Technical model users, including designers, project leads, production engineers, system installers, maintainers, and users/operators.	X	X			X
*	Leaders responsible to building their organization's MBSE capabilities and enabling MBSE on their projects	X	X			X
Model Creators (including Model Improvers):						
*	Product visionaries, marketers, and other non-technical leaders of thought and organizations	X	X		X	X
*	System technical specifiers, designers, testers, theoreticians, analysts, scientists	X	X		X	X
*	Students (in school and otherwise) learning to describe and understand systems				X	X
*	Educators, teaching the next generation how to create with models	X	X		X	
*	Researchers who advance the practice		X	X	X	
*	Those who translate information originated by others into models	X	X		X	X
*	Those who manage the life cycle of models	X	X		X	X
Complex Idea Communicators (Model "Distributors"):						
**	Marketing professionals	X	X	X		X
**	Educators, especially in complex systems areas of engineering and science, public policy, other domains, and including curriculum developers as well as teachers	X	X	X	X	
**	Leaders of all kinds	X	X	X	X	X
Model Infrastructure Providers, Including Tooling, Language and Other Standards, Methods:						
*	Suppliers of modeling tools and other information systems and technologies that house or make use of model-based information			X		
*	Methodologists, consultants, others who assist individuals and organizations in being more successful through model-based methods	X	X	X	X	
*	Standards bodies (including those who establish modeling standards as well as others who apply them within other standards)	X				X
INCOSE and other Engineering Professional Societies						
*	As a deliverer of value to its membership					X
*	As seen by other technical societies and by potential members					X
*	As a great organization to be a part of					X
*	As promoter of advance and practice of systems engineering and MBSE					X

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Break Out Session:
Agile Test Drive, Hot Spot Collection

During this break out session, use the hand-outs to:

- Identify Health Care Domain areas you believe are opportunities, problems, and accomplishments for an Agile approach—discuss at session end, turn in.
- Identify ISO 15288 areas you believe are opportunities, problems, and accomplishments for an Agile as well as MBSE methods—discuss at session end, turn in.
- Review and comment on the INCOSE Feature Pattern for Model Stakeholders—discuss at session end, turn in.
- This also gives INCOSE some "agile feedback" on its products in process.
- In return, you will also have "take home copies" that you can carry home (or download) and try out privately.

Discussion

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Speaker

William D. (Bill) Schindel chairs the Model-Based Systems Engineering Patterns Working Group of the INCOSE/OMG MBSE Initiative. An ASME member, he is part of the ASME VV50 standards team's effort to establish guides and standards for model verification, validation, and uncertainty quantification. Schindel is president of ICTT System Sciences, and has practiced systems engineering for over thirty years, across multiple industry domains. He earned the B.S. and M.S. degrees in mathematics, and is an INCOSE Fellow and Certified Systems Engineering Professional.