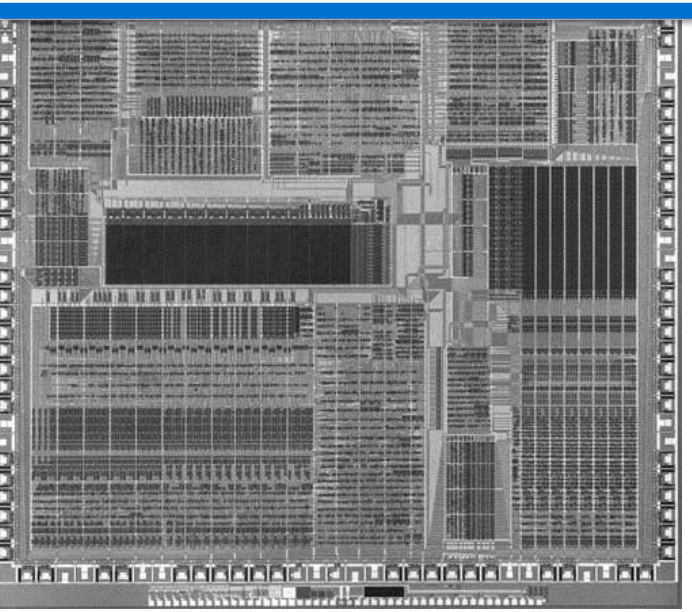
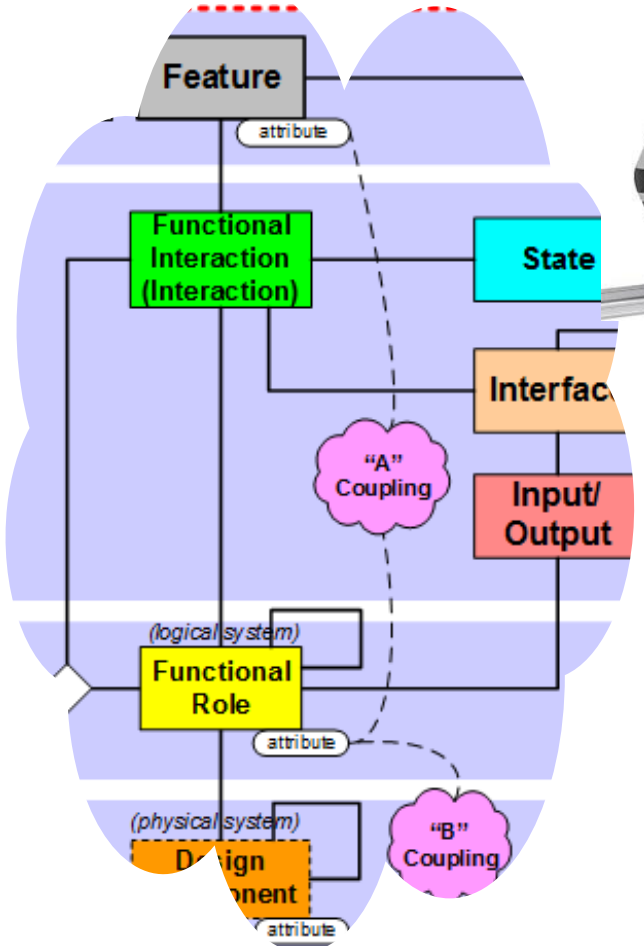
2017 annual INCOSE international workshop

Los Angeles, CA, USA

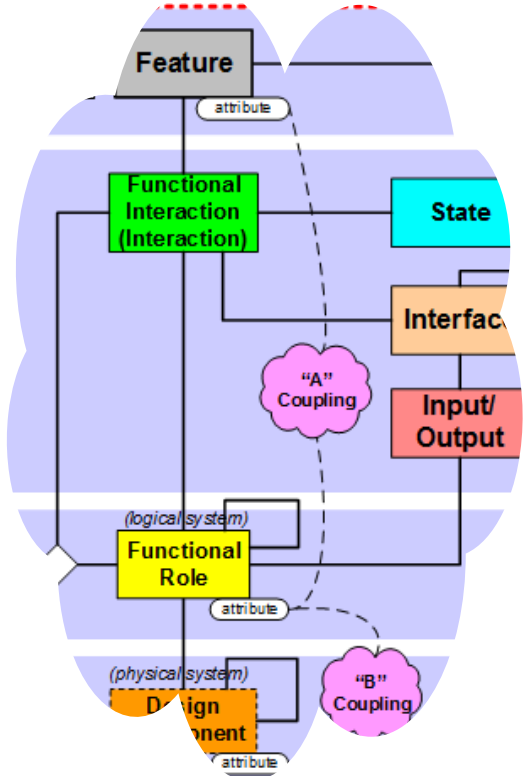
January 28 - 31, 2017

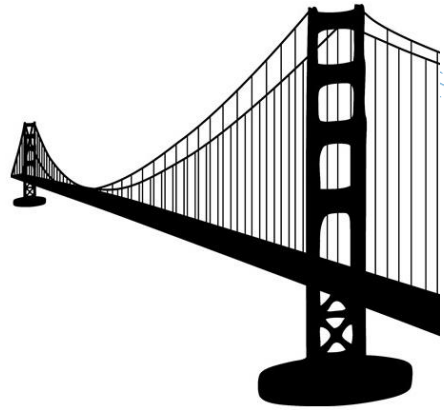
MBSE Patterns Working Group

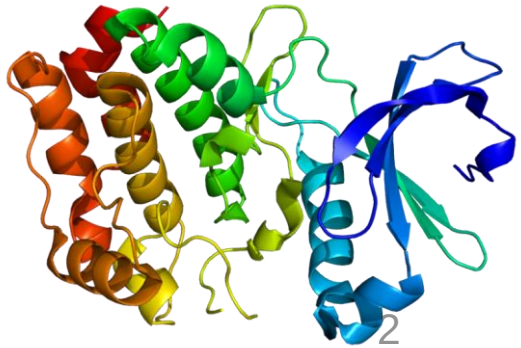




Contents







We began three years ago, as the MBSE Initiative Patterns Challenge Team:

- Part of the joint INCOSE/OMG MBSE Initiative
- More recently, our team formally became the INCOSE MBSE Patterns Working Group
- Because of our MBSE focus, and in order to continue to support the MBSE Initiative, we continue to also be listed as part of that INCOSE/MBSE Initiative

This Working Group is concerned with *configurable, re-usable system models*: "S*Patterns"

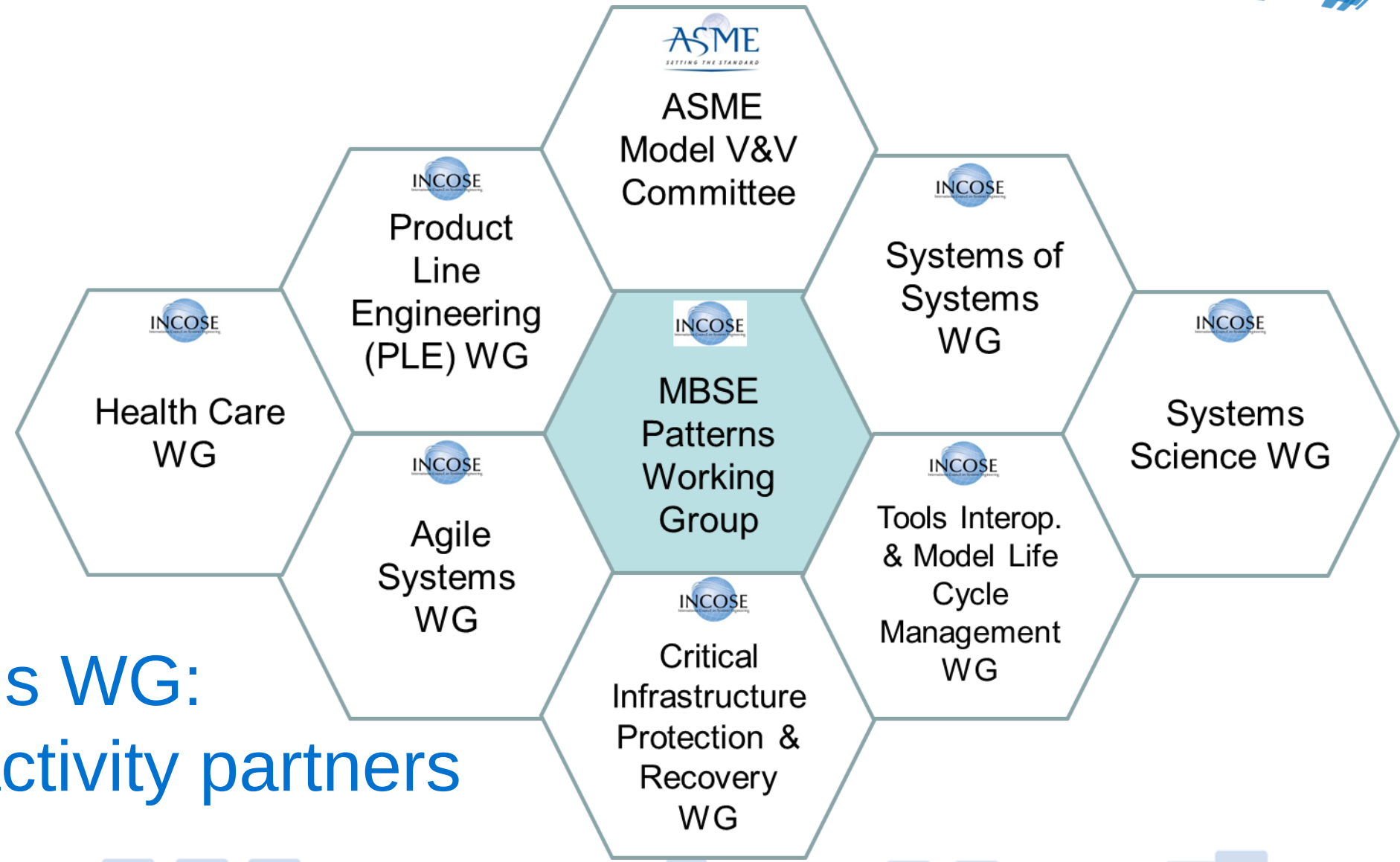
1. Models containing a certain minimal set of elements are called S*Models (S* is short for "Systematica")
2. Those underlying elements are called the S*Metamodel, which was inspired by the physical sciences
3. S*Models using those elements may be expressed in any modeling language (e.g., SysML, or other languages)
4. S*Models can be created and managed in many different COTS modeling tools.
5. Re-usable, configurable S*Models are called S*Patterns
6. By "Pattern-Based Systems Engineering" (PBSE) we mean MBSE enhanced by these generalized assets
7. These are system-level patterns (models of whole managed platforms), not just smaller-scale component design patterns

The INCOSE Patterns Working Group: *Who are we?*

- Our most active members come from across diverse domains:
  - Automotive
  - Advanced Manufacturing
  - Aerospace
  - Consumer Products
  - Defense
  - Health Care, Medical Devices, Pharmaceuticals
  - Others
  - Today's attendees?
- During the last three years, over 200 colleagues have participated in Patterns Working Group activities:
  - Team meetings, work sessions, tutorials, meetings with other groups
  - Construction of system patterns
  - Writing related papers for IS, IW, and regional INCOSE conferences
  - Invited presentations of our team's work to INCOSE chapter meetings

Working group web site:
http://www.omgwiki.org/MBSE/doku.php?id=mbse:patterns:patterns
Meeting web site:
http://www.omgwiki.org/MBSE/doku.php?id=mbse:patterns:patterns_challenge_team_mtg_01.28-31.17

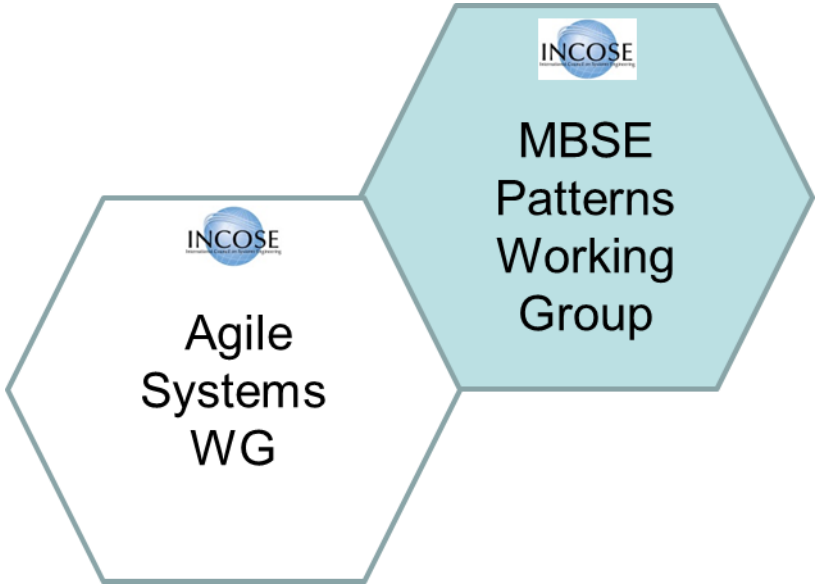
Working Group Partners in Progress



MBSE Patterns WG: Current joint activity partners

Working Group Partners in Progress

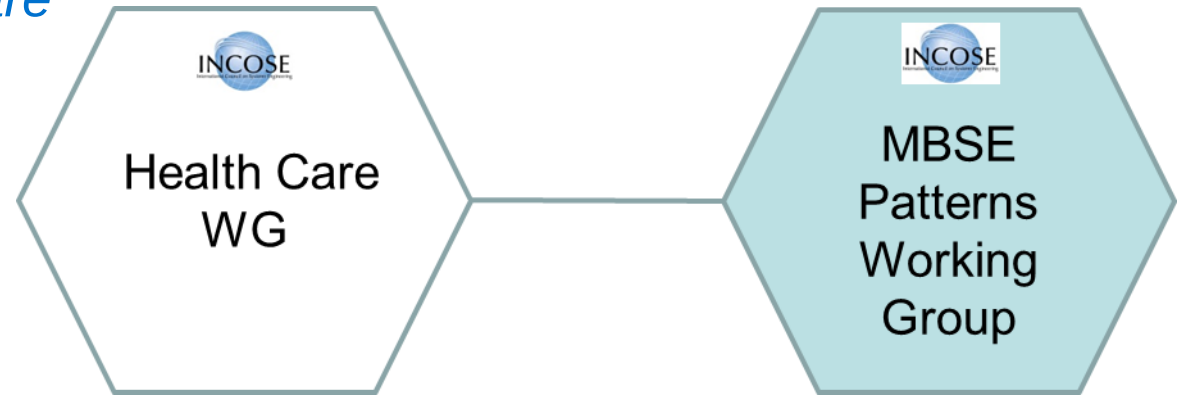
Primary Contact:
Rick Dove, Paradigm Shift, Intl.



Agile Systems Engineering Life Cycle Management (ASELCM) Discovery Project: Creating, validating ASELCM S*Pattern

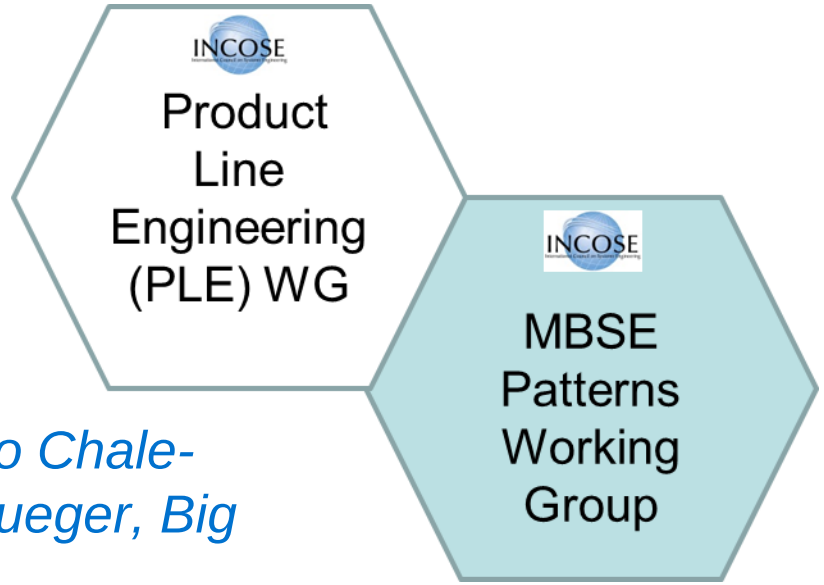
Working Group Partners in Progress

Primary Contact:
Chris Unger,
GE Health Care



Supporting the INCOSE Agile Health Care Systems Conference (third year) & the Health Care version of ASELCM Pattern

Working Group Partners in Progress

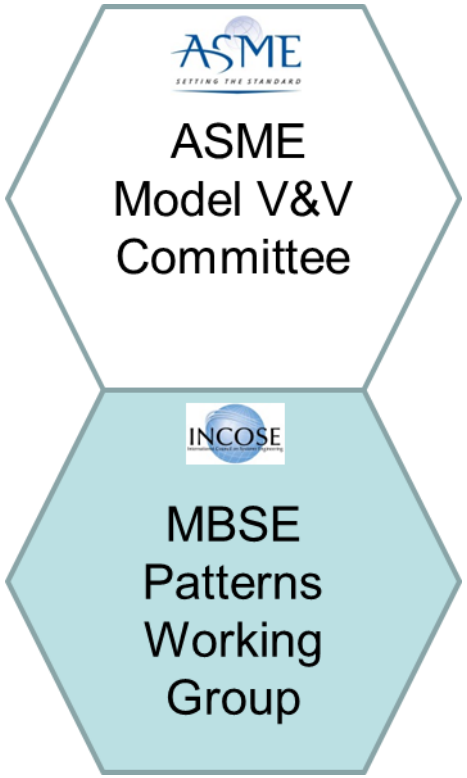


Primary Contacts: *Guillermo Chale-Gongora, Alstom; Charles Krueger, Big Lever*

Joint demonstration of Legacy Product Line Pattern Harvest and Ecosystem for Product Line Life Cycle Patterns & Configurations

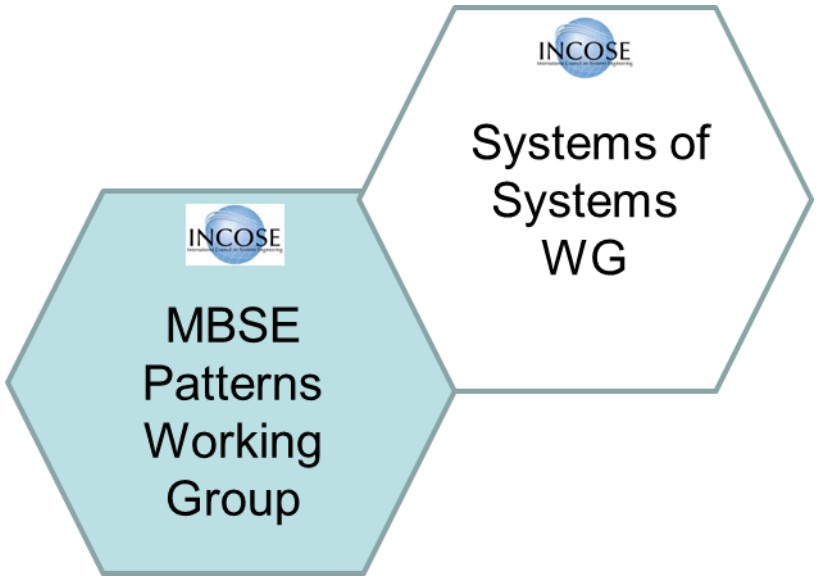
Working Group Partners in Progress

Primary Contact:
Joe Hightower, Boeing,
ASME VV50 Committee



Supporting creation of ASME Guidelines & Standards for Computational Models, over their Life Cycles

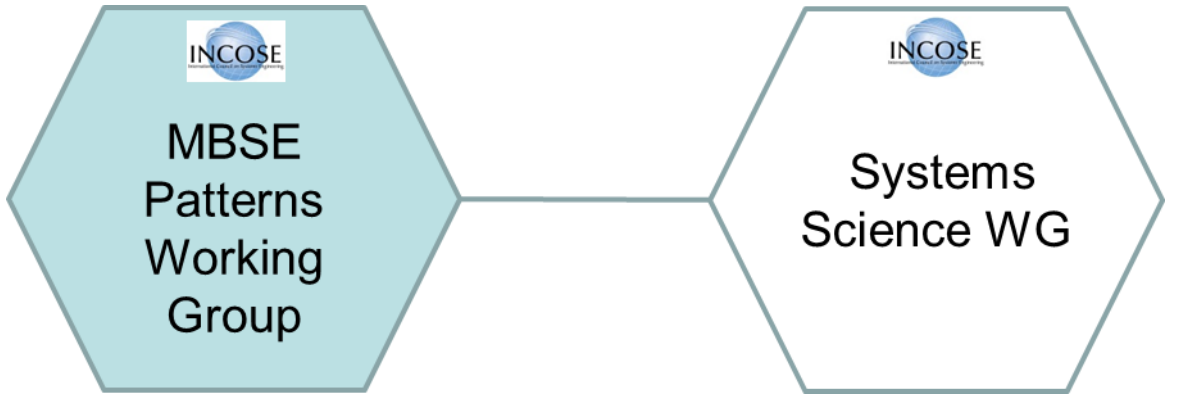
Working Group Partners in Progress



Primary Contact:
John Fitzgerald, Newcastle U.

Support of SoS Pattern Library, including build-out of S*Metaclasses

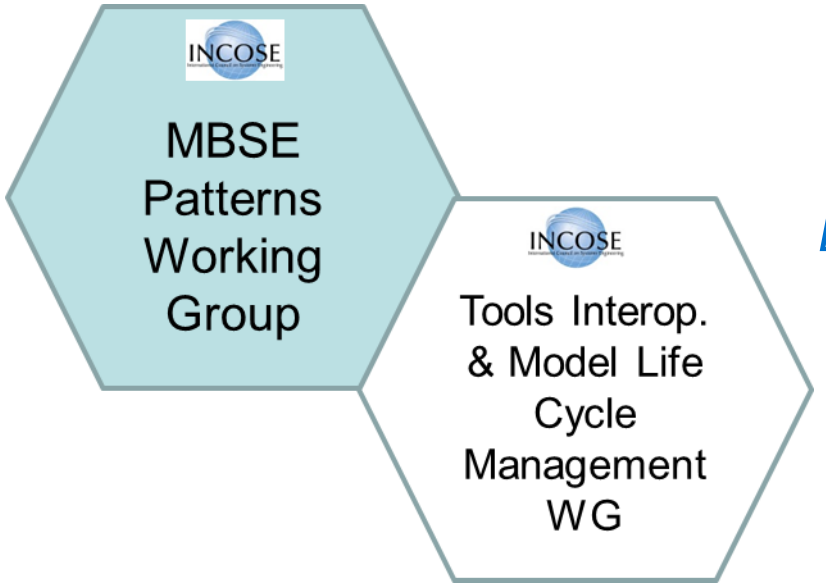
Working Group Partners in Progress



Primary Contact:
David Rousseau, Centre for Systems Philosophy

S*Interactions & S*Patterns as
a basis for a hard science of systems

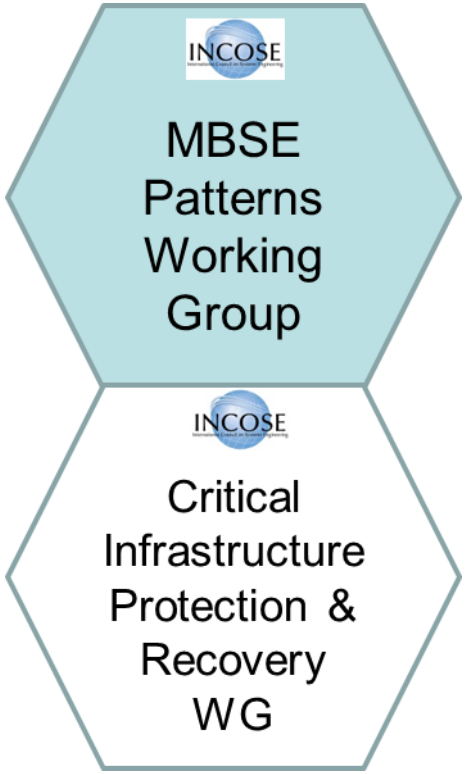
Working Group Partners in Progress



Primary Contact:
Lonnie VanZandt, Sodius

Patterns of collaboration in future innovation ecosystems, including illustrative content

Working Group Partners in Progress



Primary Contact:
Mike DeLamar, Bechtel

S*Patterns for Critical Infrastructure, Electrical Power, Common Recovery Model; including ASELCM Systems 1, 2, 3

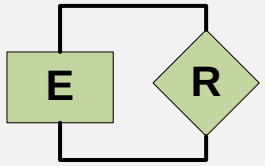
Emergence of Patterns from Patterns: S*Pattern Class Hierarchy

More General

More Specific

Definition of **Relational Modeling Paradigm**

Entity-Relationship Paradigm

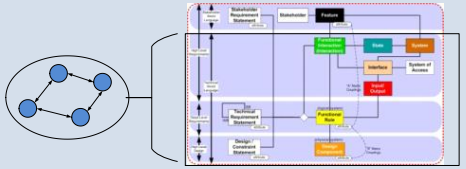


E=Entity
R= Relationship

Structured or unstructured semantic web

Minimal System S*Metamodel: Definition of (Elementary) System, Material Cause

S*Metamodel Core



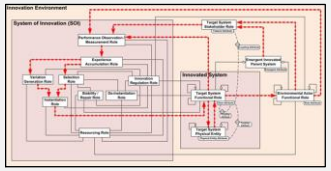
Core S*Metamodel

Smallest model of a system, for engineering or science

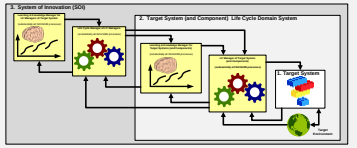
Emergence & Definition of **System of Innovation**, Fitness, Value, Purpose, Stakeholders, Agility, Final Cause, Formal Cause, Efficient Cause, Intelligence, Management, Science, Living Systems

EI Pattern, SOI Pattern, Fitness, Value

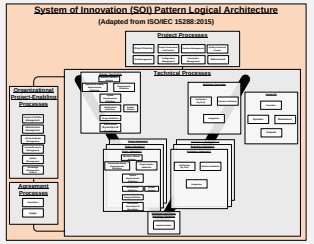
S*Purpose, Fitness, Value



System of Innovation Pattern



Agile Sys Life Cycle Pattern



ISO 15288 System Life Cycle Mgmt Pattern

Emergence & Definition of **Domain Specific Systems**

Domain Specific Pattern

- Terrestrial Vehicle Domain Pattern
- Manufacturing System Pattern
- Product Service System Pattern
- Space Tourism Pattern
- Electrical Power Domain Pattern
- Aircraft Flight Control Pattern
- Medical Device Pattern
- Distribution System Pattern
- Socio-Technical Pattern
- Critical Infrastructure Domain Pattern

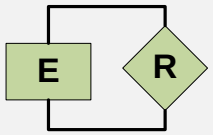
Emergence of Patterns from Patterns: S*Pattern Class Hie

More General

More Specific

Definition of **Relational Modeling Paradigm**

Entity-Relationship Paradigm



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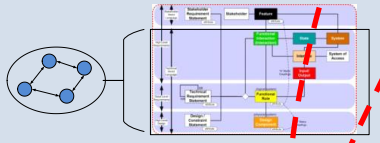

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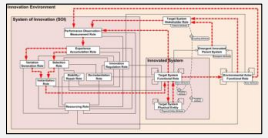
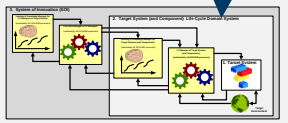
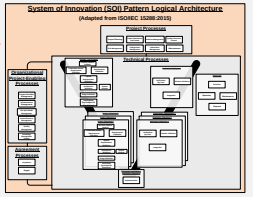


System of Innovation Pattern



Agile Sys Life Cycle Pattern



ISO 15288 System Life Cycle Mgmt Pattern

Emergence & Definition of **Domain Specific Systems**

Domain Specific Pattern

Terrestrial Vehicle Domain Pattern
Manufacturing System Pattern
Product Service System Pattern
Space Tourism Pattern
Electrical Power Domain Pattern
Aircraft Flight Control Pattern
Medical Device Pattern
Distribution System Pattern
Socio-Technical Pattern
Critical Infrastructure Domain Pattern

ASME Model V&V Committee

INCOSE Product Line Engineering (PLE) WG

INCOSE Systems of Systems WG

INCOSE Health Care WG

INCOSE MBSE Patterns Working Group

INCOSE Systems Science WG

INCOSE Agile Systems WG

INCOSE Tools Interop. & Model Life Cycle Management WG

INCOSE Critical Infrastructure Protection & Recovery WG

Recent Patterns WG public activities

- INCOSE IS2016 (Jul, 2016)
- ISSS 2016 (Jul, 2016)
- INCOSE Agile Health Care Systems Conferences 2016, 2017
- INCOSE Great Lakes Regional Conference 2016 (Sep, 2016)
- INCOSE Socorro Systems Summit (Oct, 2016)
- INCOSE/IEEE Energy Tech 2016 Conference (Nov, 2016)
- ASME VV 50 Model V&V Standards Committee (Nov, Dec, Jan)

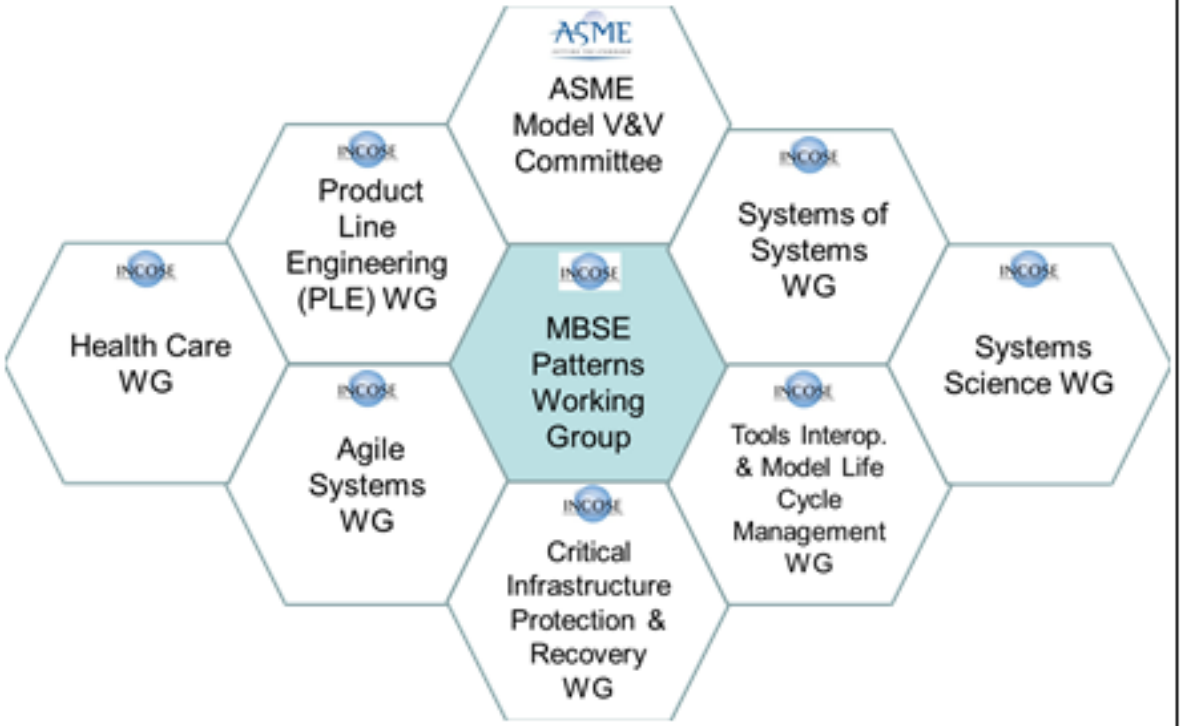
Summary of Patterns WG activities at IW2017:

- Patterns WG meeting slots and related events on Sunday and Monday (Jan 29-30):
  - ASME-INCOSE Model V&V Standards Support
  - Current and future PWG projects discussion
  - PLE WG: Joint meeting with Product Line Engineering WG
  - CIPR WG: Joint meeting with Critical Infrastructure Protection and Restoral WG
- Additional meetings with “partner” Working Groups during their IW meetings:
  - CIPR: Critical Infrastructure Protection and Recovery WG
  - SoS: Systems of Systems WG
  - Agile: Agile Systems Engineering WG
  - SSWG: System Science WG
  - TIMLM: Tools Interoperability & Model Life Cycle Mgmt WG
- Support for other (CAB, MBSE Workshop) IW activities.

Details of agenda . . .

Agenda, Partner Events of Interest: INCOSE MBSE Patterns Working Group, at IW2017, and Web Conferencing	US Pacific Time (PT)	Room	Global Meet

MBSE Patterns WG: Joint IW activities, interests, project partners



Patterns WG Pre-reading and Background:

Meeting events and materials for activities of the MBSE Patterns WG at IS2016:
http://www.omgwiki.org/MBSE/doku.php?id=mbse:patterns:patterns_challenge_team_mtg_01.28-31.17

Minutes of previous meeting of the WG---July 17, 2016, at IS2016:
http://www.omgwiki.org/MBSE/doku.php?id=mbse:patterns:mbse_patterns_wg_team_mtg_07.17.16

INCOSE WG web site for MBSE Patterns WG:
http://www.incose.org/ChaptersGroups/WorkingGroups/Transformational/mbse-patterns

WG INCOSE/OMG mbse wiki site:
http://www.omgwiki.org/MBSE/doku.php?id=mbse:patterns:patterns

MBSE Patterns WG Charter:
http://www.incose.org/docs/default-source/Working-Groups/MBSE-Patterns-WG/mbse-patterns-wg-re-charter-2016-incose-approved-v2-2-1.pdf?sfvrsn=2

PBSE Methodology Summary from the Patterns WG:
http://www.omgwiki.org/MBSE/doku.php?id=mbse:pbse

Agenda, Partner Events of Interest: INCOSE MBSE Patterns Working Group, at IW2017, and Web Conferencing	US Pacific Time (PT)	Room	Global Meet
Patterns WG General Meeting 1: Introductions, brief review of WG's mission and agenda for IW Brief summary of Patterns WG activities since last (IW2016) meeting PLE WG – Patterns WG – TIMLM WG Joint Review: • Joint Demonstration Project 1: Ecology Content (also during Monday session) • Joint Demonstration Project 2: Legacy	Sunday 10:30-12:00	Patterns WG Mtg Room: Suite 9	X
MBSE Workshop—Related Partner Sessions:			
Model Ecosystem Overview, Lonnie VanZandt	Sunday 2:00-2:30	Salon E	
ASME Model V&V Standardization, Joe Hightower	Sunday 3:30-4:00	Salon E	
MBSE Workshop Reception	Sunday 5:30-6:30	Zen Garden	
Patterns WG General Meeting 2: Critical Infrastructure Protection & Recovery (CIPR) WG – Patterns WG Joint Review: • Energy Tech 2016 Product Activities • Extending the ASELCM Pattern CIPR and Electrical Power Grid Applications	Monday 8:00-9:00	(CIPR WG meeting room)	
Patterns WG General Meeting 2 (continued): Other joint activities at this IW—events, projects, session times, and session rooms Current and future working group projects and future project interests from membership and partners	Monday 9:00-10:00	Patterns WG Mtg Room: Suite 8	X
System Science – Patterns WG Contributed Session: S*Patterns as a basis for systems science	Monday 10:30-11:30	System Science WG Mtg Room: Suite 10	
Agile Systems – Patterns WG Contributed Session: S*Pattern for Agile Systems Engineering Life Cycles: Four case study enterprises and relate S*Models	Monday 11:30-12:00	Agile Systems WG Mtg Room: Suite 9+11	
Tools Interoperability and Model Lifecycle Management (TIMLM) WG – Patterns WG Supported Session: Workshop on Concept Model for Collaborative and Cooperative Engineering	Monday 1330-1730	TIMLM WG Mtg Room: Salon F	

Agenda, Partner Events of Interest: INCOSE MBSE Patterns Working Group, at IW2017, and Web Conferencing	US Pacific Time (PT)	Room	Global Meet
Patterns WG Session Contribution to Agile System WG – System Science WG Joint Session on System Summits: 2016 INCOSE Socorro System Summit, Fail Fast and Recover Early--Session Experience, Summit Format	Tuesday 0800-0900	Agile WG & SSWG Mtg Rm: Salon E	
Complex Systems WG- Patterns WG Joint Meeting: Review of interest in joint project by CxSWG and Patterns WG	Tuesday 1000-1030	Complex Sys WG Mtg Rm Suite 5	
Critical Infrastructure Protection & Recovery (CIPR) WG – Patterns WG Support: Discussion of MBSE support for CIPR WG	Tuesday 1030-1100	CIPR WG Mtg Rm Salon A	
MBSE Workshop Outbriefs: Patterns and other WGs	Tuesday 1300-1400	Salon E	
Working group poster displays at closing reception (Marketplace, formerly the WG Bazaar)	Tuesday 1400-1630		

For more information, contact-- **MBSE Patterns WG:** Bill Schindel schindel@ictt.com Troy Peterson tpeterson@systemxi.com

To remotely access the above Patterns WG sessions marked "X" for Global Meet in far right column:

- PARTICIPANT GlobalMeet Join Details - Join as GUEST

Meeting Details Web Address: https://incose.pgimeet.com/GlobalmeetThree
Access Number: 1-719-457-6209
USA /Canada (toll free): 1-866-398-2885
Guest Passcode: 195 372 9323

Dial In Numbers:
USA/Canada: 1-719-457-6209
Canada, Montreal: +1 514 669 5928
Canada, Toronto: +1 647 426 9172
Argentina (toll free): 0800 666 2649
Australia (toll free): 1 800 804 786
Australia, Brisbane: +61 (0) 7 3015 0535

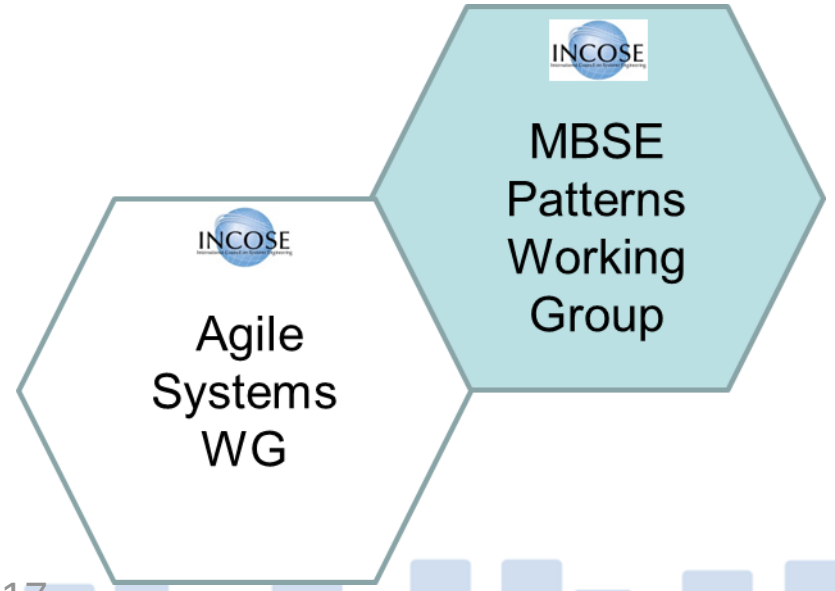
Joint activities—detail sections follow

- With Agile SE WG: Joint Activity Materials
- With Product Line Engineering WG: Joint Activity Materials
- With ASME Model V&V Committees: Model V&V Joint Activity Materials
- With SoS WG: Joint Activity Materials
- With Health Care WG: Joint Activity Materials
- With Critical Infrastructure Protection, and Recovery WG: Joint Activity Materials
- With Systems Science WG: Joint Activity Materials
- With Tools Interoperability & Model Life Cycle Mgmt. WG: Joint Activity

With Agile SE WG: Joint Activity Materials

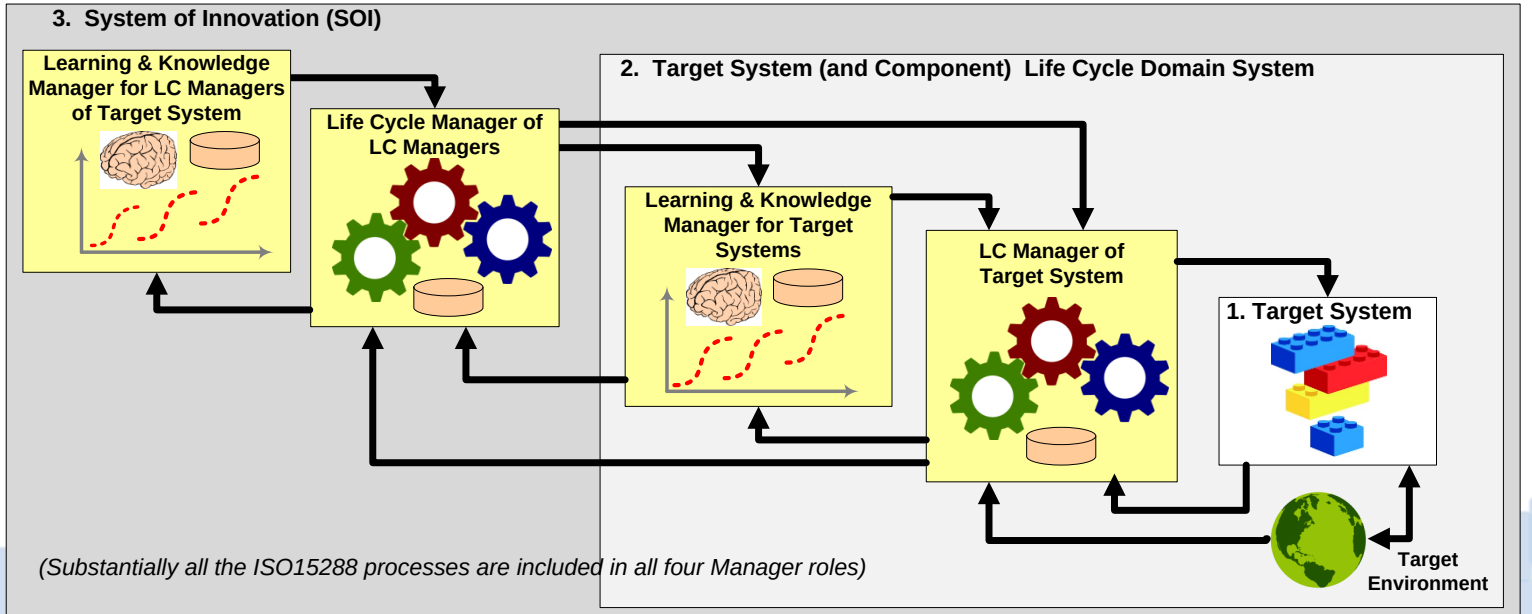
- Agile Systems Engineering Life Cycle Management (ASELCM) Discovery Project: Creating, validating the ASELCM S*Pattern

Primary Contact:
Rick Dove, Paradigm Shift, Intl.



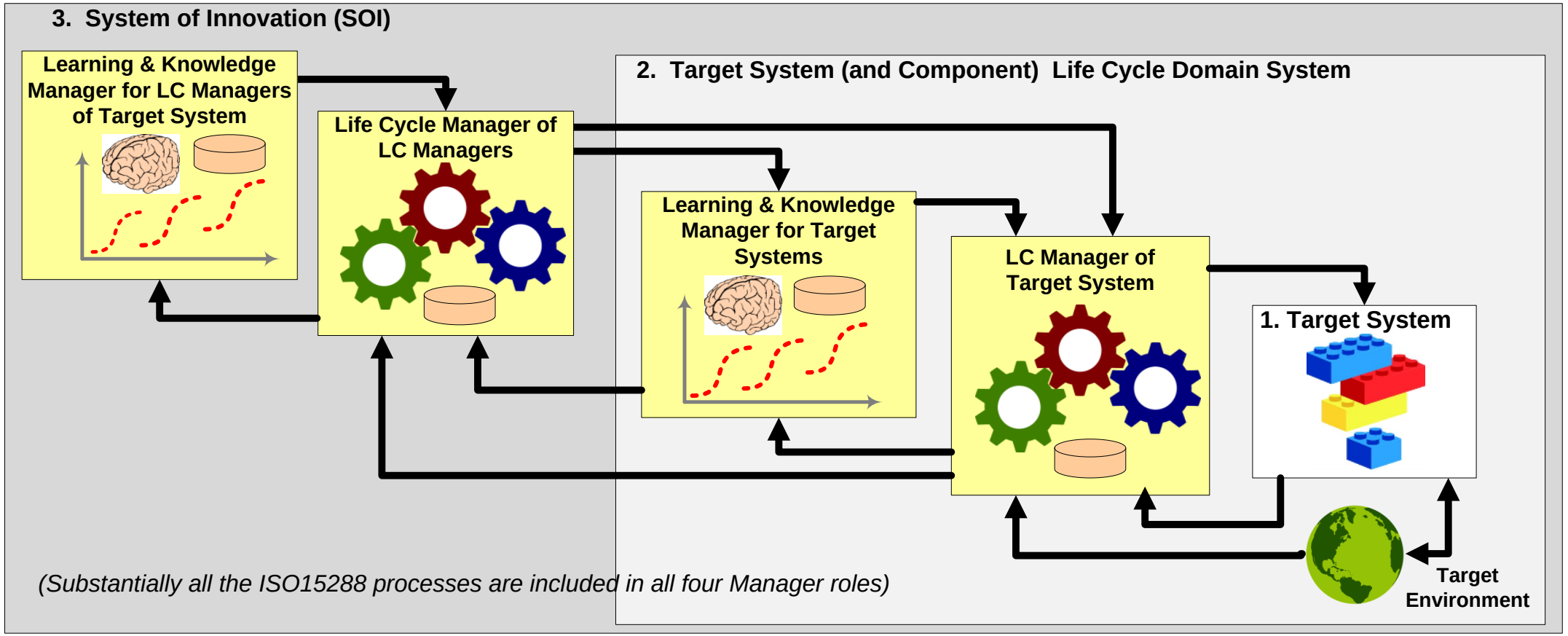
Using the ASELCM Reference Pattern on Four Case Study Sites: Model Highlights

1. Agile Systems Engineering Process Features Collective Culture, Consciousness, and Conscience at SSC Pacific Unmanned Systems Group
2. Transition to Scaled-Agile Systems Engineering at Lockheed Integrated Fighter Group
3. Agile SE Process for Centralized SoS Sustainment at Northrop Grumman
4. Agile Hardware/Firmware/Software Product Line Engineering at Rockwell Collins

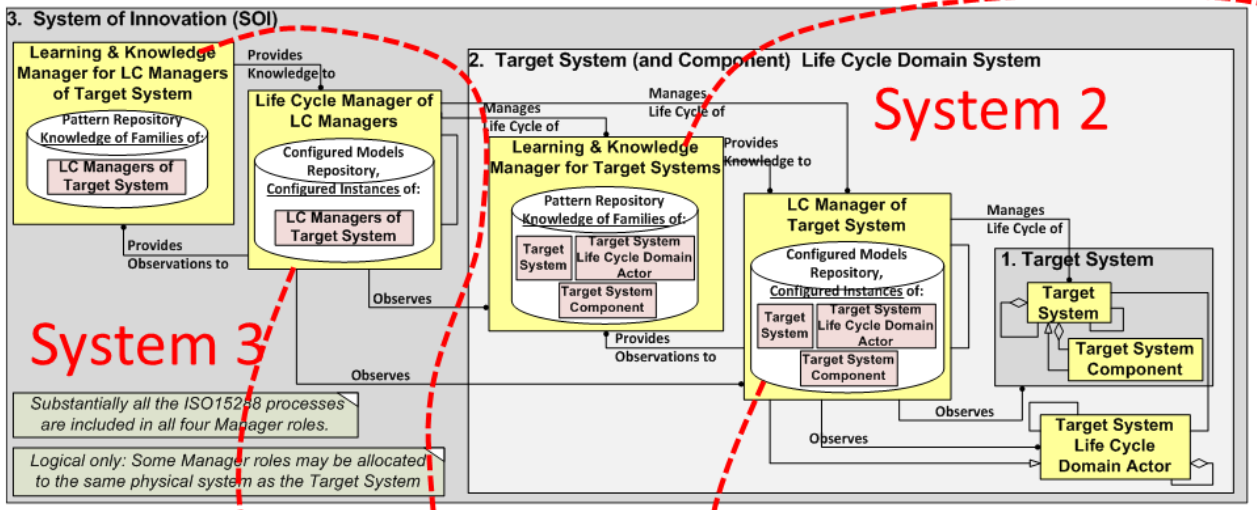


Agile Systems WG Meeting
INCOSE IW17, Jan 30, 2017
Bill Schindel schindel@ictt.com

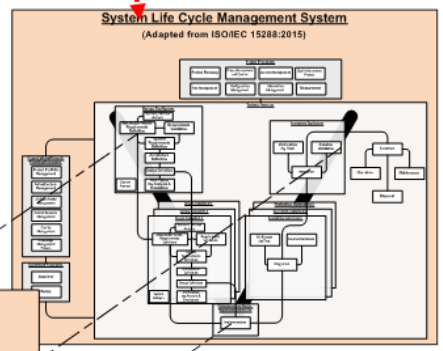
ASELCM Pattern Logical Architecture



- 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.

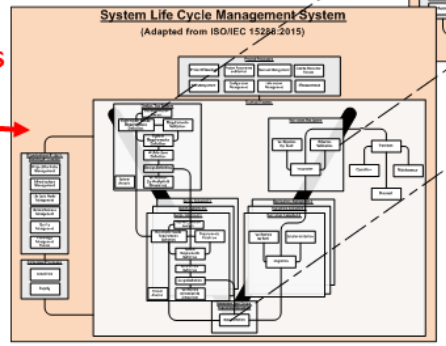


Performs most of these ISO processes, to manage what is being learned about S1 space.

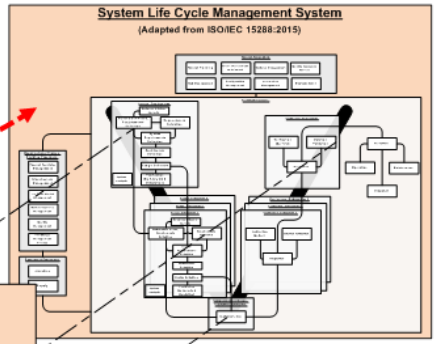


Manages Target System Family Patterns

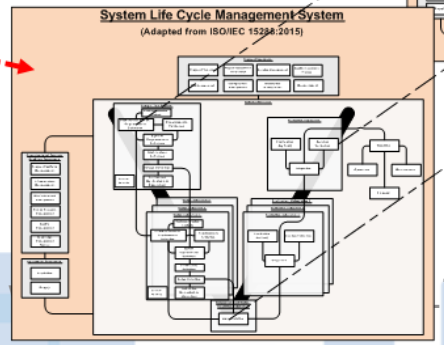
Performs most of these ISO processes, to manage S1 instances , using S1 patterns



Manages LC Management System Family Patterns



Performs most of these ISO processes, to manage S2 instances , using S2 patterns

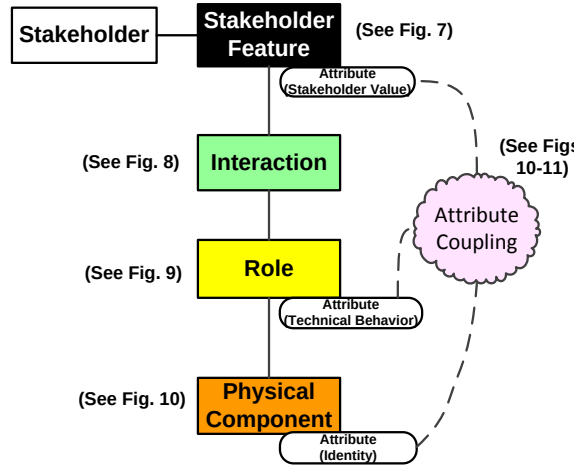


Performs most of these ISO processes, to manage what is being learned about S2 space.

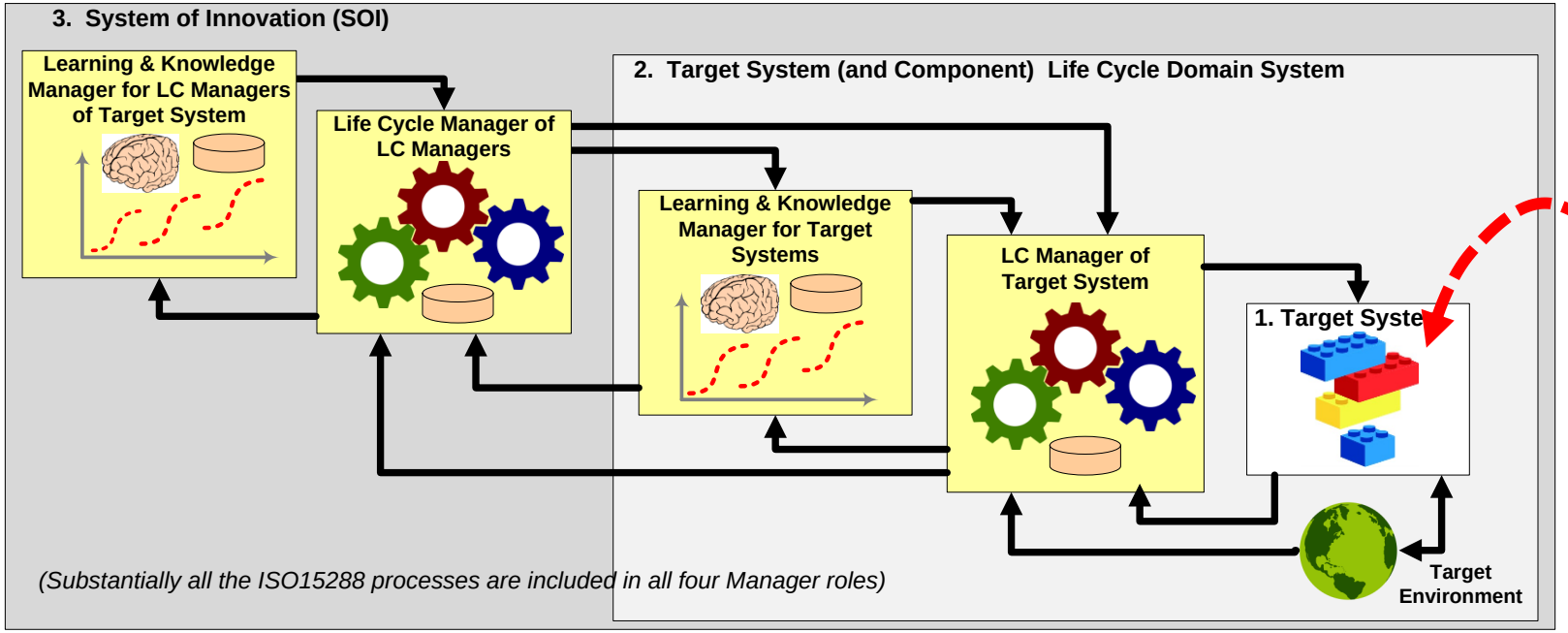
Four "Vees" in ASELCM

ASELCM Pattern: System 1 (Target System) agility, driven by System 2 (Life Cycle Management) and System 3 (System of Innovation).

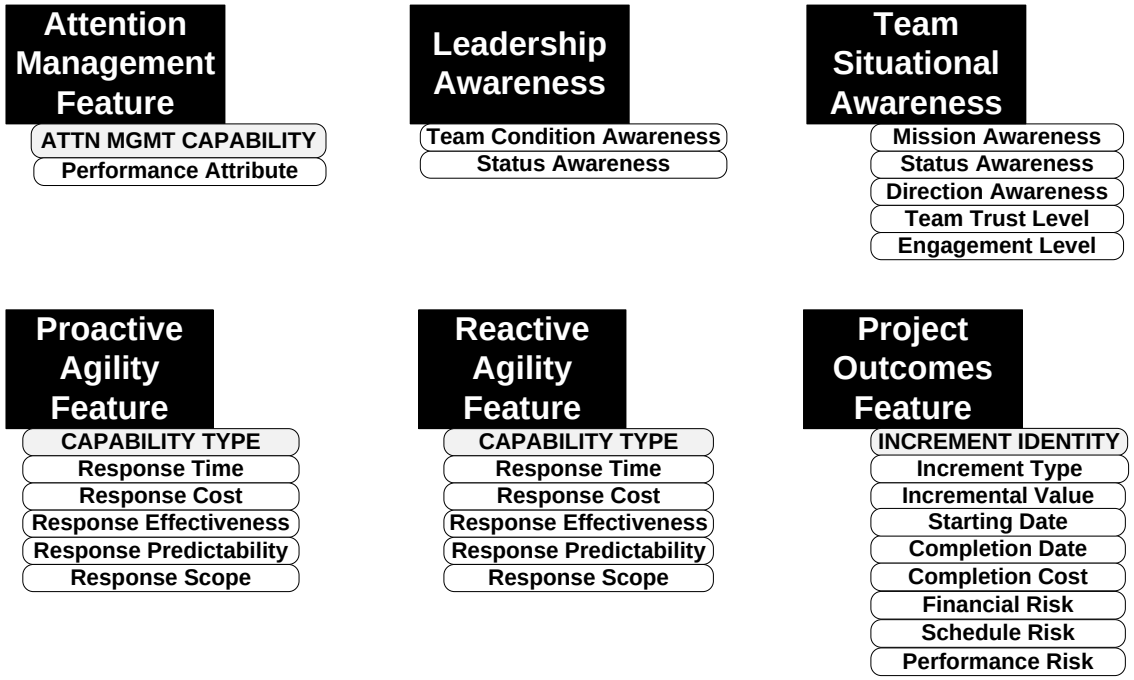
Central to the case studies: System 2, 3 Features, Interactions, Roles, Couplings



1. Agile Systems Engineering Process Features Collective Culture, Consciousness, and Conscience at SSC Pacific Unmanned Systems Group



Helped us understand/represent how their approach effectively addresses the “UURVE” environment. In the framework of the ASELCM Pattern, this can be seen as a “System-3 question”



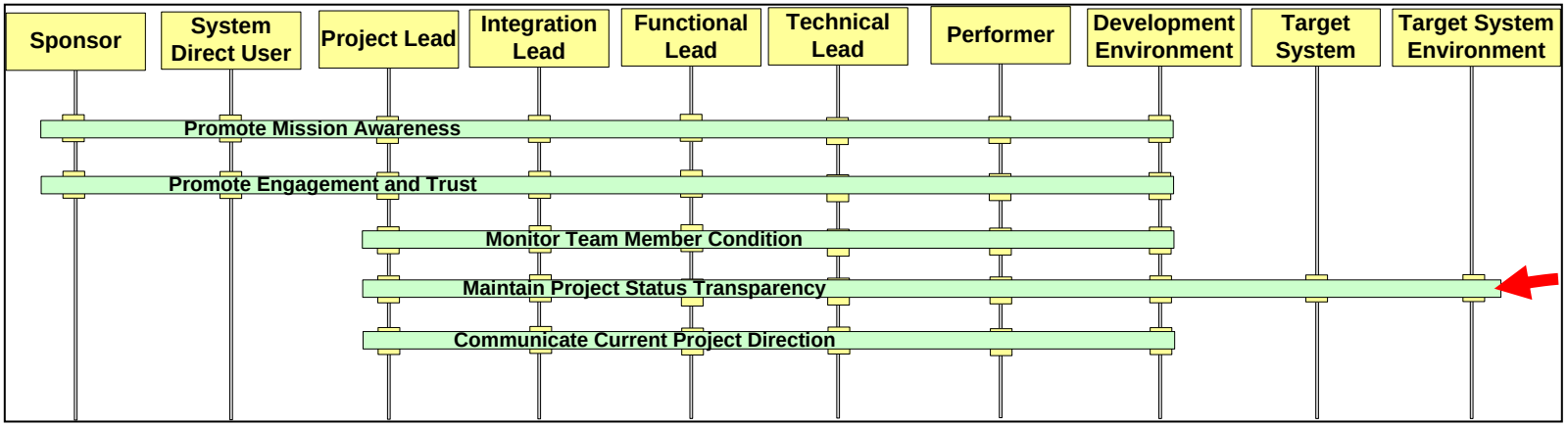
Selected Subset of System-2 Stakeholder Features and their Attributes

System 2’s “Agile Stakeholder Stories”:

“As a <*stakeholder role*> I want <*system behavior*> so that < *value statement*>.”

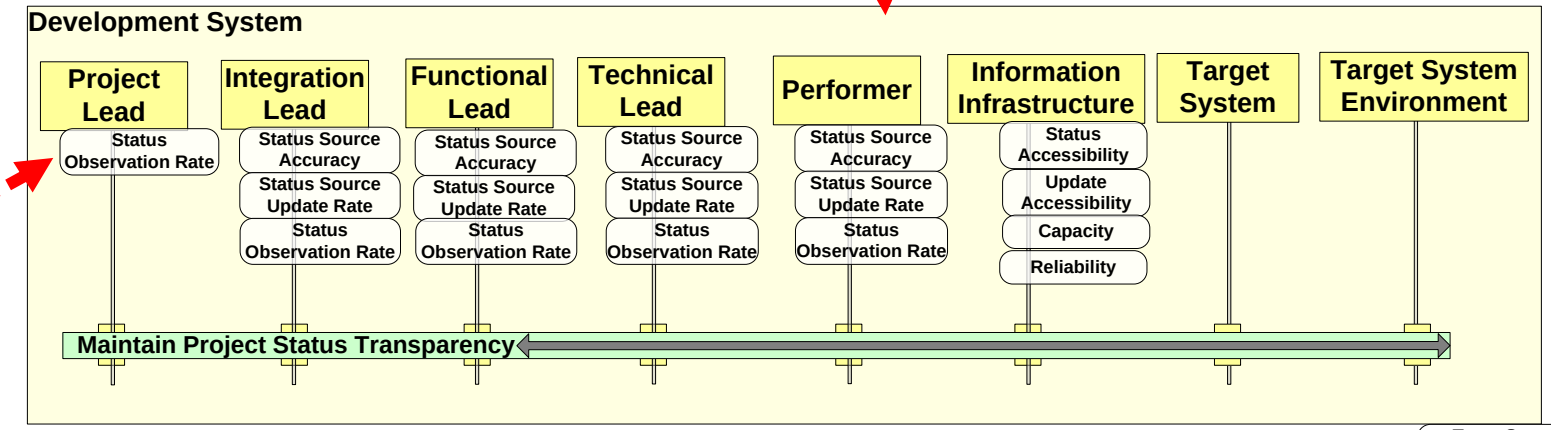
- “As a <*Sponsor*> I want <*timely project incorporation of emerging technologies*> so that <*I obtain a best-in-class autonomous vehicle system*>.”
- “As a <*Functional Lead*> I want <*to obtain timely project status*> so that <*I direct vehicle navigation system development in a timely manner*>.”
- “As a <*Project Performer*> I want to <*obtain timely project directional awareness*> so that <*I contribute responsively to the overall project*>."

SPAWAR System Center Pacific (SSC-Pac): Unmanned System Integration, Test, and Experimentation (UxS ITE): Interactions & Emergence --

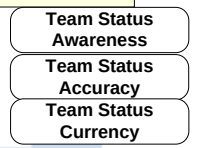


Selected Subset of ASELCM Interactions, System-2

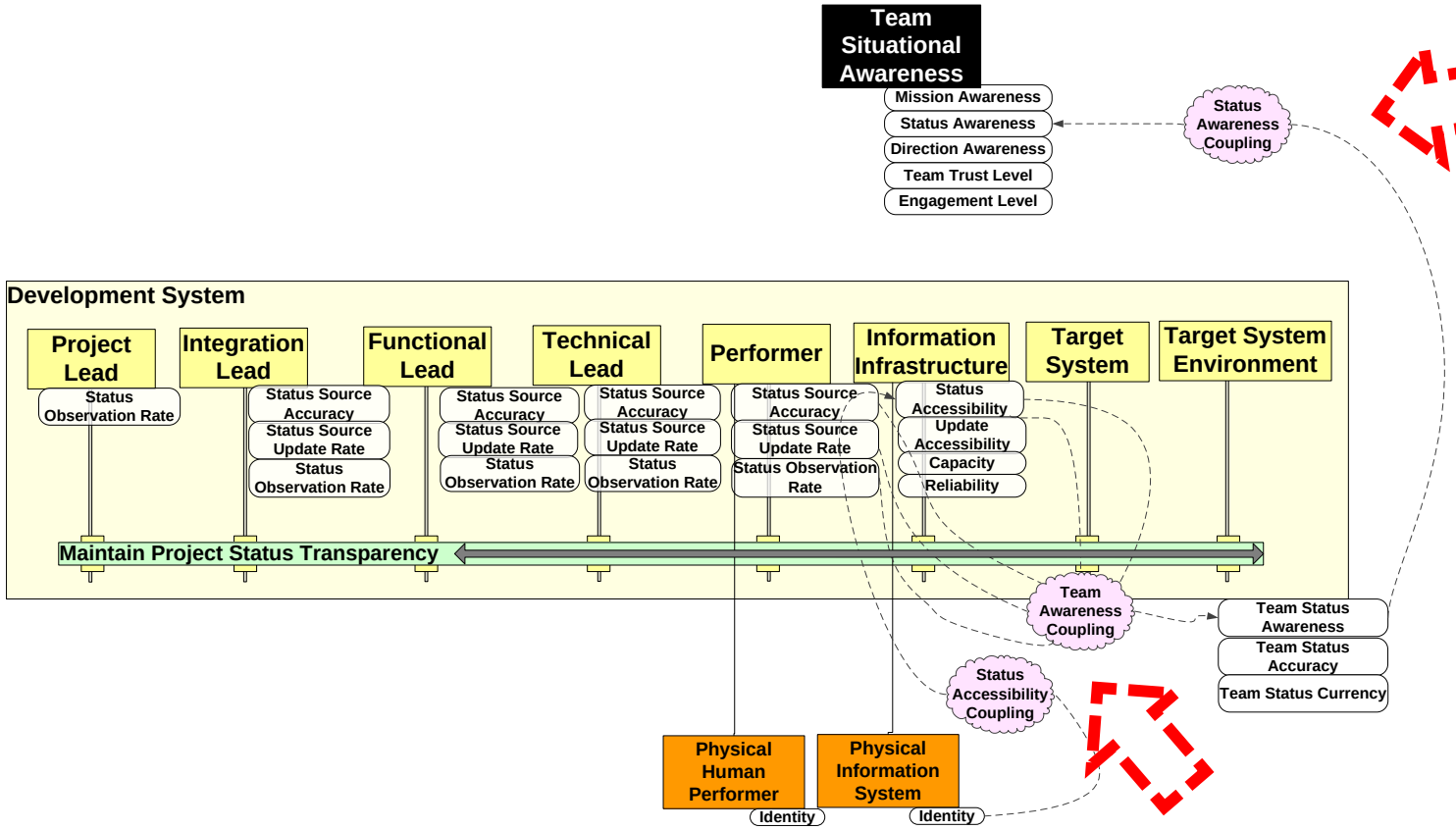
One Interaction

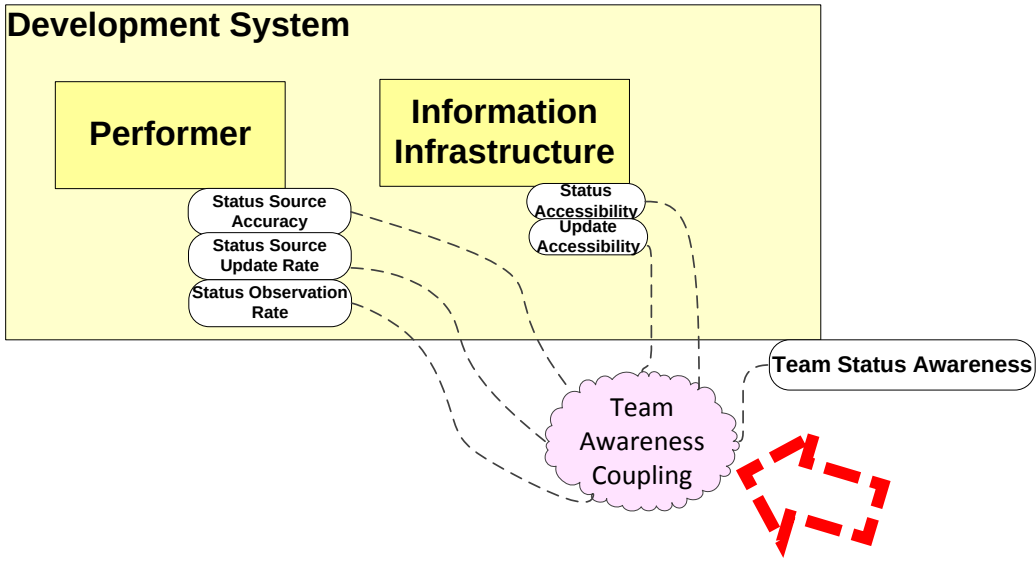


For “Maintain Project Status Transparency” Interaction, Attributes of Individual Component Roles, and Emergent Systemic Attributes



SPAWAR System Center Pacific (SSC-Pac): Unmanned System Integration, Test, and Experimentation (UxSITE) : Attribute Couplings

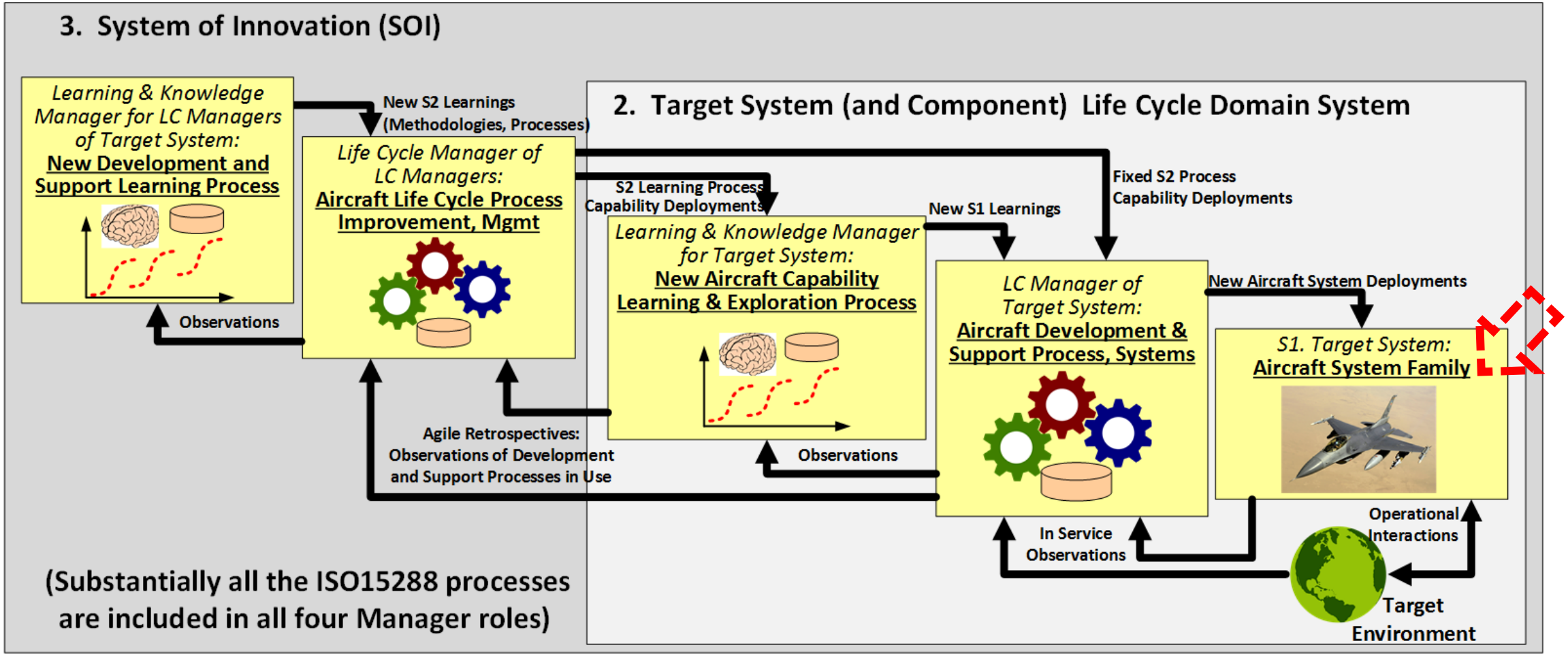




Modeled Parametric Couplings of ASELCM Features, Functional Roles, and Physical Components

Team Status Awareness Arises from Other Attributes

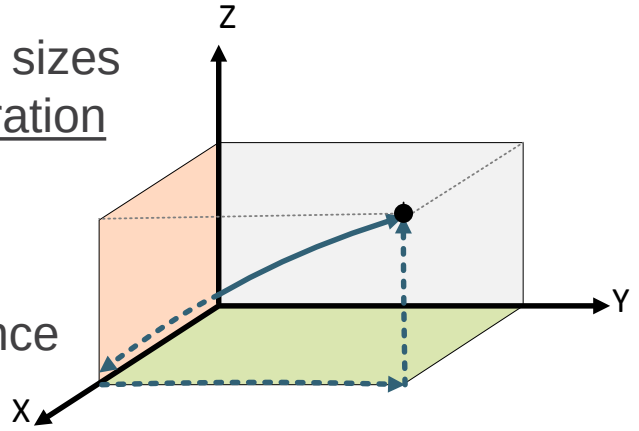
2. Transition to Scaled-Agile Systems Engineering at Lockheed Integrated Fighter Group



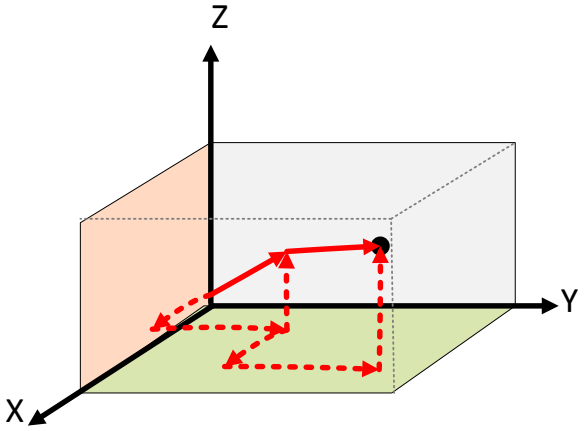
2. Transition to Scaled-Agile Systems Engineering at Lockheed Integrated Fighter Group: Configurations, Costs

Optimal "Flow": smaller batch sizes can result in different configuration trajectories:

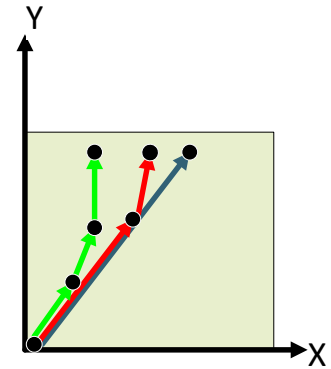
Example subspaces:
Reqs, Dsn, Performance



(a) Large "Batch" Increment

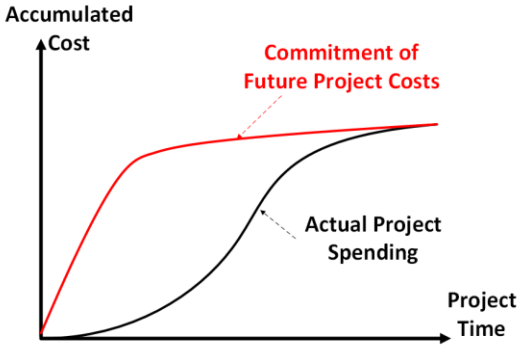


(b) Smaller "Batch" Increments

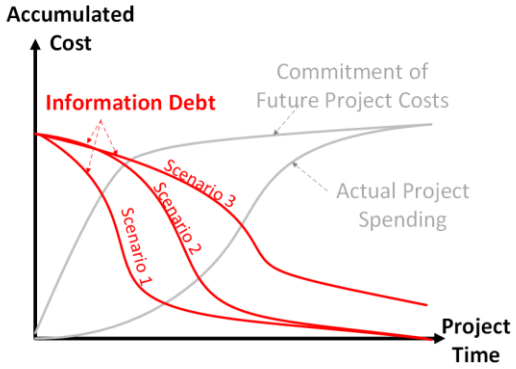


(c) Different "Batch" sizes can result in different trajectories, destinations

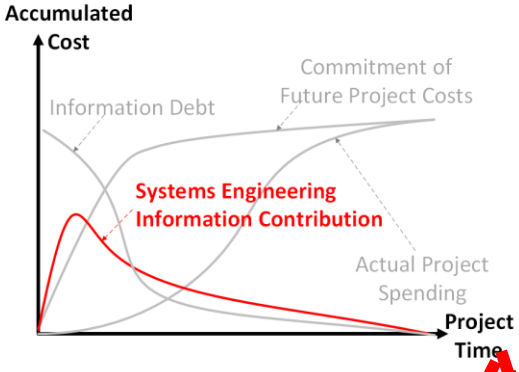
Information Debt: Balance Sheet Model of Learning



(a) When Project Costs Are Committed versus Incurred



(b) Information Debt is Reduced Over the Course of Project

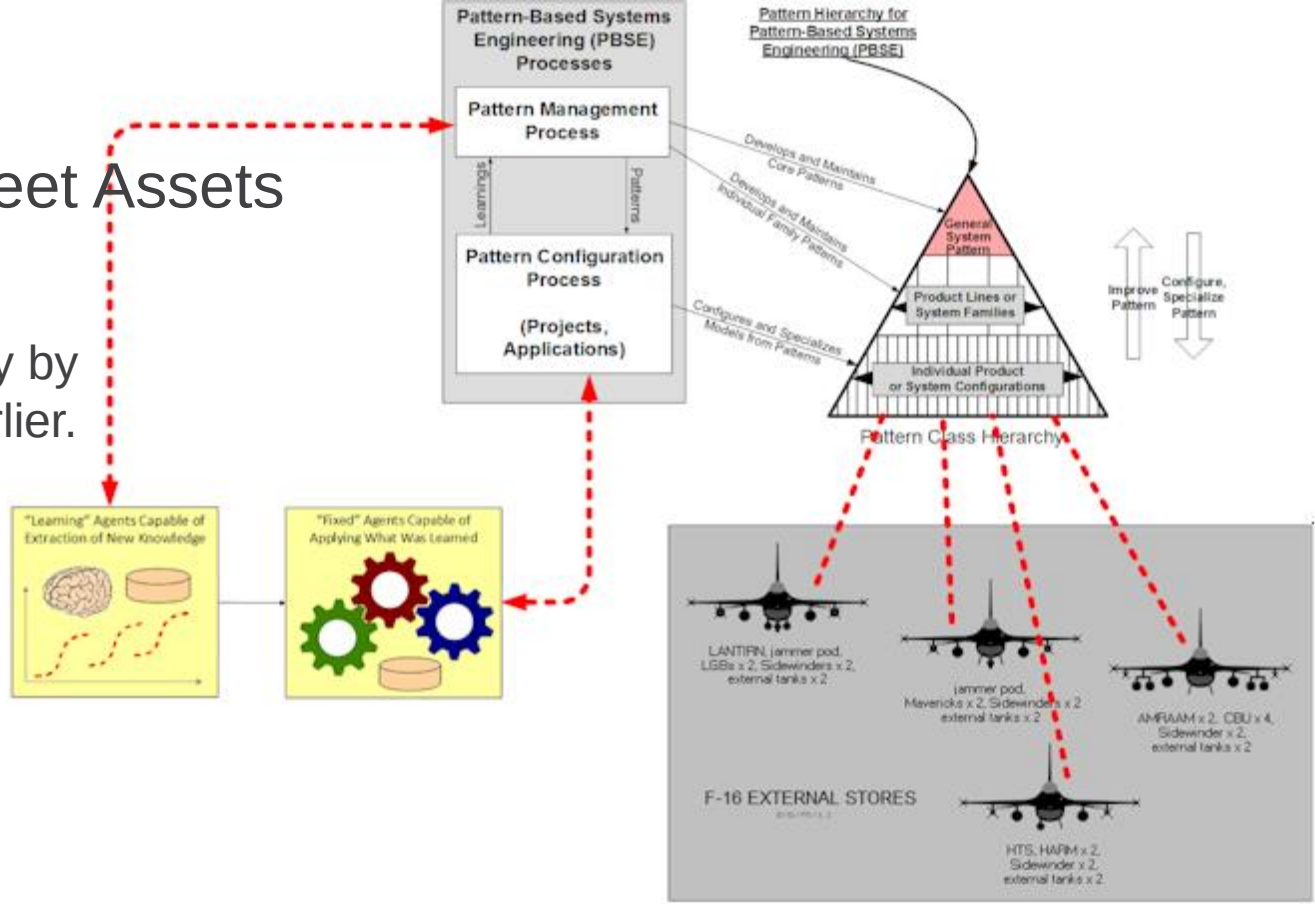


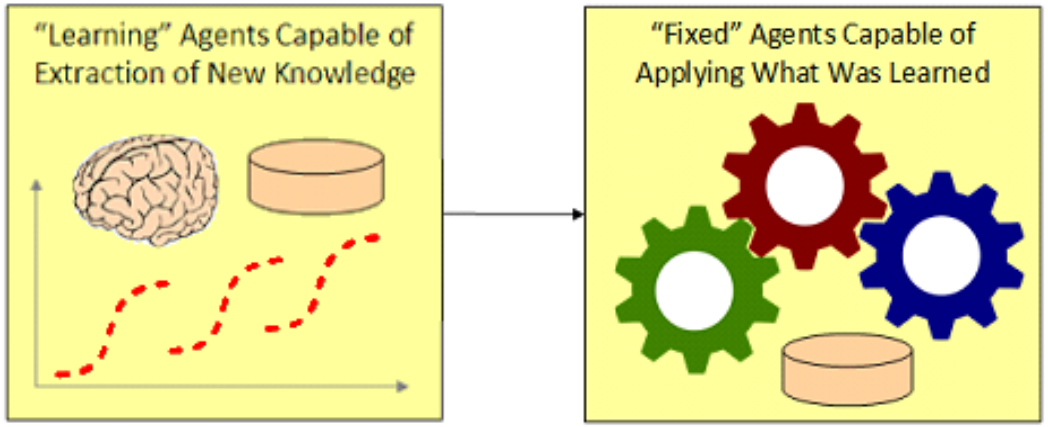
(c) Systems Engineering Information Is Generated to Reduce Information Debt

Financial Flows—Accumulated Project Costs, Information Debt, and SE Information Contribution.

System 2 Learning Observed:
Explicit System 1 Patterns as Balance Sheet Assets

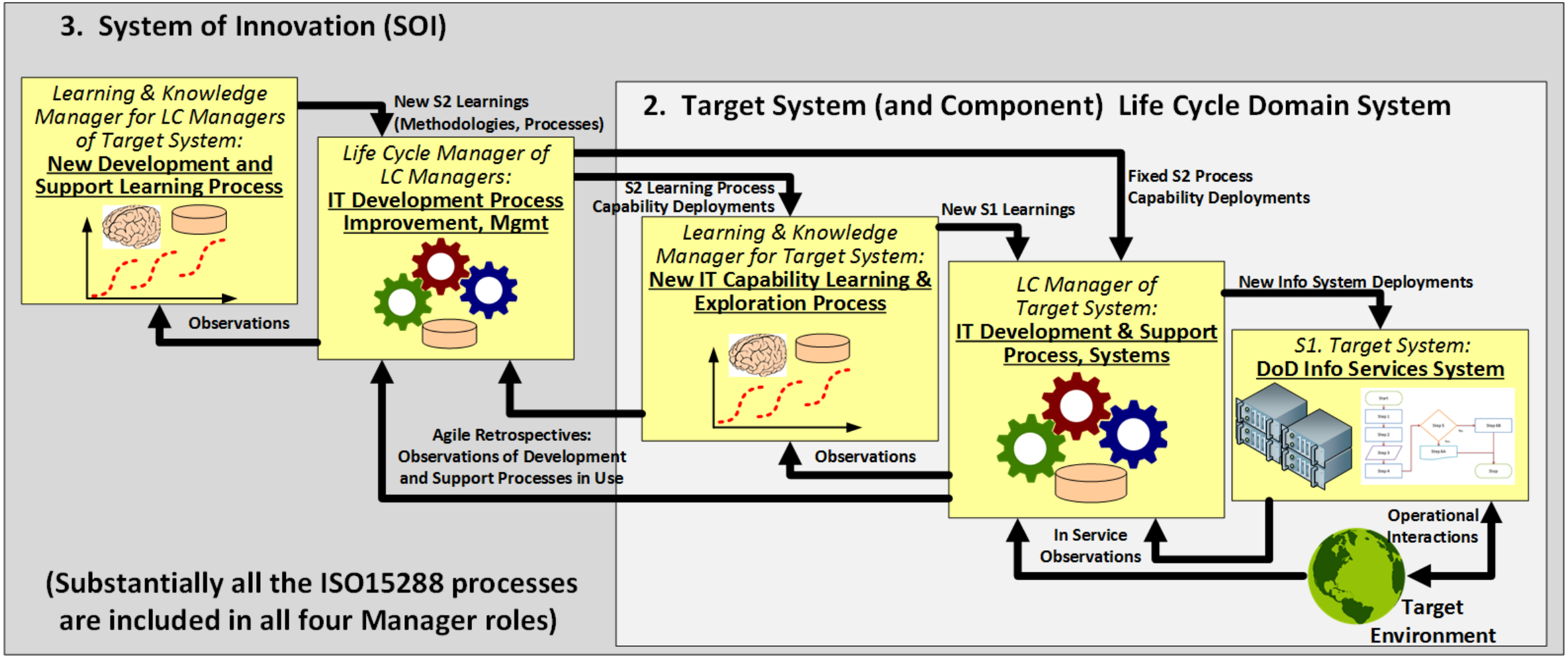
Platform architectures increase agility by rapidly lowering information debt earlier.



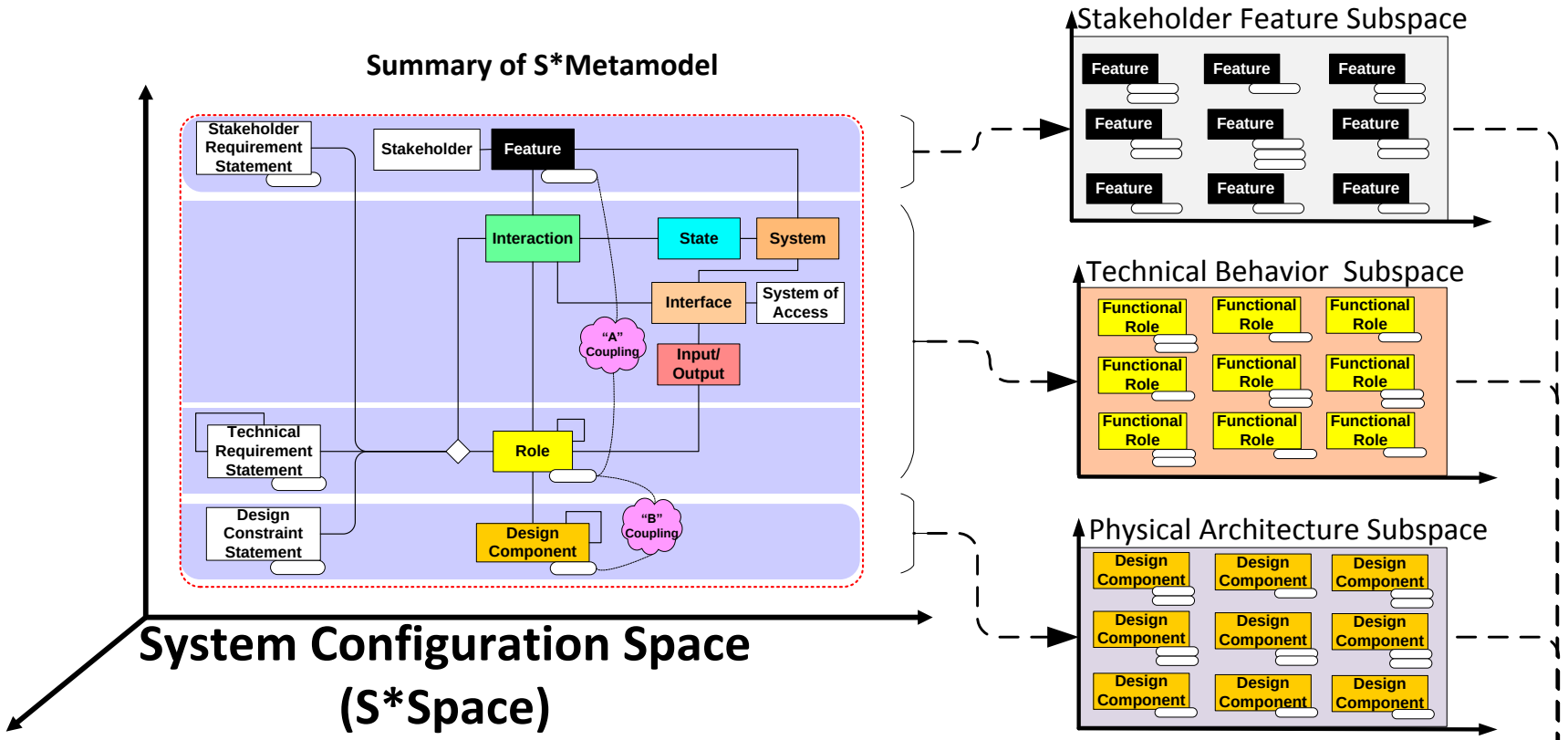


Where are the pattern assets accumulated?
ASELCM human or other learning processes, learned assets, and their uses

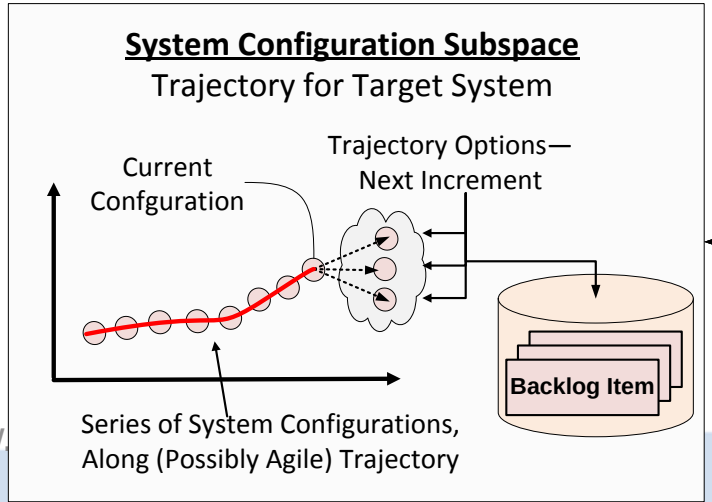
3. Agile SE Process for Centralized SoS Sustainment at Northrop Grumman



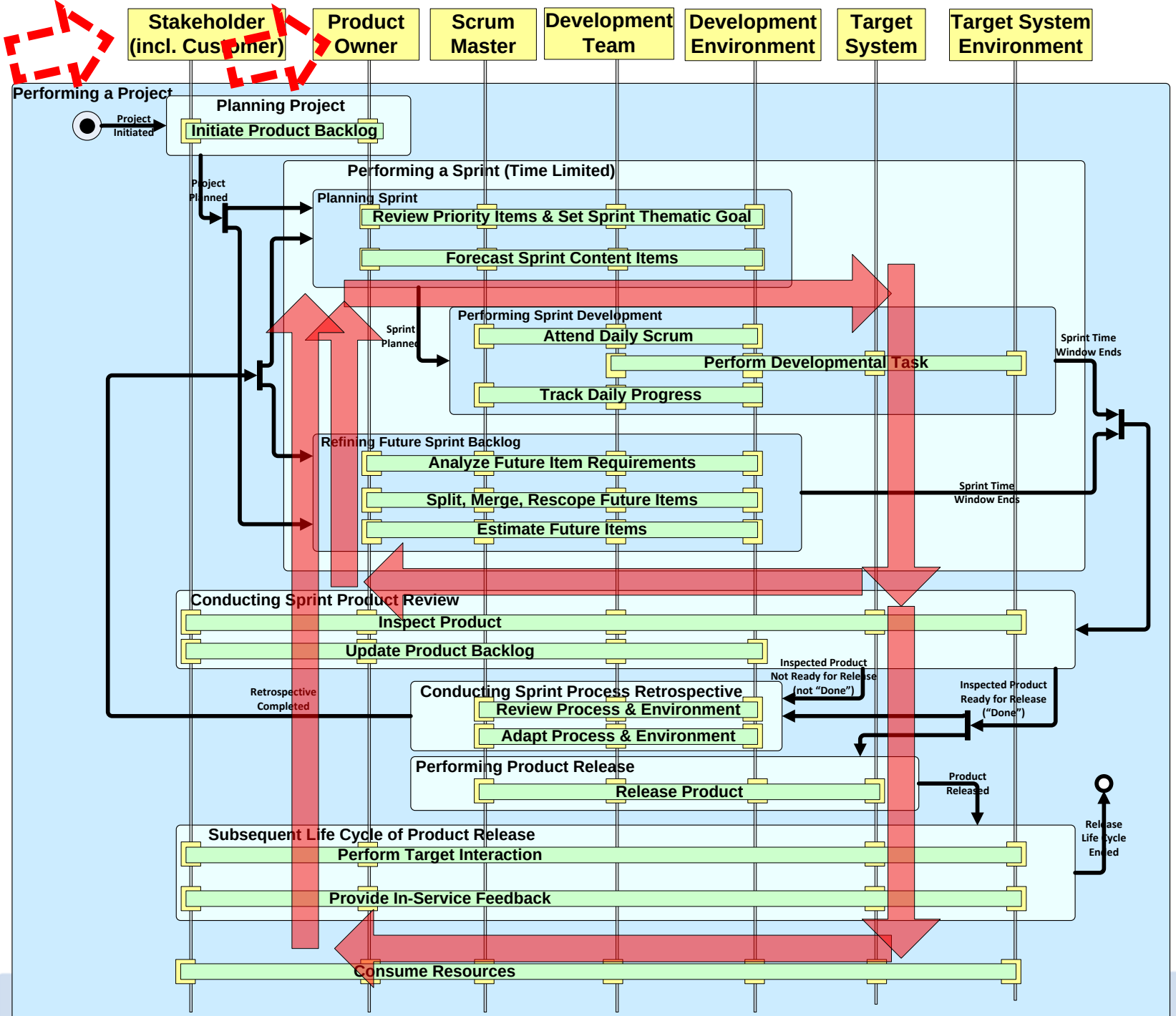
Agile trajectories in S1 Configuration Space: Optimal Control & Estimation



GCSS-J agile trajectory in system configuration space and sub-spaces

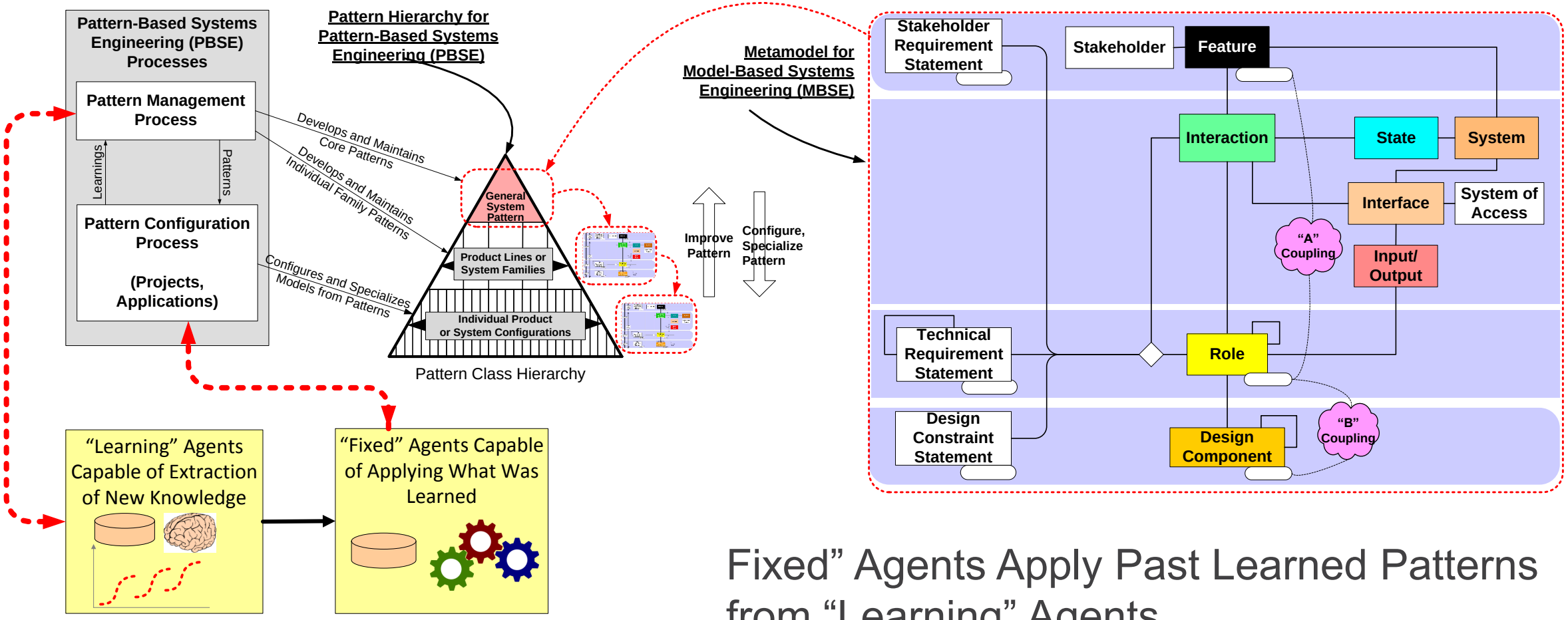


Trajectory uncertainty and risk: Trading and sharing risks, decisions



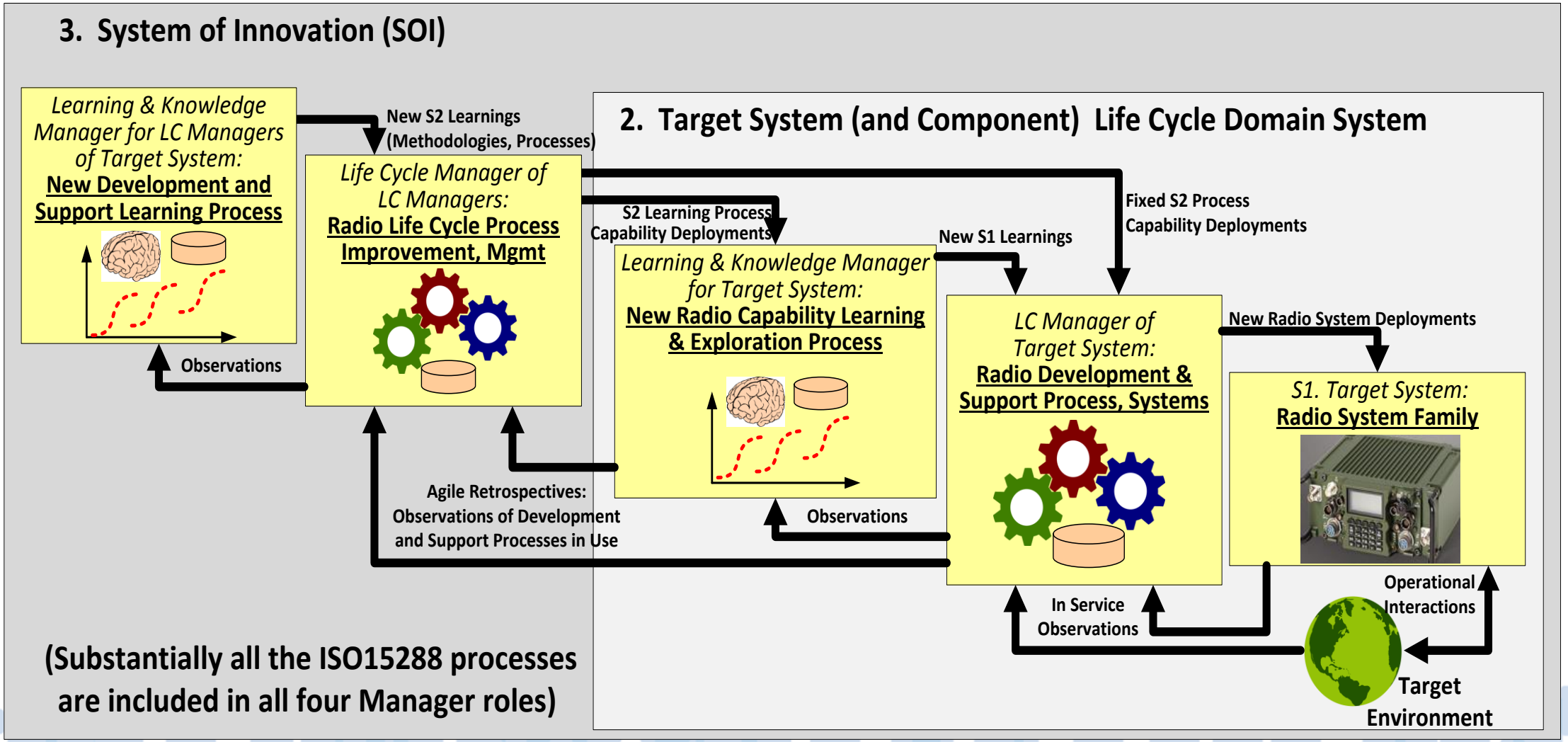
Nested feedback loop processes traverse system configuration space

States, Modes, and Learning in System 2

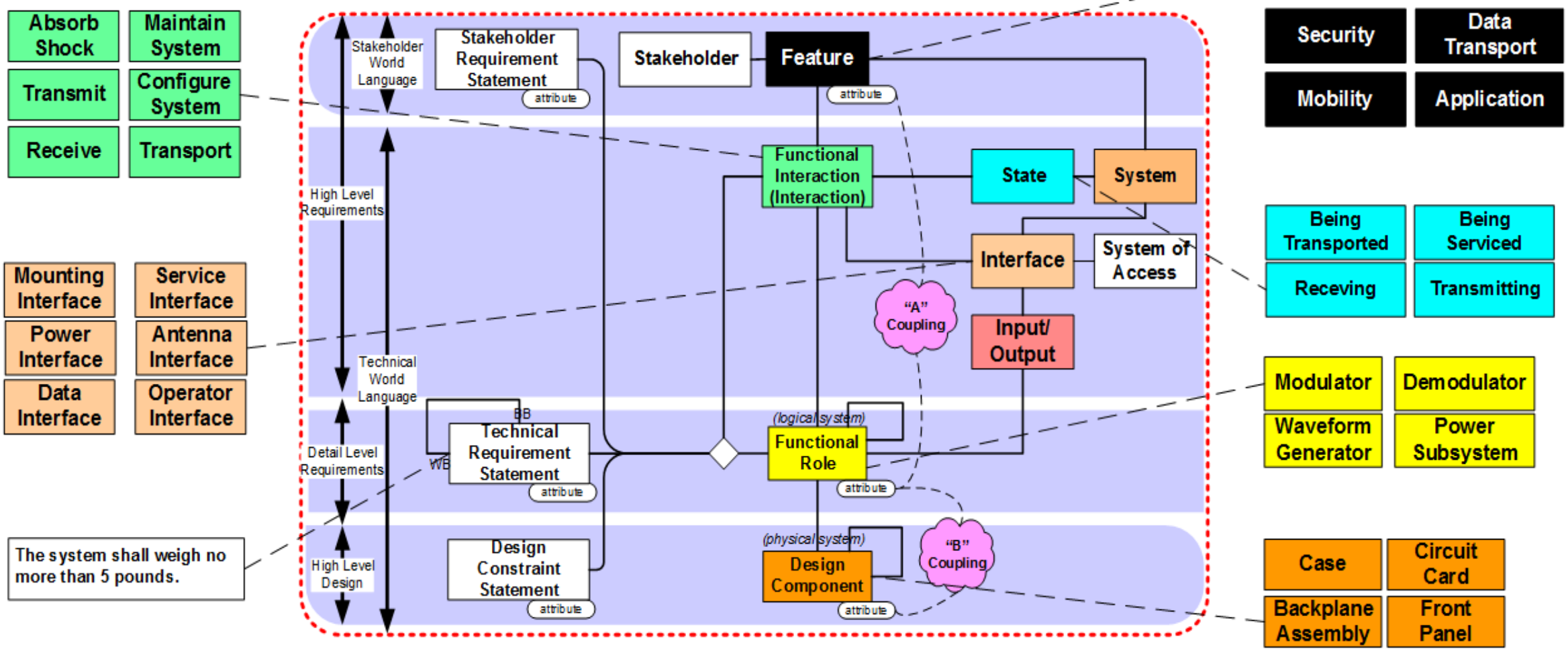


Fixed" Agents Apply Past Learned Patterns from "Learning" Agents

4. Agile Hardware/Firmware/Software Product Line Engineering at Rockwell Collins



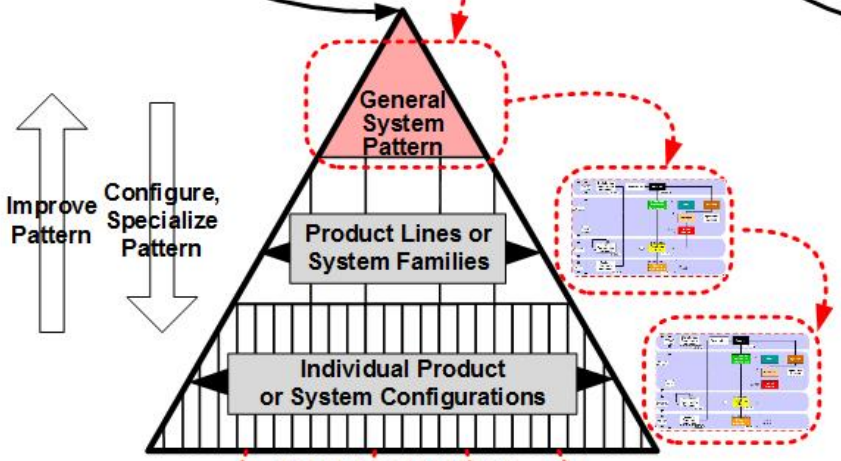
Summary of S*Metamodel
Defines System Family Configuration Space



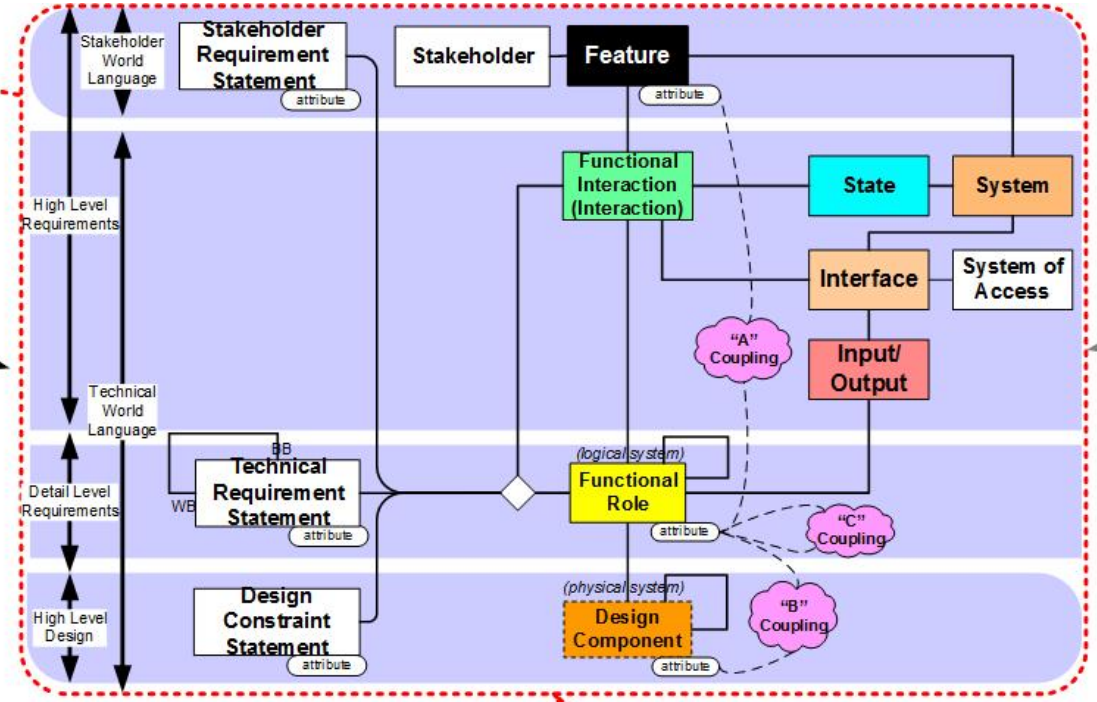
Product line family issues ultimately include the minimal system model issues (Illustrative examples for generic radio systems)

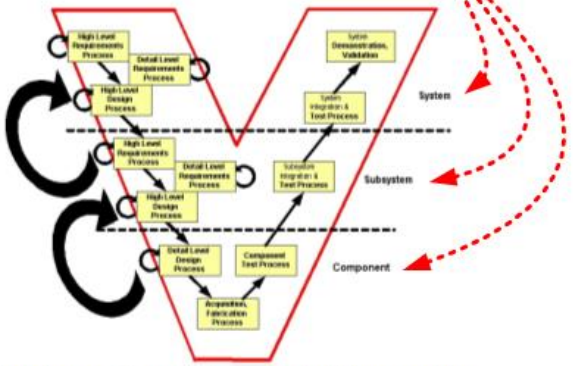
S*Pattern Hierarchy for Pattern-Based Systems Engineering (PBSE)

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



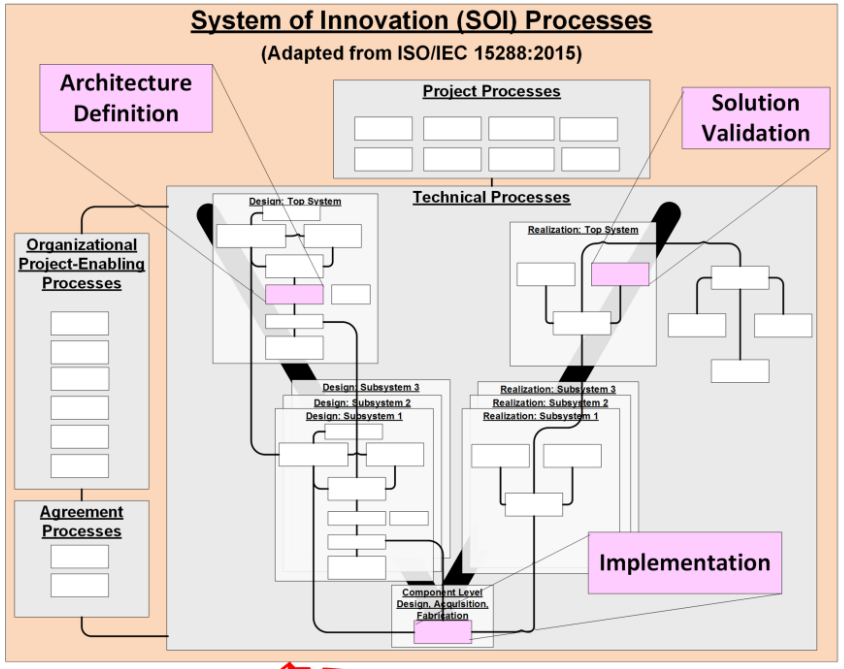
System Pattern Class Hierarchy





System Containment Hierarchy

Product lines configure varying products from those pattern assets.



All ISO15288 life cycle processes are candidates for Product Line Engineering learning and configurability—e.g., Test

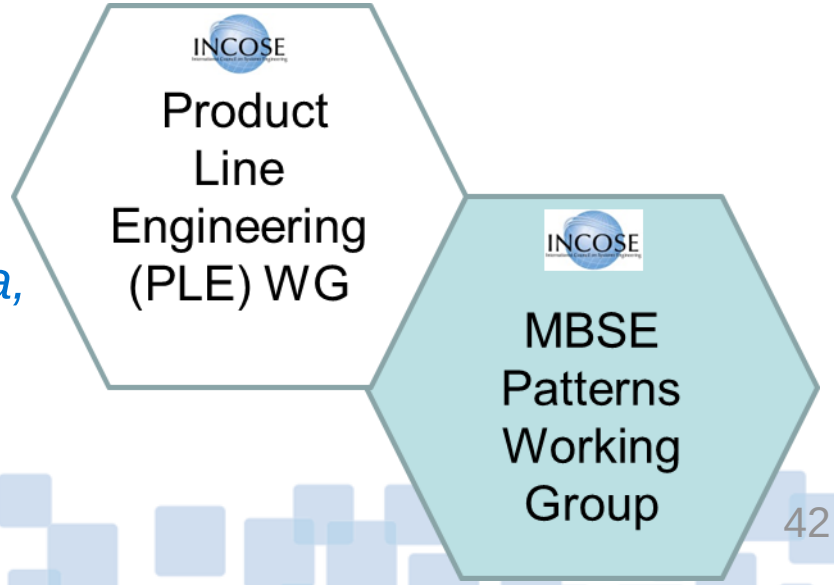
Additional Recent INCOSE ASELCM Applications

- INCOSE Agile Health Care Systems Conf. 2016:
  - Health Care Domain ASELCM Pattern
- INCOSE/IEEE/NASA Energy Tech 2016 Conf:
  - Critical Infrastructure Domain ASELCM Pattern
  - Power Distribution Domain ASELCM Pattern

With Product Line Engineering WG: Joint Activity Materials

- Joint Projects:
  1. Demonstration of Legacy Product Line Pattern Harvest, using Method of Projections
  2. Demonstration (also with TIMLM WG) Collaborative Innovation Ecosystem, for Product Line Life Cycle Patterns & Configurations

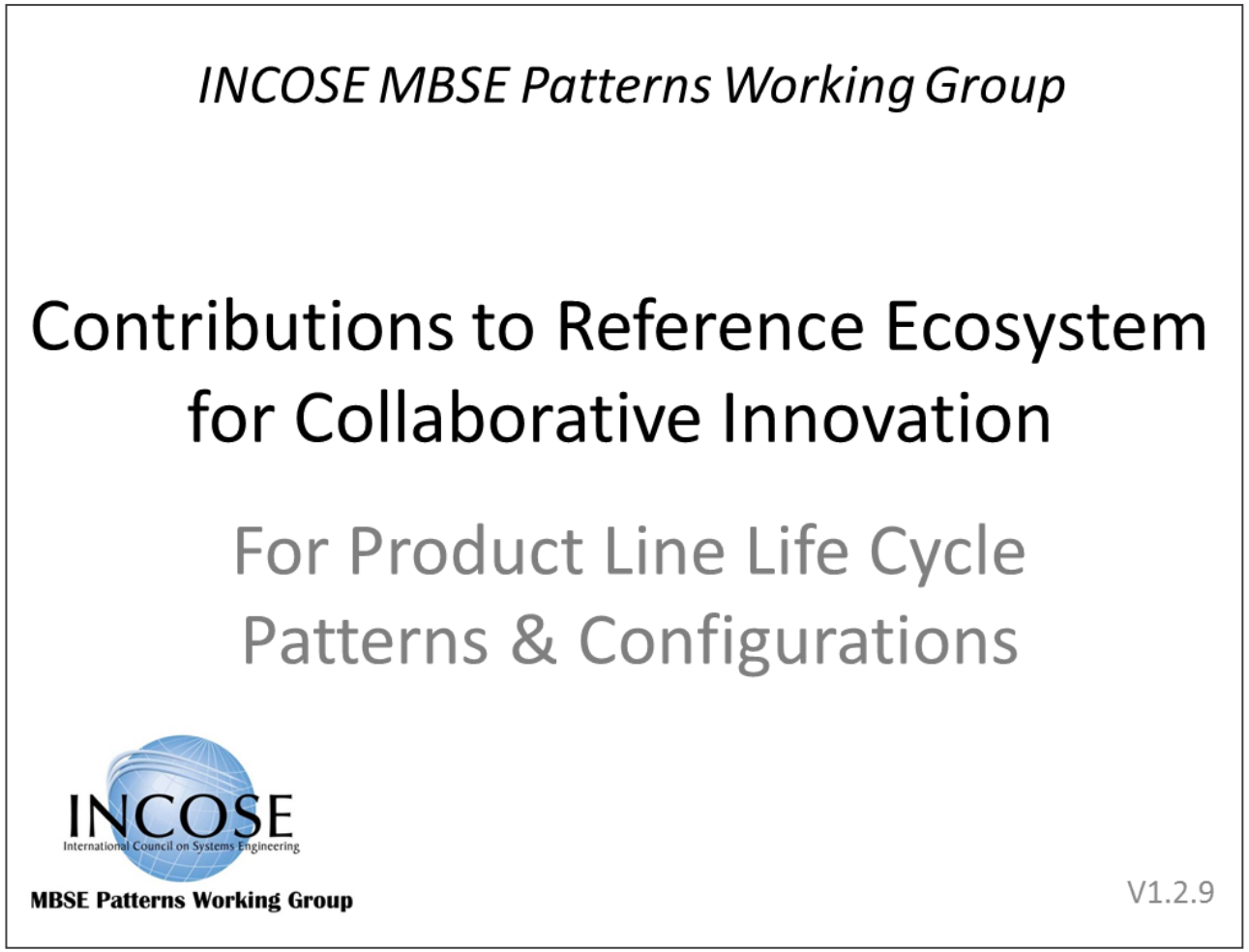
Primary Contacts: *Guillermo Chale-Gongora, Alstom; Charles Krueger, Big Lever*



Project 1: Demonstration of Legacy Product Line Pattern Harvest, using Method of Projections

- What is status of collection of legacy system rough data set?
- Preliminary review of available raw data set

Project 2: Demonstration Collaborative Innovation Ecosystem, for Product Line Life Cycle Patterns & Configurations



Draft for review

Project Objectives

1. Specify, construct, and demonstrate a reference ecosystem of product life cycle tools, processes, and example content . . .
2. Illustrating a vision (or set of visions) of future approaches to collaboration between people and information systems, integrated across the ISO15288 system life cycle processes . . .
3. Leveraging the concepts of sound systems engineering, model-based representations and patterns, product line engineering, and agility in the face of risk, variability, and uncertainty . . .
4. Integrating the work and resources of multiple INCOSE Working Groups in related areas . . .
5. By providing this point of reference, accelerating the Model-Based Transformation described by INCOSE Vision 2025 and encouraged by the INCOSE Board of Directors adopted strategic objective.

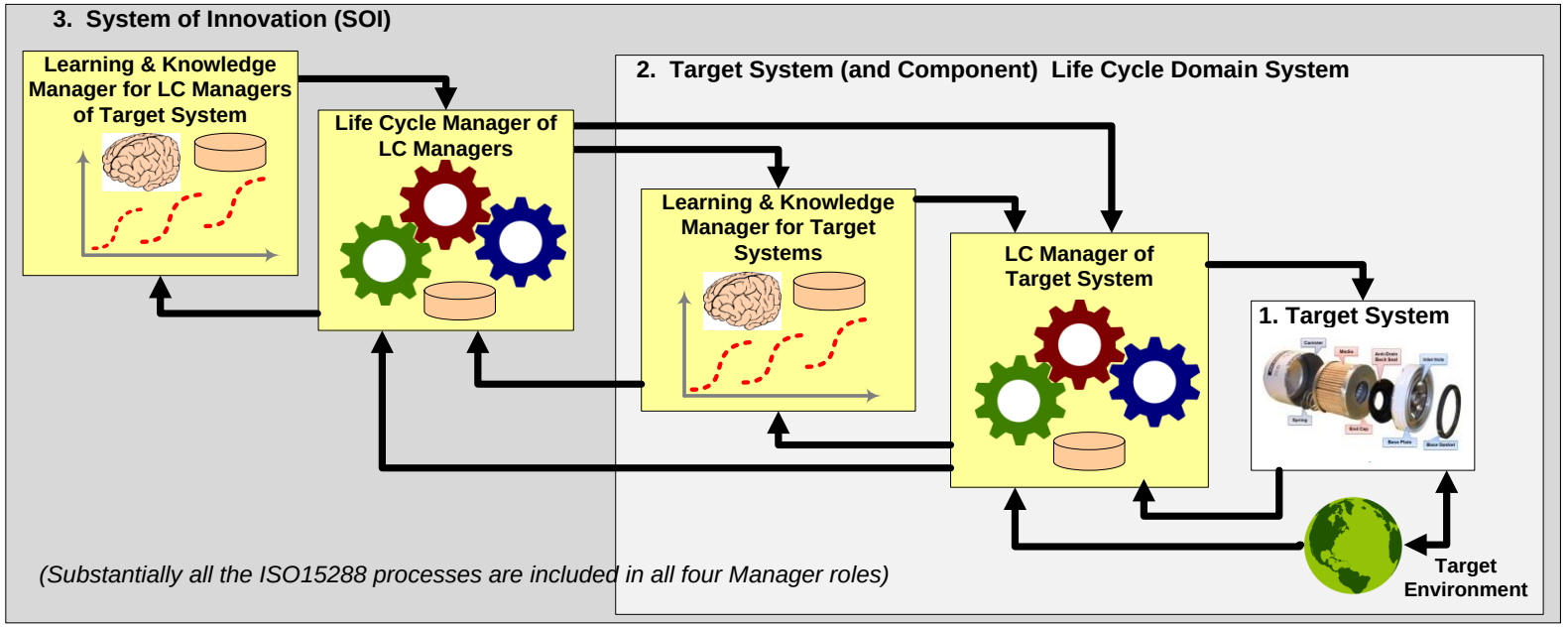
Working Groups Involved

- MBSE Patterns Working Group
- Product Line Engineering Working Group
- Tools Interoperability and Model Life Cycle Management Working Group (*)

(*) The following material represents Patterns WG and PLE WG joint activity underway, but does not yet reflect TIMLM WG activity also underway, which will be discussed in INCOSE IW2017.

Patterns Working Group Contributions to this Project

- ASELCM System 1 Patterns: S*Pattern-based representation of engineered systems, over their life cycle, including product line patterns and specific configurations thereof. (This is system 2 work.)
- ASELCM System 2 Patterns: S*Pattern-based representation of the systemic patterns of (human, machine) activity characterizing System 2 collaboration over System 1 life cycles; including general patterns and specific configurations thereof. (This is System 3 work.)



ASELCM Pattern

Patterns Working Group Contributions to this Project

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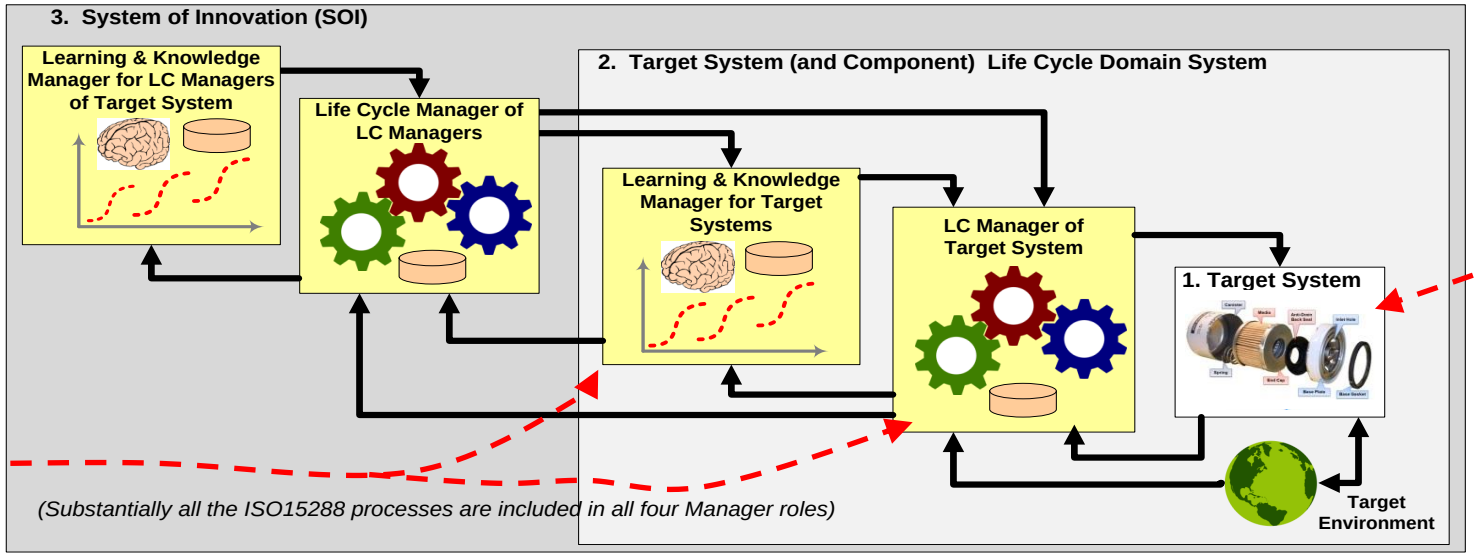


ASELCM Pattern

We expect this project will involve contributions of ideas, effort, or otherwise from multiple external sources

- Currently in very early stage, using ideas, products, information, effort from the following, with more expected to get involved over time . . .

More to follow, especially to cover ISO15288 Life Cycle Processes

System 1 Model Content

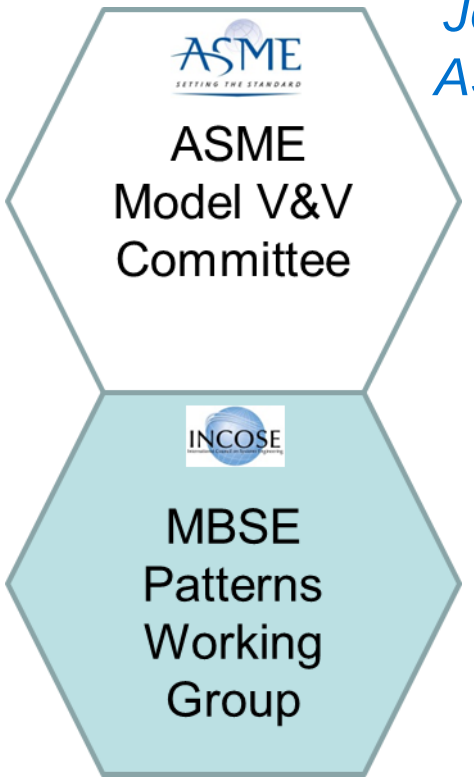
- Product Line Model S*Pattern—for Oil Filter Family Product Line:
  - And product configurations thereof, over their life cycles
- Related Manufacturing System S*Pattern—for Oil Filter Manufacturing Platform Product Line:
  - And system configurations thereof, over their life cycles
- Represented as S*Patterns and S*Models, in multiple COTS tools for model authoring, analysis, simulation, configuration management, and otherwise.

Preliminary System 1 Example Data

- Oil Filter S*Pattern:
  - Descriptive product line document samples
  - Modeled in multiple SysML modeling tools
  - Integrated with configuration agent capabilities, for creating configured S*Models from S*Patterns
- S*Examples of the above, in progress so far:
  - Magic Draw/CSM + Big Lever Gears
  - Enterprise Architect + Reference Configuration Agent
  - Other types of tools and information systems to follow

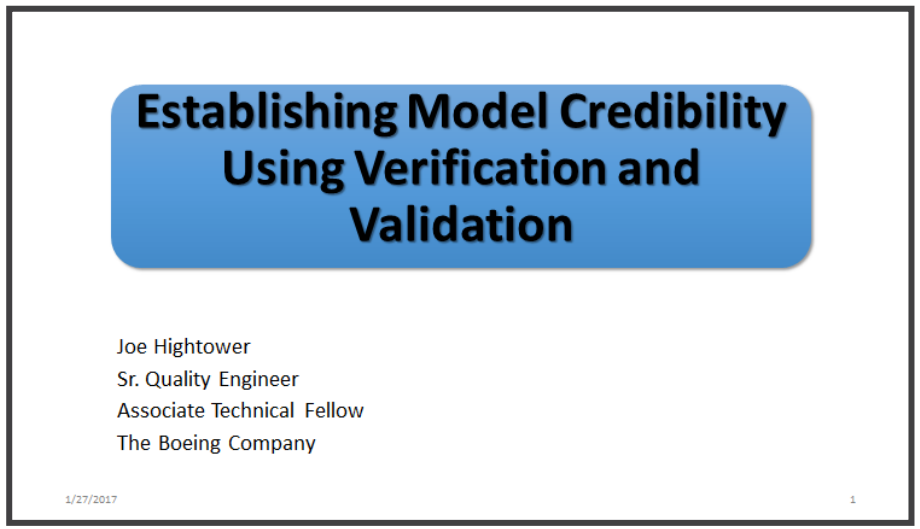
With ASME Model V&V Committees: Model V&V Joint Activity Materials

- Supporting creation of ASME Guidelines & Standards for Computational Models, over their Life Cycles

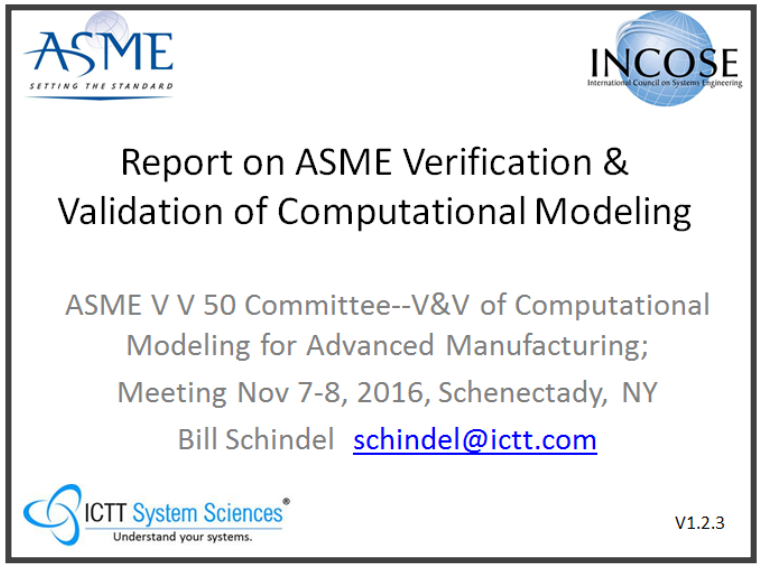


Primary Contact:
Joe Hightower, Boeing,
ASME VV50 Committee

With ASME Model V&V Committees: Model V&V Joint Activity Materials



IW2017 MBSE Workshop talk



Report on ASME Verification & Validation of Computational Modeling

ASME V V 50 Committee--V&V of Computational Modeling for Advanced Manufacturing;

Meeting Nov 7-8, 2016, Schenectady, NY

Bill Schindel schindel@ictt.com

ICTT System Sciences®
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V1.2.3

Content

- Purpose and Scope
- Intended Audience & Interests
- Background on ASME Model V&V Activities
- Model Verification and Validation – Awareness
- The Opportunity for ASME and INCOSE
- November 7-8, 2016, V V 50 Meeting—Topics

- References
- VV50 Committee Leadership

Purpose and Scope

- This is a report on the ASME V V 50 Standards Committee on V&V of Computational Modeling in Advanced Manufacturing.
- This report is focused on the Nov 7-8, 2016 meeting of the committee, but also includes general background on the ASME Standards Committees on Verification and Validation of Computational Modeling.
- This report is the for the Intended Audiences listed on the next page, and is focused on only certain limited aspects of the above.
- See the References for more information, or contact the author.

Intended Audience & Interests

- Indiana Virtual Verification Institute (VVI) Core Team
- INCOSE MBSE Leadership, INCOSE Patterns Working Group, and INCOSE Crossroads of America (CoA) Chapter
- Enterprises applying MBSE models

Intended Audience & Interests

- Reason for interests:
  - Although the use of models is not new, it is continuing to increase in importance and frequency.
  - There is not a shared agreement, across individuals and organizations, as to the description of uncertainty, risk, or confidence in those models.
  - As potential reliance on models grows, the need for such a framework also grows—trust is essential to commerce and society.
  - This is not just true for the “computational models” of interest to the ASME standards effort, but also to the more general class of “system models” (of which the former are a part) over system life cycles, of interest to the INCOSE systems community.
  - INCOSE sees the opportunity to collaborate with ASME, in describing frameworks that are as consistent as appropriate.

Background on ASME Model V&V Activities

- ASME generates formal standards across a wide range of subjects.
- Because the use of computational modeling and simulation of physical systems (e.g., FEA models, dynamical simulations, etc.) has become widespread, ASME formed a standards committee effort related to the verification and validation of such models.

Model Verification and Validation – Awareness

- Systems engineers and others are used to referring the "verification and validation" as related to designed systems, in this way:
  - Validation that the stated candidate requirements for a real system are appropriate in the eyes of the stakeholders in that system. (*Are we working on the right requirements?*)
  - Verification that the that a stated candidates design for a real system will result in a system meeting the stated requirements for that system. (*Are we working on the right design?*)
- However, the ASME Model VV effort is directly concerned not with the above V&V of systems, but instead with the verification and validation of computational models:
  - Although those might even be models of the same system as referenced above, the V&V of those models turns out to be a different idea than the V&V of the systems.

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

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

Model Validation

Model validated?

Model

Model verified?

Model Verification

Does the Model implementation adequately represent what the Model says?

Describes Some Aspect of

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

Do the System Requirements describe what stakeholders need?

System Validation

Requirements validated?

System of Interest

Design verified?

System Verification

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

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

Computational Models: Additional Distinguishing Aspects

- An additional distinction in currently visible models and modeling efforts is also delineated by the model V&V effort:
  - Internal "Physics-Based Models": These describe *and explain* external system behavior, using model content that shows how externally-visible behavior is generated by internal interactions, based on physics or other "scientific" or first principles models, of at least one level of decomposition. The emphasis is on discovery and use of the explanatory science of the decomposition.
  - External (black box) "Data Driven Models": These describe external system behavior, but solely in terms of the "black box" patterns of that behavior that can be seen externally, without regard for any "internal why" explaining the internal origin of that behavior. The emphasis is on discovery and use of the patterns of external behavior.
  - "Hybrid" Models: These combine both of the above aspects.

Data Driven Models "Black Box"

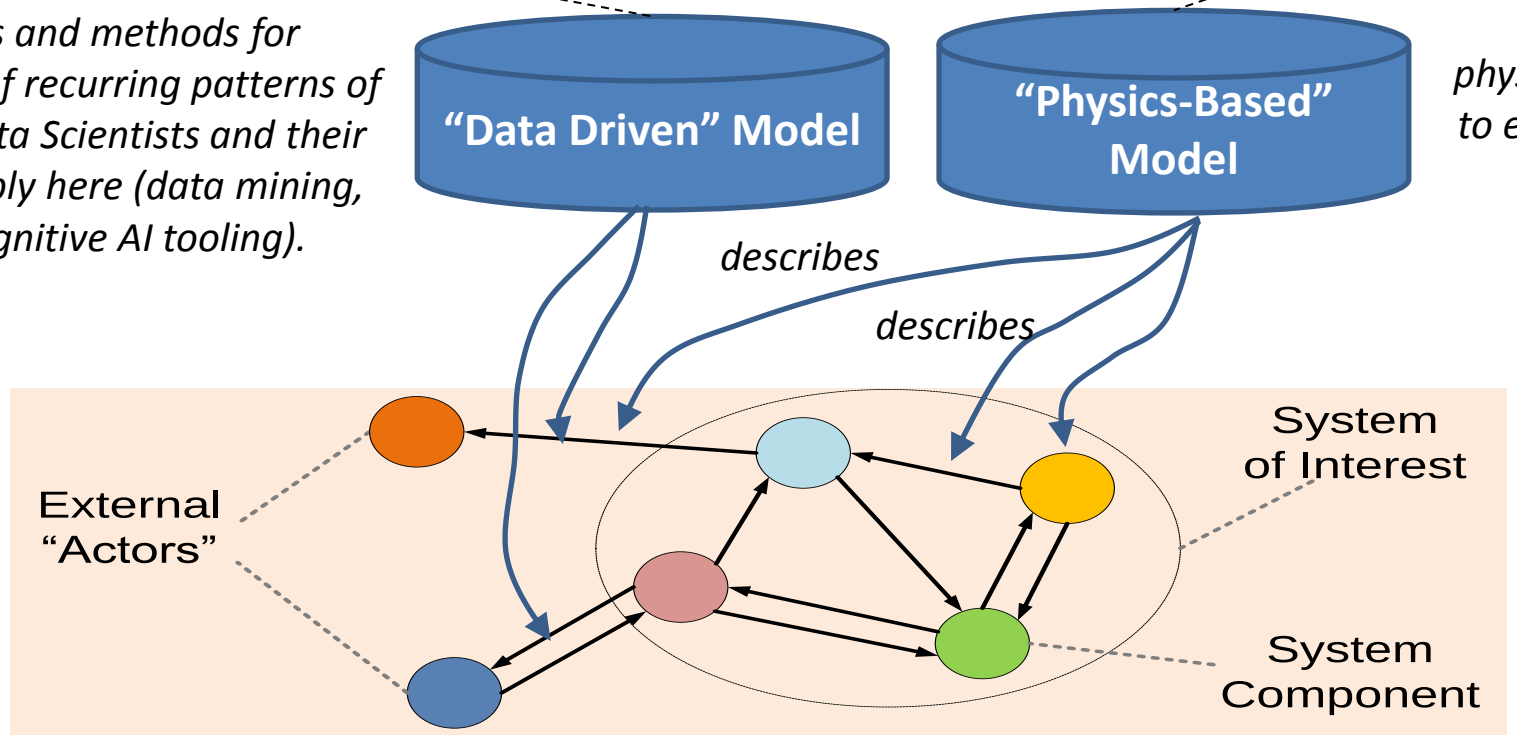
What is the behavior of the System of Interest, visible externally to the external actors with which it interacts?

Special interests: Tools and methods for discovery/extraction of recurring patterns of external behavior. Data Scientists and their newer IT tools can apply here (data mining, pattern extraction, cognitive AI tooling).

Physics Based "Internal Explanatory" Models

What are the internal interactions of the System of Interest, and how do they combine to cause/explain the behavior that is externally visible as interactions with external actors?

Special interests: The hard sciences physical laws, and how they can be used to explain the externally visible behavior of the System of Interest. Physical Scientists and models from their disciplines can apply here.



When expressed in S*Metamodel framework, the distinction and relationships of these two types of models becomes explicitly clear. It can be seen that this distinction retraces the history of the physical sciences, but with the latest tools. Remember the centuries-earlier studies of the night skies for patterns in the motion of stars and planets, followed later by the explanatory models of Newton and others.

The Opportunity for ASME and INCOSE

- INCOSE has a parent society-level initiative supporting the acceleration of the transformation of Systems Engineering to a model-based discipline:
  - The system models of interest to the INCOSE community are broader than the computational models of interest in the ASME Model V&V standardization effort—but the latter are a key subset of the former.
  - Moreover, many of the key ideas of Model V&V apply to that broader class of models, beginning with the concepts of model V&V itself, the issues of model life cycle management, concepts of data-driven and physics-based models, and others.
- Bill Schindel, co-chair of the INCOSE MBSE Patterns Working Group, joined ASME earlier in 2016, and has offered to join the Model Life Cycle Management sub-team (chaired by Joe Hightower, Boeing) of the ASME VV50 standards committee.
  - Bill has invited Joe to address the INCOSE MBSE Workshop at the International Workshop to be held in late January, 2017, in LA, concerning ASME VV 50.
  - Bill has also suggested that Joe consider joining or collaborating with the Model Management Working Group of INCOSE, which has related interests to Joe's.
- Opportunity for INCOSE and ASME to collaborate on their common interests:
  - The V and V of models (including general system models as well as computational)
  - The management of models over their life cycles
  - How the V&V of models fits into the larger system life cycle framework of ISO15288.
  - INCOSE IN Chapter supporting set up of an Indiana-based Virtual Verification Institute, including Additive Manufacturing applications.
- If the above prove to be of interest down the road, INCOSE also has a history of formalizing collaboration relationships with other organizations, use of Memoranda of Understanding, etc. – but usually after we have interested people active.

Nov. 7-8, 2016, ASME V V 50 Meeting Topical Highlights

- Hosted at GE Global Research, Schenectady, NY
- Approximately 23 attendees, plus 4 remote
- Chair: Sudarsan Rachuri, Pgm. Mgr., DOE Smart Manufacturing, Institute
- Vice-Chair: Mark Bennett, Pgm. Mgr., AFRL Manufacturing Technology Division
- ASME: Marian Heller, Steve Weinman, Dean Bartles
- Participants included: DOE, NIST, SWRI, AFRL, UL, MIT, Vanderbilt, Honeywell, GE, Boeing, Deere, ICTT
- GE's Brilliant Factory approach, use cases, challenges, review and tour of GE additive manufacturing and smart manufacturing facilities
- DOE Advanced Manufacturing Office focal issues include energy, clean energy processes, IT
- Plans for May meeting, at annual V&V Symposium

Nov. 7-8, 2016, ASME V V 50 Meeting Topical Highlights

- ASME Model V&V approach,
- data driven versus physics based models,
- standards teams and activities,
- membership types and expectations,
- sub-teams, including terminology, concepts taxonomy, model life cycle (Bill Schindel joined)
- connection to other ASME model VV committees (solid mechanics, fluid dynamics and heat transfer, nuclear, medical devices)
- manufacturing types coverage by committees,
- connection of product design models to manufacturing models,
- use cases,
- potential INCOSE-ASME collaboration,
- ASME model-based enterprise committee,
- types of ASME publications,
- levels of abstraction,
- ASME position on examples not in standards,
- ASTM library of unit operations,
- strategy for engaging software suppliers,
- PMML, CRISP-DM,
- NAS/NAE reports,
- special modeling challenges of additive manufacturing

References

- ASME Model V&V committees, draft documents https://cstools.asme.org/csconnect/CommitteePages.cfm?Committee=100003367

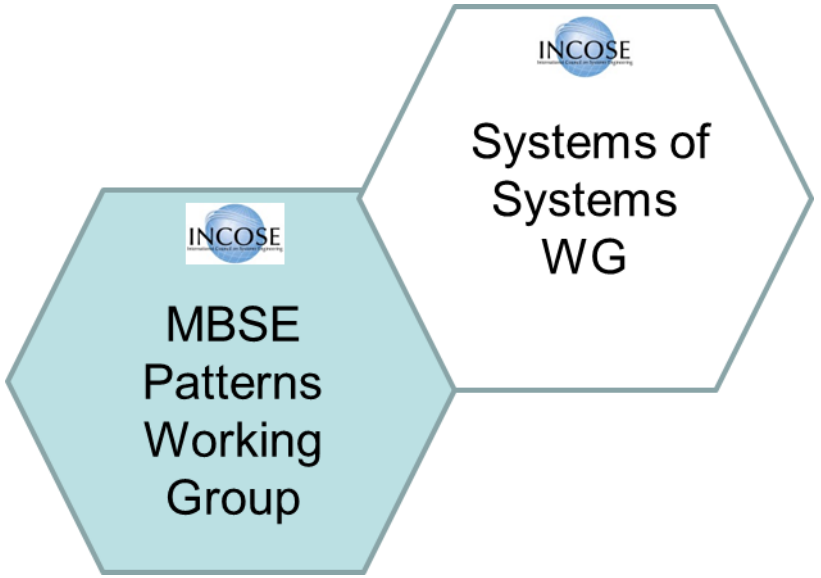
VV50 Committee Leadership

- Chair: Sudarsan Rachuri, Pgm. Mgr., DOE Smart Manufacturing, Institute

- Vice-Chair: Mark Bennett, Pgm. Mgr., AFRL Manufacturing Technology Division

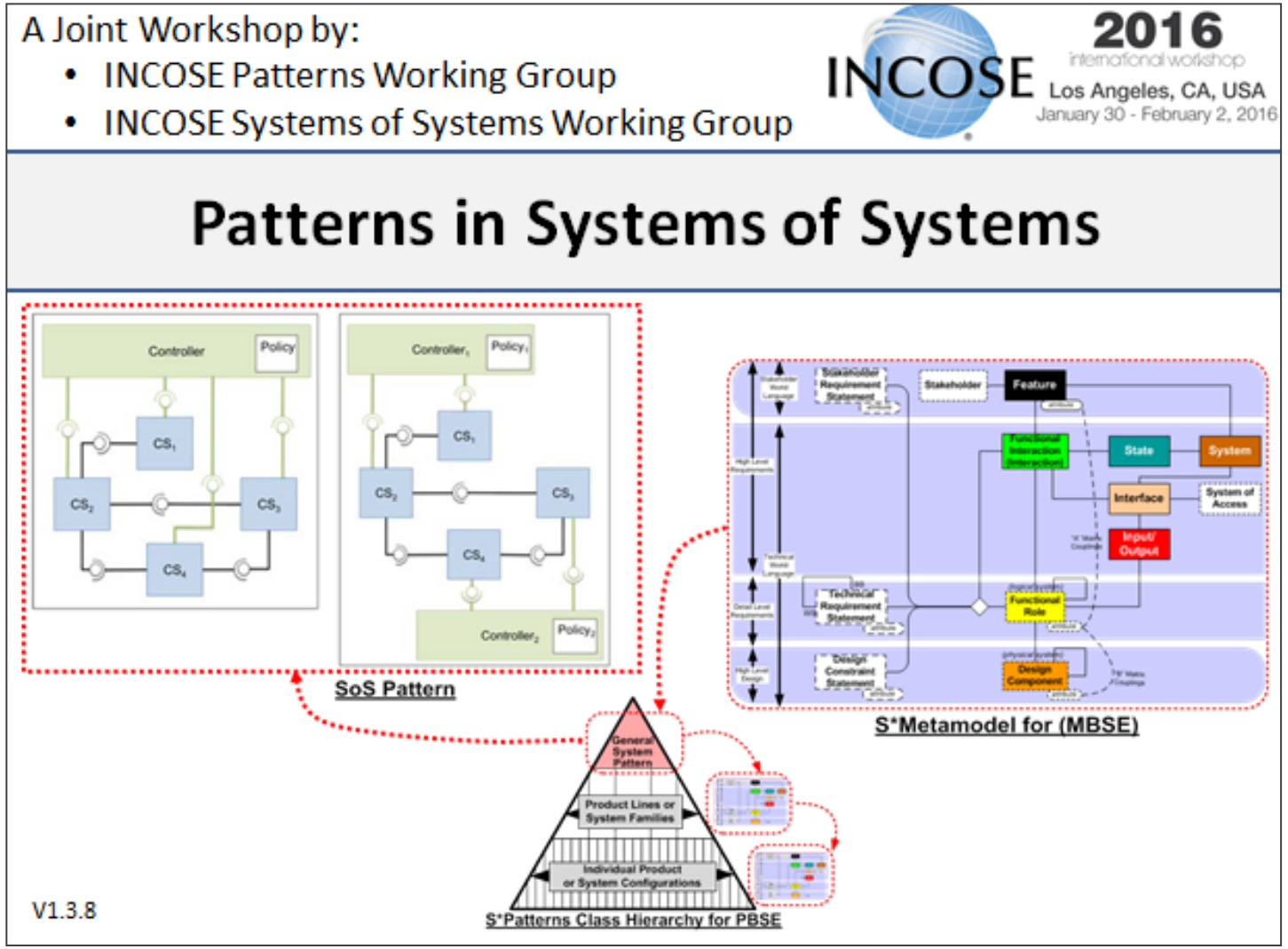
With SoS WG: Joint Activity Materials

- Support of SoS Pattern Library, including build-out of S*Metaclasses



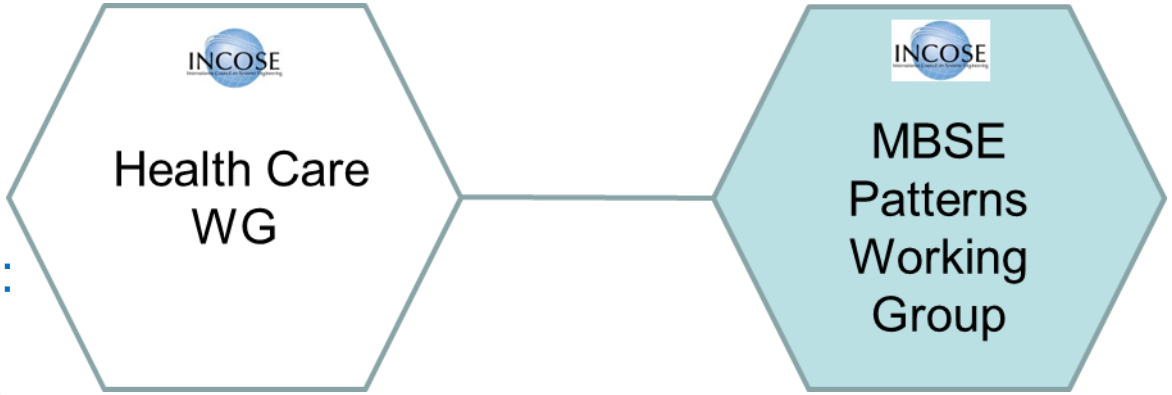
Primary Contact:
John Fitzgerald, Newcastle U.

From the IW2016 Patterns in SoS Workshop



With Health Care WG: Joint Activity Materials

- Supporting the INCOSE Agile Health Care Systems Conference (third year) & the Health Care version of ASELCM Pattern



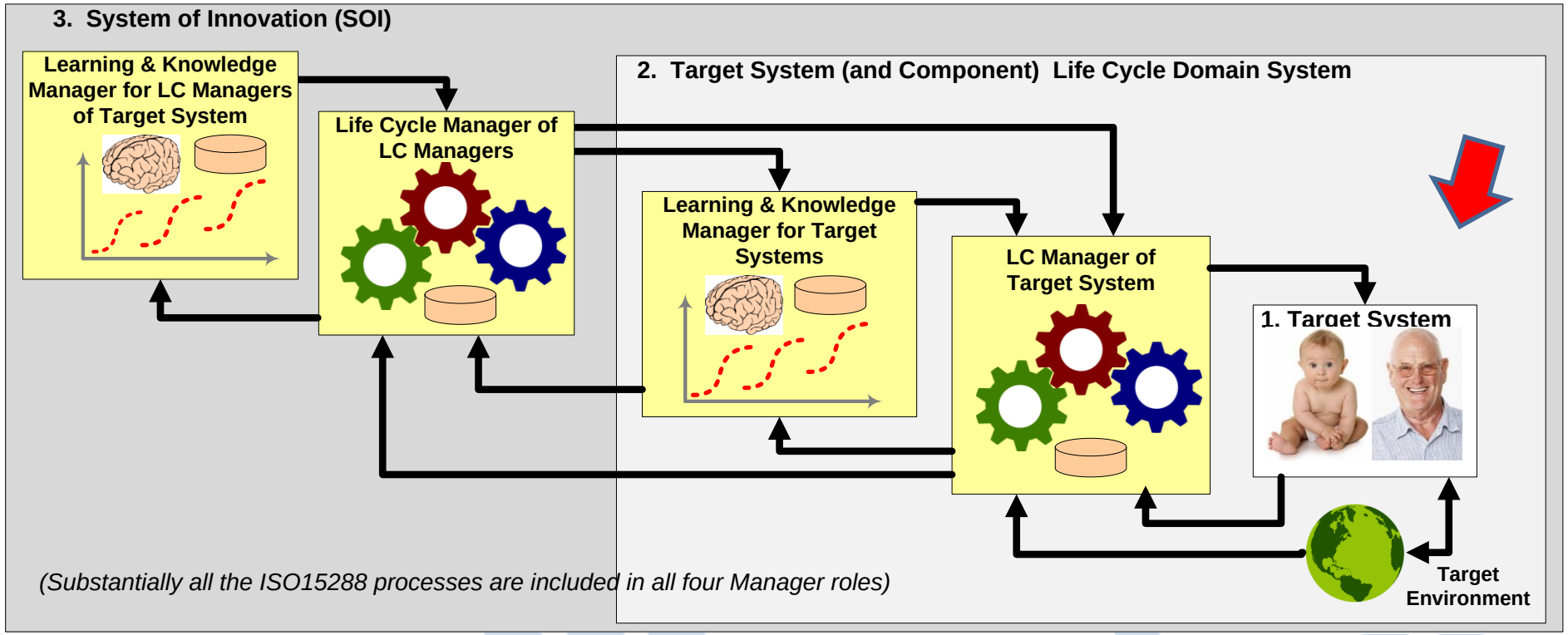
Primary Contact:
Chris Unger,
GE Health Care

Agile Health Care Systems Conference

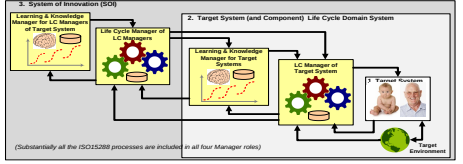
- Second conference held May, 2016, Chicago:
  - Presentations and attendance by medical systems enterprises
  - Also included sessions by Rick Dove and Bill Schindel
- Support on behalf of Agile and Patterns WG (Schindel):
  - Service on Conference Planning Committee, 2016 and 2017 conferences
  - Recruited keynote speaker: Operation Iraqi Freedom Command Surgeon, country-wide medical commander, Dr. Donald Dagliano—agile theater medicine keynote (additional help from Kevin Gunn)
  - Administration of conference web sites for PR, registration, submissions
- Now supporting third conference planning (May, 2017, Chicago)
- Primary conference organizer: INCOSE Health Care WG
  - Planning Committee also supported by Crossroads of America Chapter

2016 Agile Health Care Systems Conference

- One session and break out group addressed the application of the ASELCM Pattern to assessing agility opportunities in the Health Care Domain:



Results of that 2016 break out group use of ASELCM Pattern:



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.)

Sticky note: In the domain model, identify potential corrections or improvements to the model

3. Health Care System of Innovation (SOI)

Learning & Knowledge Manager for Health Care Delivery Systems
Pattern Repository, Describing Knowledge of Families of:
Health Care Delivery System

Provides Knowledge to

Life Cycle Manager of Health Care Delivery System
Configured Models Repository, Describing Configured Instances of:
Health Care Delivery System

Provides Observations to

Manages Life Cycle of

2. Patient Health Life Cycle Domain System

Learning & Knowledge Manager for Target Systems (and Components)
(substantially all ISO15288 processes)
Pattern Repository, Describing Knowledge of Families of:
Patient
Patient Environment
Patient Component

Provides Knowledge to

Health Care Delivery System
(Health Care equivalents of Agile (extended) ISO15288 Model, including HC equivalents of Performance, Fault, Configuration, Accounting, and Security Management Processes)
Configured Models Repository, Describing Configured Instances of:
Patient
Patient Environment
Patient Component

Provides Observations to

Observes

Manages Life Cycle of

1. Target System
Patient
Patient Subsystem
Patient Environment

Pharma Molecule Database
Health Care Research Web Site
Crowd-Sourced Health Care Web Site
Health Care Expert
Code of Federal Regulations & Guidances

Best Medical Practices Database
Evidence-Based Medicine Repository
Contract Research Organization (CRO)

Practice Management System Supplier
Medical School
Nursing School
Teaching Hospital
Health Care Organizational Change Consultant
Medical Practice Consultant
Health Care Delivery Holding Company
Health Care Systems Engineering, Fabrication, Construction & Installation
Provider Insurer
Health Care Certification Agent

Health Care Delivery Investor
Pharmaceutical Supplier
Medical Devices and Equipment Supplier
Orthopedics Manufacturer
Medical Information Technologies Supplier
Contractual Medical Trials Business
Contractual Medical Products Developer
Contract Medical Manufacturer
Health Care Systems Maintenance & Support
Health Care Regulator
Health Care Licenser
Medical Products Marketing
Health Care Policy

More Specialties or Types of Individuals That Are Involved
Life Scientist
Medical Journal
Life Sciences Textbook
Personal Genetics Is Limited
Genetics Database
Life Sciences Repository

Caregiver
HC Education Service
Health Care Payer
Insuring Employer
Insuring Family
Business Office
Facilities and Infrastructure
HR Role
Health Services Marketing
Safety, Quality Assurance
Pharmacy Benefit Management
Health Care Plan It Should Be ISO 15288
Episodic Care Does It Follow ISO 15288
Decision Support

Health Care Organization
Health Care Practitioner
Medical Record System
Diagnostic Service System
Care Plan Development
Therapeutic Service System
Pharmacy
Transcription Service System
Coding Process
Health Care Equipment
Medical Device
Drugs CFR312 Biologics
Outcomes Analyses
Patient Interface to Health Care (including insurance)

Hospital
Private Practice
Clinic

Home Environment
Occupational Environment
School Environment
Extracurricular Environment

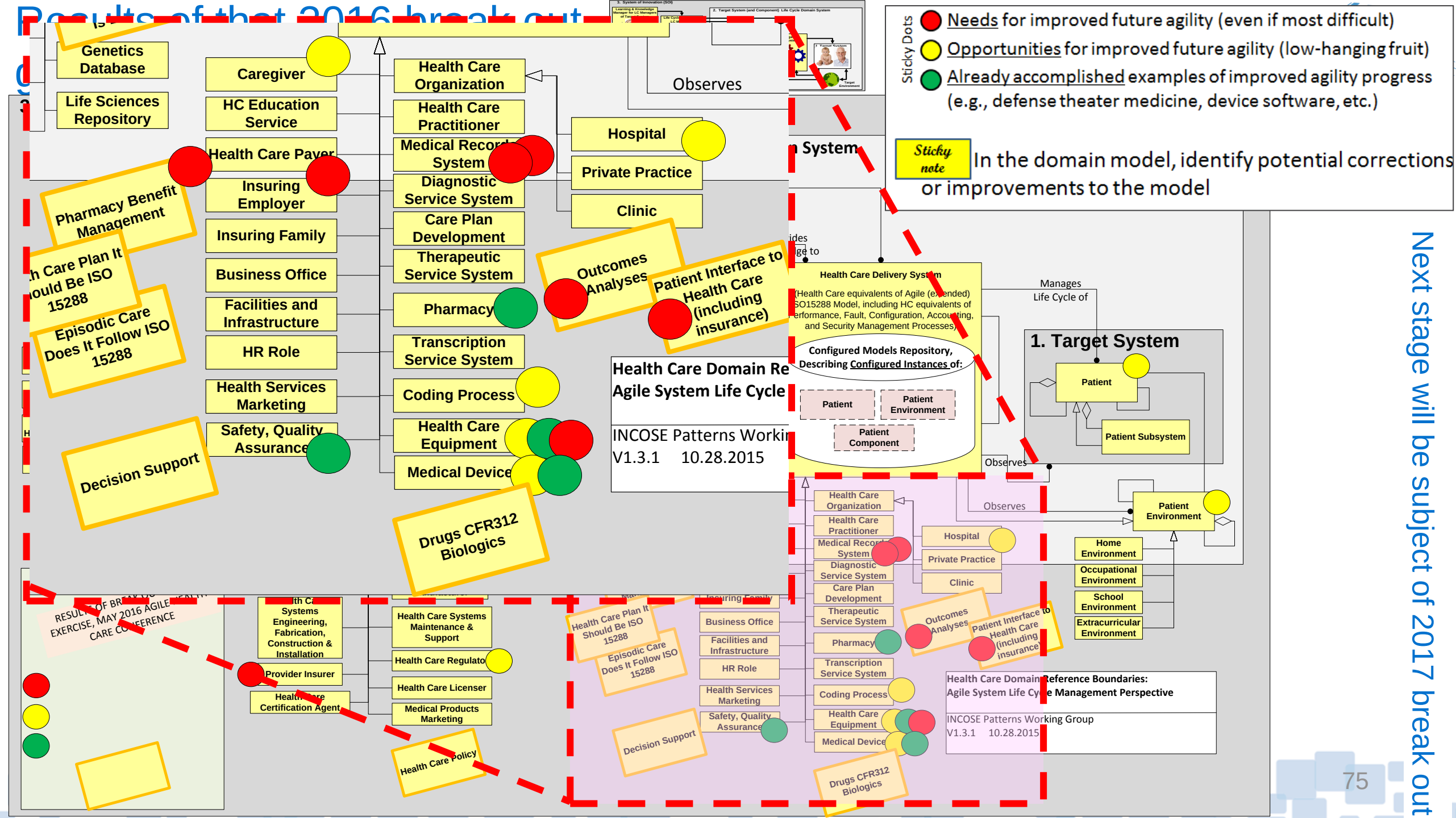
RESULTS OF BREAK OUT GROUP EXERCISE, MAY 2016 AGILE HEALTH CARE CONFERENCE

Health Care Domain Reference Boundaries:
Agile System Life Cycle Management Perspective

INCOSE Patterns Working Group
V1.3.1 10.28.2015

Next stage will be subject of 2017 break out

Results of that 2016 break out



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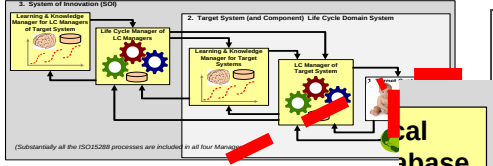
Results of that 2016 break out group use of ASELCM Pattern:



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Learning & Knowledge Manager for Health Care Delivery Systems

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Provides Knowledge to

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Configured Model Repository, Describing Configured Instances of:

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Manages Life Cycle of

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2. Patient Health Life Cycle Domain Syst

Learning & Knowledge Manager for Target Systems (and Components)

(substantially all ISO15288 processes)

Pattern Repository, Describing Knowledge of Families of:

Patient

Patient Environment

Patient Component

Provides Knowledge to

(Health ISO15288 Performan and Se

Provides Observations to

Observes

Provides Observations to

Observes

Pharma Molecule Database

Health Care Research Web Site

Crowd-Sourced Health Care Web Site

Health Care Expert

Best Medical Practices Database

Evidence-Based Medicine Repository

Contract Research Organization (CRO)

Code of Federal Regulations & Guidances

Practice Management System Supplier

Medical School

Nursing School

Teaching Hospital

Health Care Organizational Change Consultant

Medical Practice Consultant

Health Care Delivery Holding Company

Health Care Systems Engineering, Fabrication, Construction & Installation

Provider Insurer

Health Care Certification Agent

Health Care Delivery Investor

Pharmaceutical Supplier

Medical Devices and Equipment Supplier

Orthopedics Manufacturer

Medical Information Technologies Supplier

Contractual Medical Trials Business

Contractual Medical Products Developer

Contract Medical Manufacturer

Health Care Systems Maintenance & Support

Health Care Regulato

Health Care Licenser

Medical Products Marketing

More Specialties or Types of Individuals Are Involved Tha

Life Scientist

Medical Journal

Life Sciences Textbook

Personal Genetics Is Limited

Genetics Database

Life Sciences Repository

Caregiver

HC Education Service

Health Care Payer

Insuring Employer

Insuring Family

Business Office

Facilities and Infrastructure

HR Role

Health Services Marketing

Safety, Quality Assurance

Pharmacy Benefit Management

Health Care Plan It Should Be ISO 15288

Episodic Care Does It Follow ISO 15288

Decision Support

Health Care Policy

RESULTS OF BREAK OUT GROUP EXERCISE, MAY 2016 AGILE HEALTH CARE CONFERENCE

Needs for improved future agility (even if most difficult)

anging fruit)

ility progress

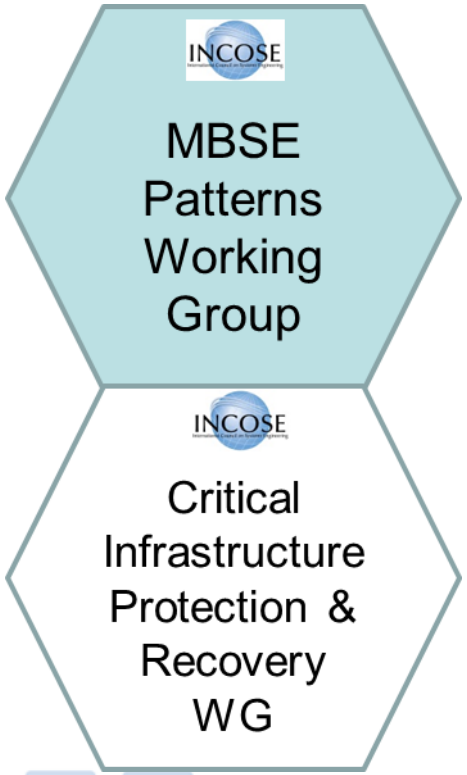
, etc.)

al corrections

Next stage will be subject of 2017 break out

With Critical Infrastructure Protection, and Recovery WG: Joint Activity Materials

- S*Patterns for Critical Infrastructure, Electrical Power, Common Recovery Model: including ASELCM Systems 1, 2, 3

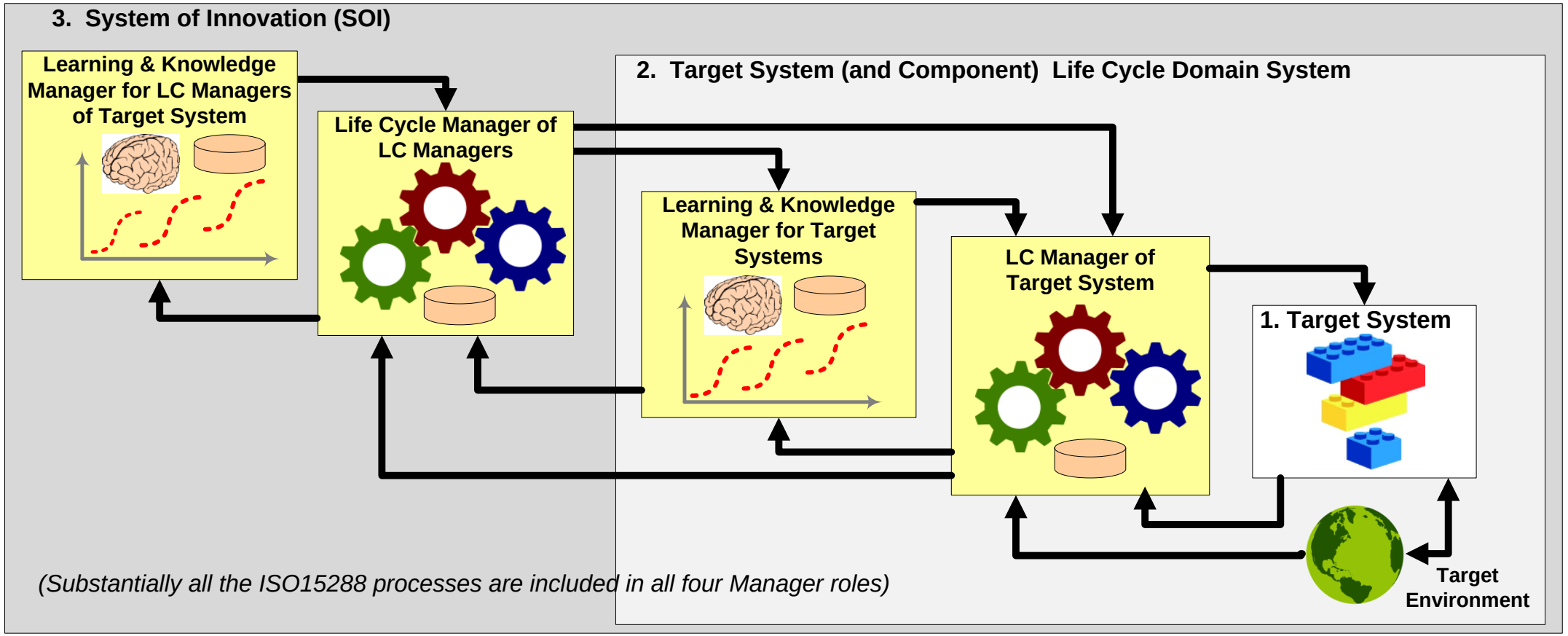


Primary Contact:
Mike DeLamar, Bechtel
Mark Walker, BCT

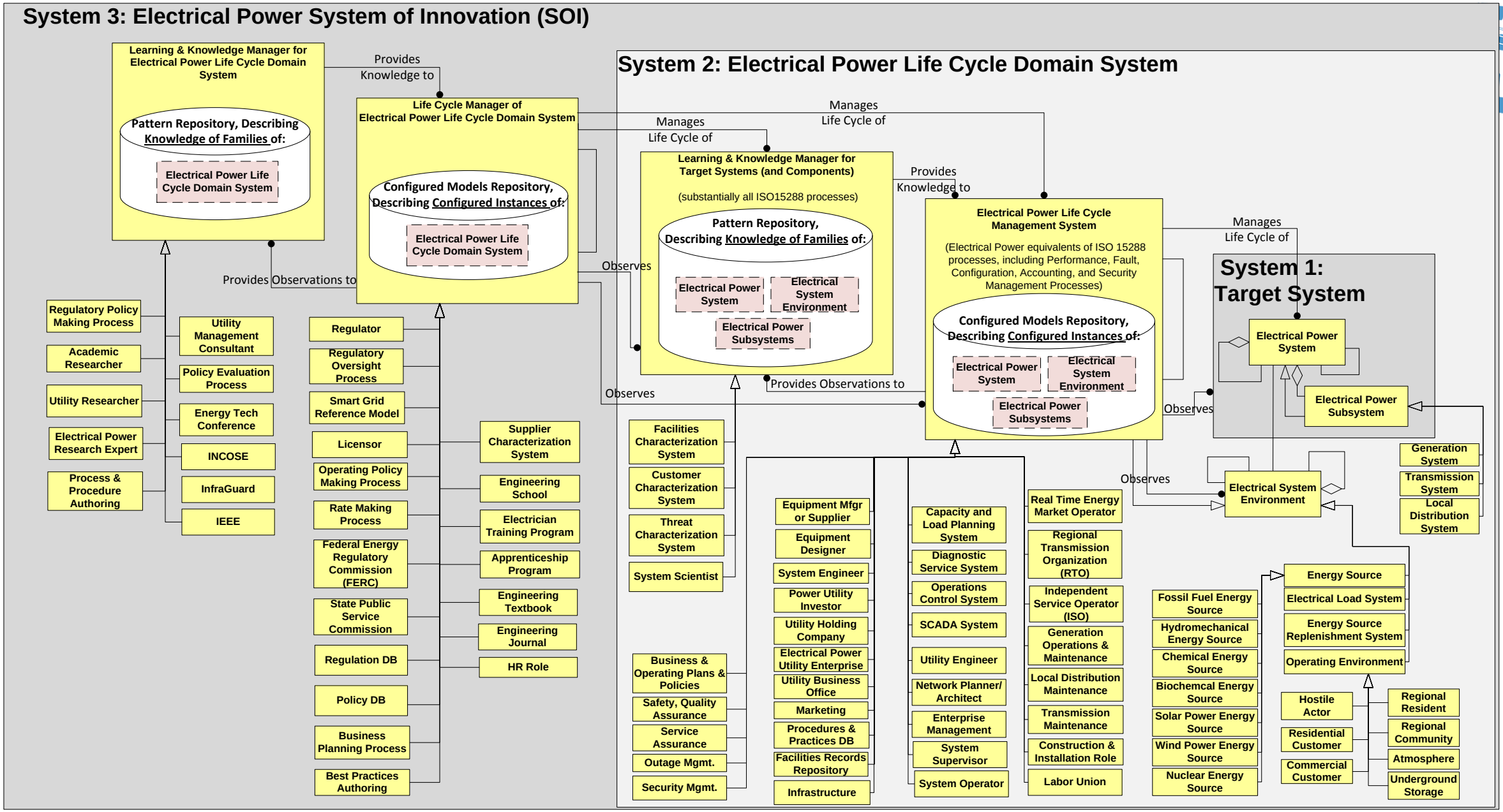
IEEE / INCOSE / NASA Energy Tech 2016 Conference

- Held November, 2016, Cleveland
- Electrical Power Grid + Critical Infrastructure Protection, Recovery
- Utilized ASELCM Pattern as framework to develop initial domain pattern content for this conference and its discussion
- Model-Based Facilitation used to solicit, capture, and understand conference sessions and group discussion, in system context.
- Conference proceedings being generated by organizers, supported by explanatory S*Patterns.
- Follow on plans include continued ASELCM MBSE Pattern support for Common Recover Model (CRM) research by Purdue U doctoral student, power industry expert.
- Discussion of similar activity being held by Patterns WG with CIPR WG at IW 2017.

ASELCM Pattern Logical Architecture



- 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.

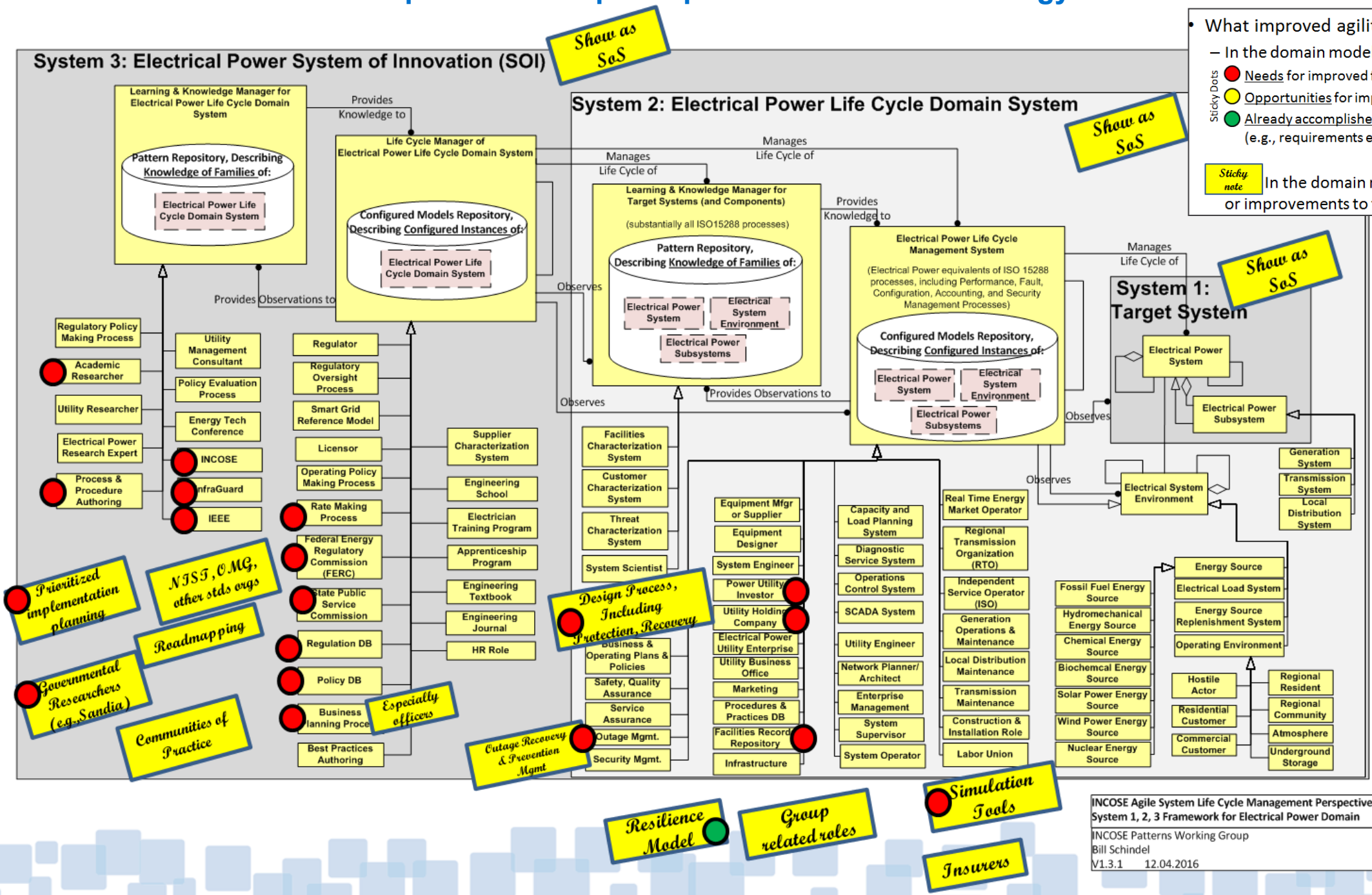


System 2, 3 framework for Electrical Power Grid

INCOSE Agile System Life Cycle Management Perspective: System 1, 2, 3 Framework for Electrical Power Domain

INCOSE Patterns Working Group
Bill Schindel
V1.3.1 12.04.2016

Use of ASELCM Pattern to capture Track 1 participants' discussion at Energy Tech 2016 Conference:



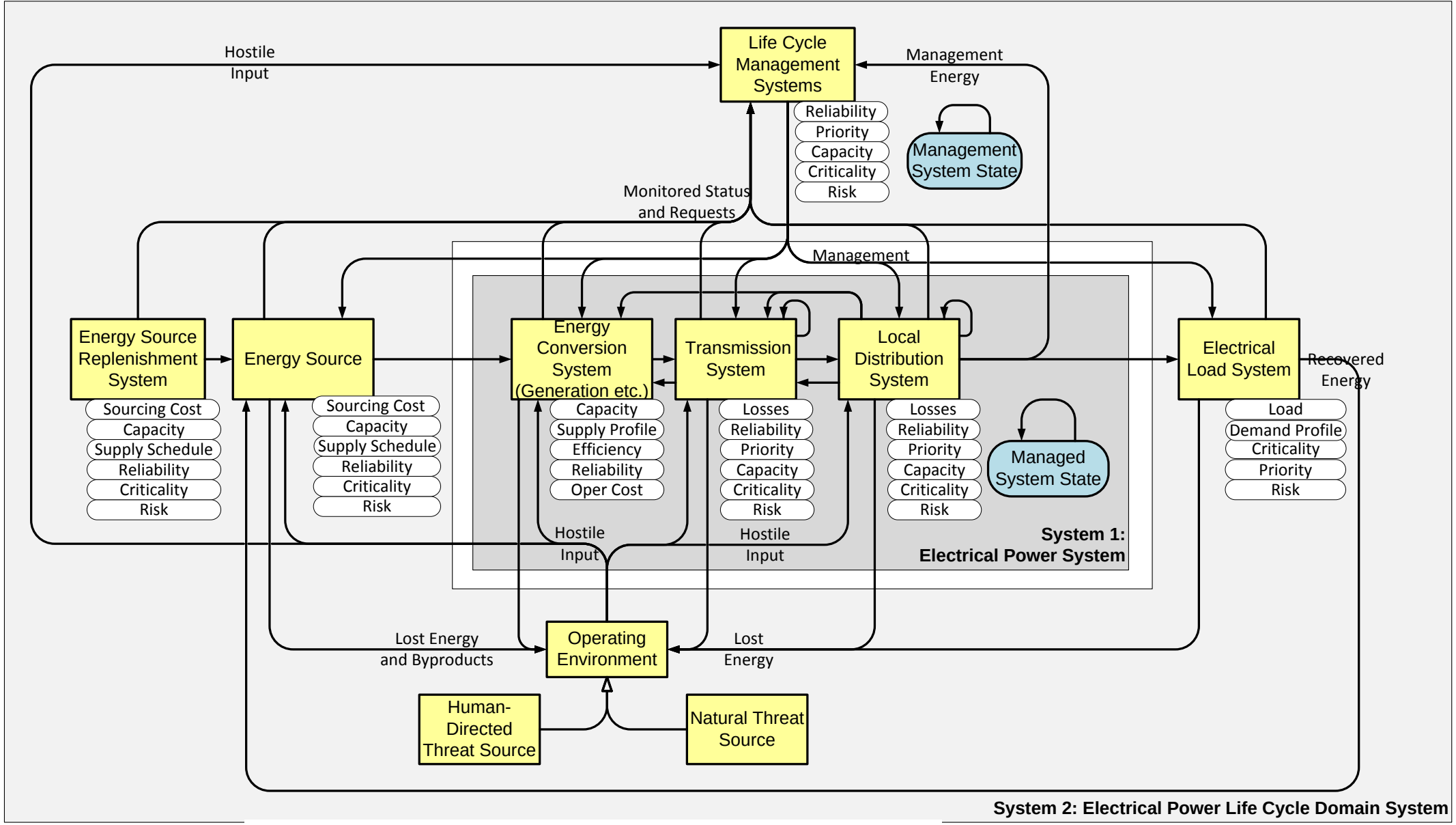
- What improved agility or MBSE use "results"?
  - In the domain models, marked the highest cases of:

Sticky Dots
- Needs for improved future results (even if most difficult)
- Opportunities for improved future results (low-hanging fruit)
- Already accomplished examples of improved results progress (e.g., requirements engineering, simulation, etc.)

Sticky note In the domain model, identify potential corrections or improvements to the model / framework.

INCOSE Agile System Life Cycle Management Perspective: System 1, 2, 3 Framework for Electrical Power Domain

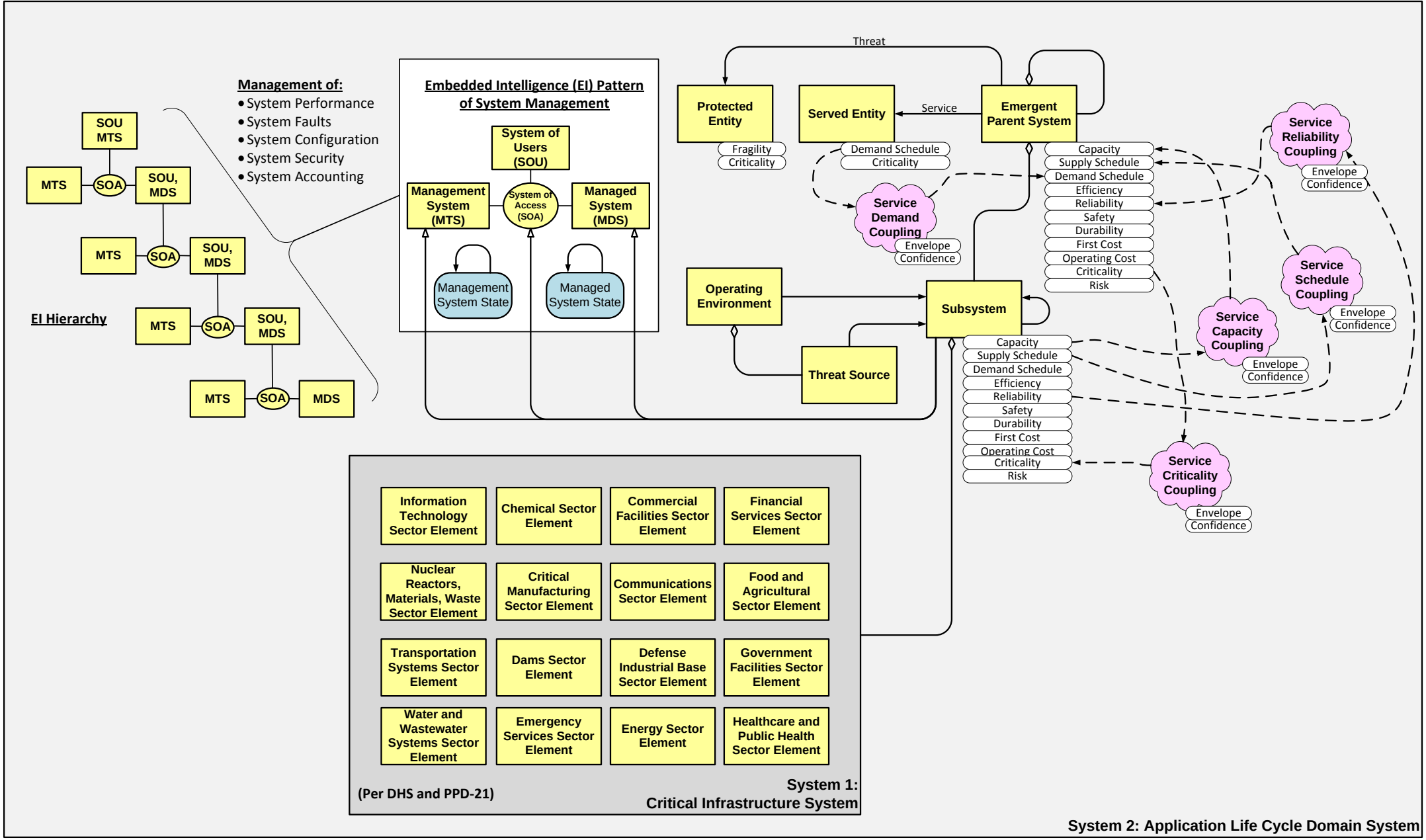
INCOSE Patterns Working Group
Bill Schindel
V1.3.1 12.04.2016



System 1 framework for Electrical Power Grid

INCOSE Agile System Life Cycle Management Perspective: System 1 & 2 Summary, for Electrical Power Domain

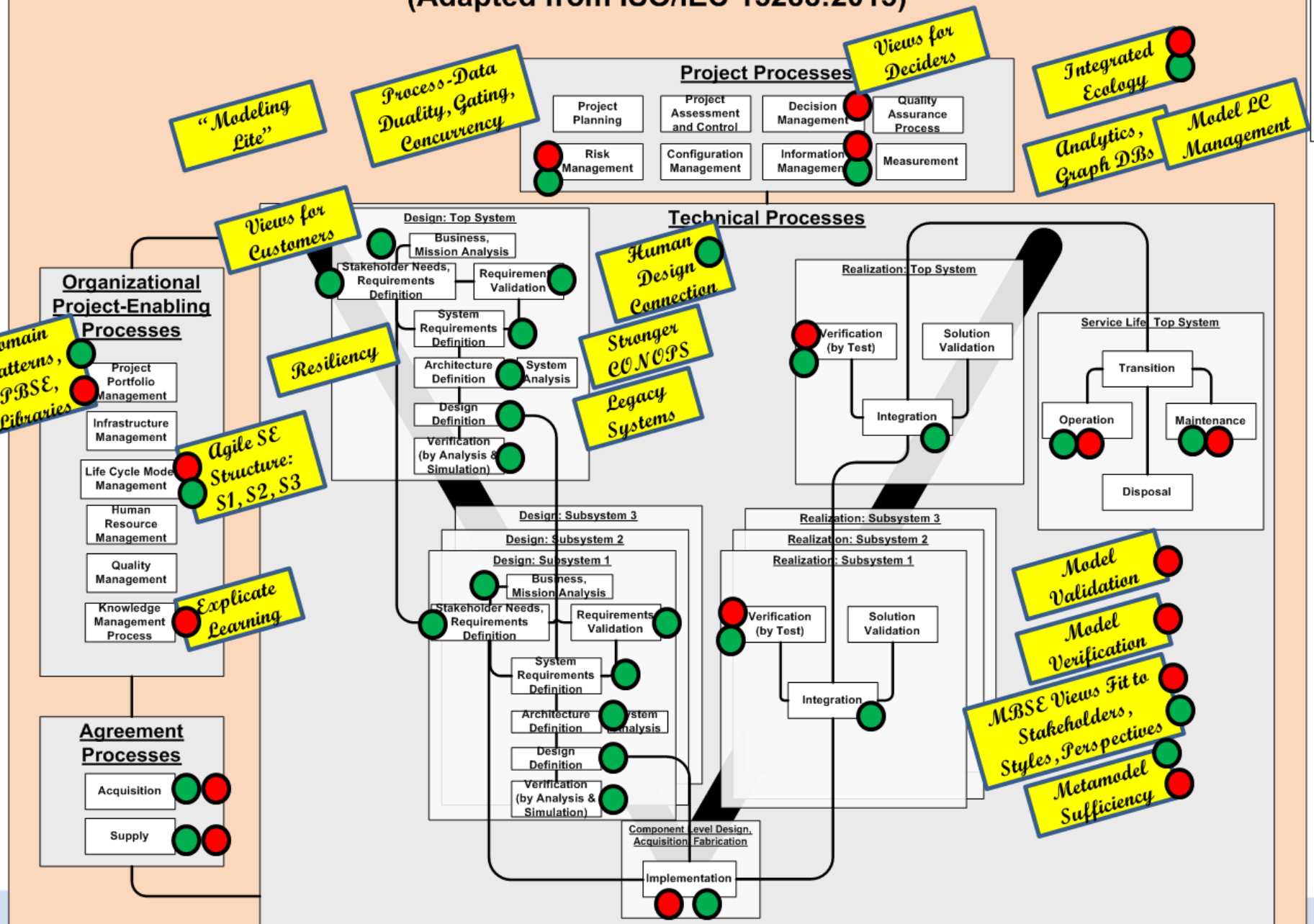
INCOSE Patterns Working Group
Bill Schindel schindel@ictt.com
V1.3.2 12.04.2016



System 1 framework for Critical Infrastructure, per US DHS CIPR categories

System of Innovation (SOI) Pattern Logical Architecture

(Adapted from ISO/IEC 15288:2015)



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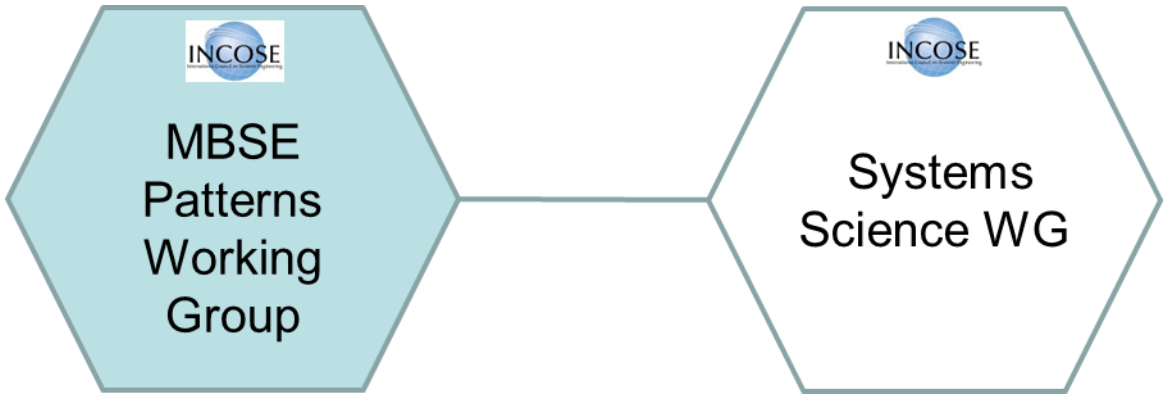
- Already accomplished examples of improved results progress (e.g., requirements engineering, simulation, etc.)

Sticky note — In the domain model, identify potential corrections or improvements to the model / framework.

Use of ASELCM Pattern to capture Track 1 participants' discussion at Energy Tech 2016 Conference (MBSE Focus)

With Systems Science WG: Joint Activity Materials

- S*Interactions & S*Patterns as a basis for a hard science of systems



Primary Contact:
David Rousseau, Centre for Systems Philosophy

Questions posed by SSWG: Patterns WG to present against these in Jan 30 SSWG Workshop

1. What are [S*Patterns & S*PBSE]? Basic description or definition.
2. Why are we interested in [S*Patterns & S*PBSE]? Why are they important? What could/do they reveal about systems?
3. How can/do we use [S*Patterns & S*PBSE] in the context of SE? What SE practices could leverage knowledge about [S*Patterns & S*PBSE]? How would SE be different/stronger if we had some/more/better [S*Patterns & S*PBSE]?
4. How can we discover/develop/improve [S*Patterns & S*PBSE]?
5. What do you see as the most important next step for SysSci/SE to make advances in [S*Patterns & S*PBSE]?

Quick summary of answers, details follow in Pres1 (IS 2016) and Pres2 (ISSS 2016) and Doc3 (INCOSE 2015)

1. What are [S*Patterns & S*PBSE]? Basic description or definition.
   - *Answered in Doc 3. S*Models are MBSE models conforming to the S*Metamodel. S*Patterns are configurable, reusable general S*Models of families of systems. A configured S*Pattern is itself an S*Model of a more specific system.*

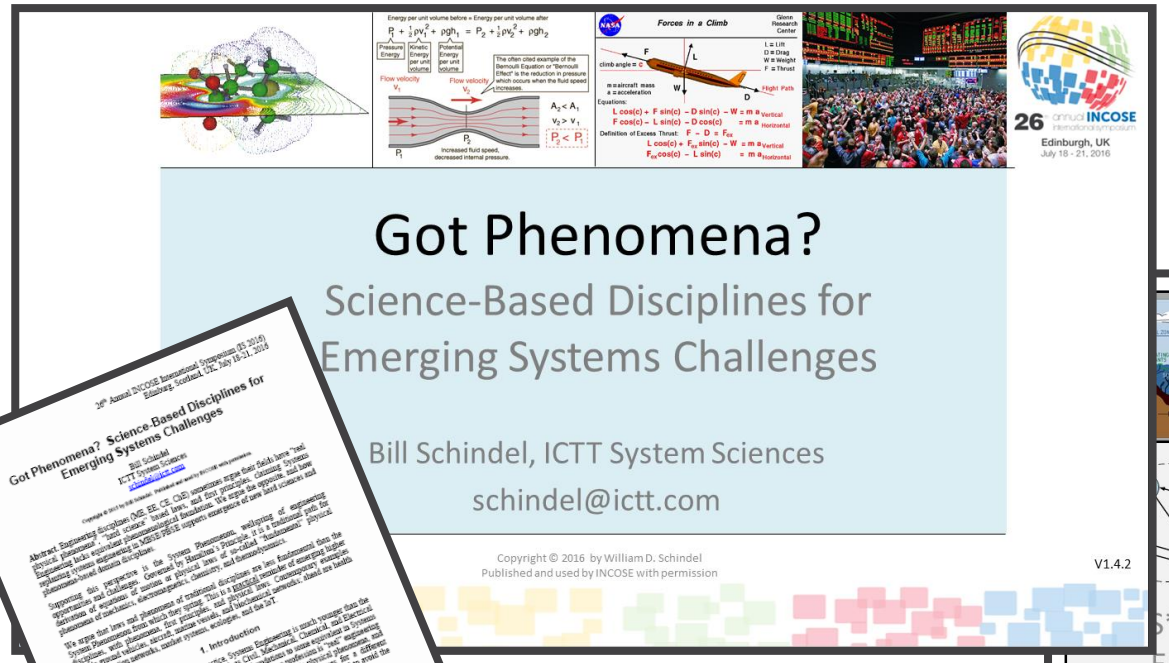
2. Why are we interested in [S*Patterns & S*PBSE]? Why are they important? What could/do they reveal about systems?
   - *When "we" are engineers, the answer is that they provide a more effective way (PBSE) to perform (MB) systems engineering (e.g., ISO 15288), leveraged by revealed S*Patterns. When we are engineers or scientists, S*Models provide predictive and explanatory representations of systems and system phenomena. See Pres1, 2.*

3. How can/do we use [S*Patterns & S*PBSE] in the context of SE? What SE practices could leverage knowledge about [S*Patterns & S*PBSE]? How would SE be different/stronger if we had some/more/better [S*Patterns & S*PBSE]?
   - *They are already used for many years to perform SE across many domains. "Leverage" is the very essence of PBSE, using S*Pattern assets. For MBSE practitioners not using PBSE, their work would be reduced, speed increased, and early stage quality/completeness improved. See Doc3.*

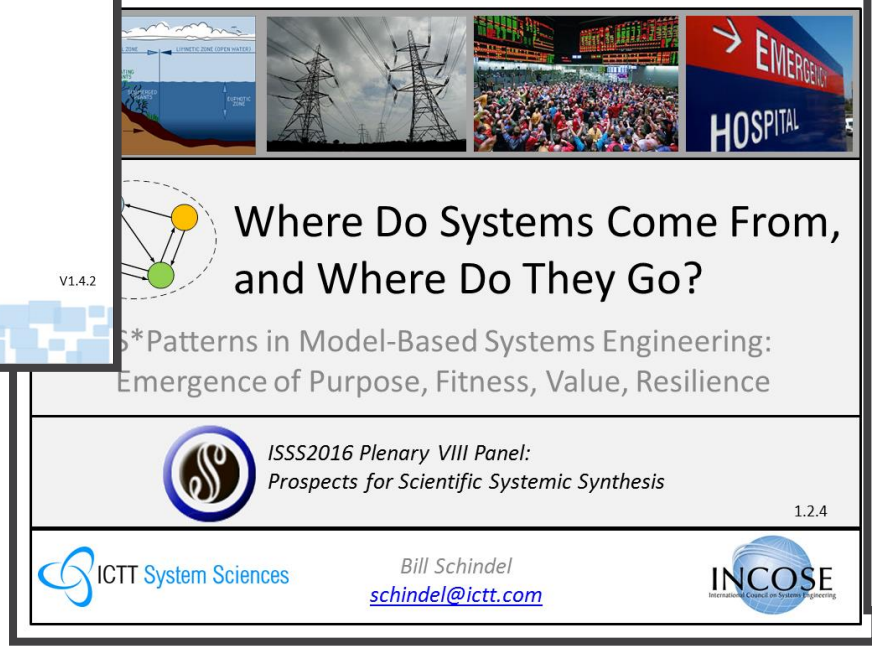
4. How can we discover/develop/improve [S*Patterns & S*PBSE]?
   - *The Uncover the Pattern (UTP) process is a good introduction to pattern discovery, a part of Pattern Management. The larger picture of ongoing pattern improvement is described by the INCOSE ASELCM Pattern. See Pres2.*

5. What do you see as the most important next step for SysSci/SE to make advances in [S*Patterns & S*PBSE]?
   - *First step for anyone interested is to practice their use personally—this is a contact/practice, not spectator, sport.*
   - *As to advances in patterns, the essence of the ASELCM Pattern is that improvement.*
   - *See Pres2.*

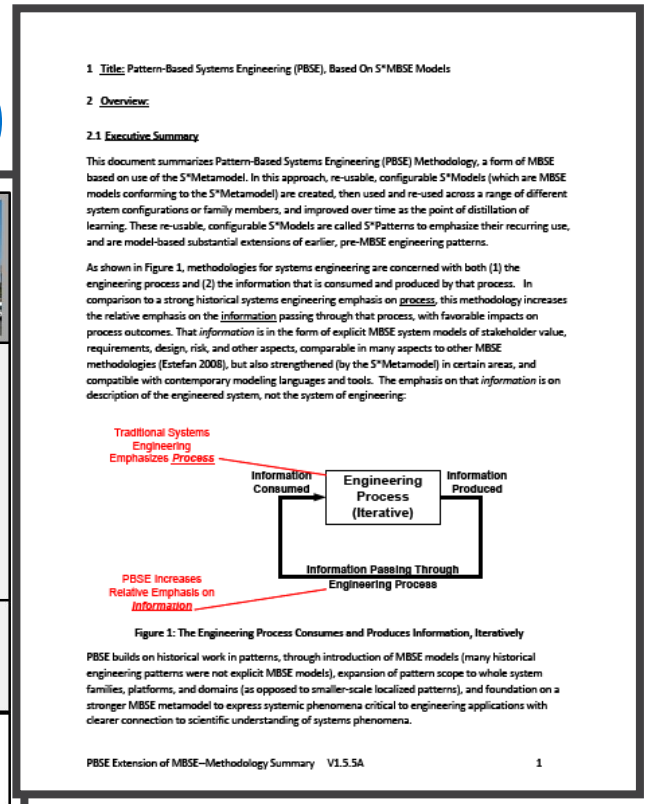
Pres1 (IS 2016)



Pres2 (ISSS 2016)



Doc 3 (2015)



1 Title: Pattern-Based Systems Engineering (PBSE), Based On S*MBSE Models

2 Overview:

2.1 Executive Summary

This document summarizes Pattern-Based Systems Engineering (PBSE) Methodology, a form of MBSE based on use of the S*Metamodel. In this approach, re-usable, configurable S*Models (which are MBSE models conforming to the S*Metamodel) are created, then used and re-used across a range of different system configurations or family members, and improved over time as the point of distillation of learning. These re-usable, configurable S*Models are called S*Patterns to emphasize their recurring use, and are model-based substantial extensions of earlier, pre-MBSE engineering patterns.

As shown in Figure 1, methodologies for systems engineering are concerned with both (1) the engineering process and (2) the information that is consumed and produced by that process. In comparison to a strong historical systems engineering emphasis on process, this methodology increases the relative emphasis on the information passing through that process, with favorable impacts on process outcomes. That *information* is in the form of explicit MBSE system models of stakeholder value, requirements, design, risk, and other aspects, comparable in many aspects to other MBSE methodologies (Estefan 2008), but also strengthened (by the S*Metamodel) in certain areas, and compatible with contemporary modeling languages and tools. The emphasis on that *information* is on description of the engineered system, not the system of engineering:

Figure 1: The Engineering Process Consumes and Produces Information, Iteratively

PBSE builds on historical work in patterns, through introduction of MBSE models (many historical engineering patterns were not explicit MBSE models), expansion of pattern scope to whole system families, platforms, and domains (as opposed to smaller-scale localized patterns), and foundation on a stronger MBSE metamodel to express systemic phenomena critical to engineering applications with clearer connection to scientific understanding of systems phenomena.

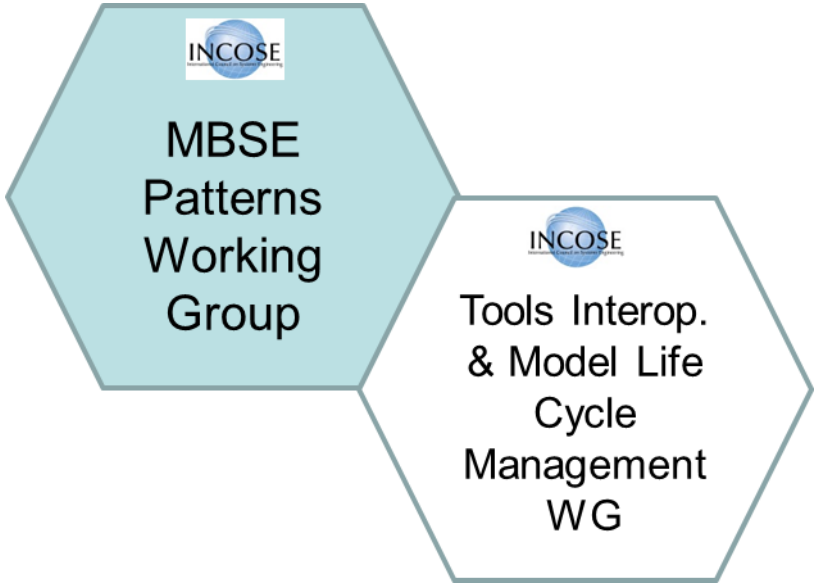
PBSE Extension of MBSE–Methodology Summary V1.5.5A 1

Additional references:

Many additional references on Patterns WG web site: http://www.omgwiki.org/MBSE/doku.php?id=mbse:patterns:patterns

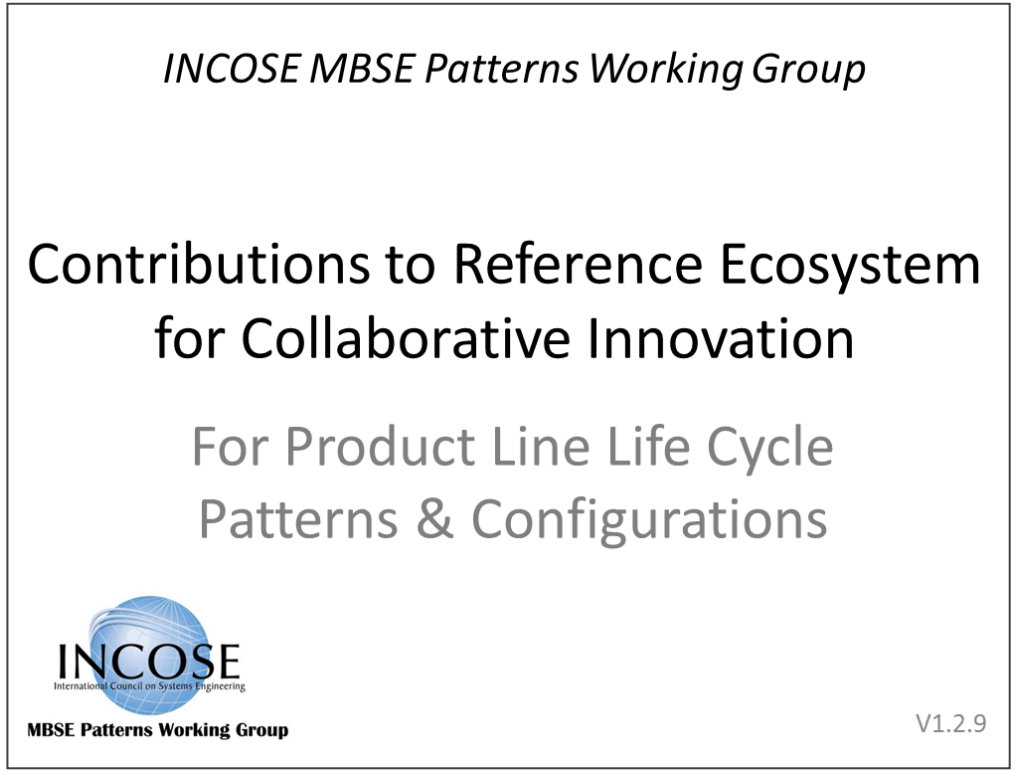
With Tools Interoperability & Model Life Cycle Management WG: Joint Activity

- Patterns of collaboration in future innovation ecosystems, including illustrative content



Primary Contact:
Lonnie VanZandt, Sodius

With Tools Interoperability & Model Life Cycle Management WG: Joint Activity



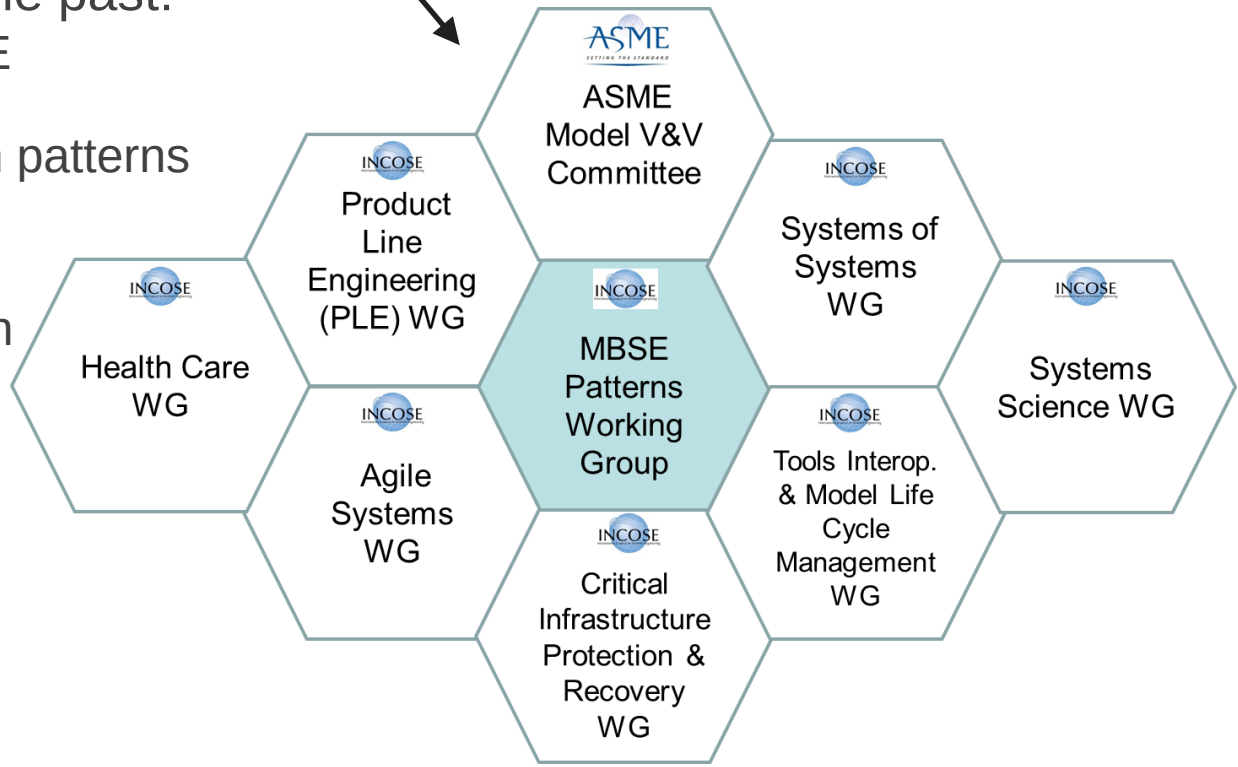
- More WG and other partners to be added.

Patterns WG Planning and Support

- Roles as an INCOSE/OMG MBSE Challenge Team:
  - Support for MBSE Initiative, and for its lead team
  - Support for MBSE Transformation, and for its lead team
- Roles as an INCOSE WG:
  - New Patterns WG web site, in INCOSE main web:
    http://www.incose.org/ChaptersGroups/WorkingGroups/Transformational/mbse-patterns
  - Existing (main) Patterns WG web site maintained within INCOSE-OMG joint MBSE Initiative “MBSE wiki”:
    http://www.omgwiki.org/MBSE/doku.php?id=mbse:patterns:patterns

Patterns WG Planning and Support

- Future potential PWG Projects:
  - *Depends on your interest to work on them*
  - Existing projects with partners
  - Others that our members have mentioned in the past:
    - Support for deliverables of the INCOSE MBSE Transformation Lead Team
    - Additional targeted system application domain patterns
    - Targeted science domain patterns
    - ISO 15288 Implications of PBSE
    - PBSE support for COTS Tools and Information Systems
    - Visualization
    - PBSE Implementation strategies & roadmaps, scenarios
    - PBSE contribution to SEBoK
- Interest in these or other projects
- Open Discussion



Example S*Pattern Content

- INCOSE PBSE Tutorial:
  - http://www.omgwiki.org/MBSE/lib/exe/fetch.php?media=mbse:patterns:pbse_tutorial_glrc_2013_v1.6.3_reduced_pdf.pdf
- More examples and materials on WG web wiki site:
  - http://www.omgwiki.org/MBSE/doku.php?id=mbse:patterns:patterns

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