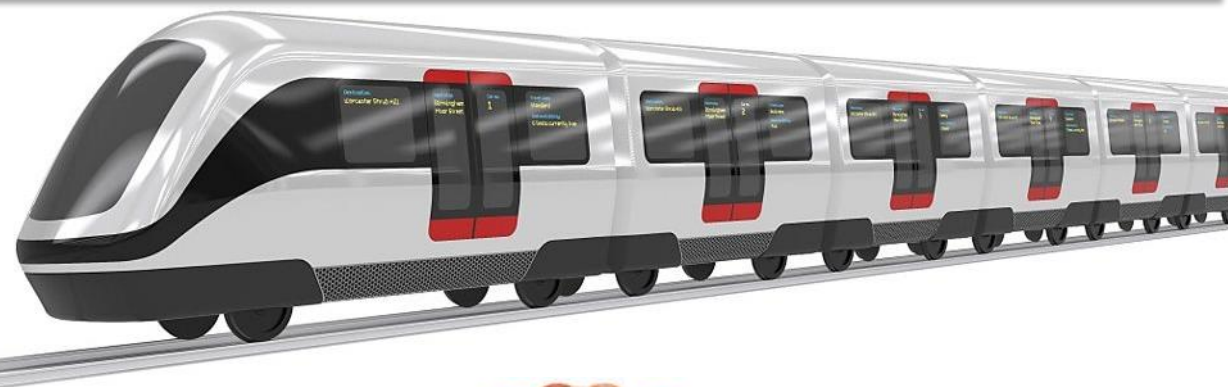
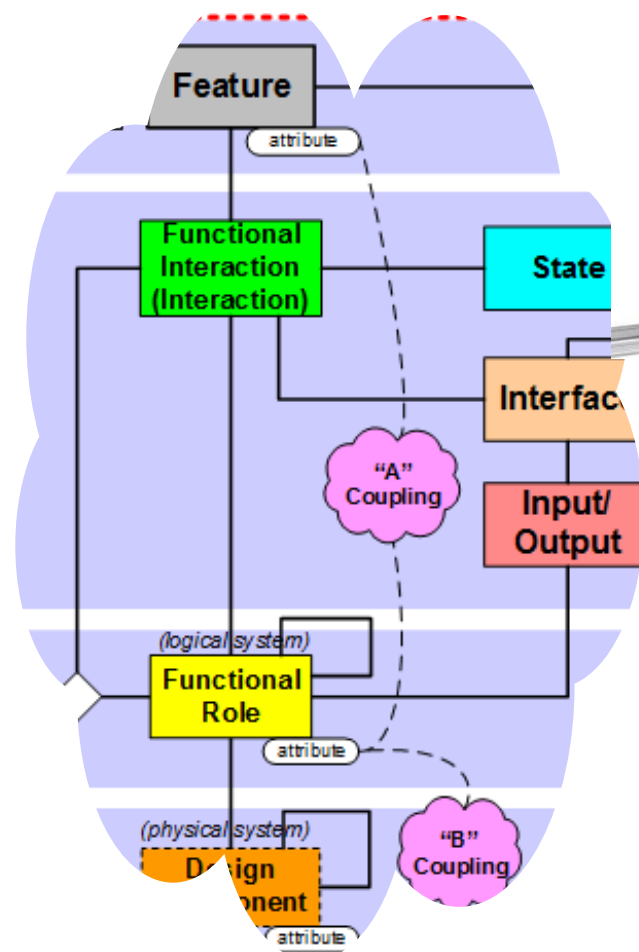
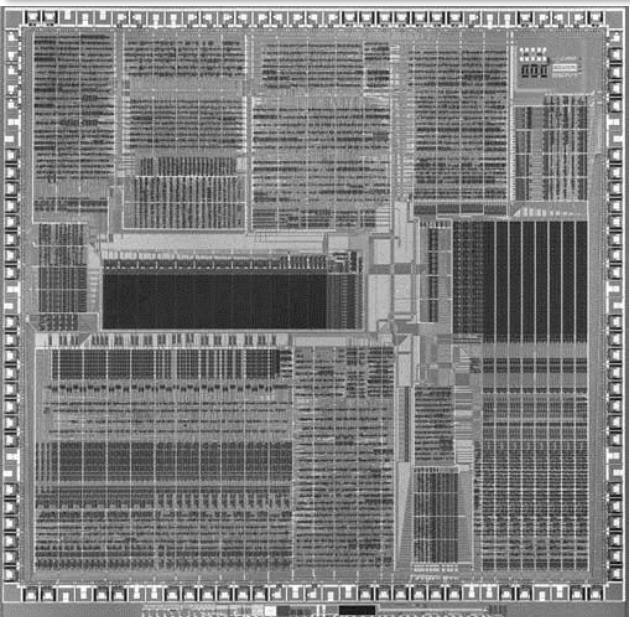




28th Annual **INCOSE**
international symposium

Washington, DC, USA
July 7 - 12, 2018

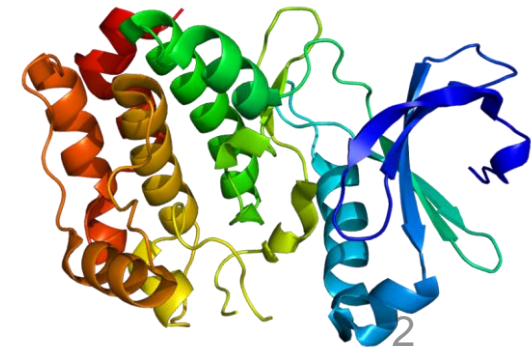
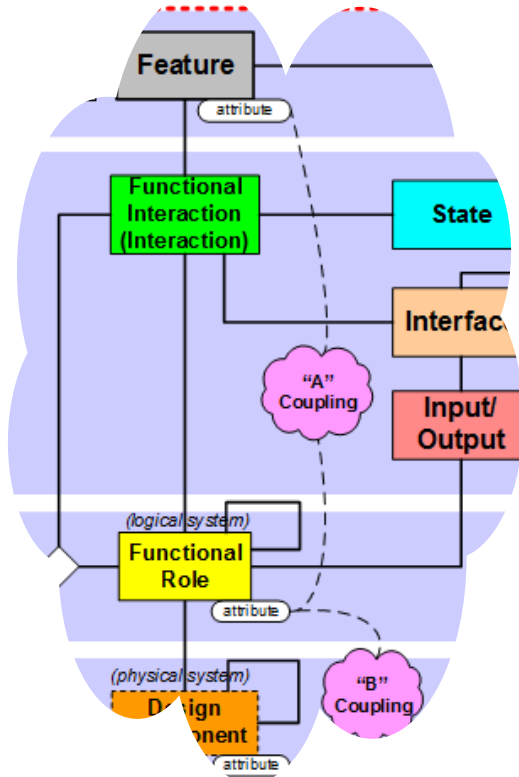
MBSE Patterns Working Group





Contents

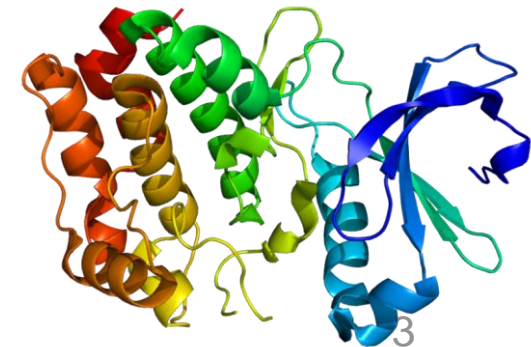
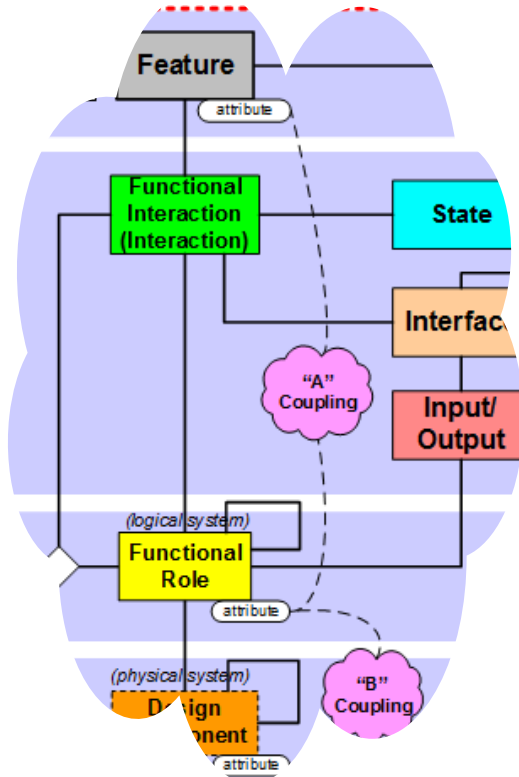
- Introduction to MBSE Patterns, and the Patterns WG
- Status of WG Projects
- Future Projects of Interest to Attendees
- References





Introduction to MBSE Patterns, and the Patterns WG

- Who we are—including our partners
- Types of activities
- IS2018 activities—when and where to find us
- How to get involved
- A “Patterns 101” introduction





As an INCOSE entity, we began five years ago, as the MBSE Initiative Patterns Challenge Team:

- Part of the joint INCOSE/OMG MBSE Initiative, formed years earlier as MBSE Patterns Challenge Team.
- In 2016, 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, and use the OMG/INCOSE MBSE wiki in addition to INCOSE web site.

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 (have been) expressed in any modeling language (e.g., SysML, or other languages)
4. S*Models can be (have been) created and managed in many different COTS modeling tools.
5. Recurring/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 include system-level patterns (models of whole managed platforms and environments), not just smaller-scale component design patterns
8. There are many references, examples, starter assets available.

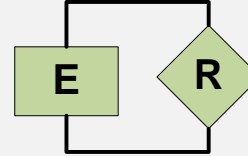
More General

Emergence of Patterns from Patterns: S*Pattern Class Hierarchy



Definition of **Relational Modeling Paradigm**

Entity-Relationship Paradigm

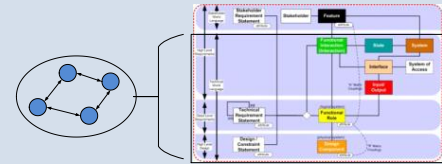


E=Entity
R= Relationship

Structured or unstructured semantic web

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

S*Metamodel Core



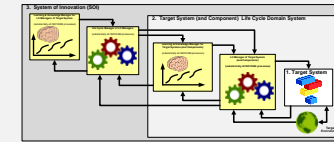
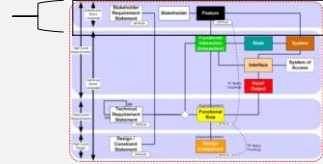
Core S*Metamodel

Smallest model of a system, for engineering or science

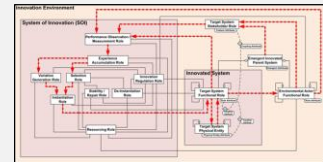
Emergence & Definition of **System of Innovation**, Fitness, Value, Purpose, Stakeholders, Agility, Final Cause, Formal Cause, Efficient Cause, Intelligence, Management, Science, Living Systems

EI Pattern, SOI Pattern, Fitness, Value

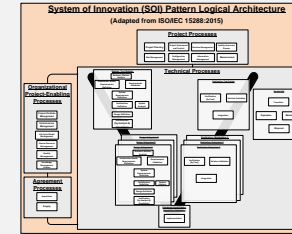
S*Purpose, Fitness, Value



Agile Sys Life Cycle Pattern



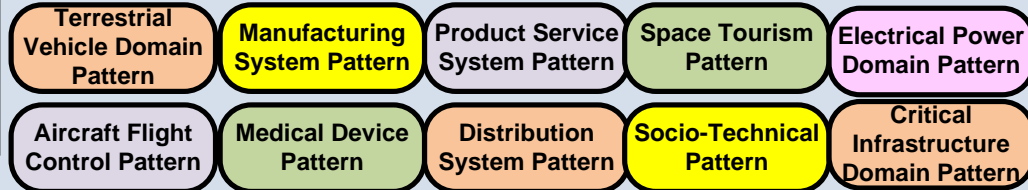
System of Innovation Pattern



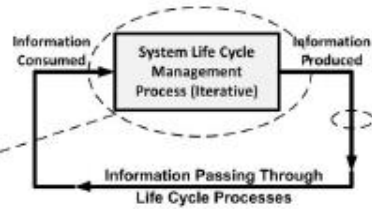
ISO 15288 System Life Cycle Mgmt Pattern

Emergence & Definition of **Domain Specific Systems**

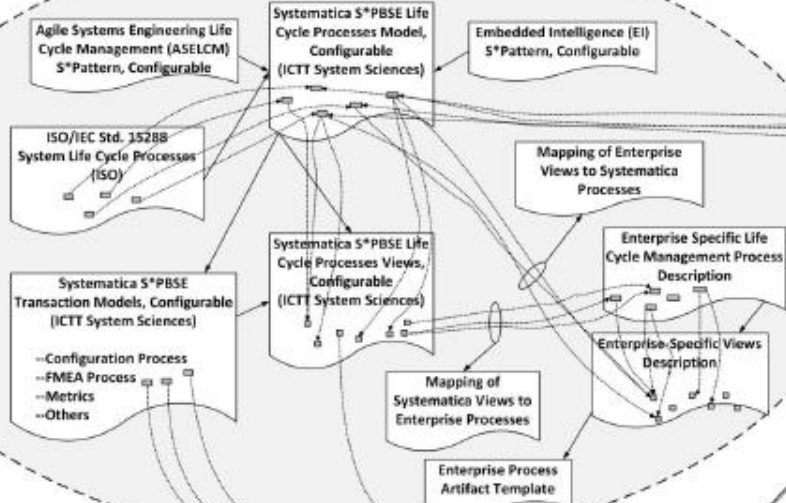
Domain Specific Pattern



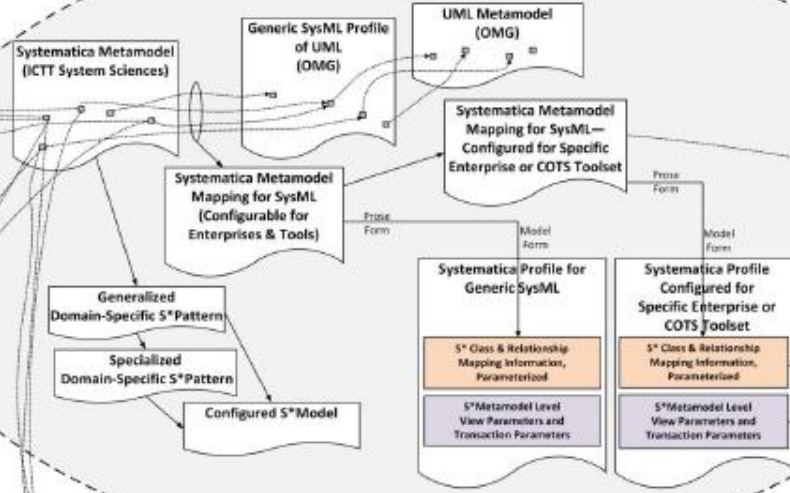
More Specific



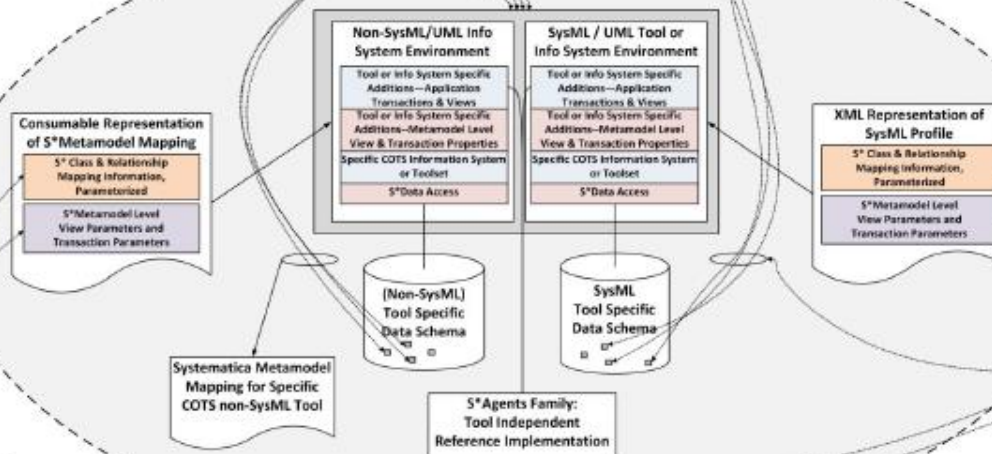
Process



Information



Automation



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 five 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

Patterns WG web site:

<http://www.omgwiki.org/MBSE/doku.php?id=mbse:patterns:patterns>

IS 2018 Patterns WG meeting web site:

http://www.omgwiki.org/MBSE/doku.php?id=mbse:patterns:mbse_patterns_wg_participation_in_incose_is2018



Agenda, Partner Events of Interest: INCOSE MBSE Patterns Working Group, at IS2018, and Web Conferencing	US Eastern Time (ET)	Room	Global Meet
<p style="text-align: center;"><u>MBSE Patterns WG:</u> <u>Joint IS activities,</u> <u>interests, conversations,</u> <u>project partners</u></p>			
<p><u>Patterns WG Pre-reading and Background:</u></p> <p>INCOSE WG web site for MBSE Patterns WG: http://www.incose.org/ChaptersGroups/WorkingGroups/Transformational/mbse-patterns</p> <p>WG INCOSE/OMG mbse wiki site: http://www.omgwiki.org/MBSE/doku.php?id=mbse:patterns:patterns</p> <p>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</p> <p>PBSE Methodology Summary from the Patterns WG: http://www.omgwiki.org/MBSE/doku.php?id=mbse:pbse</p>			



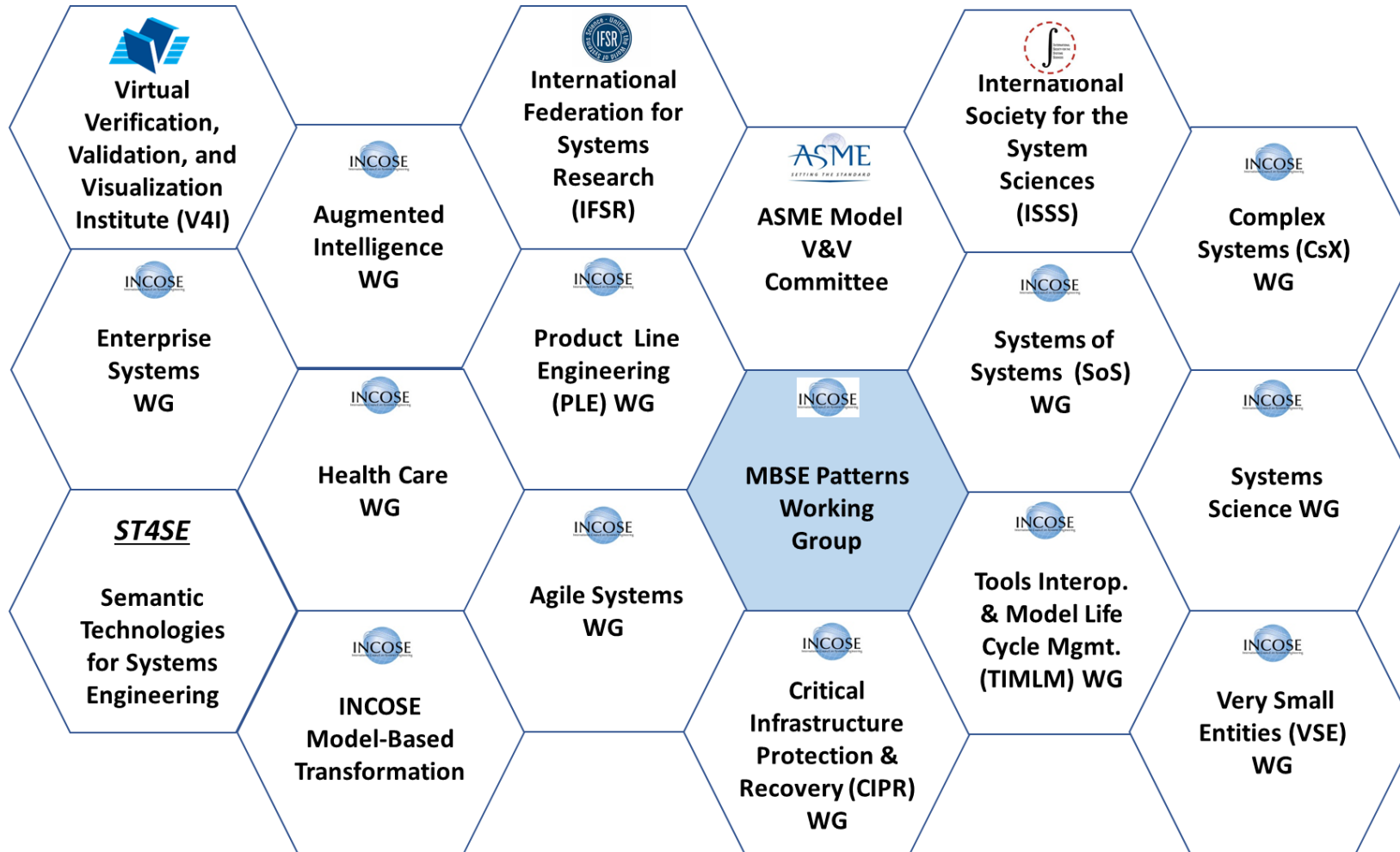
Agenda, Partner Events of Interest: INCOSE MBSE Patterns Working Group, at IS2018, and Web Conferencing	US Eastern Time (ET)	Room	Global Meet
<p><u>INCOSE Transformation: An MBSE Workshop: 8 Short "Lightning Talks" on model-based applications and insights:</u></p> <p>Introduction</p> <p>Evolving MBSE to Enable the Digital Future - David Long</p> <p>Changing the World with Models - Troy Peterson</p> <p>Seven Reasons to Trust/Distrust Models - Donna Rhodes</p> <p>ROI on the edge of MBSE - Mark Sampson</p> <p>Break</p> <p>Autonomous Vehicle Development Using MBSE - Chris Davey</p> <p>Using MBSE to Decrypt the Innovation Process and Corporate Memory - Bob Sherman</p> <p>Modeling Counterintuitive Results - Ricardo Valerdi</p> <p>Manufacturing Software: Opportunities and Obstacles - Stephen Mellor</p> <p>Panel / Forum</p> <p>Closing</p> <p>See also: https://www.incose.org/symp2018/symposium/technical-program-highlights</p>	<p>SATURDAY</p> <p>01:30</p> <p>01:45</p> <p>02:05</p> <p>02:25</p> <p>02:45</p> <p>03:05</p> <p>03:20</p> <p>03:40</p> <p>04:00</p> <p>04:20</p> <p>04:50</p> <p>05:10</p>	<p>Independence Ballroom DE - Level 5b</p>	<p>--</p>
<p><u>System Science Working Group: A System Science Workshop</u></p>	<p>SUNDAY</p> <p>8:00-5:00</p>	<p>Banneker, Level 1b</p>	<p>--</p>
<p>MBSE Patterns WG Meeting (Day 1 of 2 Days):</p> <p>Patterns WG Collaborations and Projects: Current Status, Next Steps, Future Interests of Members - Spread over Sunday and Monday meetings of this Working Group, to include:</p> <ul style="list-style-type: none"> • The INCOSE MBE Transformation and the System of Innovation Pattern • ASME Model V&V Patterns Project, VVUQ Pattern • Health Care Embedded Controls Pattern Collaboration (See also Monday IS session on this) • Patterns in the Public Square: Regulated Innovation (See also Tuesday IS Panel on this below) • IFSR Conversation Product: An MBE Manifesto • Augmented Intelligence Challenge Team Collaboration • Semantic Technologies for Systems Engineering (ST4SE) Collaboration • Interface Patterns Project • SoS WG Collaboration (See also Wednesday IS Panel on this below) • VSE Patterns Project • Agile Patterns Project and WG Collaboration (See also Monday IS session on this) • S3 Pattern and INCOSE OCM—Enterprise WG collaboration • TIMLM Patterns (includes ASME Model Life Cycle working group connection) • PLE WG Project • V4 Institute Collaboration, Tools Mappings • CIPR WG Collaboration and related CIPR Patterns • SysSciWG and ISSS Collaboration (See also Sunday session on this above) <p>Future Project Interests of Attendees</p> <p>(Note: The above agenda topics will be spread across the Sunday and Monday meetings of this WG)</p>	<p>SUNDAY</p> <p>1:30 – 5:00</p>	<p>Tiber Creek B</p>	<p>YES, Link below</p>

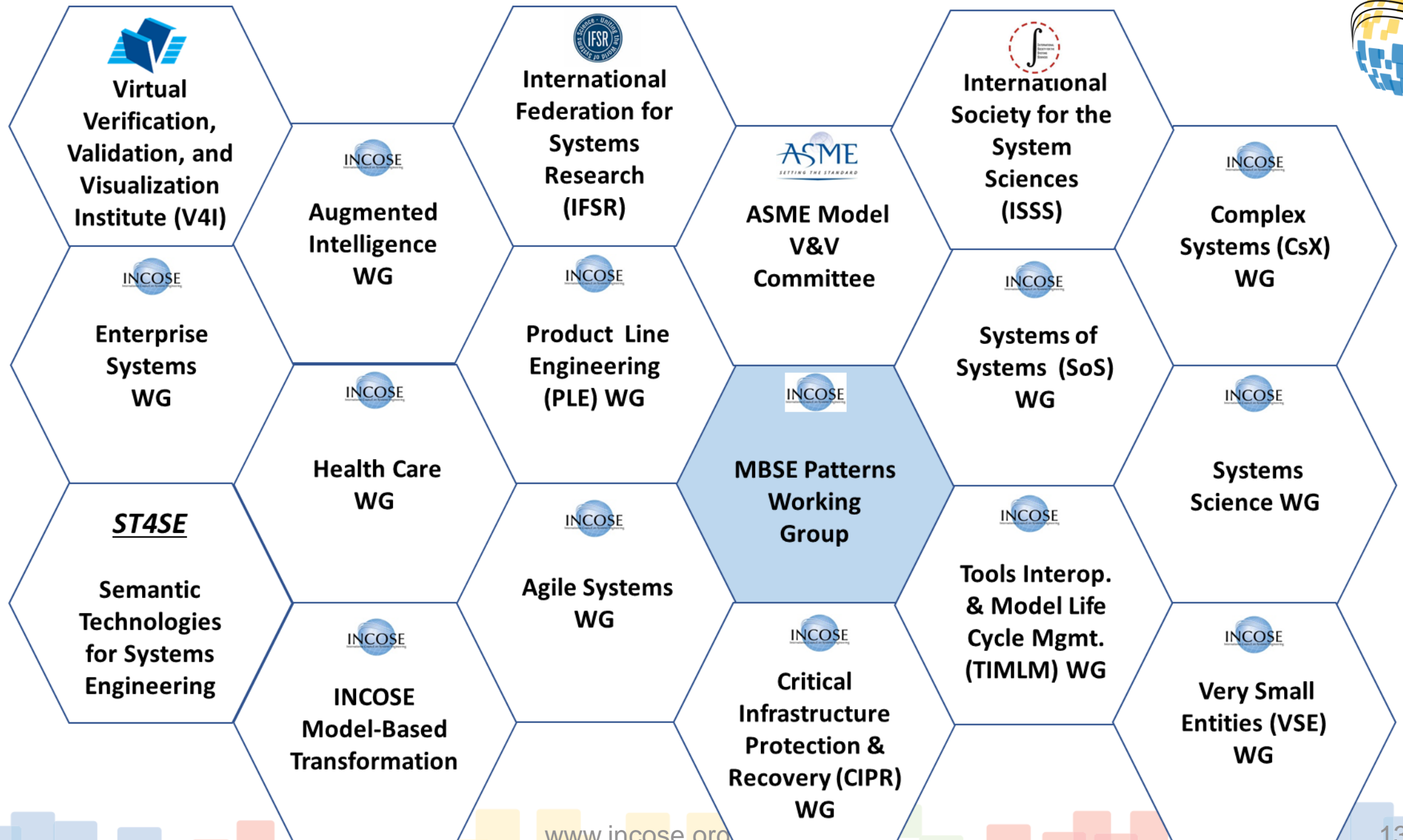


Agenda, Partner Events of Interest: INCOSE MBSE Patterns Working Group, at IS2018, and Web Conferencing	US Eastern Time (ET)	Room	Global Meet
<p><u>MBSE Patterns WG Meeting (Day 2 of 2 Days):</u></p> <p>Patterns WG Collaborations and Projects: Current Status, Next Steps, Future Interests of Members - Spread over Sunday and Monday meetings of this Working Group, to include:</p> <ul style="list-style-type: none"> • • • (continuing detailed topics list in Sunday meeting agenda above) • • <p>Future Project Interests of Attendees</p> <p>(Note: The above agenda topics will be spread across the Sunday and Monday meetings of this WG)</p>	<p><u>MONDAY</u></p> <p>1:30 – 3:00</p>	<p><i>Banneker</i></p>	<p>YES, Link below</p>
<p><u>Other Monday IS Sessions Related to MBSE Patterns:</u></p> <p>Tech Ops Invited Presentation: “Embedded Control of Medical Devices—Trust, but Verify”, Health Care WG, Chris Unger, Marc Horner, Bill Schindel</p> <p>Case Study: “Agile Systems Engineering at Lockheed Martin Aeronautics Integrated Fighter Group”, Agile WG, Rick Dove, Ken Garlington, Bill Schindel</p>	<p>1:30 – 2:15</p> <p>3:30 – 4:15</p>	<p><i>IS Track 6</i></p> <p><i>IS Track 2</i></p>	<p>--</p>
<p><u>Tuesday IS Sessions Related to MBSE Patterns:</u></p> <p>Panel: “Accelerating Innovation Effectiveness: Model-Facilitated Collaboration by Regulators, Technical Societies, Customers, and Suppliers”, Dr. Tina Morrison (FDA), Dr. Joseph Pelletiere (FAA), Steven Donaldson (DoD), Troy Peterson (INCOSE), Marian Heller (ASME), Logen Johnson (SAE), Bill Schindel (Moderator)</p>	<p><u>TUESDAY</u></p> <p>10:00-12:10</p>	<p>IS Track 7</p>	<p>--</p>
<p><u>Wednesday IS Sessions Related to MBSE Patterns:</u></p> <p>Panel: “Systems of Systems Engineering- An Approach to Agile Systems Engineering?” Moderator: Judith Dahmann (The MITRE Corporation) Panelists: Rick Dove (Paradigm Shift International); Stephen Cook (Shoal Engineering); Alan Harding (BAE Systems); Matthew Wylie (Shoal Engineering); William Schindel (ICTT System Sciences); Duncan Kemp (UK Ministry of Defence)</p>	<p><u>WEDNESDAY</u></p> <p>10:00 – 12:10</p>	<p>IS Track 7</p>	<p>--</p>



A hallmark of the Patterns WG: *Most of our work is with other WGs and entities--*

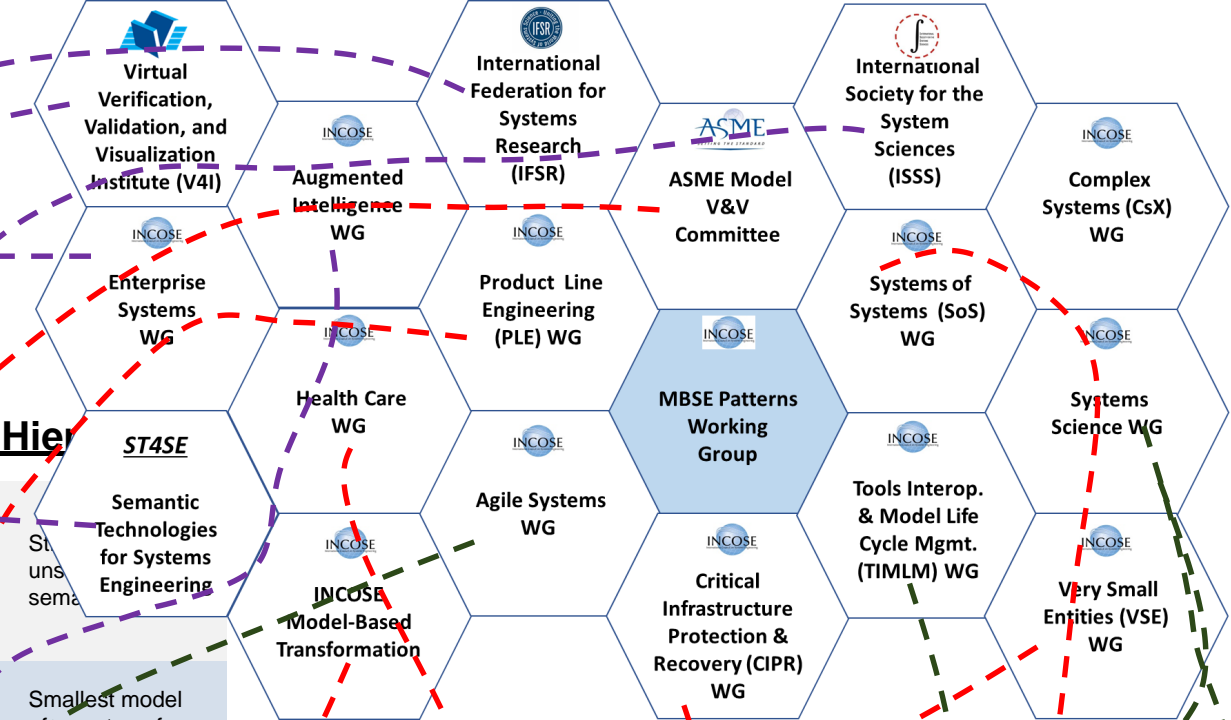
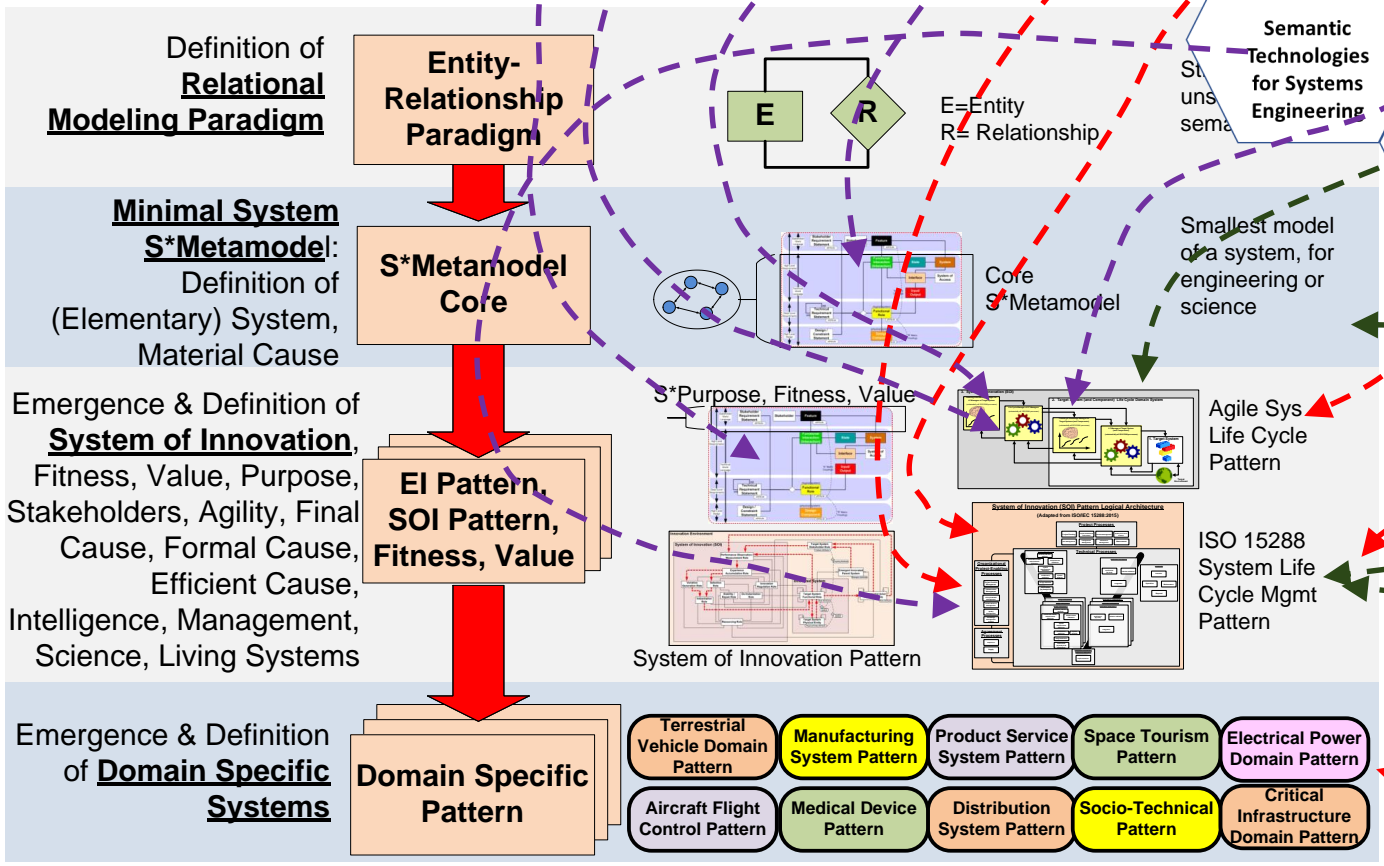




WG partner collaborations occur for patterns at different, but coordinated, levels of abstraction.

More General
↓
More Specific

Emergence of Patterns from Patterns: S*Pattern Class Hier



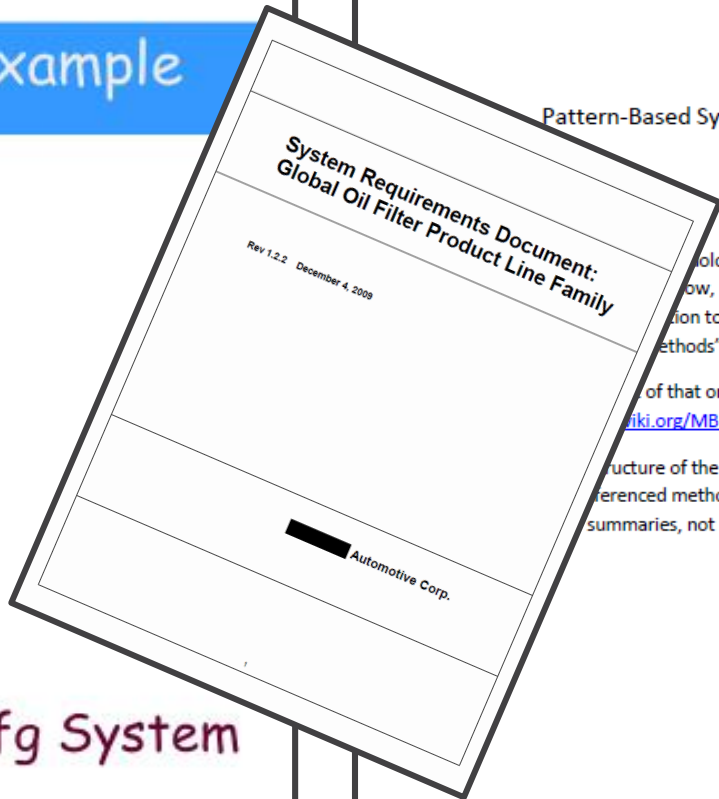


S*Patterns 101 Introduction References

Samples from a simple illustrative example



- Product: Oil Filter
- Manufacturing System: Oil Filter Mfg System



MBSE Methodology Summary:

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

Methodology summary for Pattern-Based Systems Engineering using S*MBSE flow, resulting from Patterns Challenge Team review, feedback, and related contribution to the INCOSE-maintained on-line directory "MBSE Methodology: List of methods".

More information of that on-line directory may be found at http://wiki.org/MBSE/doku.php?id=mbse:methodology#mbse_benchmarking_survey

The structure of the following sections conforms to the standard summary outline template referenced methodology directory. The typical methodology descriptions in that directory are summaries, not detailed "how to" manuals, for each methodology.



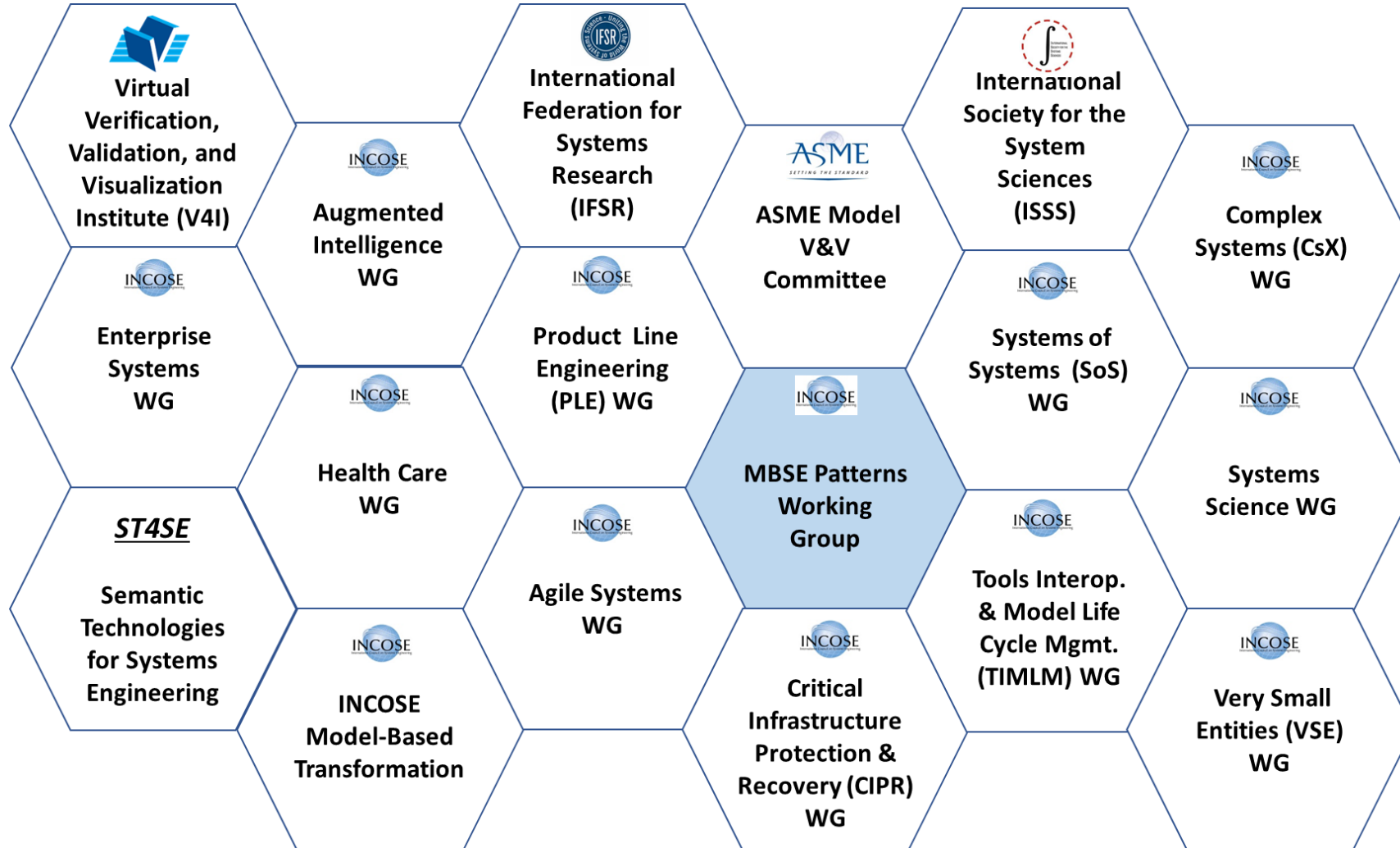
Patterns WG Collaborations and Projects: Current Status, Next Steps, Future Interests of Members:

Spread over Sunday and Monday meetings of
this Patterns Working Group

Following project and collaboration summaries:

- The INCOSE MBE Transformation and the System of Innovation Pattern
- ASME Model V&V Patterns Project, VVUQ Pattern
- Health Care Embedded Controls Pattern Collaboration (also Monday IS session)
- Patterns in the Public Square: Regulated Innovation (also Tuesday IS Panel)
- IFSR Conversation Product: An MBE Manifesto
- Augmented Intelligence Challenge Team Collaboration
- Semantic Technologies for Systems Engineering (ST4SE) Collaboration
- Interface Patterns Project
- SoS WG Collaboration (also Wednesday IS Panel)
- VSE Patterns Project
- Agile Patterns Project and WG Collaboration (also Monday IS session)
- S3 Pattern and INCOSE OCM—Enterprise WG collaboration
- TIMLM Patterns (includes ASME Model Life Cycle working group collaboration)
- PLE WG Project
- V4 Institute Collaboration, Tools Mappings
- CIPR WG Collaboration and related CIPR Patterns
- SysSciWG and ISSS Collaboration (also Sunday session on this)

Working Group Partners in Progress

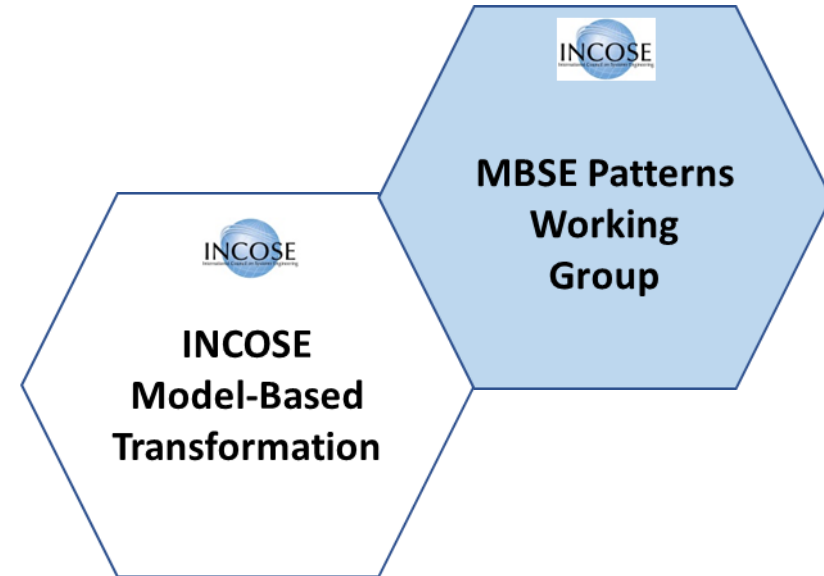


MBSE Patterns WG: Joint IW activities, interests, conversations, project partners

With INCOSE Model-Based Transformation



Primary Contact:
*Troy Peterson, INCOSE
AD for MB Transformation*



Supporting INCOSE BoD objective for the transformation of
Systems Engineering to a Model-Based Discipline

Transformation Support: Status July 2018



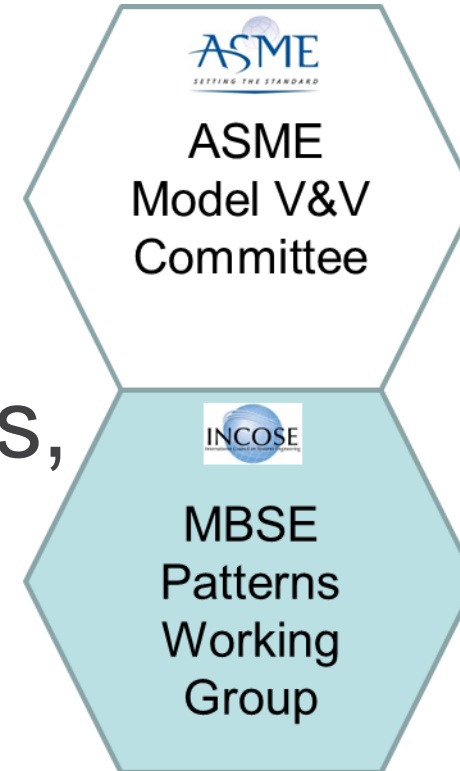
- MBSE penetration planning tool
- Model planning pattern
- Starter kit contributions, across System of Innovation Pattern (S1, S2, S3)
- Uniform packaging metadata of selected model exemplars
- S*Patterns IP landscape reference model
- S*Patterns Community support by Systems of Innovation, Inc.



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

Primary Contacts:
*Joe Hightower, Boeing,
Gordon Shao, NIST,
ASME VV50 Committee*

- Supporting creation of ASME Guidelines & Standards for Managing Credibility (Model VVUQ) of Computational Models, over their Life Cycles





Model VVUQ Project Status Jan 2018

- Member ASME VV50 Standards Committee: Presented related report to IW18 MBSE Workshop on Jan 21, 2018.
- Have generated VVUQ Pattern, a computational model meta-framework providing a uniform wrapper of metadata connecting any science or engineering model to its intended uses and related model VVUQ
- Basis for an INCOSE beta product for planning and assessing models of all types
- Being used in INCOSE MB Transformation team to package a series of example models sampled by that team across literature
- Initiated a public panel series, “Patterns in the Public Square”, with invited participation by ASME, INCOSE, SAE, FDA, FAA, DoD, on issues of credible / trustable models in regulated and other public markets (at GLRC 2017, ET 2017, IS 2018, GLRC 2018)
- One of the Founding Members of the V4 Institute, under NCDMM, concerned with increasing competency to accelerate innovation using more virtual verification and validation of systems, based on trusted models. (Others include Rolls-Royce, Johnson & Johnson, Indiana University Pervasive Computing Scientific Gateways, Notre Dame University, Purdue University, Vanderbilt University, others.)

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



V1.2.1



2018
Annual **INCOSE**
international workshop
Jacksonville, FL, USA
January 20 - 23, 2018

INCOSE Collaboration In an ASME-Led Standards Activity

Standardizing V&V of Models

Bill Schindel, ICTT System Sciences
schindel@ictt.com

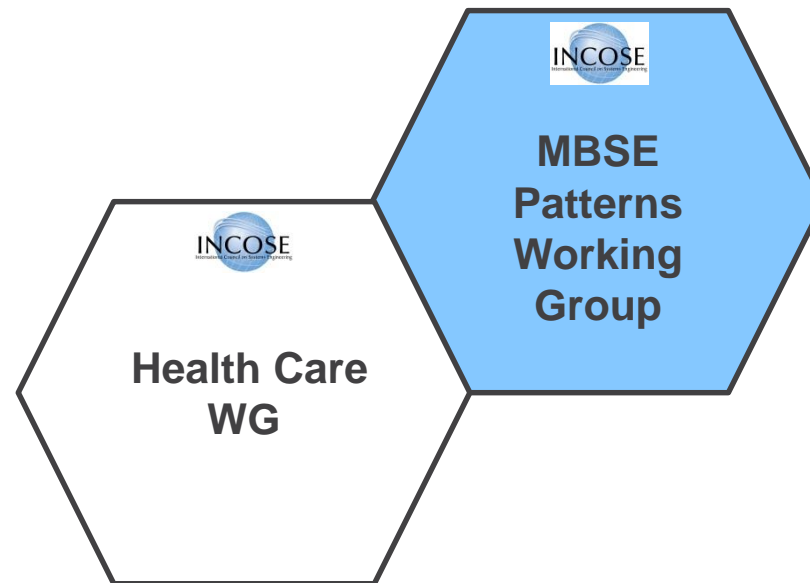
www.incose.org/IW2018



With Health Care WG: Joint Activity Materials

- Supporting the INCOSE Health Care Systems Conference (fourth year), Health Care application of ASELCM Pattern, Medical Device Embedded Controls VVUQ Pattern, and FDA participation in Patterns in the Public Square IS2018 panel.

Primary Contact:
Chris Unger,
GE Healthcare, INCOSE
Health Care WG



Health Care WG Collab: July 2018 Status



- Supported 2018 (fourth) INCOSE Health Care Conference
- Identified priority HC S2 and S3 opportunities and issues in the System of Innovation Pattern, configured for Health Care Domain
- Participated in an “after PCAST Report” session at the IISE conference in February, 2018, to pursue this further with IISE
- Now originating an embedded controls model VVUQ pattern, with WG progress report session at IS2018.
- Supported ASME AABME planning of their first health care conference in 2018.
- Dr. Tina Morrison, FDA, will participate in our invited panel at IS2018, “Patterns in the Public Square”.



Accelerating Innovation Effectiveness: Model-Facilitated Collaboration by Regulators, Technical Societies, Customers, and Suppliers



28th Annual INCOSE
International Symposium

Delivering Systems in the
Age of Globalization

July 7 - 12, 2018
Washington, DC

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IS 2018 Panel Tuesday, 10 July



Invited IS2018 session Monday, 09 July



Trusting Models of Controlled Systems

A Model VVUQ White Paper Project

Bill Schindel schindel@ictt.com
Chris Unger christopher.unger@med.ge.com
Marc Horner marc.horner@ansys.com
Bob Malins rjmalins@eaglesummittech.com

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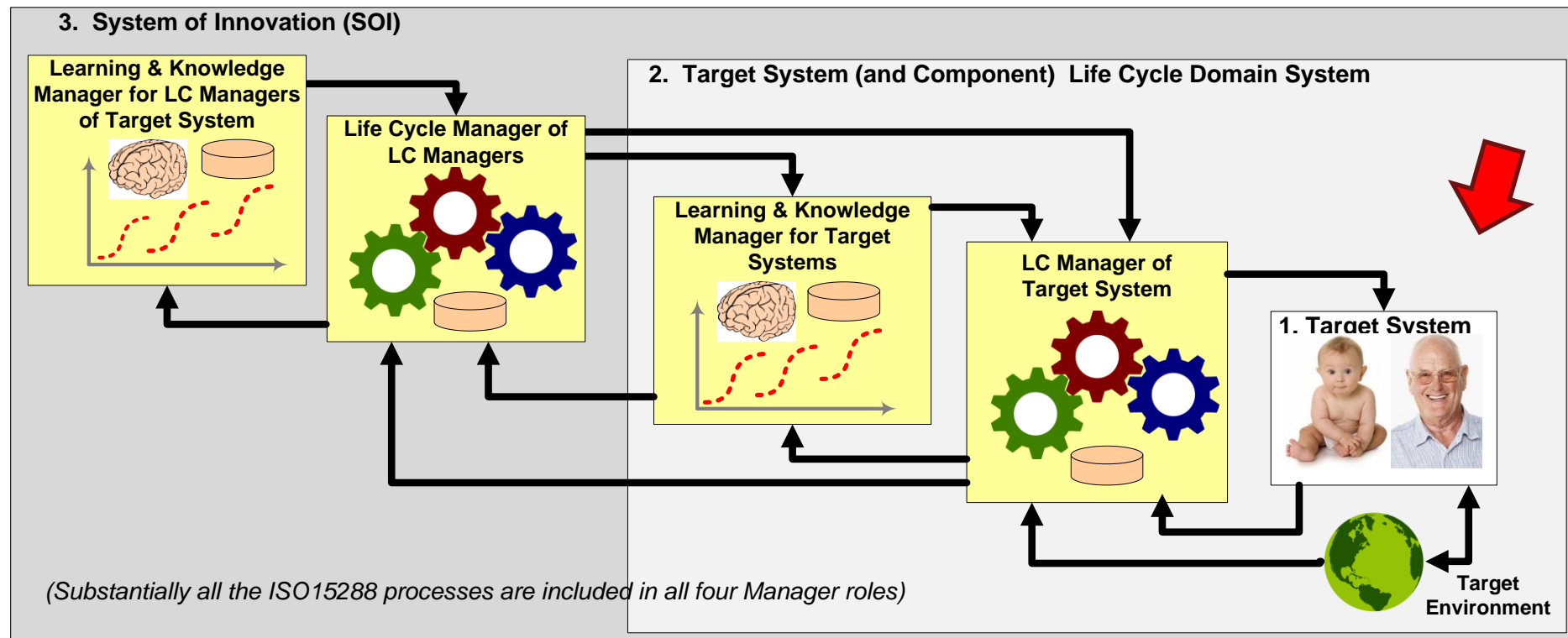
How Systems Engineering Can
Reduce Cost & Improve Quality

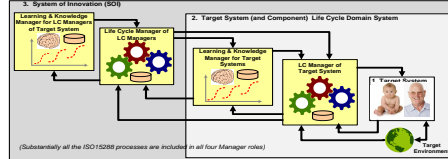
19-20 April, 2018
Twin Cities, Minnesota

2016-7 Agile Health Care Systems Conferences



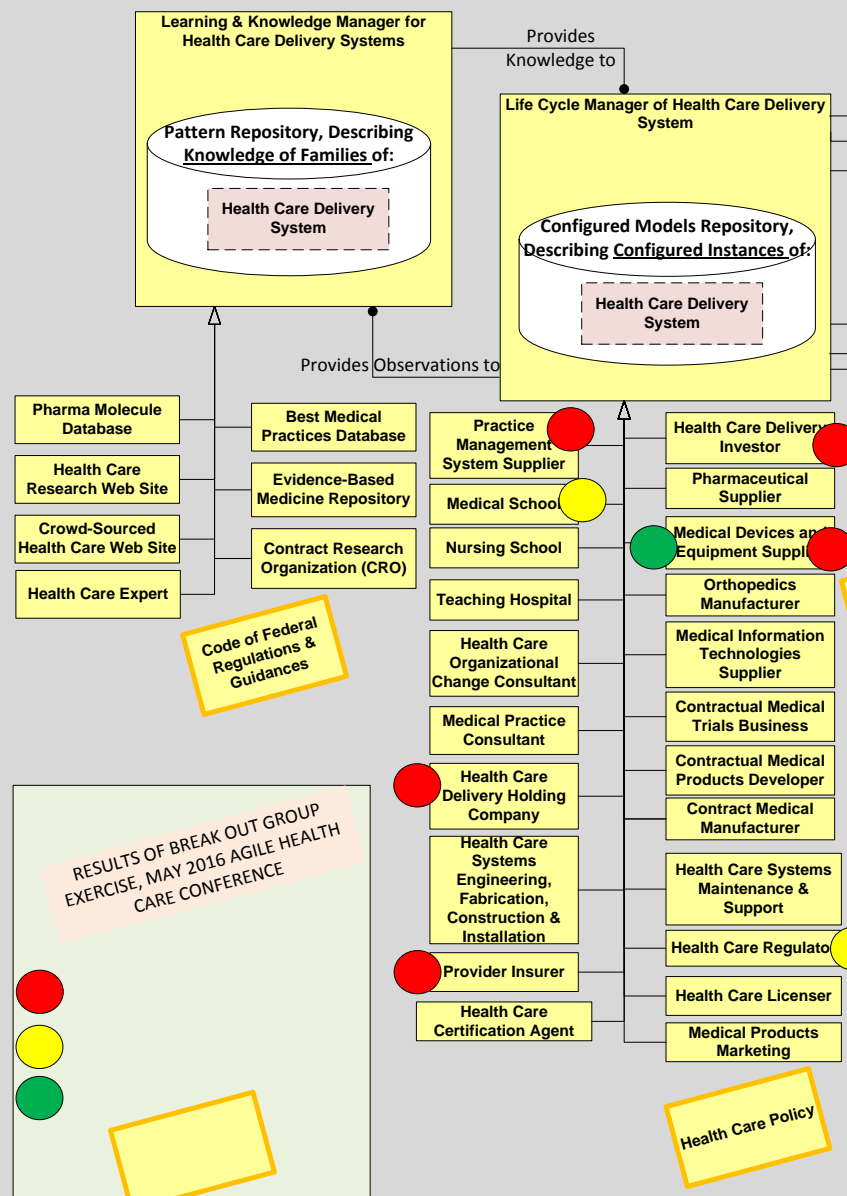
- Sessions and break out group addressed the application of the ASELCM Pattern to assessing agility opportunities in the Health Care Domain:



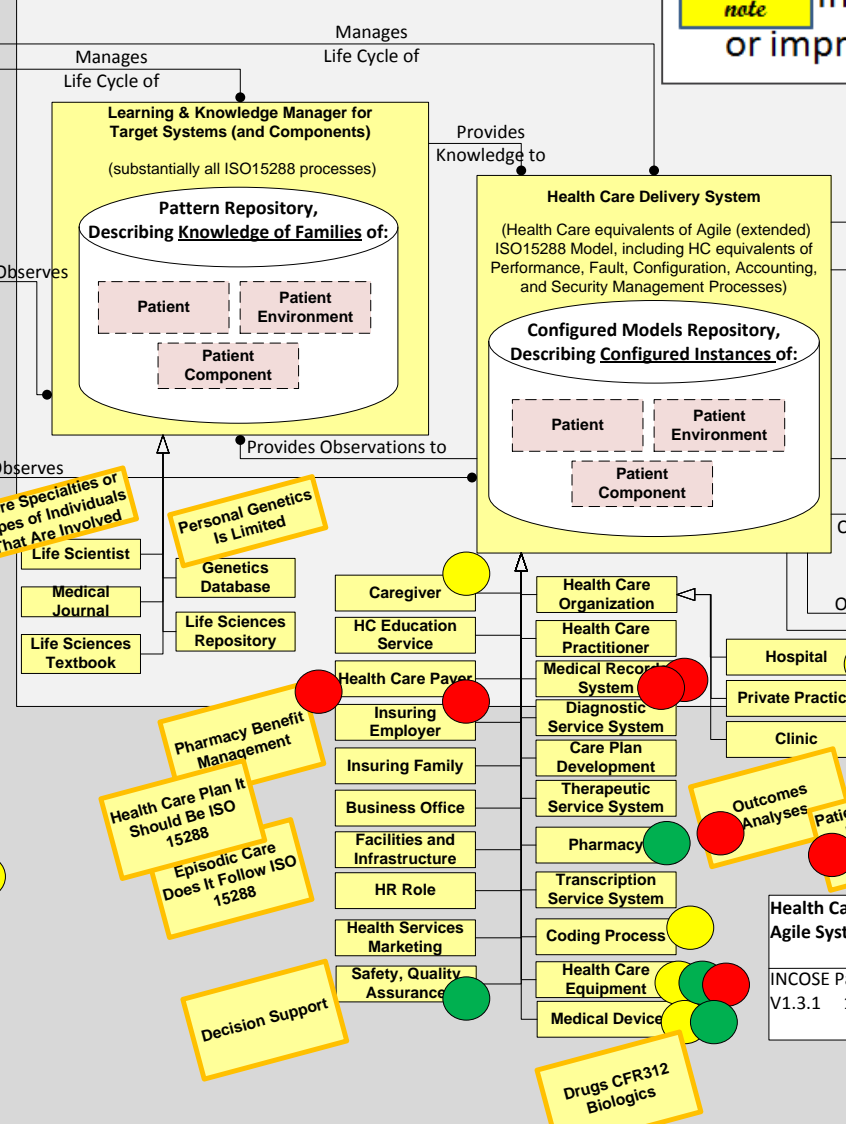


- Sticky Dots
- Needs for improved future agility (even if most difficult)
 - Opportunities for improved future agility (low-hanging fruit)
 - Already accomplished examples of improved agility progress (e.g., defense theater medicine, device software, etc.)

3. Health Care System of Innovation (SOI)

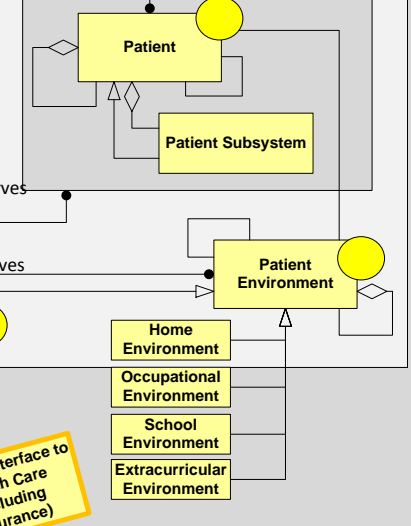


2. Patient Health Life Cycle Domain System

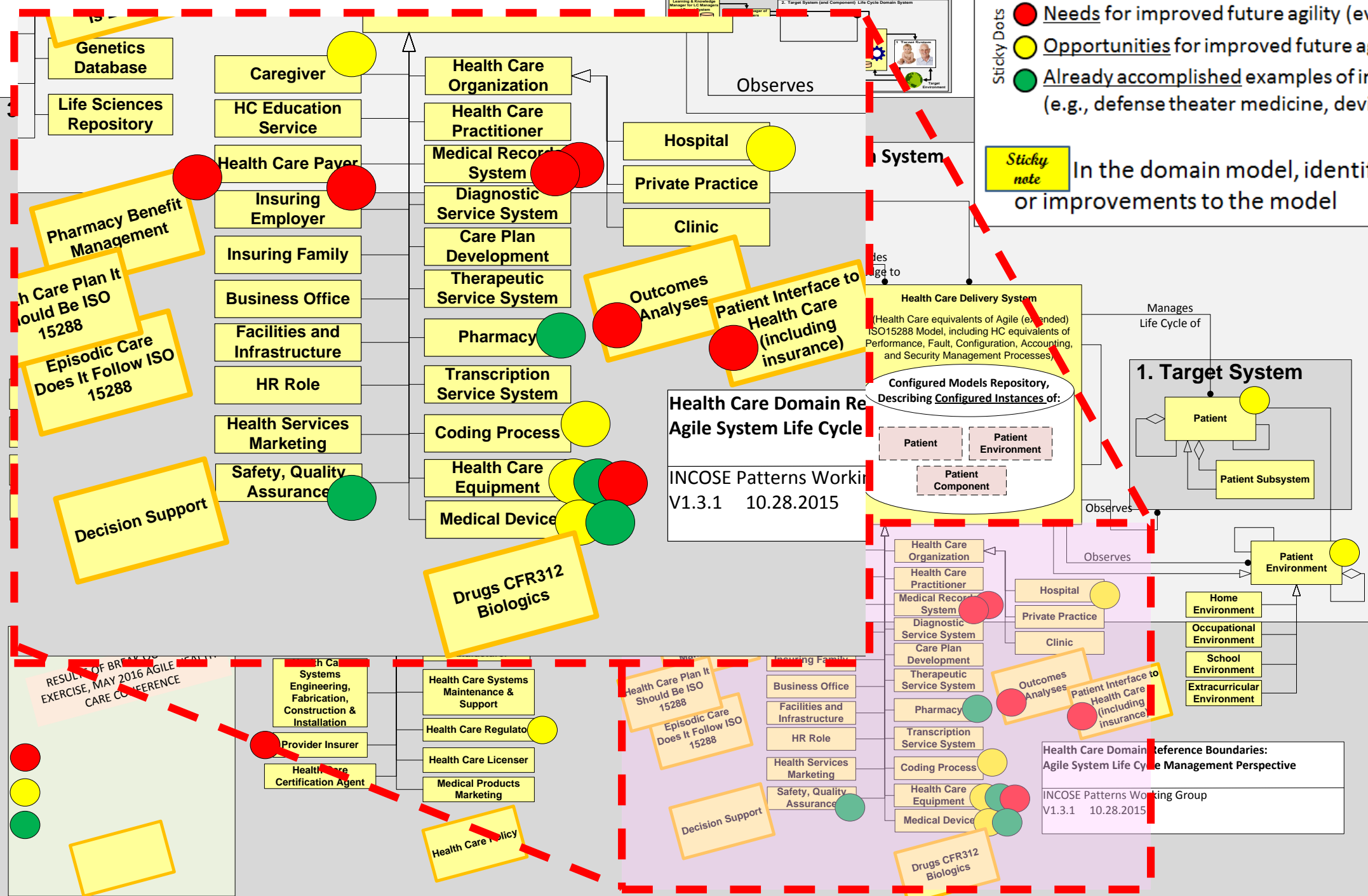


Sticky note In the domain model, identify potential corrections or improvements to the model

1. Target System



Health Care Domain Reference Boundaries: Agile System Life Cycle Management Perspective
INCOSE Patterns Working Group
V1.3.1 10.28.2015



- 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

Pharmacy Benefit Management

Health Care Plan It Should Be ISO 15288

Episodic Care Does It Follow ISO 15288

Decision Support

Outcomes Analyses

Patient Interface to Health Care (including insurance)

Drugs CFR312 Biologics

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

INCOSE Patterns Working Group V1.3.1 10.28.2015

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

INCOSE Patterns Working Group V1.3.1 10.28.2015

RESULTS OF BREAKOUT EXERCISE, MAY 2016 AGILE HEALTH CARE CONFERENCE

Health Care Policy



Patterns in the Public Square

- A collaboration across multiple professional societies, regulators, institutions
- Intended to increase awareness of the challenge and opportunity, and highlight examples of progress
- Concept: Particularly in regulated markets (but also others), shared trustable models (of proposed innovated products and other systems) have catalytic role in streamlining the innovation process, across suppliers, users, regulators, others
- This implies a future ecological framework in which the use and life cycle of trustable models is a central medium of exchange and innovation.
- Since this is not familiar country to many, successful examples help.
- Public panels and expositions on this at:
 - INCOSE GLRC 2017
 - INCOSE / IEEE ET 2017
 - INCOSE IS 2018
 - INCOSE GLRC 2018

28th annual INCOSE International Symposium
Washington, DC, USA
July 7 - 12, 2018

V1.5.2

Accelerating Innovation Effectiveness:
Model-Facilitated Collaboration by Regulators,
Technical Societies, Customers, and Suppliers

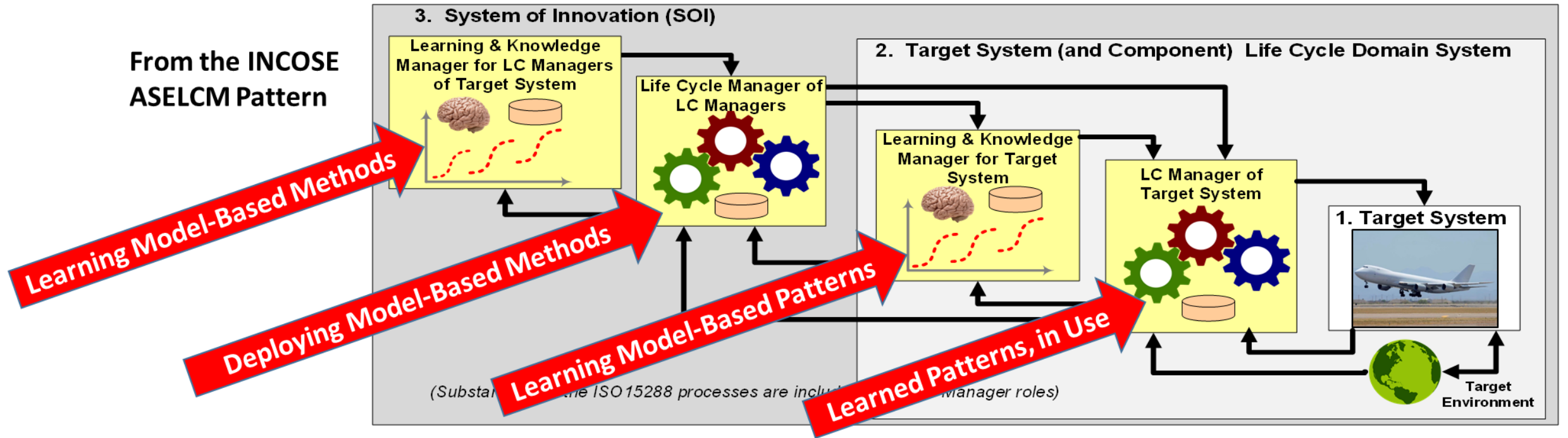
INCOSE ASME FDA FAA NAV AIR SAE INTERNATIONAL

28th Annual INCOSE International Symposium
Delivering Systems in the Age of Globalization
July 7 - 12, 2018
Washington, DC

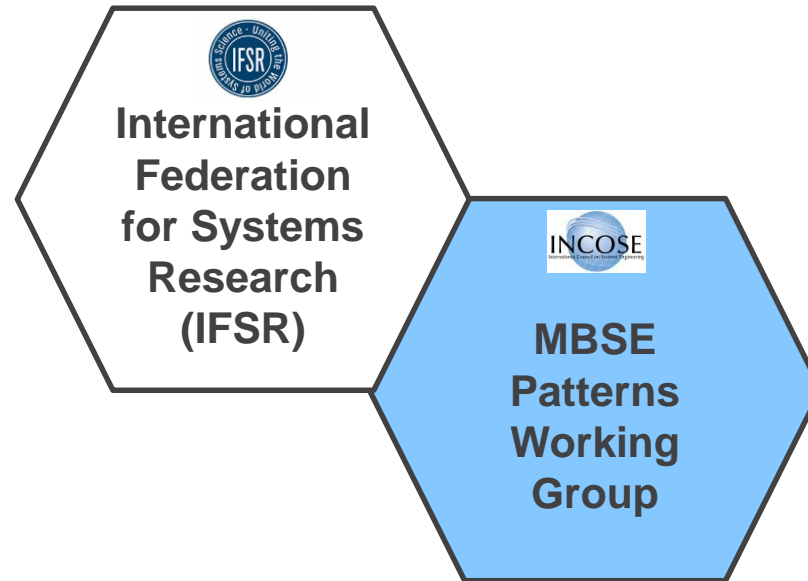
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Patterns in the Public Square



International Federation for Systems Research (IFSR) Collaboration: 2018 Systems Conversation



Primary Contact:
*Ed Carroll, Sandia
Laboratories*

A stronger foundation for information in systems engineering practice.



IFSR 2018 Conversation, Linz, Austria

- Patterns WG participation in International Federation for Systems Research (IFSR) “Conversation” event April, 2018:
 - Team organized by Ed Carroll, Sandia Laboratories
 - Seeking a stronger foundation for data-driven systems engineering
 - Very related to ASELCM Pattern, Model VVUQ Pattern, Systems Phenomenon Pattern, et.



IFSR 2018 Conversation, Linz, Austria

- Resulted in MBE Manifesto, on display at IS 2018:

A MODEL-BASED ENGINEERING (MBE) MANIFESTO

PURPOSE: *To motivate the transformation to Model-Based Engineering.*

Faced with increasing system complexity, interdependencies, breakdown of document-based methods, and other challenges, MBE provides the transformation in which we value:

- 1 Information over artifacts
- 2 Integration over independence
- 3 Expressiveness with rigor over flexibility
- 4 Model usage over model creation

We value the items on the right, but not at the sacrifice of the items on the left.

WITH THESE PRINCIPLES:

On behalf of stakeholders, MBE increases emphasis on describing the nature and content of the information produced and consumed, compared to the traditional emphasis on engineering process and procedure.

*We recognize that—**independent** of specific Information format, structure, language, syntax, the sequence or order of its production and consumption, and the domains and environments of our projects—the underlying nature (**semantics**) of the **essential** information we seek to discover and produce is **invariant** because of the very nature of engineering.*

*An essential and dynamically changing property of model information is its **credibility** to those people and processes which will **consume** that information. The critical nature of some **intended uses** of model information sets a higher bar on required investment in model **verification, validation** and **uncertainty quantification**.*

*Principles of **human-machine interaction** applied to the targeted stakeholders are vital to success. Application of advanced visualization methods **and augmented intelligence** capabilities can advance that success.*

*We seek an extended team across engineering disciplines with **common and integrated understanding** of the identity and nature of the model information as well as its content.*

*We seek effective **enterprise-wide reuse** of model-based information to more fully leverage past individual or local learning.*

Systems engineering performed according to the above principles is required for the Engineering System itself, a complex and evolving system.

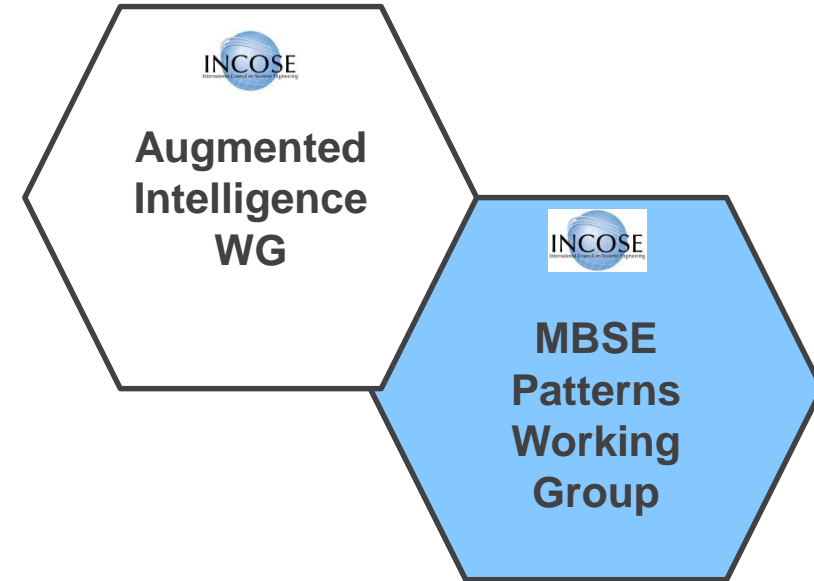
THE TEAM:
The team was assembled by invitation, intentionally drawing together different perspectives.

- Ed Carroll
Team lead-Sandia National Laboratories – Engineering Methods Research
- Nancy Hayden
SNL – Autonomous Systems/ Engineering Policy
- Sharon Trauth
SNL-Systems Engineering/ MBE Practice
- Dana Grisham
SNL-Data Governance/Agile Methods
- Chris Schreiber
Lockheed Martin Space Systems-Systems Engineering Modernization
- Bill Schindel
ICT System Sciences
- Frank Salvatore
Engility Corp-Systems Engineering/ Data Taxonomy
- Eliot Rich
Univ at Albany, SUNY-System Dynamics
- Steve Jenkins
JPL-Systems Semantics
- Anne O’Neil
Anne O’Neil Consultants-Organizational Transformation

Augmented Intelligence Challenge Team Collaboration



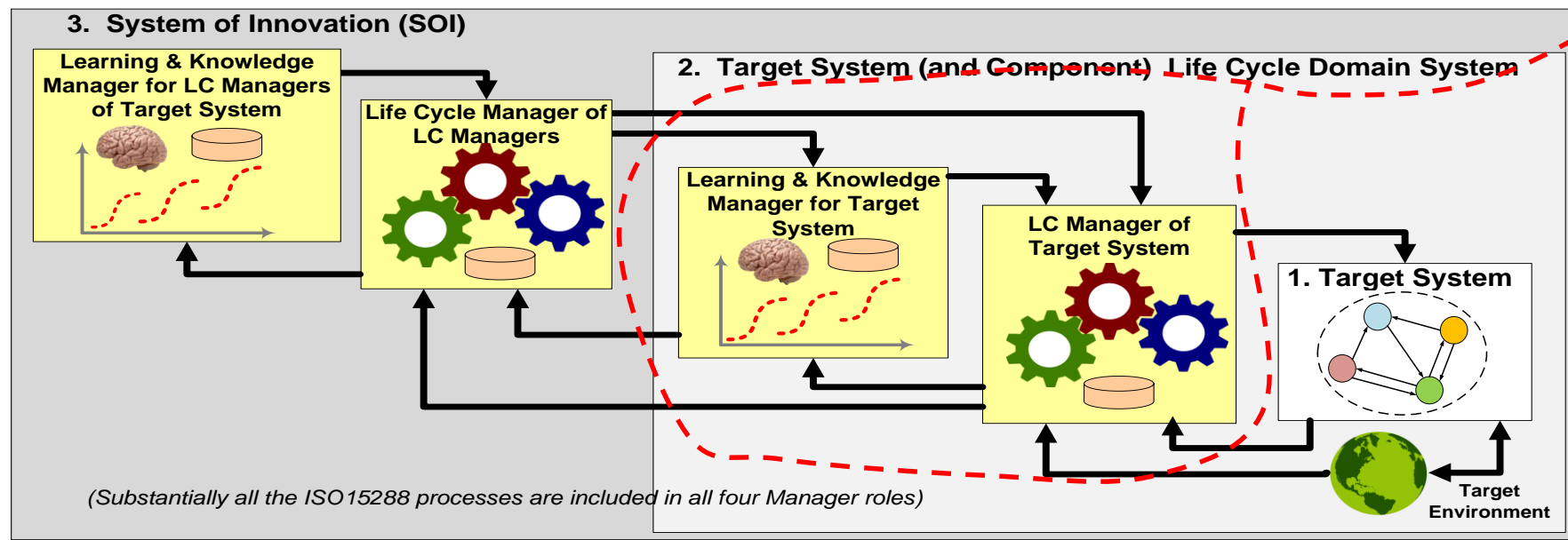
Contact: Mark Petrotta, SSI, INCOSE
Augmented Intelligence Challenge Team
Lead





Augmented Intelligence Challenge Team Collaboration

- Augmented Intelligence in support of the Systems Engineer is the focus of this 2017 start-up team's work.
- Collaborating with MBSE Patterns WG for the reference model description of the pattern describing this, as a specialization of the System of Innovation Pattern:
 - Particularly the Learning vs. Execution portion of that pattern—
 - At its core, the foundation is learned trusted pattern extract & use

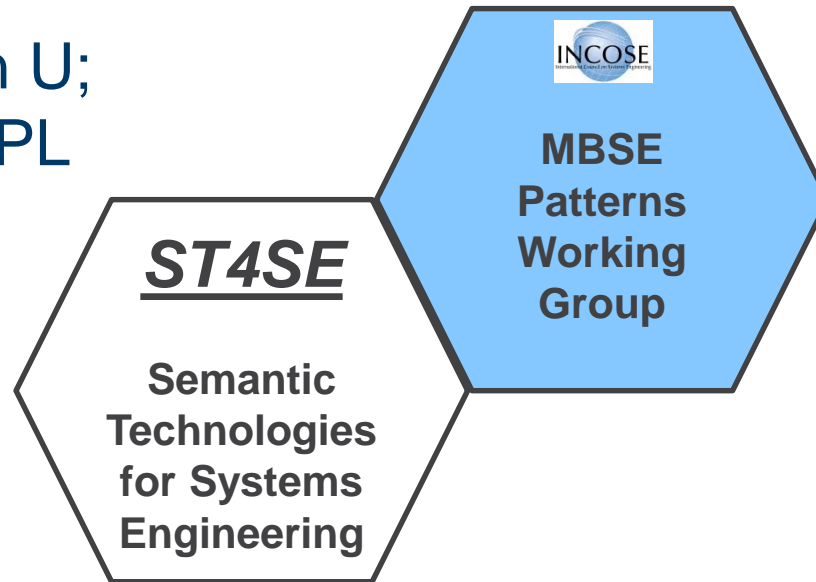




Semantic Technologies for Systems Engineering (ST4SE) Collaboration

Primary Contacts:

Chris Paredis, Clemson U;
Steve Jenkins, NASA JPL





Semantic Technologies for Systems Engineering (ST4SE) Collaboration

- A start-up aiming at becoming a (legal) foundation “To promote and champion the open-source development and utilization of ontologies and semantic technologies to support system engineering practice, education, and research.”
- Collaborating with INCOSE MBSE Patterns WG in the definition of recurring patterns applicable to the definition and use of a Systems Engineering Ontology.
 - Example: Utilizing Patterns WG Interface Patterns Project

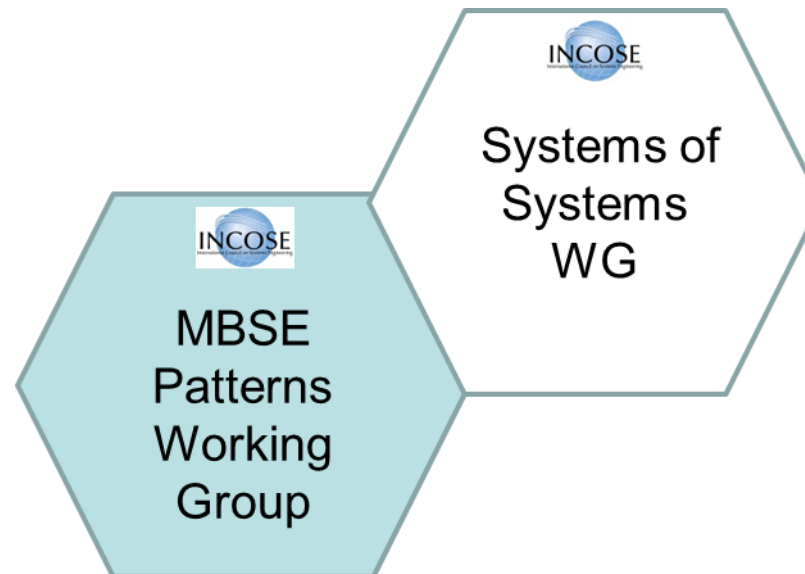
Interface Patterns Project: July 2018 Status

- Have identified relevant subset of S*Metamodel providing a basis for S*Interface Patterns
- Have identified and high level model framed selected interface types for initial attention, as configurable S*Interface Patterns (including initial use in V4 Institute and ST4SE Ontology work)
- Now creating high level model framed general Interface Control Document (ICD) query for any S*Interface
- Have reviewed related draft SysML 2.0 and JPL publications, and provided formal written feedback to SysML 2.0—in particular, on Interfaces, where some SysML updates are noted in direction of S*Interface metamodel.

Interface Pattern Project Workstreams

1. Identify interface aspects of the S*Metamodel (the most abstract interface pattern)
2. Create library of interface patterns of different types (specializations of 1) showing techniques in mechanical, communication, visual, etc.
3. Identify queries and views that are interface-based (e.g., ICD, etc.), what metadata should appear in each of these.
4. Identify interface-oriented tasks, activities in the engineering life cycle (the reasons we are doing this project)
5. Down the road, issues of governance of the resulting patterns, their life cycles
6. Tactical level tool specific items, not necessarily all interface-oriented, along with mappings to SysML or specific tools

System of Systems (SoS) WG Collaboration



Primary Contact:
*Judith Dahman, MITRE,
INCOSE SoS WG Lead*

SoS WG Collaboration: July 2018 Status

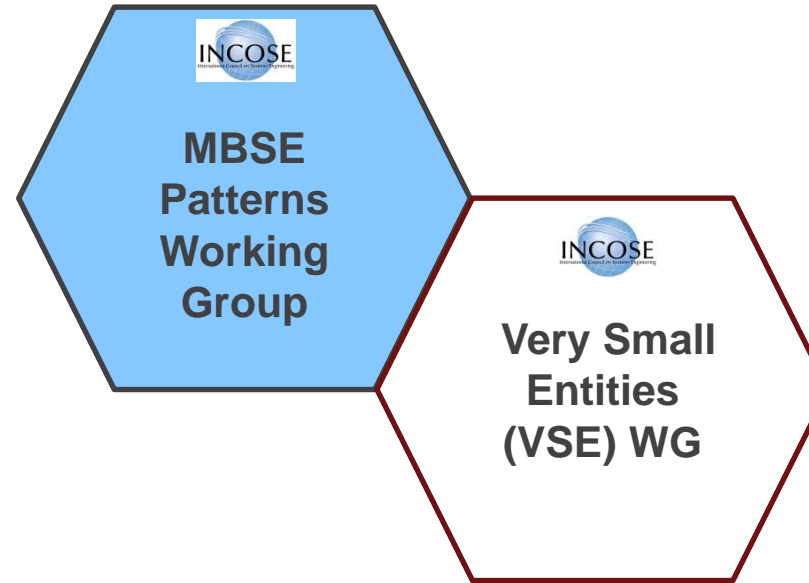


- IS 2018 Panel on Agile + SoS Engineering, July, 2018
- Held joint “SoS Patterns Workshop” at IW2016.
- Reviewed SoS architectural patterns presented by SoS WG
- Identified S*Feature sets as key illustration of S*Pattern content that could be used to express in the explicit pattern-based model various information previously shown as external prose discussion (e.g., fitness space, etc.)
- Offered to convert a few selected SoS WG Patterns to S*Pattern form to illustrate this:
 - SoS WG has indicated those patterns not yet available

Working Group Partners in Progress



Primary Contact:
Angela Robinson



Very Small Entities (VSE) Joint Project: VSE Project Pattern

VSE Working Group: Project Status July 2018



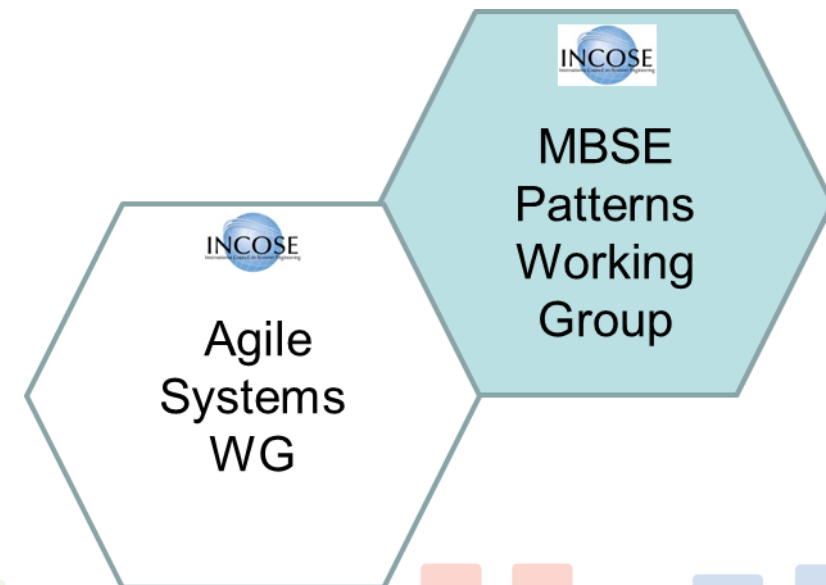
- Identified joint interest during 2017: S*Pattern representation of VSE deliverables
- Based on specialization of the S*Pattern for ISO 15288
- This also aligns this work with INCOSE ASELCM Pattern, System of Innovation Pattern, etc.
- Next steps pending availability of VSE team member time allocation.

With Agile SE WG: Joint Activity Materials



- Agile Systems Engineering Life Cycle Management (ASELCM) Discovery Project: Applying the ASELCM S*Pattern as specialization of System of Innovation Pattern

Primary Contact:
*Rick Dove, Paradigm
Shift, Intl.*



ASELCM Pattern Project: Jan 2018 Status

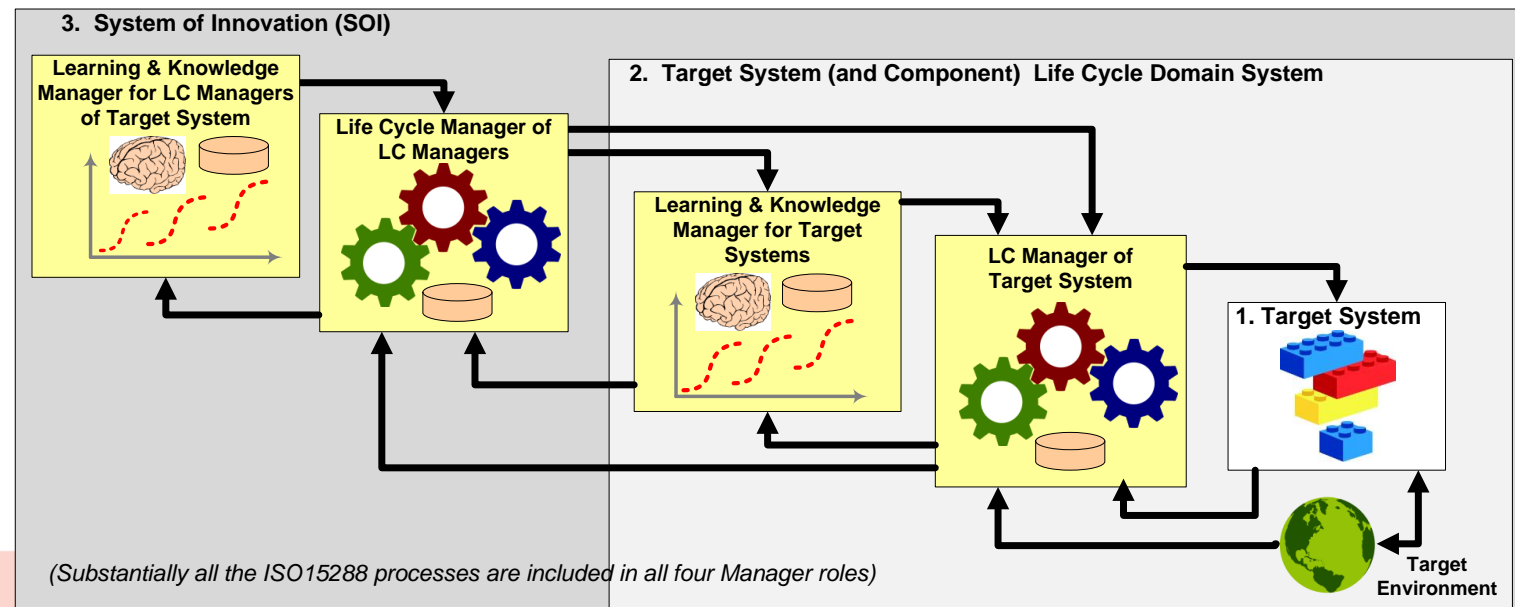


- ASELCM Pattern, specialized from ISO15288 System of Innovation Pattern, has been the basis of five co-authored INCOSE and IEEE case study papers, including an IS2017 best paper. Another to be presented at IS2018 (Lockheed Martin)
- Special issue of INCOSE INSIGHT in 2018 will feature another article on use of this model in the Navy SPAWAR case studies.
- Has been successfully applied in multiple commercial projects during 2016-2017, establishing agile pattern-based SE frameworks for advanced manufacturing, automotive, consumer products, ...
- S3 portion of ASELCM providing basis for reference model frameworks for study of challenges to innovation in Health Care (INCOSE Health Care Conferences of 2016, 2017), Electrical Power Grid and other Critical Infrastructure (INCOSE / IEEE / NASA ET 2016, 2017)
- Basis of V4 Institute framework for advanced virtual-based innovation competencies
- S3 portion of ASELCM is providing the basis for model-based reference framework for study of systems of innovation--

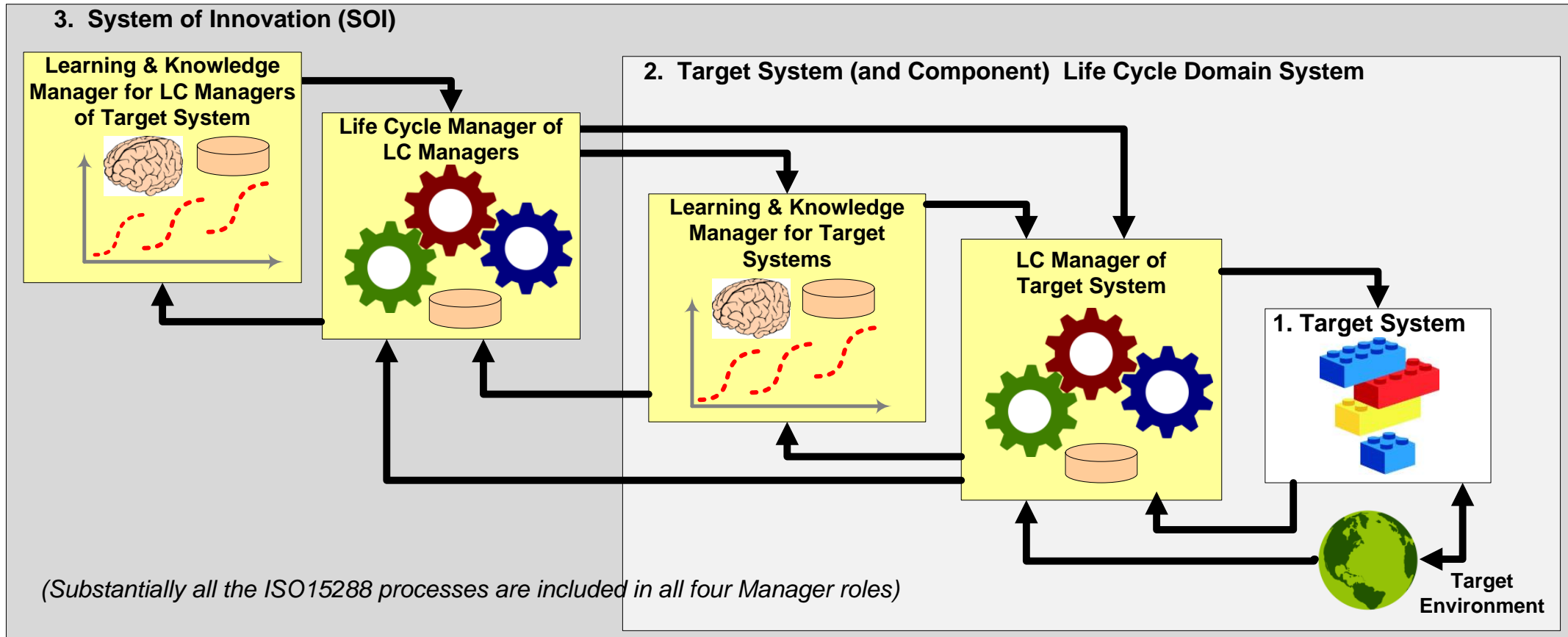
Using the ASELCM Reference Pattern on Four Case Study Sites: Model Highlights



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 (IS2017)
4. Agile Hardware/Firmware/Software Product Line Engineering at Rockwell Collins



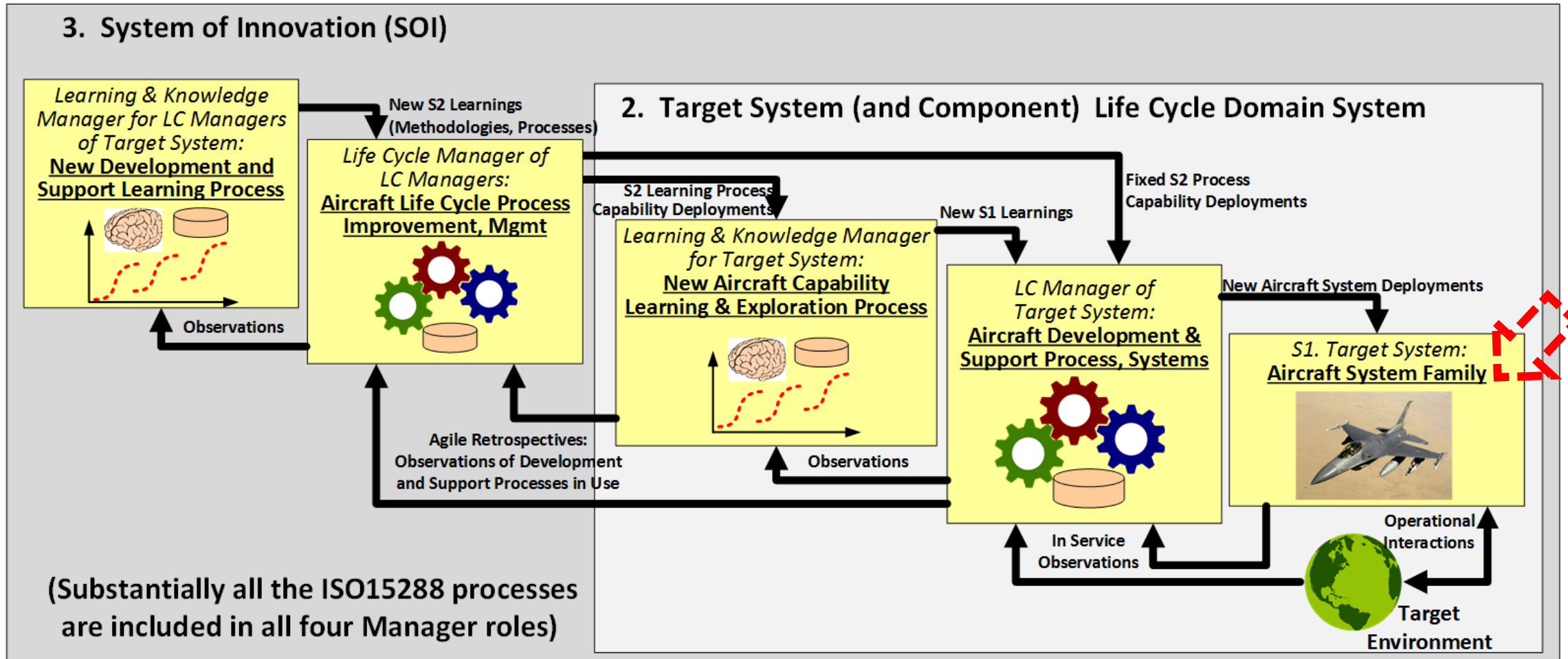
ASELCM Pattern Logical Architecture



- 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.



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

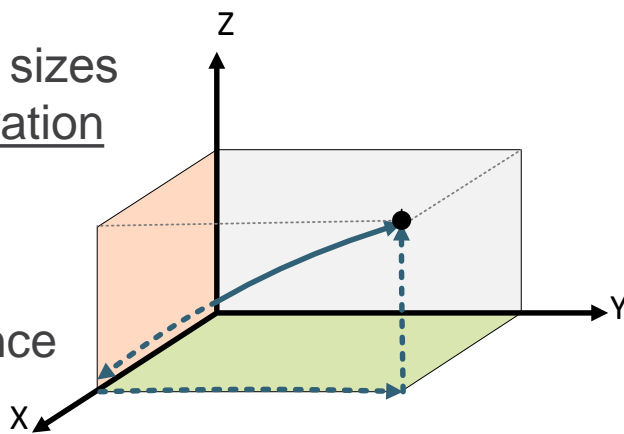




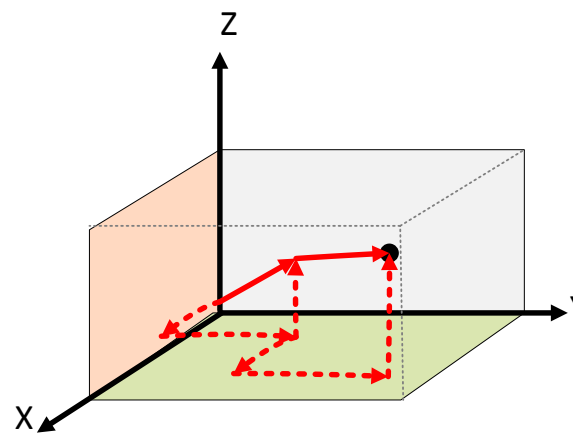
2. Transition to Scaled-Agile Systems Engineering at Lockheed Integrated Fighter Group: Configurations, Costs

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

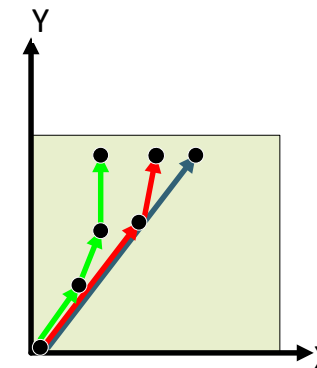
Example subspaces:
Reqs, Dsn, Performance



(a) Large “Batch” Increment

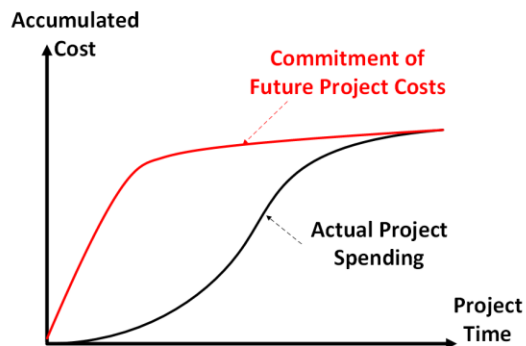


(b) Smaller “Batch” Increments

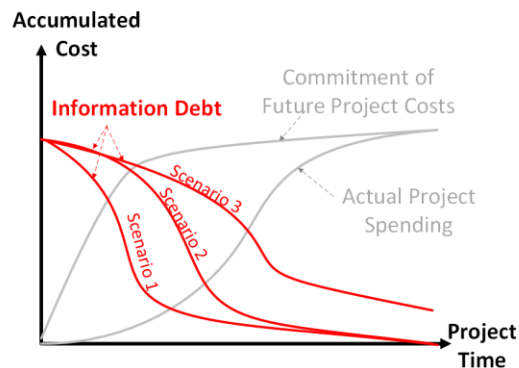


(c) Different “Batch” sizes can result in different trajectories, destinations

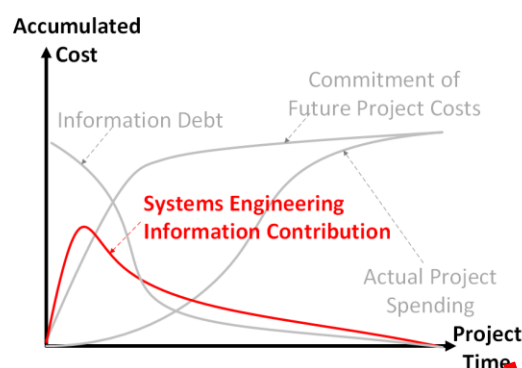
Information Debt: Balance Sheet Model of Learning



(a) When Project Costs Are Committed versus Incurred



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

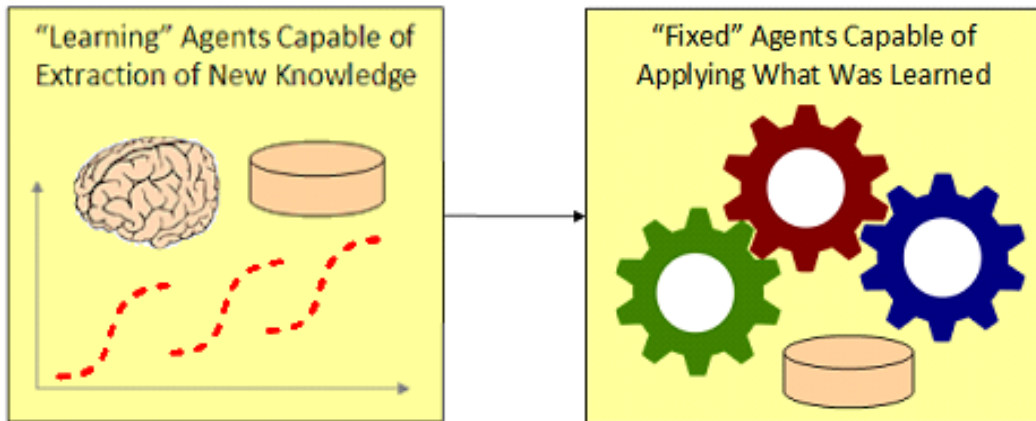
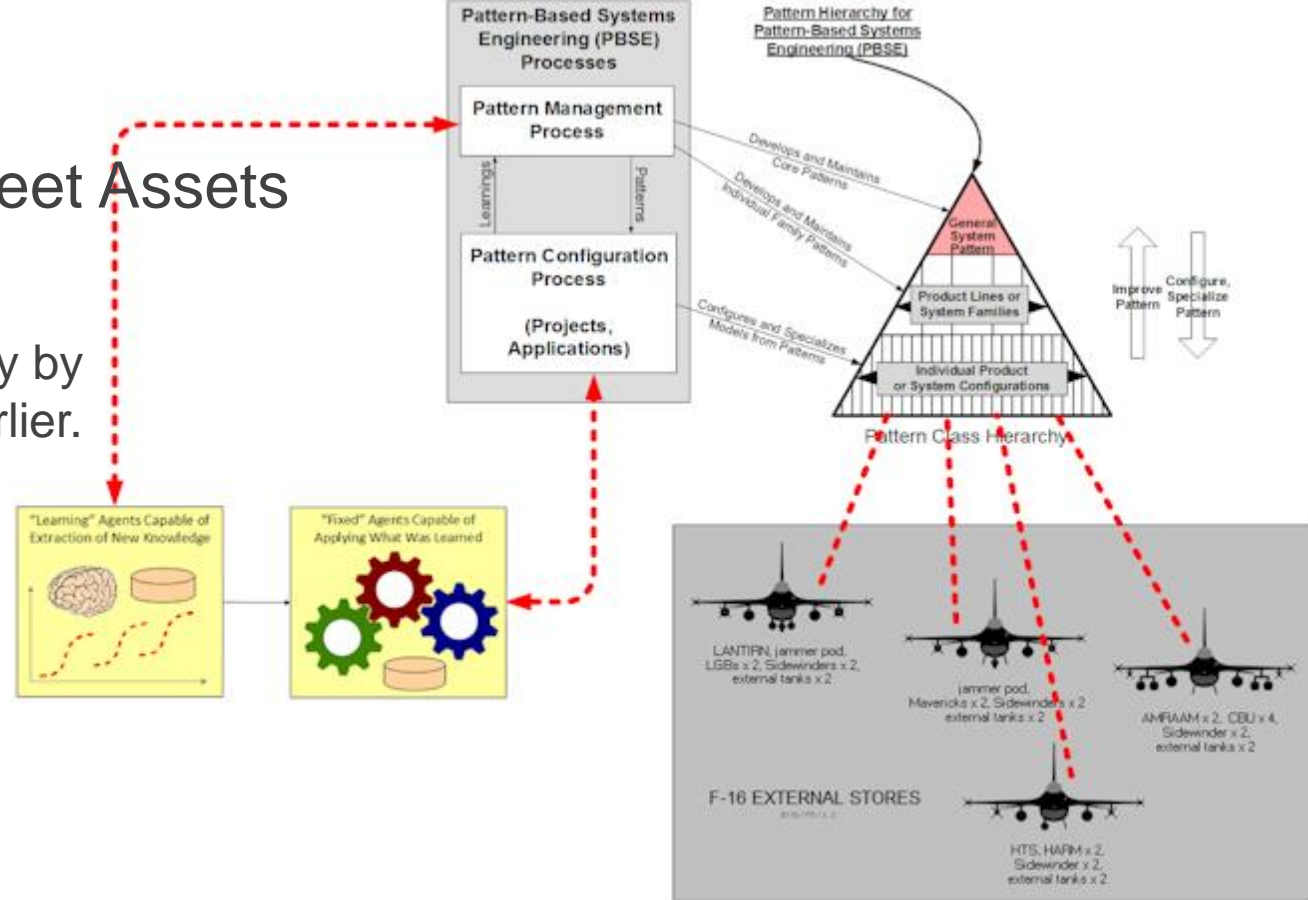


(c) Systems Engineering Information Is Generated to Reduce Information Debt

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

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

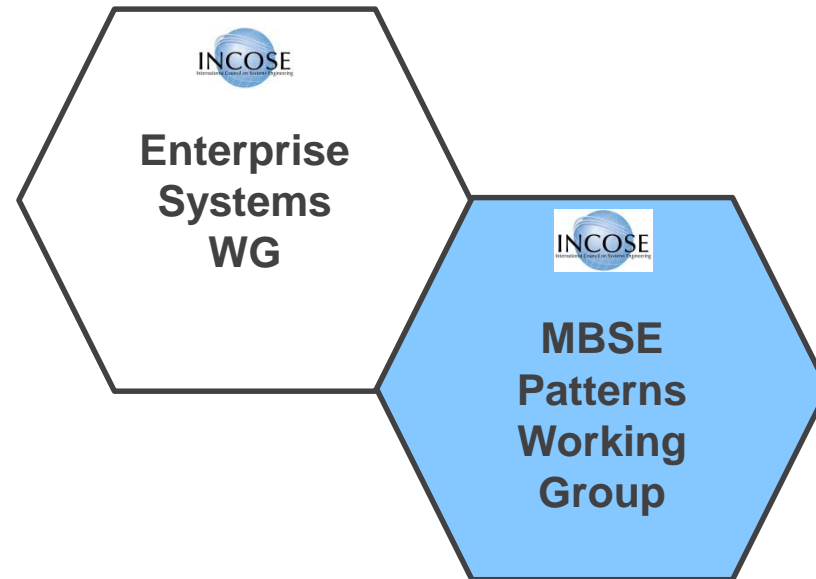
Platform architectures increase agility by rapidly lowering information debt earlier.



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



S3 Pattern and INCOSE OCM— Enterprise WG collaboration



Primary Contacts:
Enterprise WG--
Willy Donaldson,
Kevin Nortrup

S3 Pattern and INCOSE OCM— Enterprise WG collaboration

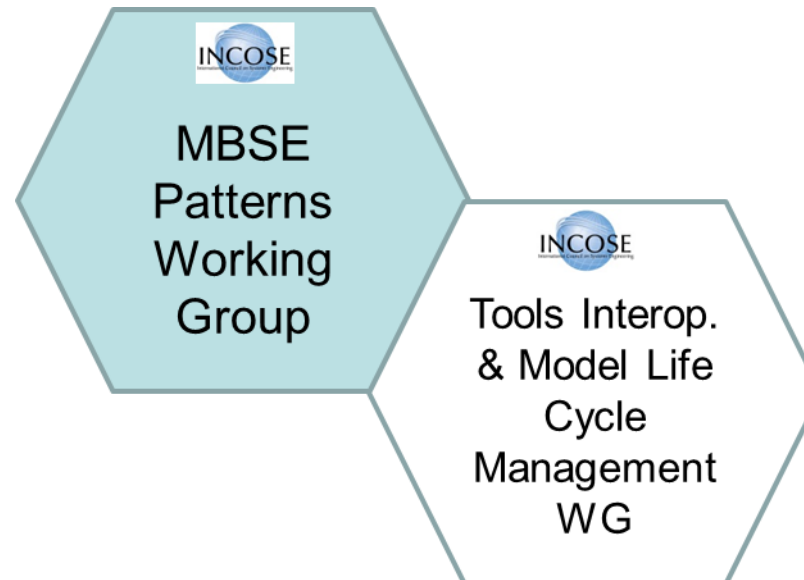


- In 2017, INCOSE Tech Ops asked the Enterprise WG to take a lead role in the Organizational Change Management (OCM) aspect associated with assimilating technical advances coming out of the other INCOSE WGs.
- Patterns WG supporting this by providing S*Patterns support, based on the INCOSE ASELCM Pattern (S3-S2-S1), where S3 is the focus of change to S2 methods, practice, performance.

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



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



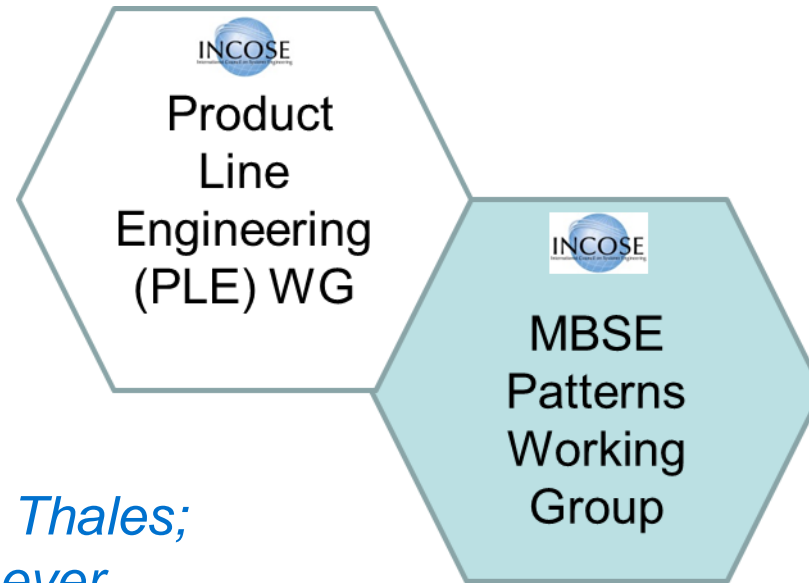
Primary Contact:
Lonnie VanZandt,
John Nallon,
TIMLM WG

TIMLM Patterns Project: July 2018 Status



- Model Life Cycle Management:
 - Joined ASME VV50 Standards Committee, Model Life Cycle Working Group, in 2016
 - NIST, DOE, Boeing, ICTT System Sciences, Bosch, GE, others working on a model-based framework describing the life cycle management of models, with special emphasis on gaining and maintaining the credibility (VVUQ) of models over their life.
 - Part of this is also a model planning framework INCOSE beta product of the Patterns WG and INCOSE MBSE Transformation
- Federated Model Repository Reference Pattern:
 - Supporting V4 Institute project creating this reference pattern, with special emphasis on Model Credibility / Model VVUQ
- Mapping to COTS-based toolchain:
 - Demonstrated mapping of the underlying S*Metamodel underlying all S*MBSE Patterns to multiple third party COTS toolsets, including multiple SysML modeling tools, multiple PLM systems, engineering Requirements Management toolsets, etc. (steady flow of additions)
 - Incorporating into S*Patterns Starter Kit as suggested by Patterns WG membership
 - Part of the overall S*Patterns Reference Landscape for managing public, private, and hybrid IP

PLE Working Group Collaboration



Primary Contacts:

*Guillermo Chale-Gongora, Thales;
Charles Krueger, Big Lever*

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



PLE WG Joint Project: Jan 2018 Status

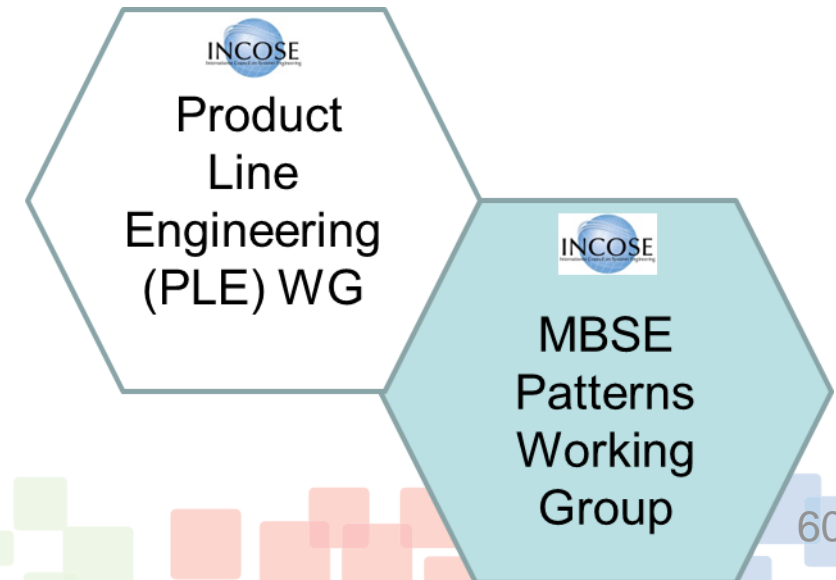
- Sample COTS legacy system document (sanitized) provided by PLE WG, for a legacy pneumatic control system product line
- Projected legacy data onto S*Pattern space, identifying S*Features, S*Interactions, S*Interfaces, S*States, S*Requirements
- Met with PLE WG at IW2018 to confirm next steps and interests

With Product Line Engineering (PLE) WG: Joint Activity Materials



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

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

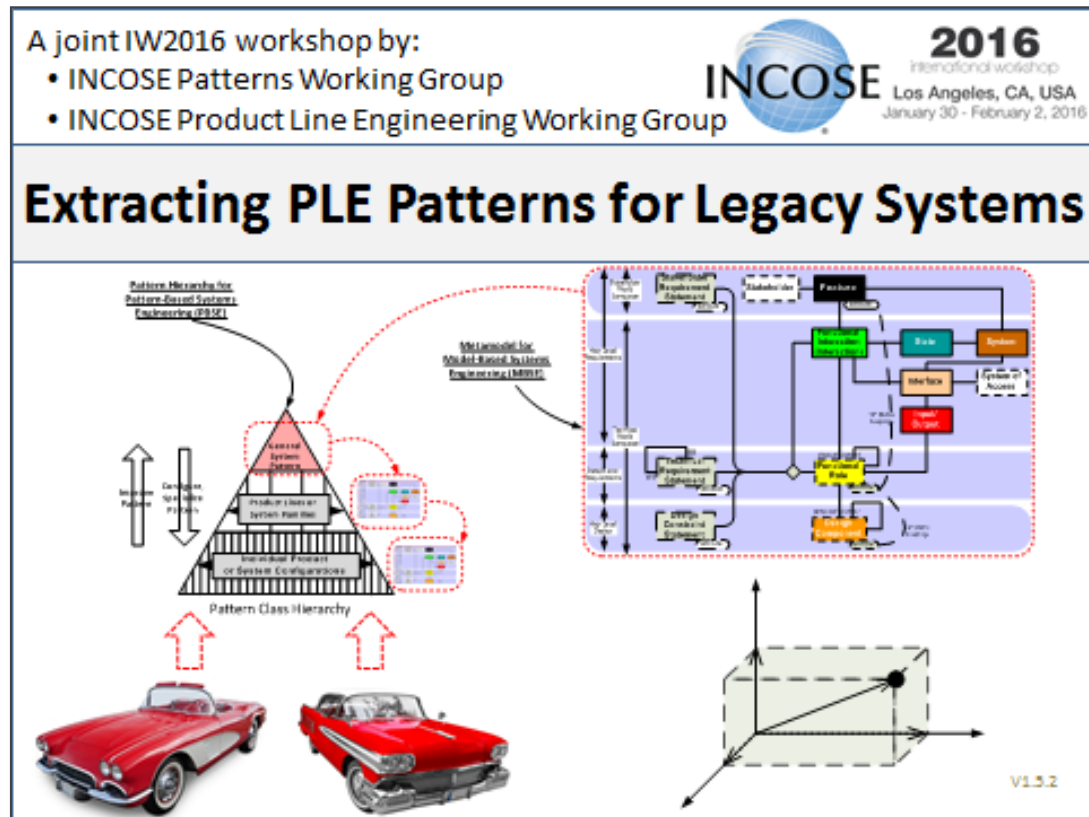


Project 1: Demonstration of Legacy Product Line Pattern Harvest, using Method of Projections



At the IW2016 joint meeting of the PLE and Patterns WGs, we reviewed a summary of the Method of Projections:

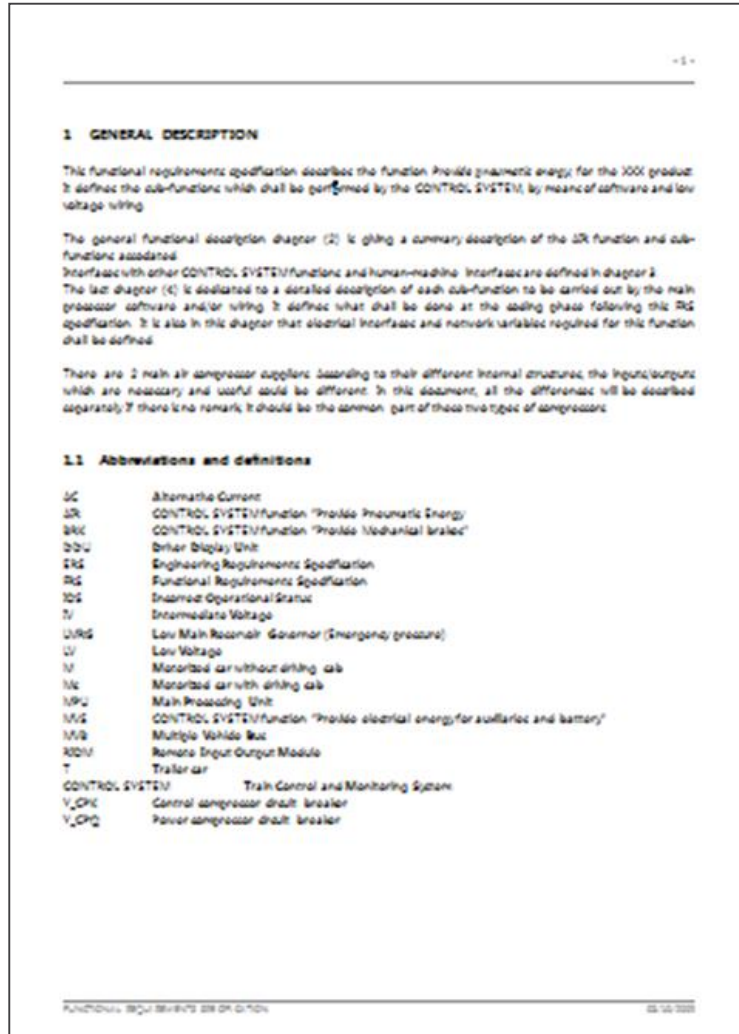
- Without a complete example, . . .
- With the intention of creating an example together in a future joint project of the two WGs.



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



- At the IW2017, joint meeting, the PLE WG provided the Patterns WG with a real world (sanitized) sample “legacy system” family document:
 - As a potential example (safety critical compressed air supply and control system) legacy document for harvesting an MBSE PLE Pattern.

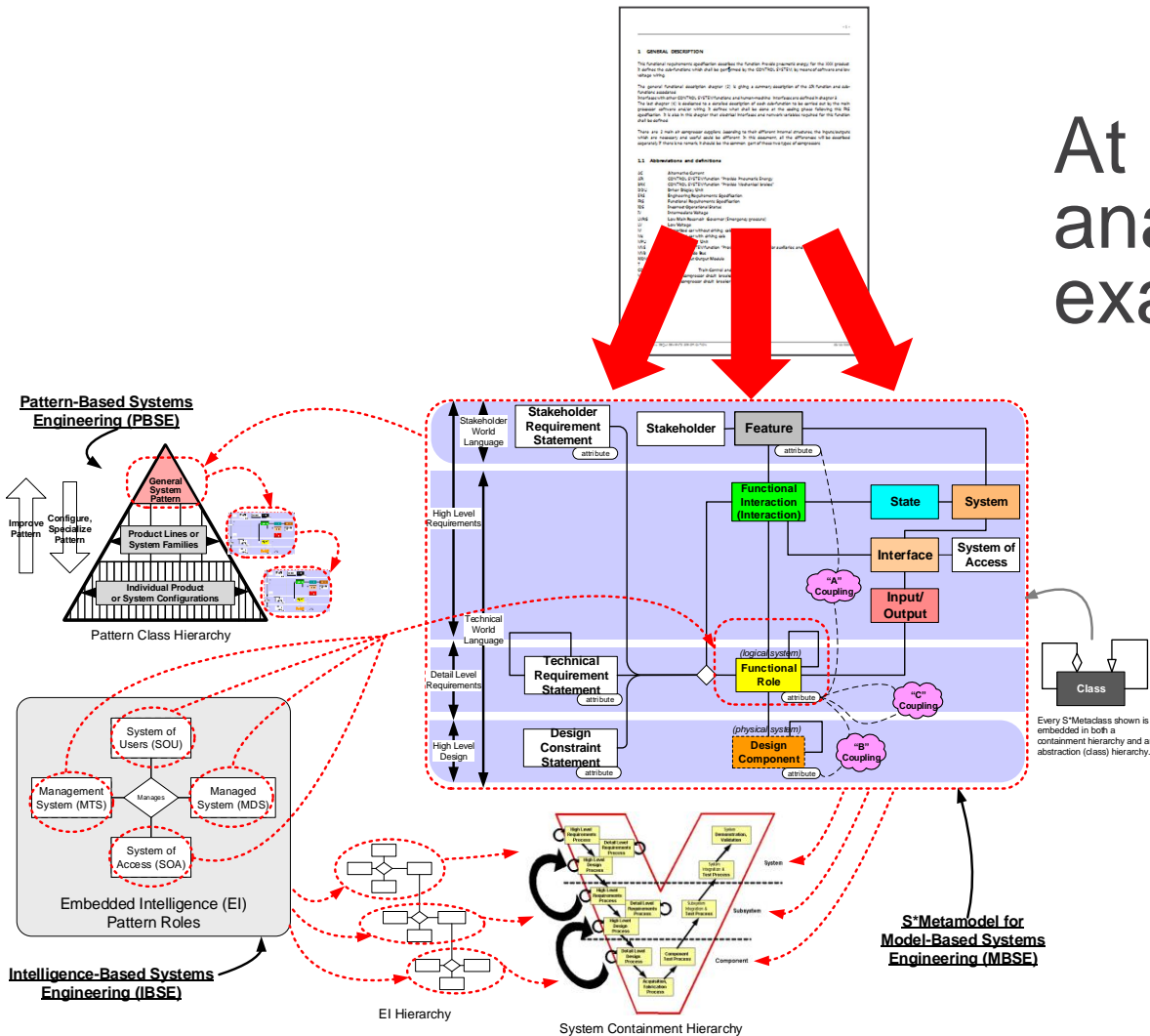


Project 1: Demonstration of Legacy Product Line Pattern Harvest, using Method of Projections



At IS2017, we reviewed the initial analysis and projection start-up for that example legacy data:

- With the special intention of deciding together some key things that we think the two WGs may agree is to be part of the special emphasis of this example;
- As the basis for continuing to work on next steps of this example.



Initial projections we see emerging from the legacy document provided (confirmed by PLE WG)

- System of Interest: MPU+Software (does PLE WG concur?)
- Actors: Train, Car, Reservoir, Compressor, Air Loads, Atmosphere, ...
- Interactions: Control Supply Air, Provide Management Information,
- States (Modes): Off, Idle, Daily Alternation, Normal, Assist, Emergency, Failure Modes, ...
- Input-Outputs: Supply Air, Status, Command, . . .
- Interfaces: Compressor Interface, Driver Interface, . . .
- Stakeholder Features: Air Service, Management Service, Safety, Configurability, . . .
- Requirements, Attributes, Attribute Couplings, Design Components, . . .



Preamble (assumptions, confirmed at IW2018)

1. A product line can (profitably) exist and be managed even though it is not described by a model, MBSE pattern, etc.
2. An MBSE Pattern is not a product line itself, but it can be a model of a product line.
3. Some (not all) MBSE Patterns can be said to describe Product Lines or Platform Systems.
4. Some Product Lines might already be described by MBSE Models, but not all have been.

Points of value add we want to emphasize in the example (confirmed at IW2018)



- Since an existing product line might not already be described by an MBSE model, then . . .
- Describing such a product line with an explicit MBSE Pattern has first of all the same kinds of potential benefits as describing system with an MBSE model:
 - reduce ambiguity,
 - improve understanding,
 - increase ability to answer analytic questions,
 - improve ability to supplement human work with automation
 - Increase ability for the whole life cycle 15288 process set to perform against a more integrated and consistent source of information

Points of value add we want to emphasize in the example (confirmed at IW2018)



- Product lines, and S*Patterns, have fixed and variable (configurable) aspects
- One view of an analyzed and automation-supported Product Line is that:
 - the variable aspects have been explicated, but . . .
 - the fixed parts, described by information “assets” that may not be model-based, *might* still be in legacy form

Points of value add we want to emphasize in the example (confirmed at IW2018)



- So, we assert that a good target for value add to the PLE WG by the MBSE Patterns WG in this example will be:
 - Even if the product line already had been analyzed for its *variable* (configurable) aspects, this demonstration adds ...
 - How to harvest an MBSE-based version of the *fixed* parts of the product line description, integrated with the variable aspects, gaining the other benefits of MBSE representation in addition to configurability.

Points of value add we want to emphasize in the example (confirmed at IW2018)



- In harvesting an MBSE Pattern for the content of the fixed part, the initial projection part of the Method of Projections is not the whole story . . .
- Within sub-spaces of the resulting model, the States, Interfaces, Features, and Interactions all act on each other to point out both incomplete and inconsistent aspects, leading to “blossoming” of the model in those subspaces
- This further improves the MBSE models’ completeness and consistency
- We agreed that this is one of our demonstration’s focal aspects

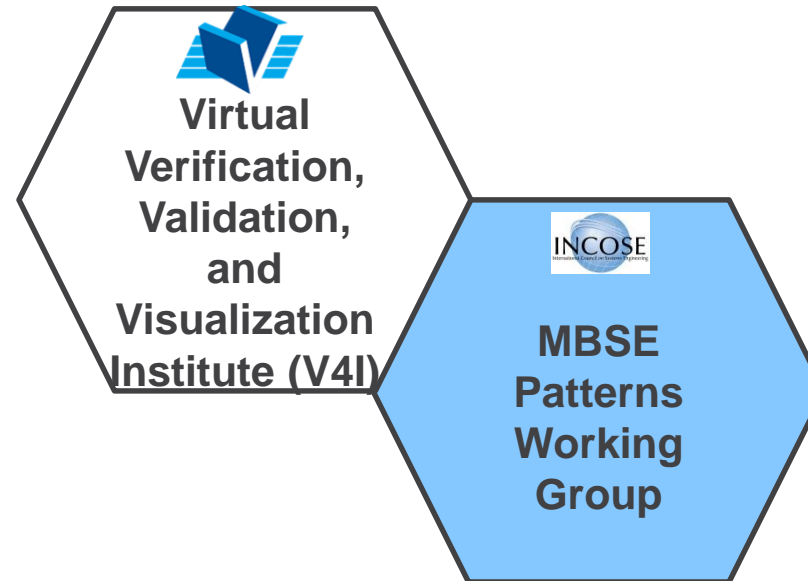
System Interactions

Making the Heart of Systems More Visible

William D. Schindel
ICTT System Sciences schindel@ictt.com

INCOSE GLRC 2013: Leadership Through Systems Engineering
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V4 Institute Collaboration



Primary Contacts:

John Matlik, Rolls-Royce, V4 Institute;
Ralph Resnick, NCDMM

V4 Institute Collaboration

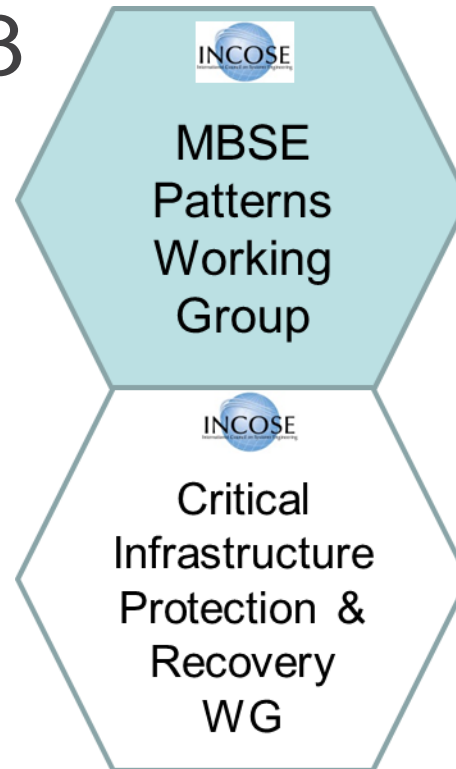


- The V4 Institute (<http://v4i.us/>) is a private-public collaboration of midwestern US industry, academia, and government:
 - Mission to raise competency in use of models to advance effectiveness of innovation—particularly in regulated markets such as flight and medicine.
 - Organized under National Center for Defense Machining and Manufacturing (NCDMM), parent of America Makes.
 - Membership includes Rolls-Royce, Johnson & Johnson, ICTT System Sciences, Notre Dame U, Vanderbilt U, Indiana U, Purdue U.
 - Member-driven roadmap, collaboration with ASME, INCOSE
- Working public reference projects for product design type certification, manufacturing process type certification, model VVUQ, reference model for model life cycle repositories, simulation and engineering tools S*mappings.
- Collaborations: Model VVUQ Pattern; Model Life Cycle Repository Reference Pattern; System of Innovation Pattern

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



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



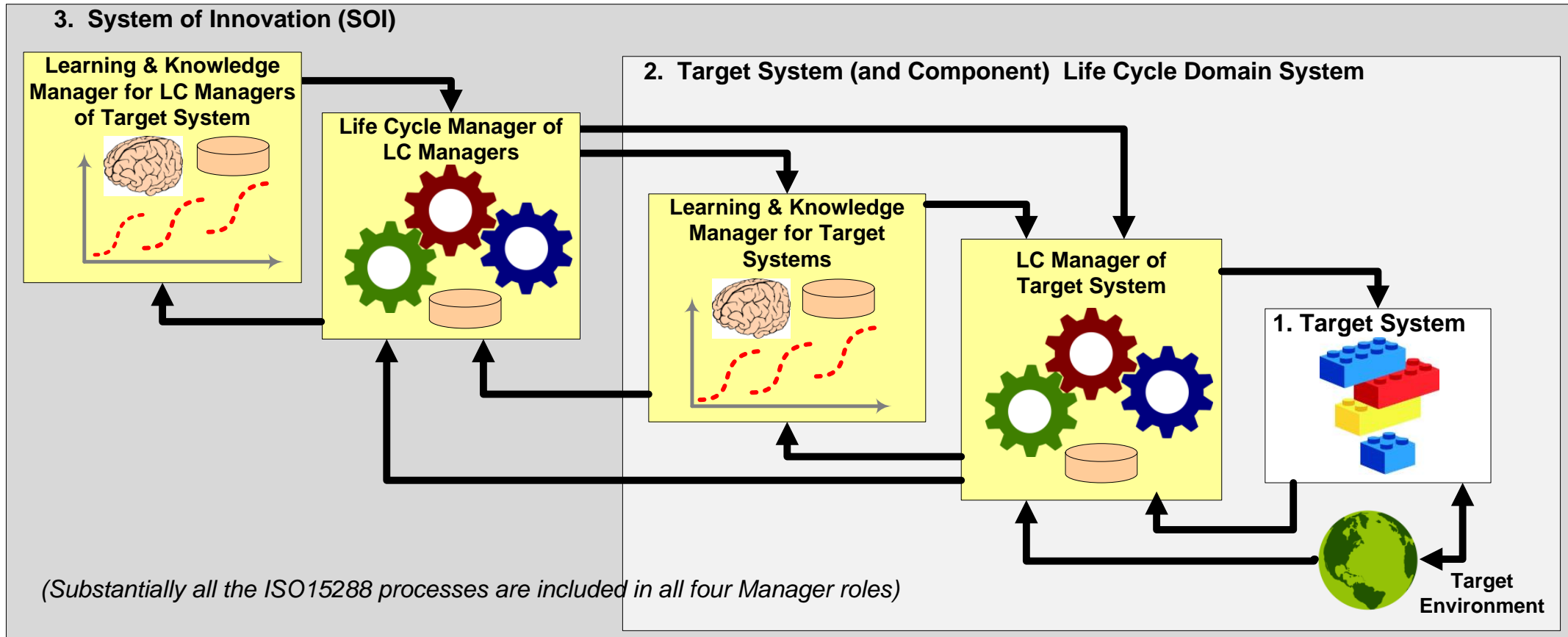
Primary Contact:
Mike DeLamar, Bechtel

CIPR Pattern Collaboration: July 2018 Status



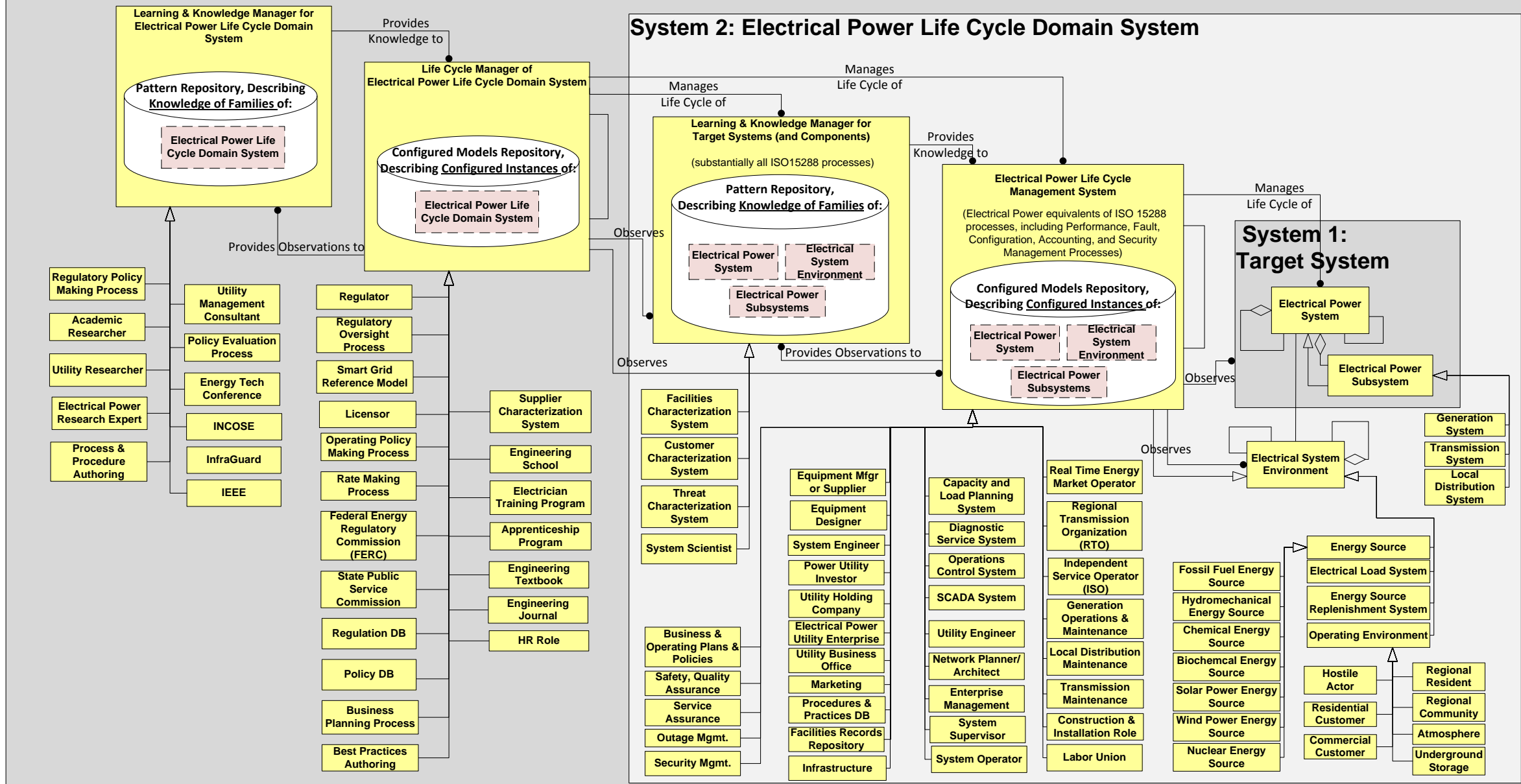
- During 2016-17, applied the ASELCM Pattern to a general Critical Infrastructure Pattern (all 16 DHS CI Systems) and a more detailed Electrical Power Grid Pattern
 - Used as basis summarizing related track discussion at ET 2016, and now subject of a related ET Proceedings publication being created by the conference.
 - Used as basis of support for project by J. Marvin, J. Cadigan, et al to demonstrate model-based framework for Big Data simulation and validation of power grid model behavior in presence of local solar generation and resale, weather variation, etc., presented by J Marvin at ET2017.
- During 2017, CIPR WG pursued SysML model of Microgrid, providing a case study about why the industry (EPRI, then ISO) CIM model is not being used as basis for that model:
 - Perhaps an illustration of the ASELCM System 3 observation we have made about general enthusiasm/tendency for re-creating from scratch models repeatedly versus sharing and improving existing models—an interesting challenge for INCOSE to consider.

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 3: Electrical Power System of Innovation (SOI)



System 2, 3 framework for Electrical Power Grid

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



System 3: Electrical Power System of Innovation (SOI)

Show as SoS

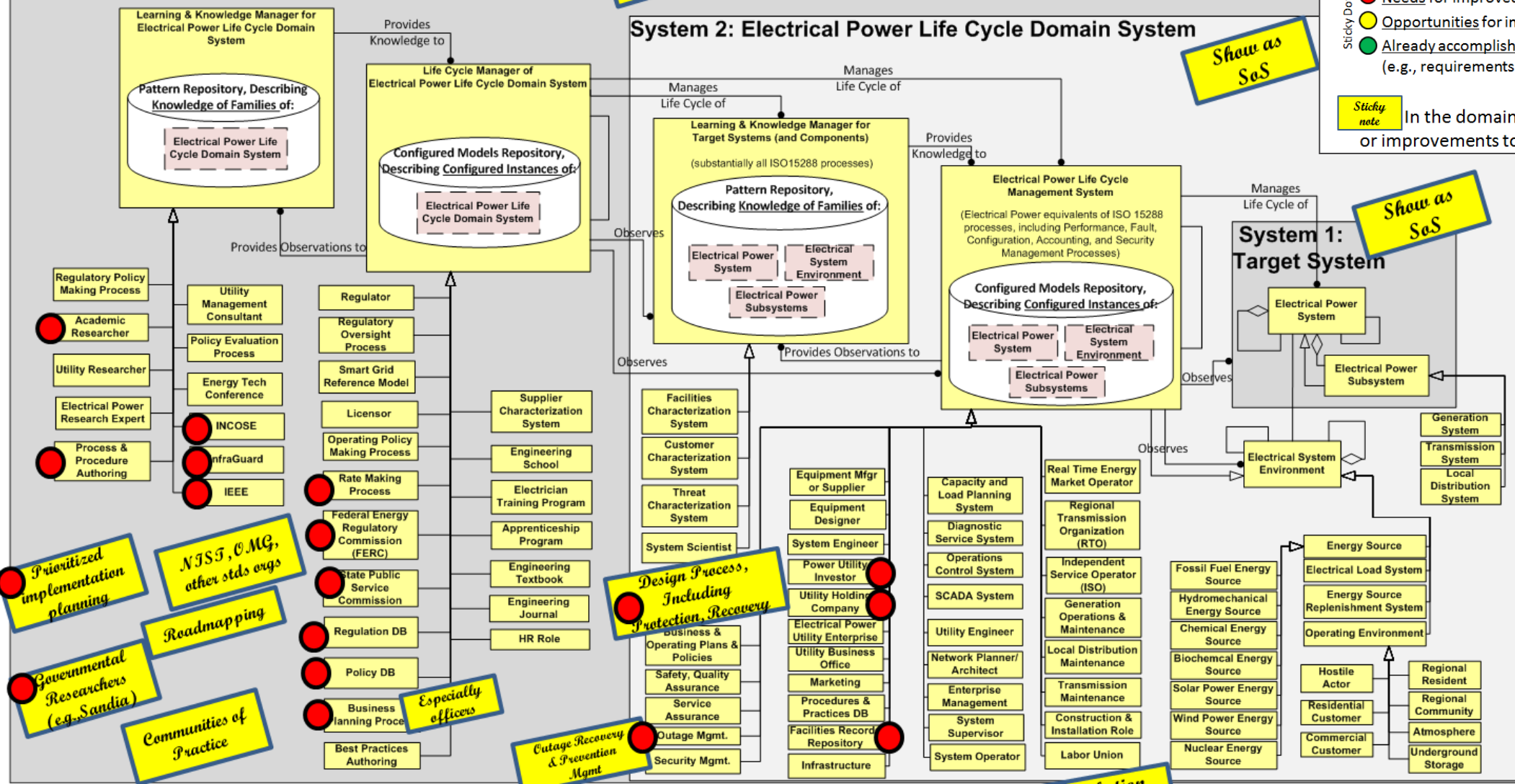
System 2: Electrical Power Life Cycle Domain System

Show as SoS

System 1: Target System

Show as SoS

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



Prioritized implementation planning
 Governmental Researchers (e.g., Sandia)
 Roadmapping
 Communities of Practice

Regulator
 Smart Grid Reference Model
 Licensor
 Operating Policy Making Process
 Rate Making Process
 Federal Energy Regulatory Commission (FERC)
 State Public Service Commission
 Regulation DB
 Policy DB
 Business Planning Process
 Best Practices Authoring

Design Process, Including Protection, Recovery
 Equipment Mfg or Supplier
 Equipment Designer
 System Engineer
 Power Utility Investor
 Utility Holding Company
 Electrical Power Utility Enterprise
 Utility Business Office
 Marketing
 Procedures & Practices DB
 Facilities Record Repository
 Infrastructure

Outage Recovery & Prevention Mgmt

Resilience Model

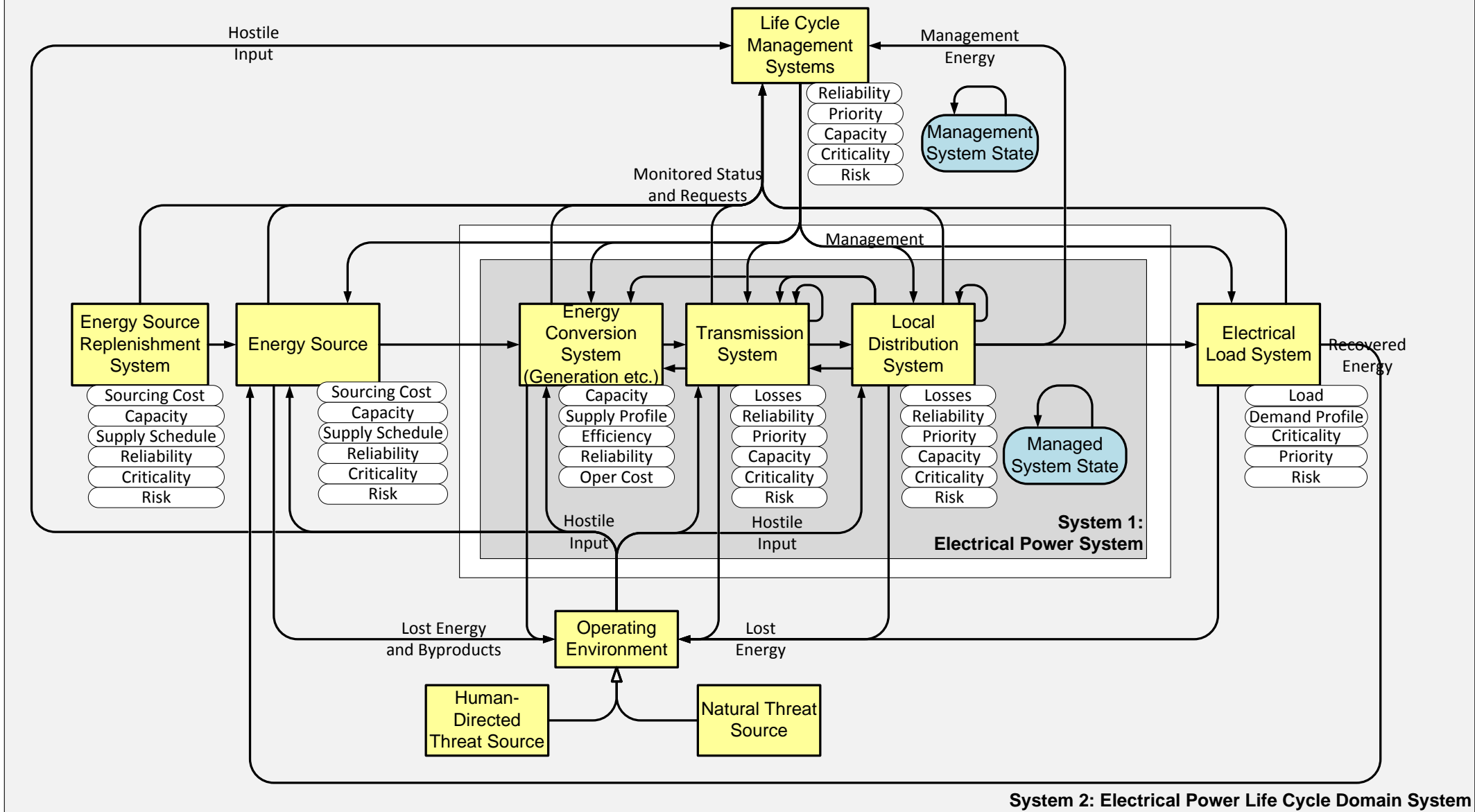
Group related roles

Simulation Tools

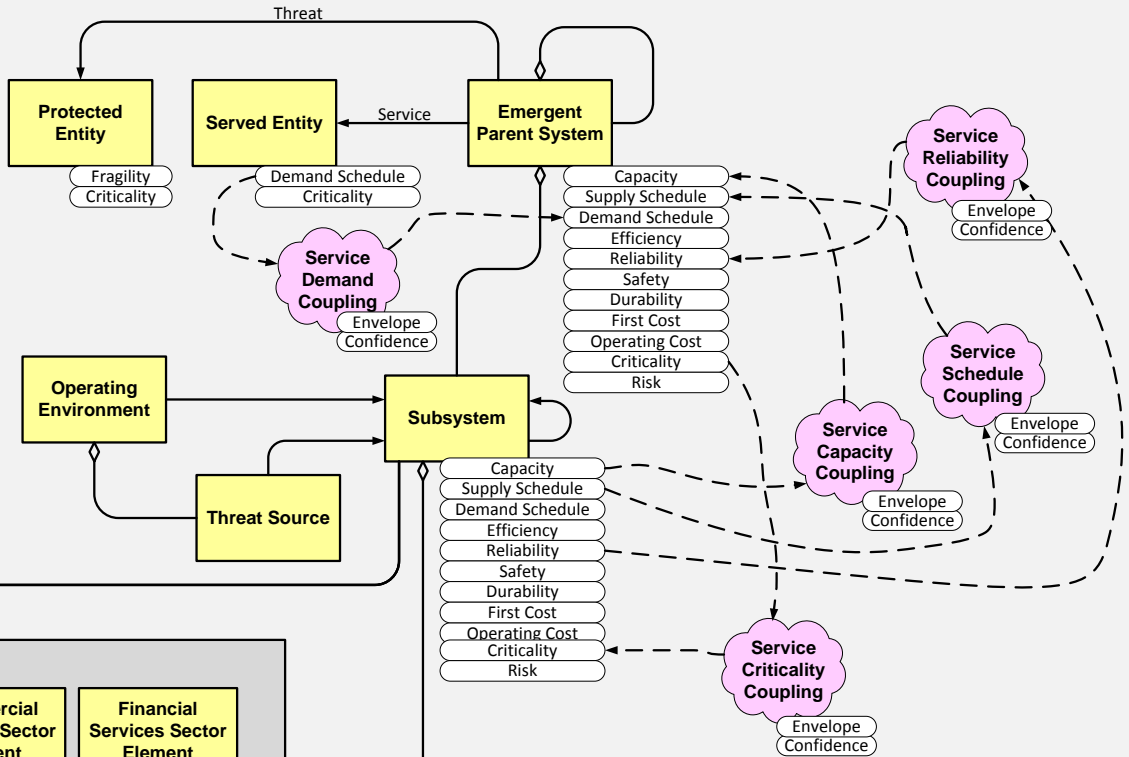
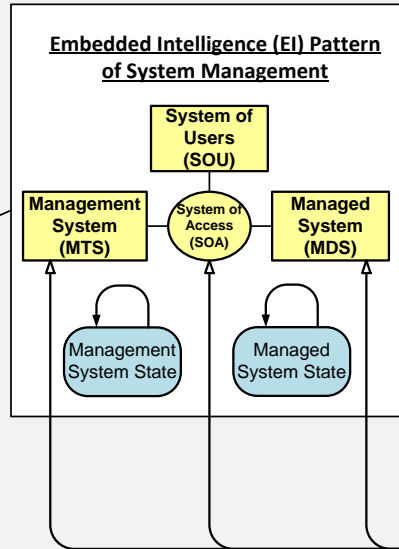
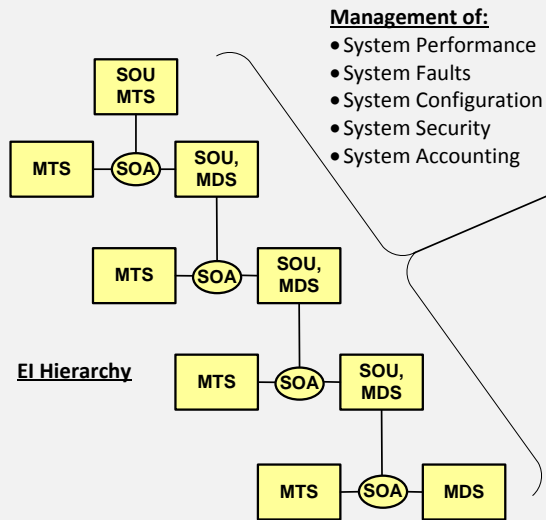
Insurers

Especially officers

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



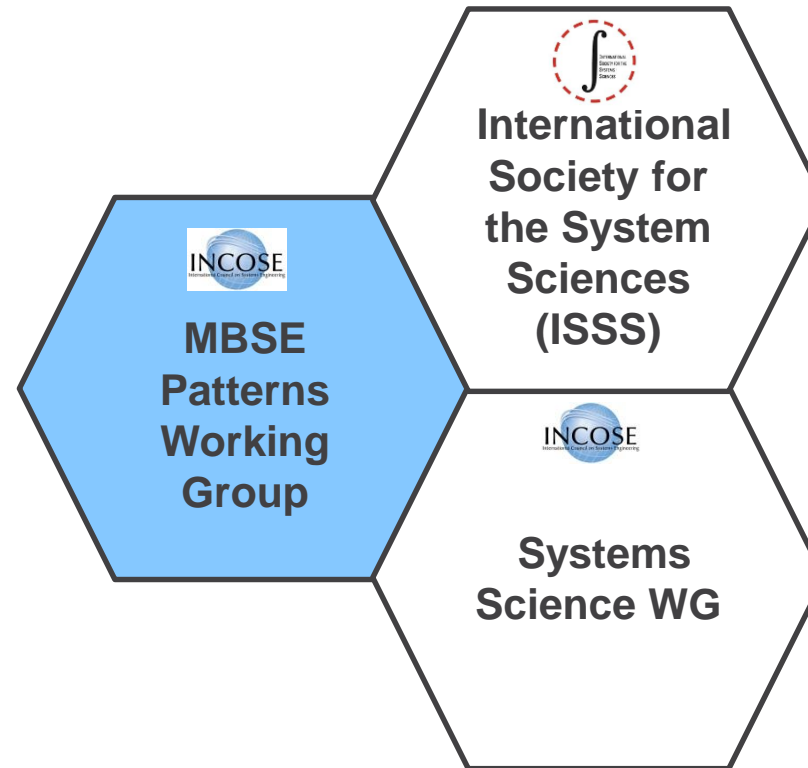
System 1: Critical Infrastructure System
(Per DHS and PPD-21)

Information Technology Sector Element	Chemical Sector Element	Commercial Facilities Sector Element	Financial Services Sector Element
Nuclear Reactors, Materials, Waste Sector Element	Critical Manufacturing Sector Element	Communications Sector Element	Food and Agricultural Sector Element
Transportation Systems Sector Element	Dams Sector Element	Defense Industrial Base Sector Element	Government Facilities Sector Element
Water and Wastewater Systems Sector Element	Emergency Services Sector Element	Energy Sector Element	Healthcare and Public Health Sector Element

System 2: Application Life Cycle Domain System

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

Collaboration: ISSS and System Science WG



Primary Contact:
James Martin,
David Rousseau

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



SSWG Collaboration Status July 2018

- Invited presentation to IW2018 SSWG, on System Phenomenon Pattern as the existing used basis for the domain-specific hard sciences (mechanics, chemistry, et al)
 - Related INCOSE publication on System Phenomenon, IS2017.
- Summary: Some systems people seem to be asserting there is a wonderful theory of systems not yet discovered. We assert that there is a wonderful theory of systems already discovered by the pioneers of physical sciences and mathematics, but it is being overlooked by some of the systems community.
- Using well-established existing frameworks from Hamilton (principle of stationary action, leading to fundamental equations at root of each physical science discipline), Noether (previous follows from symmetries, leading to conservation laws and emergent parameters),
- Presenting invited plenary to ISSS 2018 in Corvallis, OR, USA, July, 2018
- Contributing “System Patterns” chapter of *Handbook of System Science*, Springer.



Discussion

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Future Projects of Interest to Attendees

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