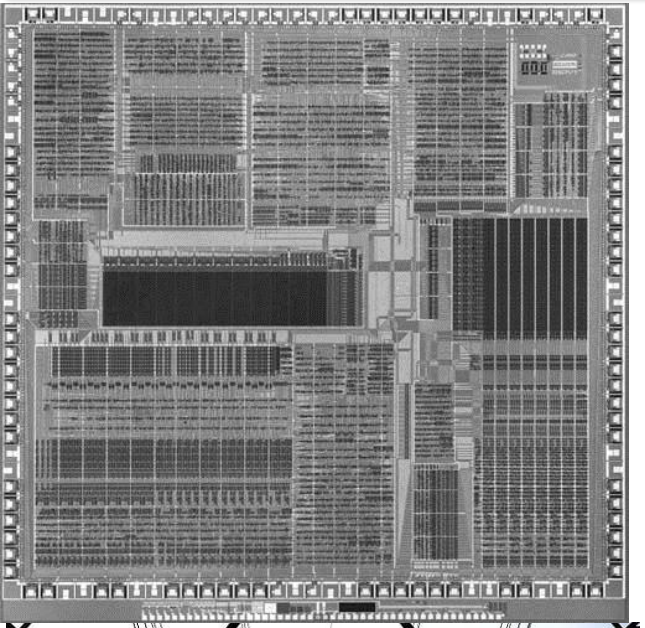
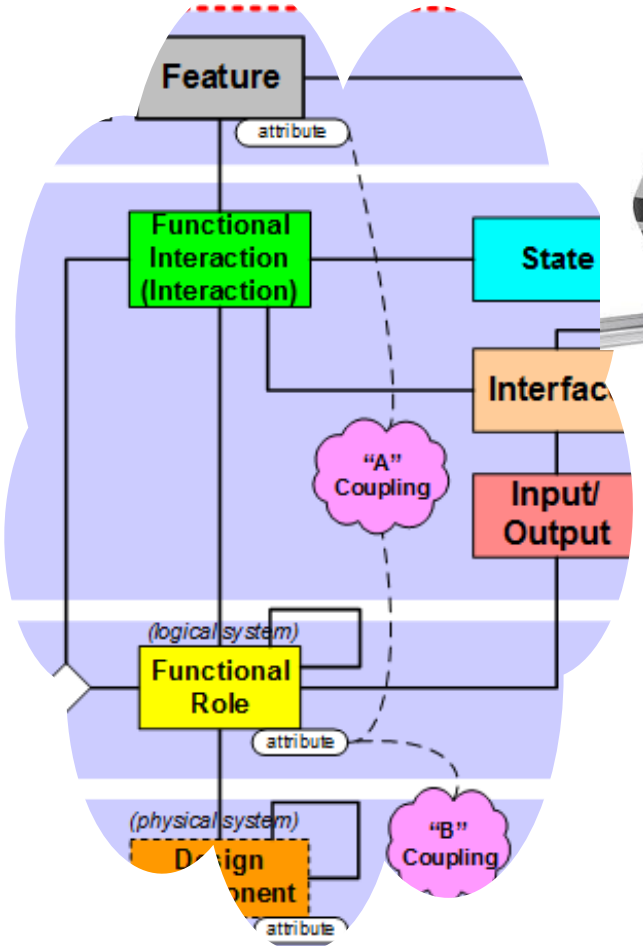
2019 Annual INCOSE international workshop
Torrance, CA, USA
January 26 - 29, 2019

MBSE Patterns Working Group





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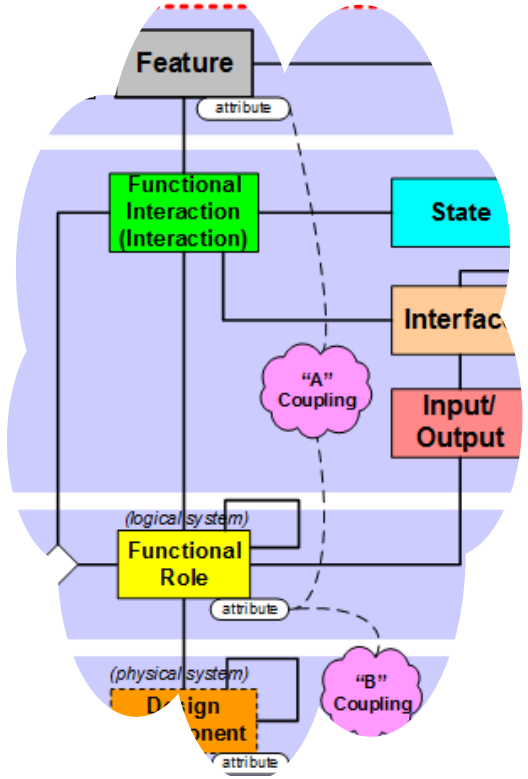
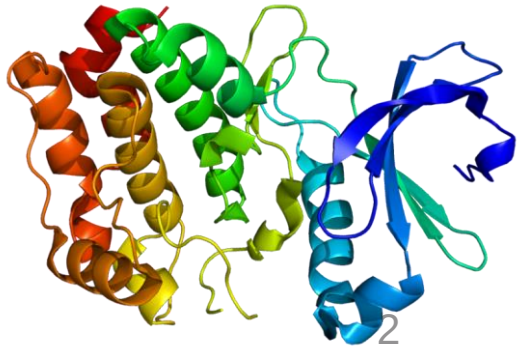
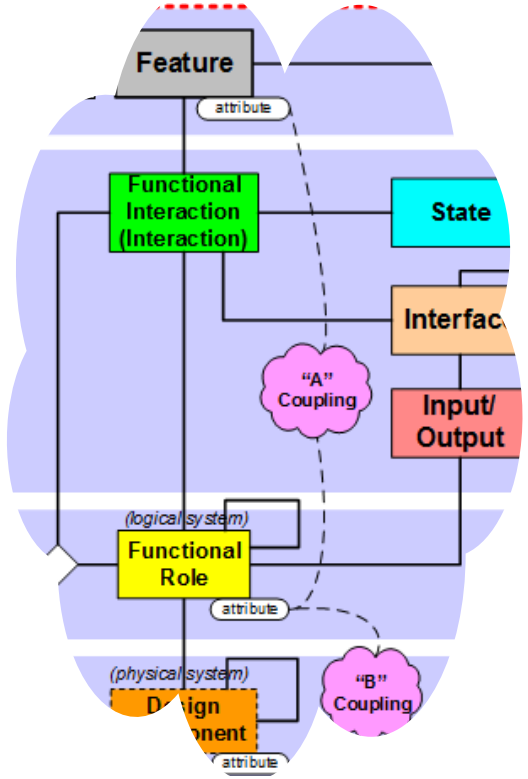


Contents

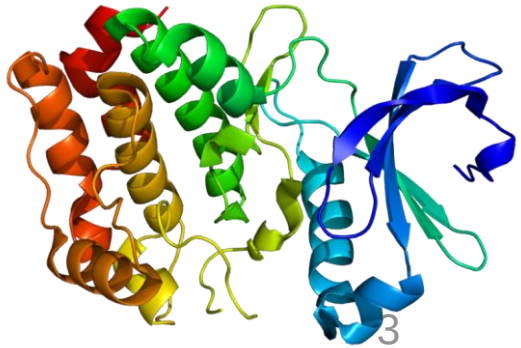
- Introduction to MBSE Patterns, and the Patterns WG
- Status of WG Projects
- Future Projects of Interest to Attendees
- References





Introduction to MBSE Patterns, and the Patterns WG

- Who we are—including our partners
- Types of activities
- IS2019 activities—when and where to find us
- How to get involved
- A "Patterns 101" introduction



As an INCOSE entity, we began six 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.

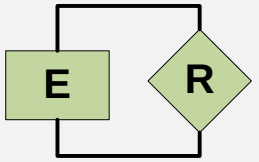
Emergence of Patterns from Patterns: S*Pattern Class Hierarchy

More General

More Specific

Definition of **Relational Modeling Paradigm**

Entity-Relationship Paradigm

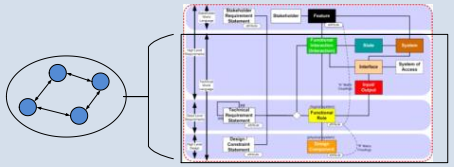


E=Entity
R= Relationship

Structured or unstructured semantic web

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

S*Metamodel Core



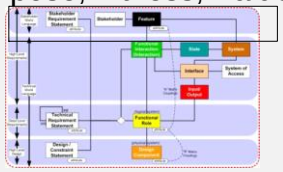
Core S*Metamodel

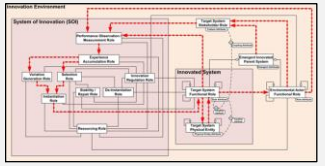
Smallest model of a system, for engineering or science

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

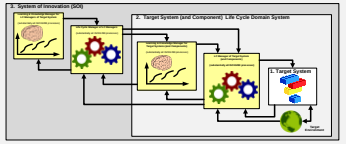
EI Pattern, SOI Pattern, Fitness, Value

S*Purpose, Fitness, Value

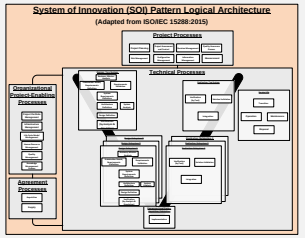




System of Innovation Pattern



Agile Sys Life Cycle Pattern

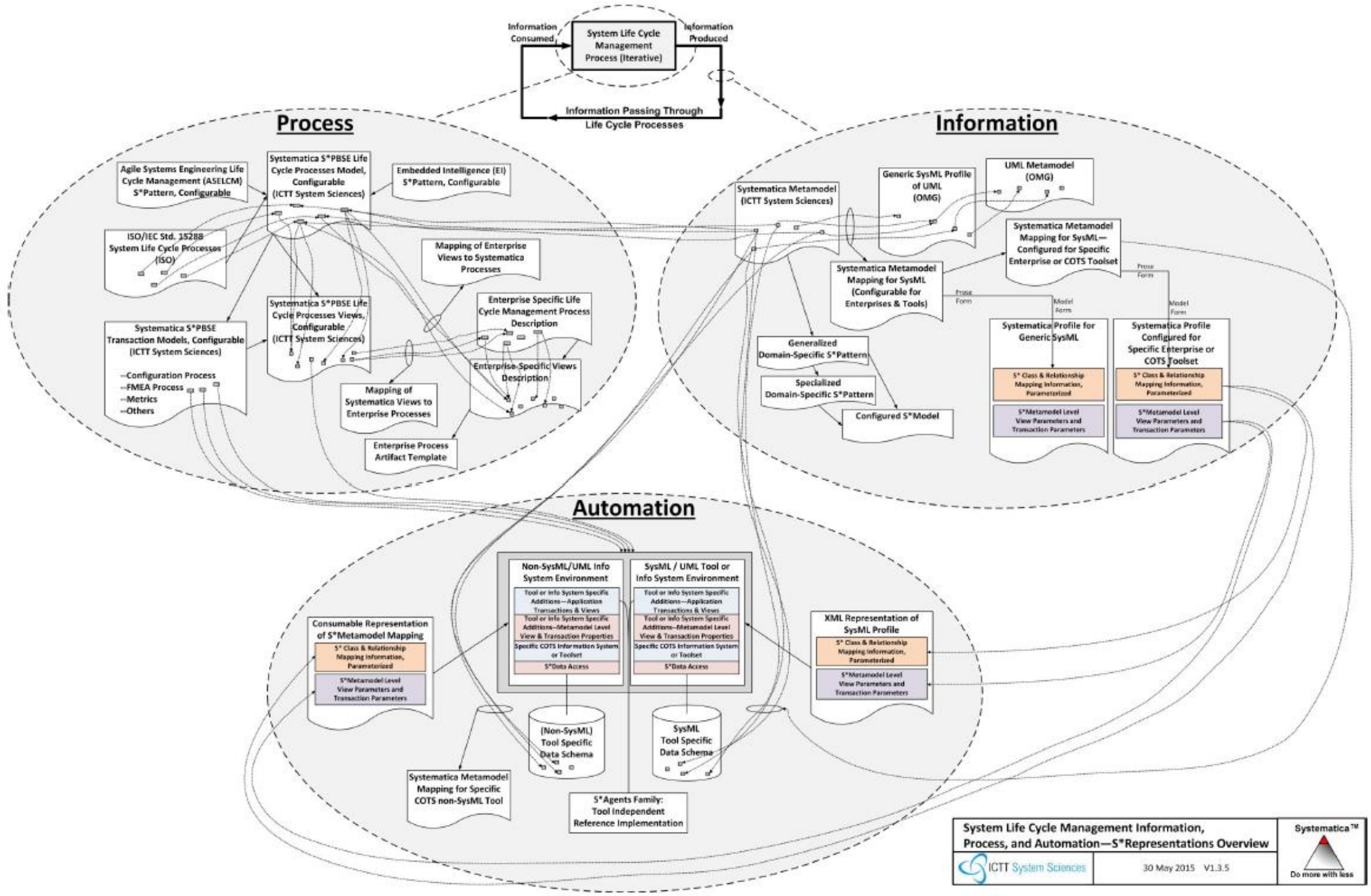


ISO 15288 System Life Cycle Mgmt Pattern

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



System Life Cycle Management Information, Process, and Automation—S*Representations Overview		Systematica™
ICTT System Sciences	30 May 2015 V1.3.5	Do more with less

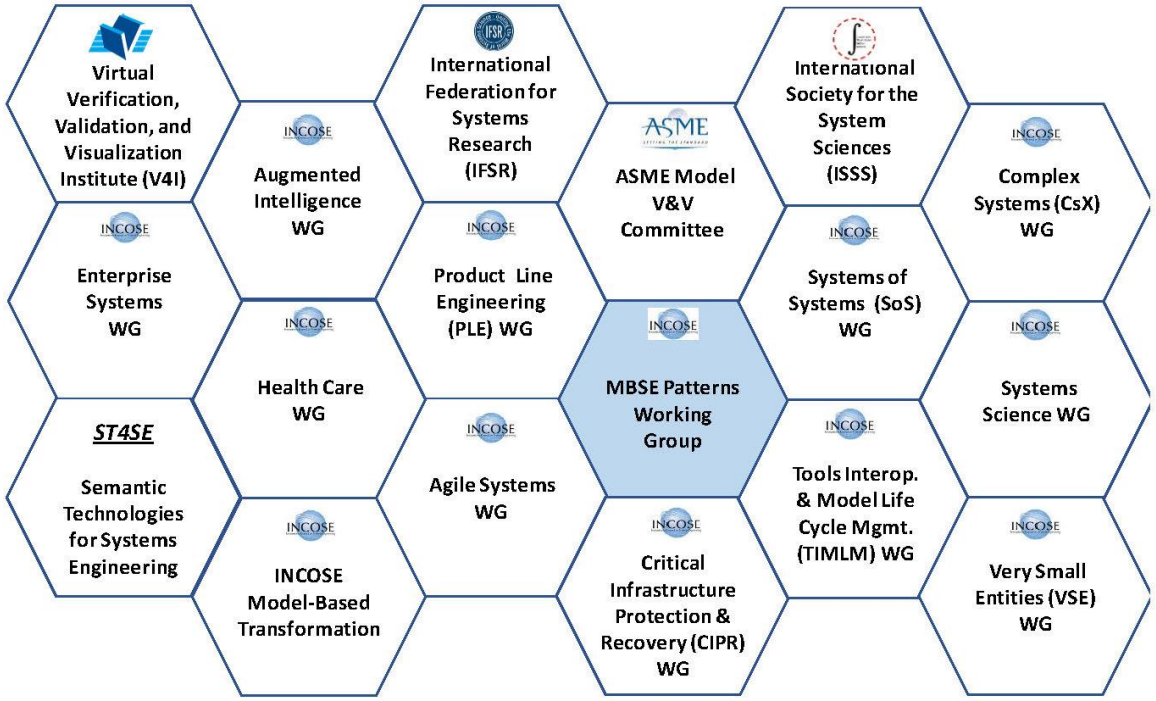
The INCOSE Patterns Working Group: *Who are we?*

- 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 six years, over 200 colleagues have participated in Patterns Working Group activities:
  - Team meetings, work sessions, tutorials, activities with other INCOSE and external 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
IW 2019 Patterns WG meeting web site:
http://www.omgwiki.org/MBSE/doku.php?id=mbse:patterns:mbse_patterns_wg_participation_in_incose_iw2019

Agenda, Partner Events of Interest: INCOSE MBSE Patterns Working Group, at IW2019, and Web Conferencing	US Pacific Time (PT)	Room	Global Meet

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



Patterns WG Pre-reading and Background:

Meeting materials for MBSE Patterns WG meeting at IW2019, January 27-28, 2019:
http://www.omgwiki.org/MBSE/doku.php?id=mbse:patterns:mbse_patterns_wg_participation_in_incose_iw2019

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 IW2019, and Web Conferencing	US Pacific Time (PT)	Room	Global Meet
Other Monday IW Sessions Related to MBSE Patterns: Joint session with System Science Working Group (SSWG), by Patterns Working Group.	**Monday** 9:00 – 10:00	*Pier 2+4*	--
MBSE Patterns WG Meeting (Day 2 of 2 Days): **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:** • • • **(continuing detailed topics list in Sunday meeting agenda *see above page*)** • • **(Joint Patterns WG – System Science WG session during 1:00 – 2:00, Pier 2+4)** • • **Future Project Interests of Attendees** **(Note: The above agenda topics will be spread across the Sunday and Monday meetings of this WG)**	**MONDAY** 1:00 – 5:00	*Salon B*	YES, Link below
Other Tuesday IW Sessions Related to MBSE Patterns: Increasing INCOSE collaborations with other Model Oriented Communities—outreach planning session Supporting enterprise transformations to model-based methods—Enterprise Working Group	**TUESDAY** 8:00 – 11:30 1:00 – 3:00	*Salon H* *Salon B*	-- --

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

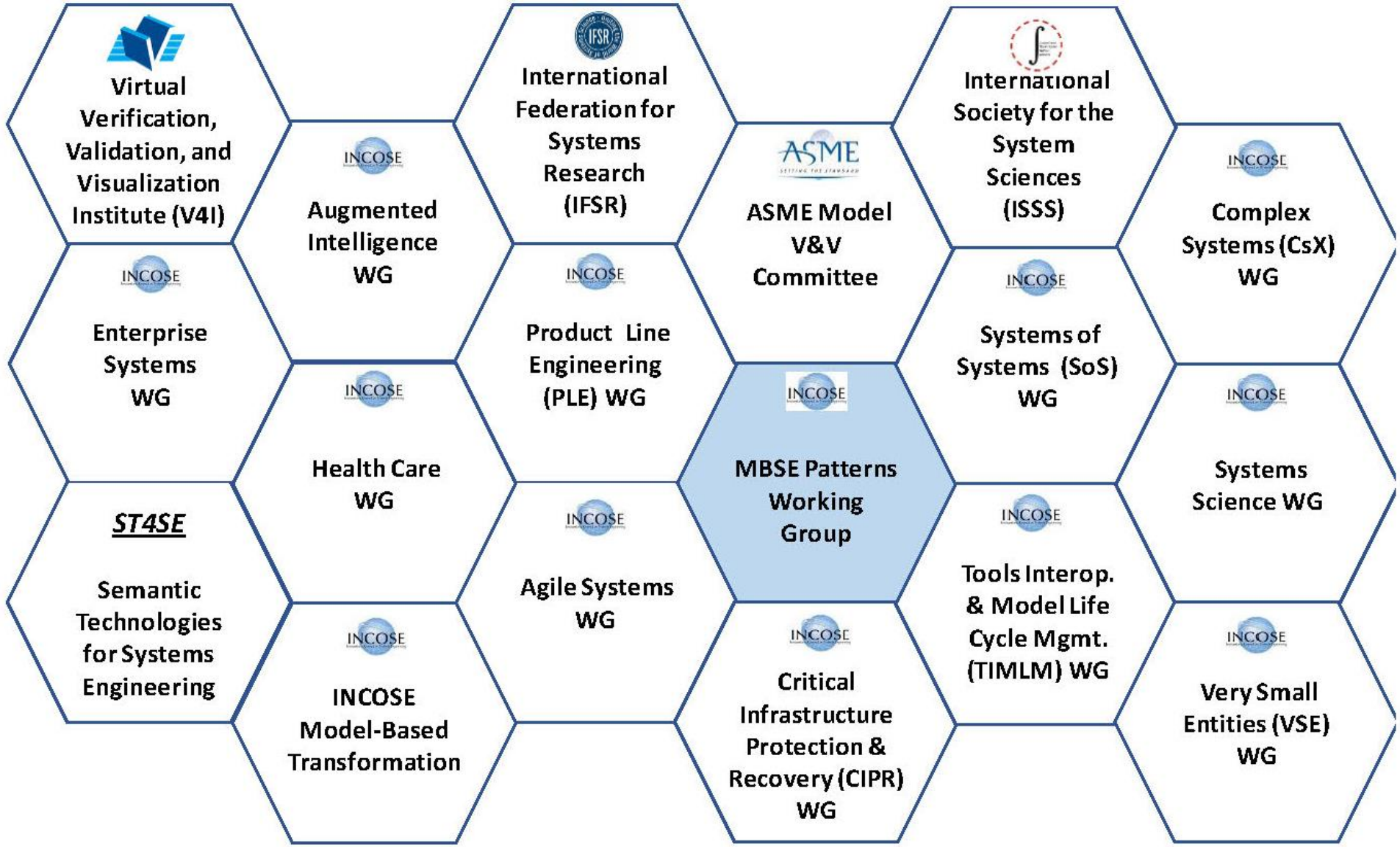
To remotely access the above Patterns WG sessions marked "YES" above for Global Meet in far-right column of above agenda:

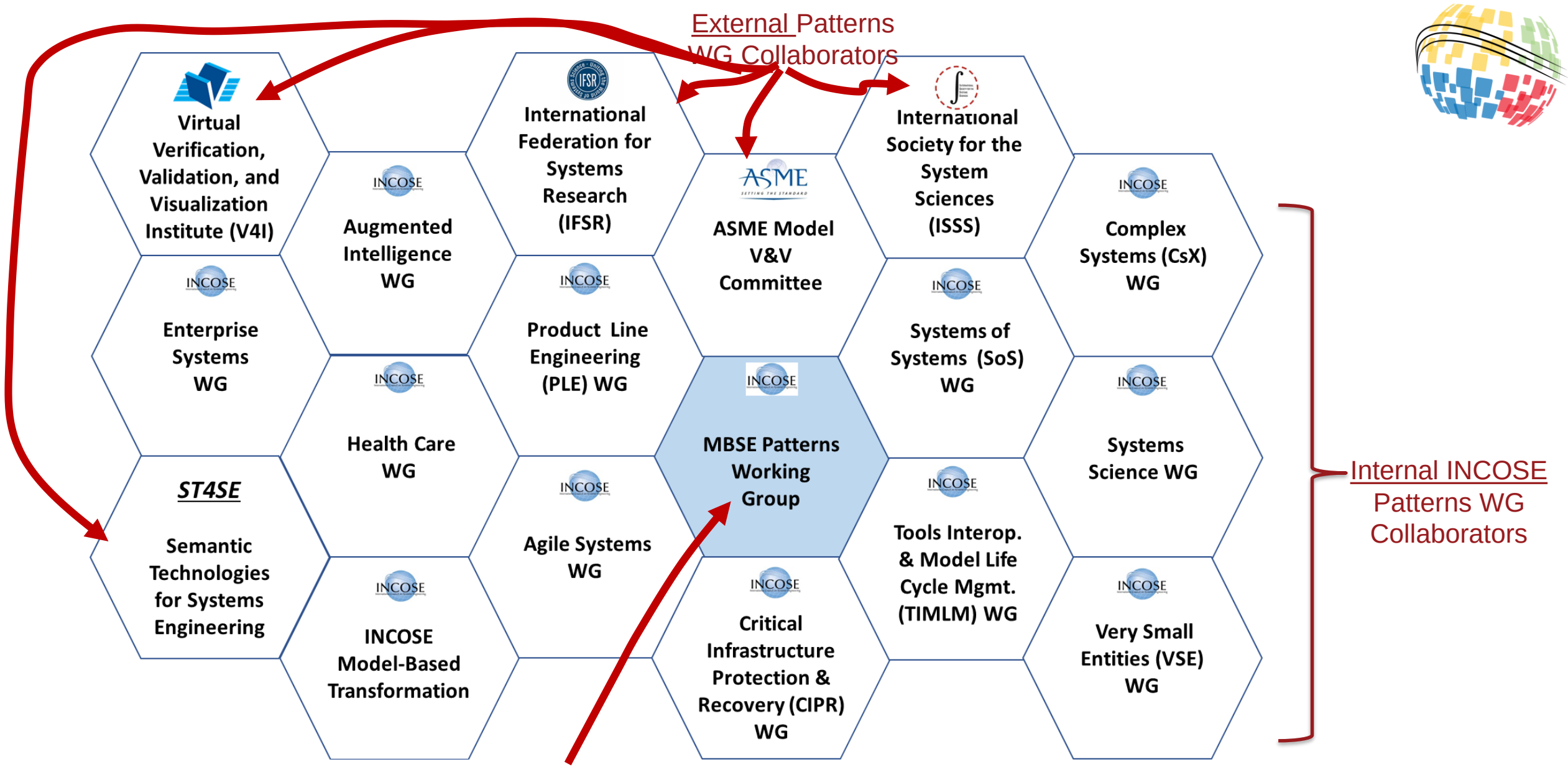
- PARTICIPANT GlobalMeet Join Details - Join as GUEST
Meeting Details Web Address: https://incose.pgimeet.com/GlobalmeetFourteen
Access Number: 1-719-867-1571
USA /Canada (toll free): 1-877-860-3058
Guest Passcode: 288 747 4803

Agenda, Partner Events of Interest: INCOSE MBSE Patterns Working Group, at IW2019, and Web Conferencing	US Pacific Time (PT)	Room	Global Meet
MBSE Workshop sessions, including: *MBSE Workshop Keynote* *7 short Saturday "Lightning Talks" on model-based engineering insights, including "A Patterns Storybook"* *Additional MBSE Workshop Sessions* *Attendee questions and discussion* *For MBSE Workshop schedule and details, see:* *https://www.incose.org/docs/default-source/events-documents/iw2019/2019_incose_iw_mbse_workshop_agenda.pdf?sfvrsn=4b0693c6_4*	***SATURDAY-SUNDAY***	*Salon E*	--
MBSE Patterns WG Meeting (Day 1 of 2 Days): following link provides meeting materials-- **http://www.omgwiki.org/MBSE/doku.php?id=mbse:patterns:mbse_patterns_wg_participation_in_incose_iw2019** **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:** • **ASELCM/System of Innovation Pattern, Links to Learning, VVUQ, and Future of SE** • **S3 Pattern and INCOSE OCM—Enterprise WG collaboration** • **Progress in Model VVUQ Reference Pattern / Model Wrapper (with ASME Stds Committee)** • **V4 Institute Collaboration on Virtual Verification** • **Medical Device Model VVUQ Application** • **Mappings to Frameworks and Tools (suggested by members at IS2018 meeting)** • **Semantic Technologies for SE (ST4SE) Collaboration (see also Sunday Hans-Peter DeKonig talk)** • **Patterns in the Public Square: Regulated Innovation (See also Tuesday IS Panel on this below)** • **IFSR Conversation Product: An MBE Manifesto (see also Saturday Ed Carroll Lightning talk)** • **Augmented Intelligence Challenge Team Collaboration** • **Interface Patterns Project** • **Agile Patterns Project and WG Collaboration, IS 2019 Report Paper** • **SysSciWG and ISSS Collaboration (see also Monday morning joint session with SSWG, below)** • **INCOSE outreach to Model Communities (see also Sunday AM session and Tuesday AM session)** **Future Project Interests of Attendees** **(Note: The above agenda topics will be spread across the Sunday and Monday meetings of this WG—see second meeting Monday afternoon, below)**	***SUNDAY*** 1:00 – 5:00	*Salon H*	YES, Link below

A hallmark of the Patterns WG:

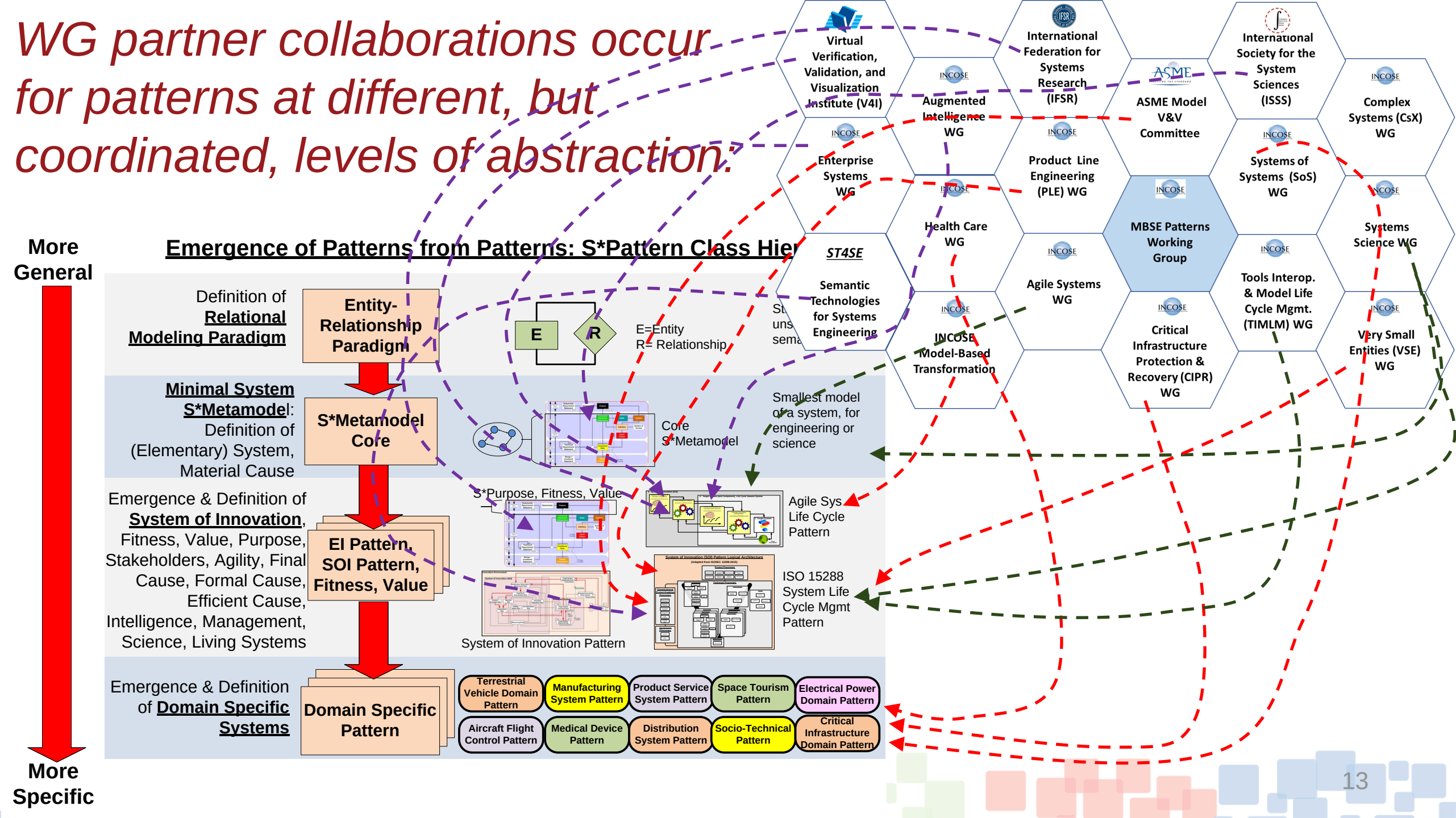
Most of our work is with other WGs or external entities--





INCOSE MBSE Patterns Working Group: Joint 2017-2019 activities, interests, collaborations, conversations, project partners

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



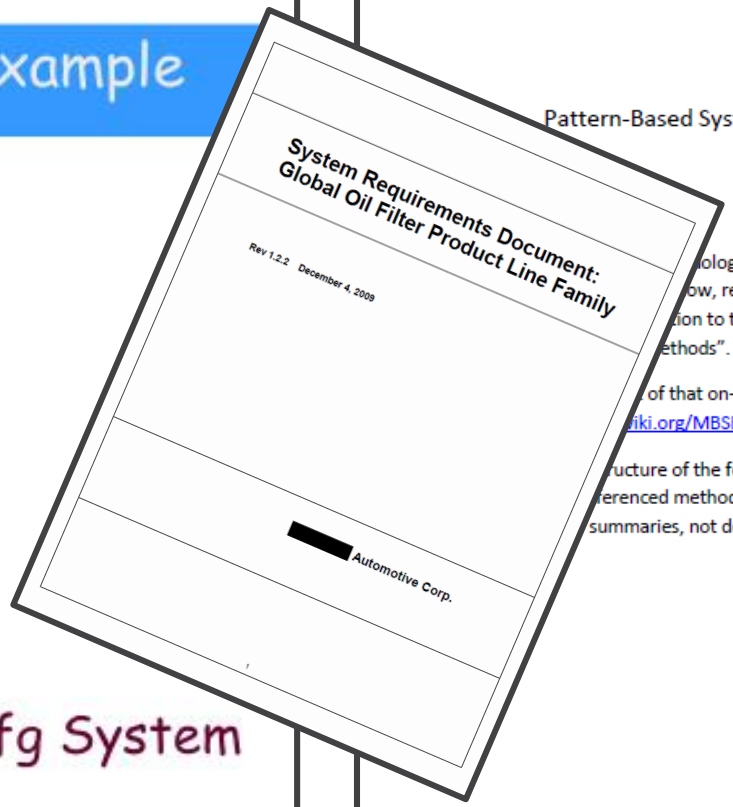
S*Patterns 101 Introduction References

Samples from a simple illustrative example

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

ICTT System Sciences

V1.4.3



MBSE Methodology Summary:

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

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

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

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

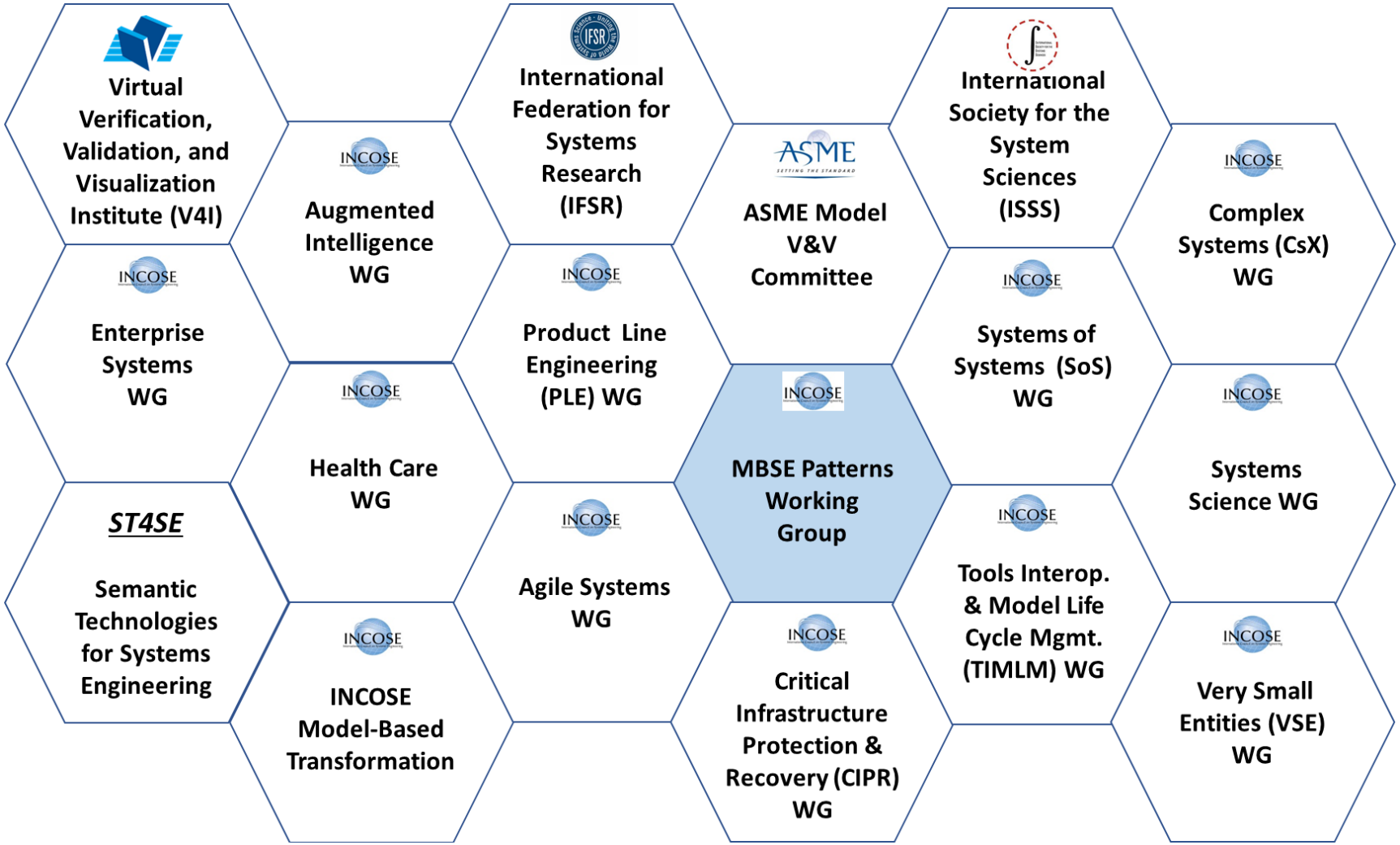
Patterns WG Collaborations and Projects: Current Status, Next Steps, Future Interests of Members:

Spread over Sunday and Monday meetings of this Patterns Working Group

Following project and collaboration summaries:

- ASELCM/System of Innovation Pattern, Learning, Model VVUQ, Future of SE
- S3 Pattern and INCOSE OCM—Enterprise WG collaboration
- Progress in Model VVUQ Ref Pattern / Model Wrapper (w/ASME Stds Cmte)
- V4 Institute Collaboration on Virtual Verification
- Medical Device Model VVUQ Application, FDA collaboration
- Patterns in the Public Square: Regulated Innovation
- Mappings to Frameworks and Tools (suggested by members at IS2018 meeting)
- Semantic Technologies for SE (ST4SE) Collaboration (see also Sunday Hans-Peter DeKonig talk)
- IFSR Conversation Product: MBE Manifesto (see also Saturday Ed Carroll talk)
- Augmented Intelligence Challenge Team Collaboration
- Interface Patterns Project
- SysSciWG and ISSS Collaboration (see also Monday AM joint session w/SSWG
- INCOSE outreach to Model Communities (see also Sun AM & and Tues AM sessions)

Working Group Partners in Progress

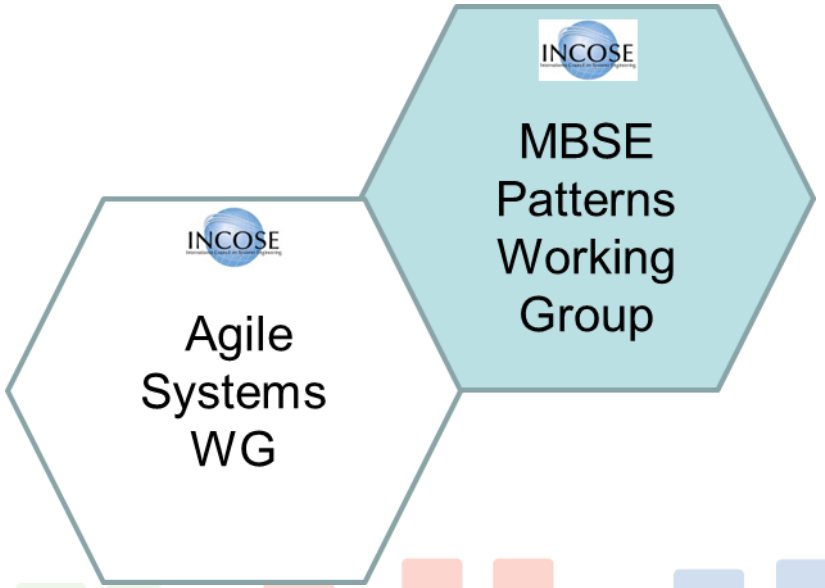


MBSE Patterns WG: Joint IW activities, interests, conversations, project partners

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.

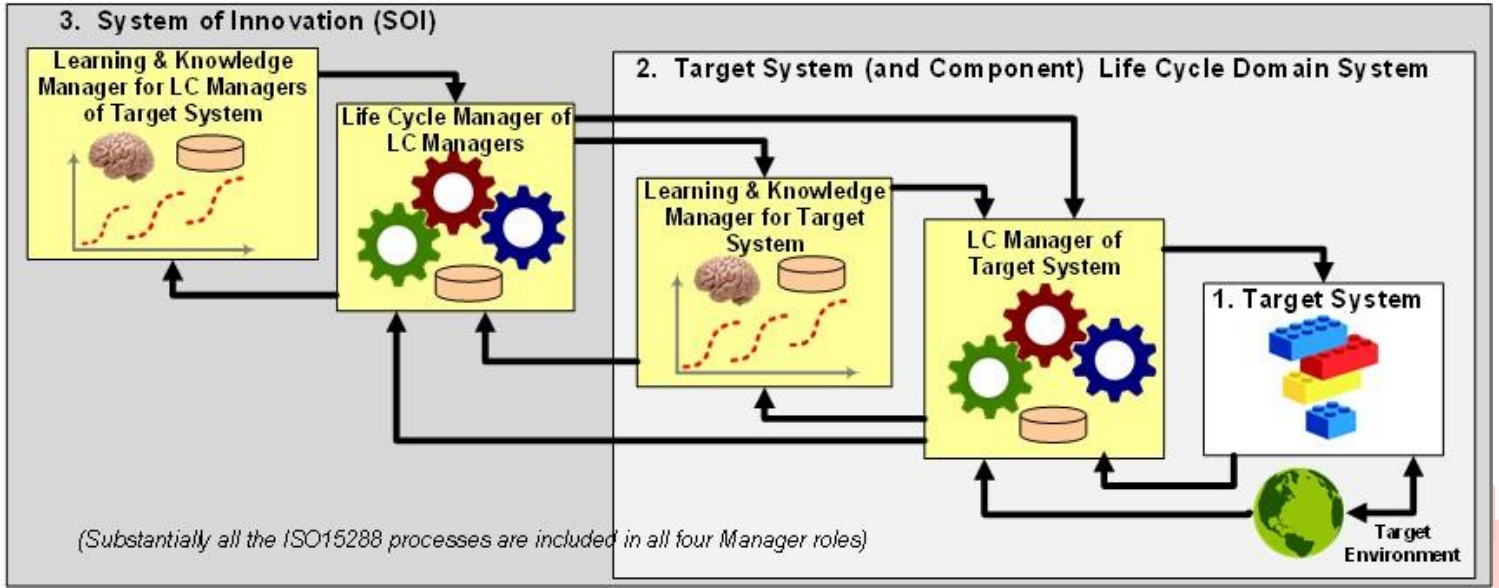


ASELCM Pattern Project: Jan 2019 Status

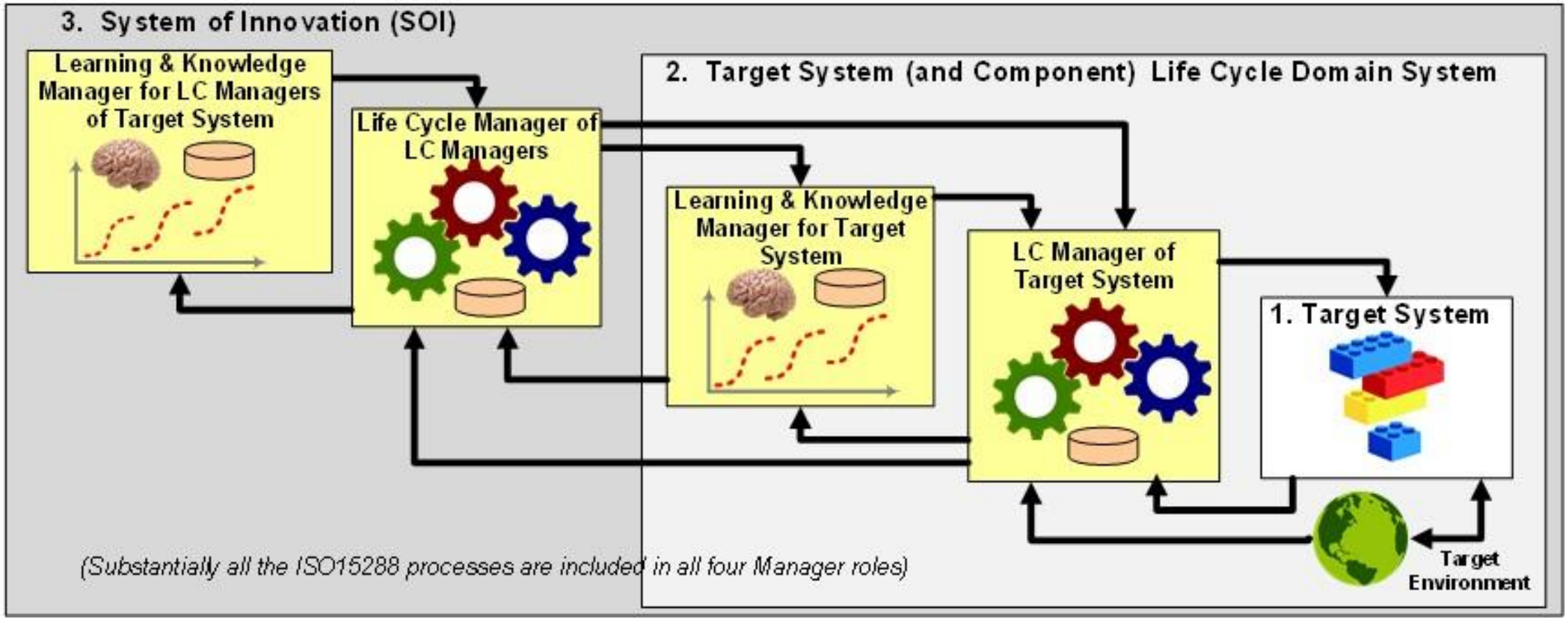
- ASELCM Pattern, specialized from ISO15288 System of Innovation Pattern, has been the basis of five co-authored INCOSE and IEEE case study papers, including an IS2017 best paper. Another submitted for IS2019
- Has been successfully applied in multiple commercial projects during 2016-2018, establishing 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
4. Agile Hardware/Firmware/Software Product Line Engineering at Rockwell Collins

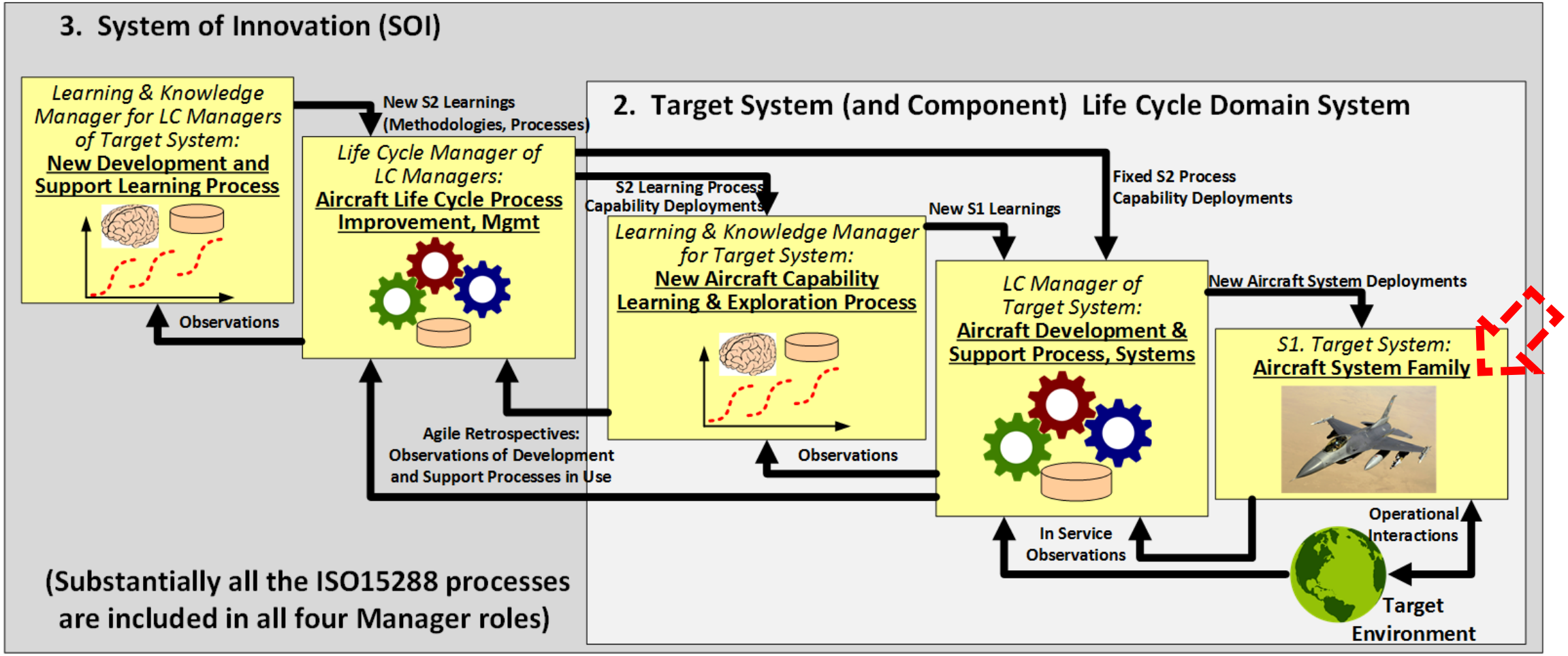


ASELCM Pattern Logical Architecture



- 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.

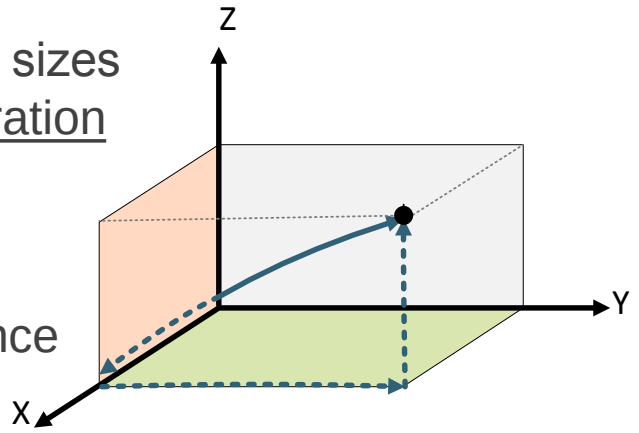
2. Transition to Scaled-Agile Systems Engineering at Lockheed Integrated Fighter Group



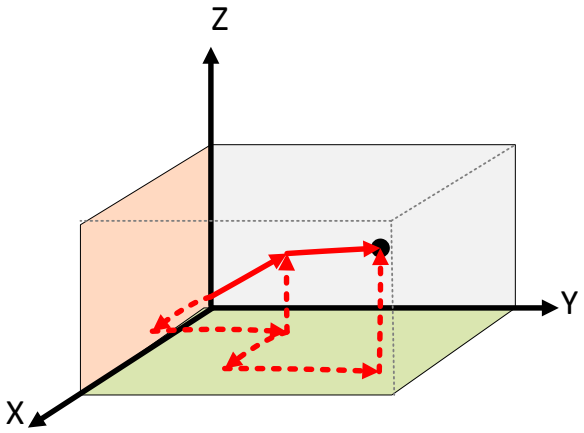
2. Transition to Scaled-Agile Systems Engineering at Lockheed Integrated Fighter Group: Configurations, Costs

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

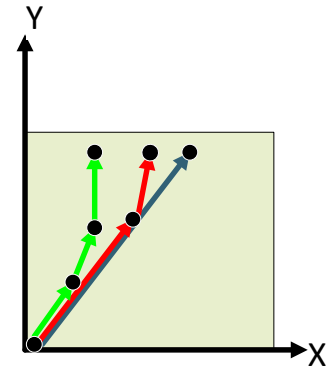
Example subspaces:
Reqs, Dsn, Performance



(a) Large "Batch" Increment

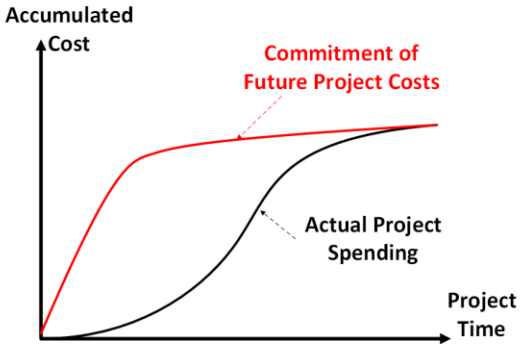


(b) Smaller "Batch" Increments

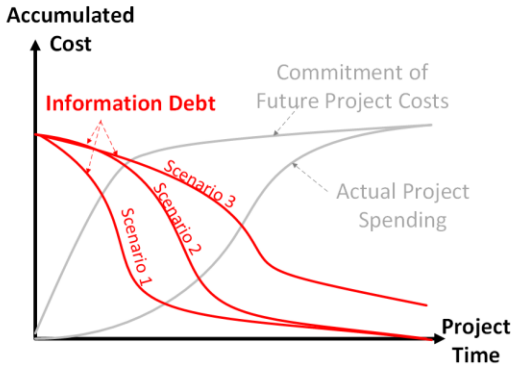


(c) Different "Batch" sizes can result in different trajectories, destinations

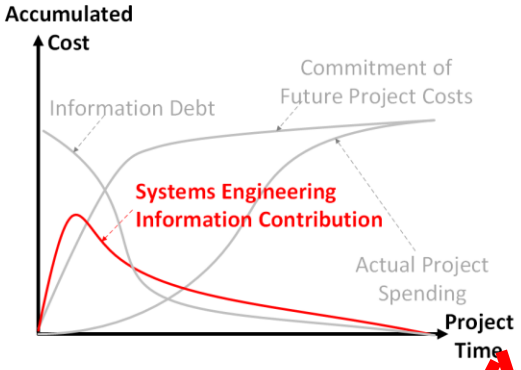
Information Debt: Balance Sheet Model of Learning



(a) When Project Costs Are Committed versus Incurred



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

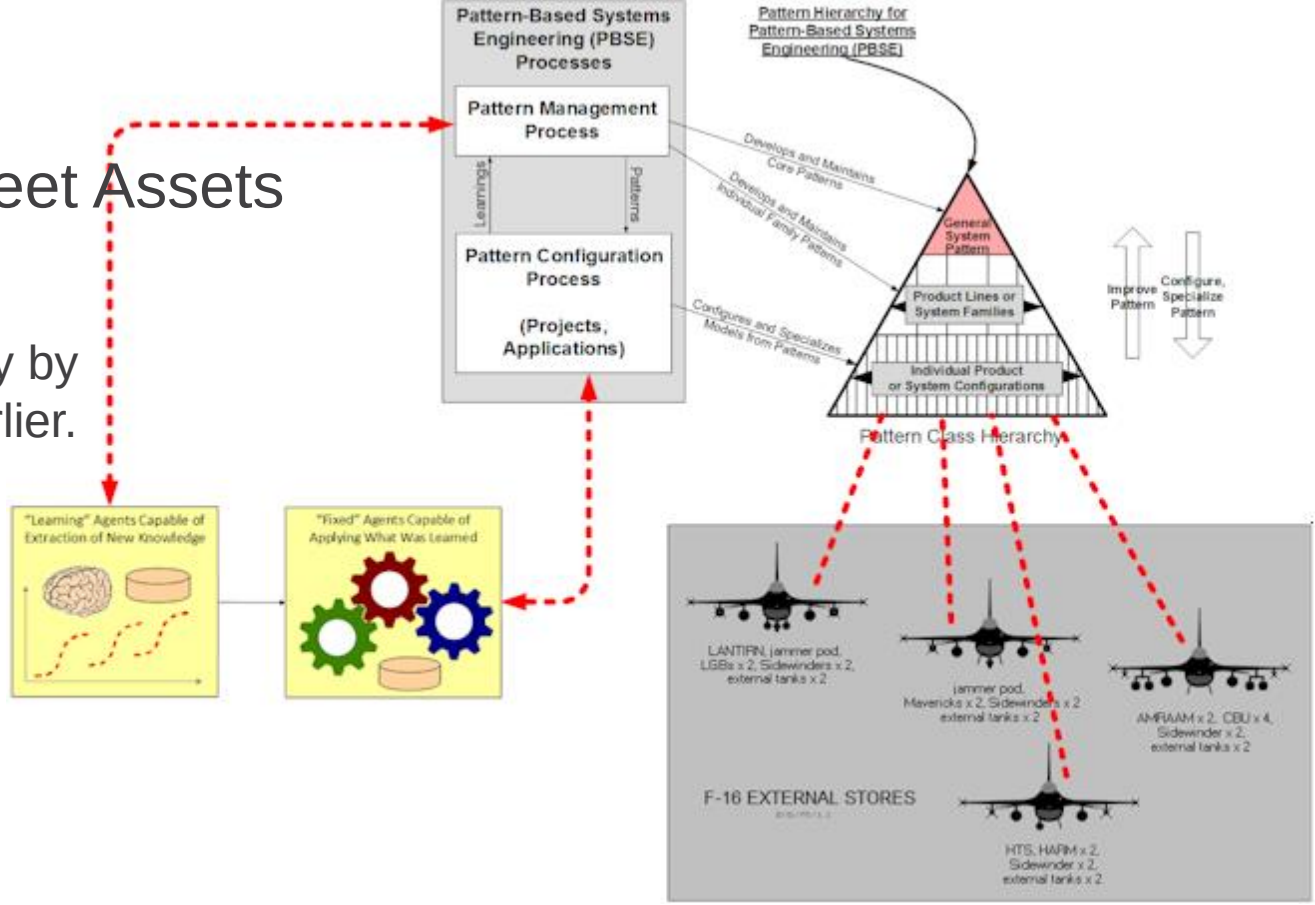


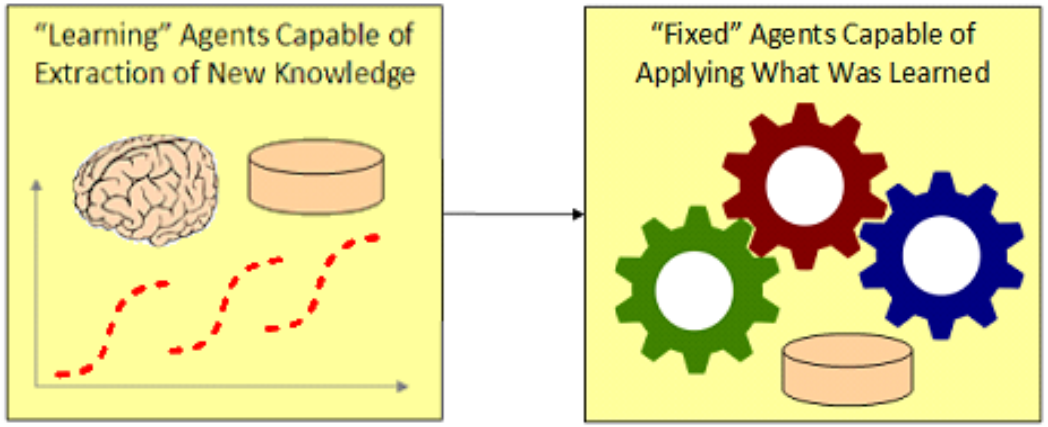
(c) Systems Engineering Information Is Generated to Reduce Information Debt

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.

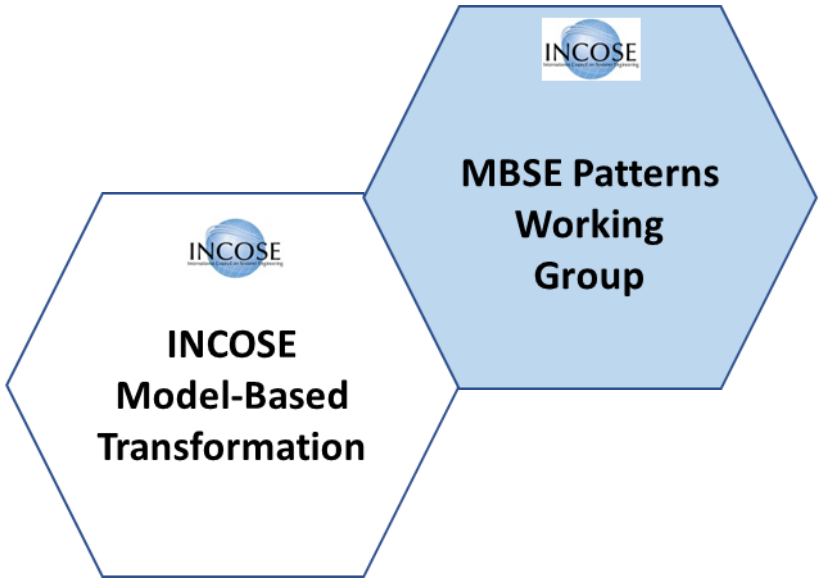




Where are the pattern assets accumulated?
ASELCM human or other learning processes, learned assets, and their uses

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 Jan 2019

- MBSE penetration planning tool
- Model planning pattern, integrated Model VVUQ 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.

Progress & Status Report

Example Products & Other Deliverables

Pilot Products Developed and Available for Beta Test Use:

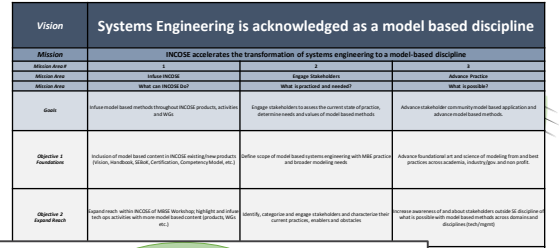
1. MB Roadmap Planning and Assessment Tool
2. Model Features Planning and Packaging Framework

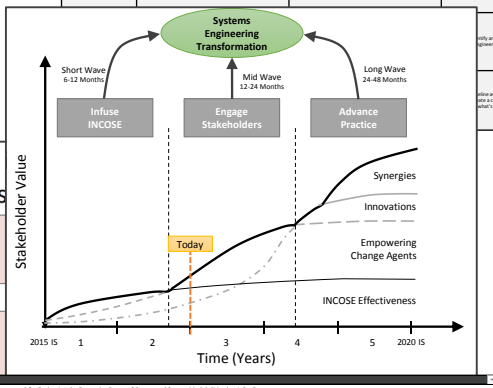
Products Under Development

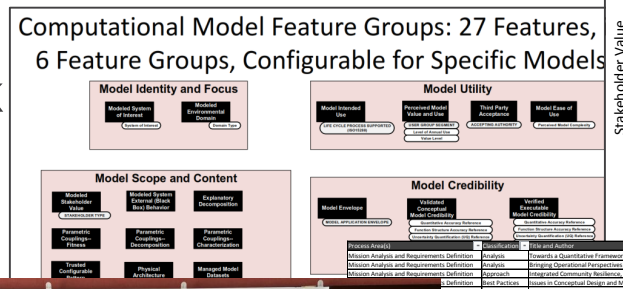
1. Model Based Exemplars
2. Model VVUQ Pattern, incl. Requirements Models

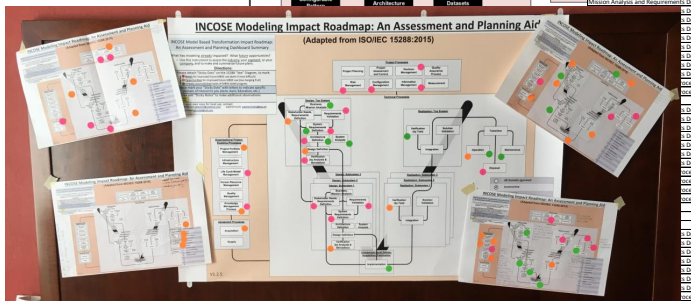
Emerging Activities, Partners We're Supporting:

1. OMG SysML 2.0
2. ASME Model VVUQ Standards Effort
3. SE Ontology Effort with SERC, JPL, et al.
4. Two New MBSE Challenge Teams:
   - Digital Artifacts
   - Production & Logistics Systems Modeling

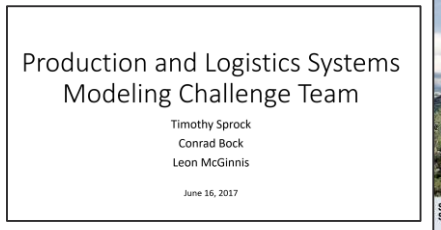


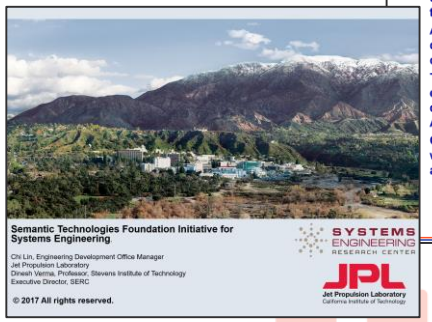


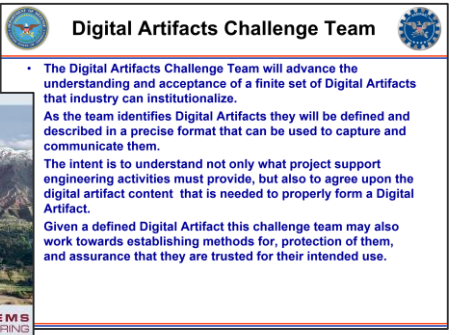




Process Area(s)	Classification	Title and Author	Domain	Citation
Mission Analysis and Requirements Definition	Analysis	Towards a Quantitative Framework for Evaluating the Expressive Power of Conceptual System Models (Mordecai, Dori)	Industry Agnostic	IS 2016
Mission Analysis and Requirements Definition	Analysis	Bringing Operational Perspectives Into The Analysis of Engineered Resilient Systems (Sitterle, Freeman, Ender, Brimhall, Balestrini-Robinson, Goerger)	Aerospace & Defense	IS 2016
Mission Analysis and Requirements Definition	Approach	Integrated Community Resilience, A Model Based Systems Engineering Approach (McDermott, Nadolski)	Infrastructure	IS 2016
Definition	Best Practices	Issues in Conceptual Design and MBSE Successes: Insights from the Model-Based Conceptual Design Surveys (Morris, Robinson, Harvey, Cook)	Industry Agnostic	IS 2016
Definition	Approach	Using Visual Diagrams and Patterns for Consistent and Complete Requirements (Lempia, Schindel, Hrabik, McGill, Graber)	Industry Agnostic	IS 2016
Definition	Analysis	Modeling-Simulation-Analysis-Leaping 21st Century Game Changer (Marvin, Schmitz, Reed)	Energy	IS 2016
Definition	Case Study	Case Study: A Model Based Systems Engineering (MBSE) Framework for Characterising Transportation Systems Over the Full Life Cycle (Scott, Arabian, Fullelove, Campbell)	Transportation	IS 2016
Definition	Approach	Making Smart Cities Smarter – MBSE Driven IoT (Hause, Hummel)	Infrastructure	IS 2016
Definition	Approach	A Framework for Small Satellite Architecture Design (Canar, Ryan, Tuttle)	Space	IS 2016
Definition	Approach	Applying Model-based SE Techniques for Dependable Land Systems (Payne, Fitzgerald, Bryans, Winthorpe)	Aerospace & Defense	IS 2016
Definition	Analysis	Evaluation of Illustrative ConOps and Decision Matrix as tools in concept selection (Sokl, Muller)	Energy	IS 2016
Cross Areas	Approach	Getting Started With MBSE in Product Development (Kass, Kobas)	Industry Agnostic	IS 2016
Cross Areas	Foundations	MBSE++ – Foundations for Extended Model-Based Systems Engineering Across System Lifecycle	Industry Agnostic	IS 2016
	Best Practices	Insights from Large Scale Model Based Systems Engineering at Boeing (Malone, Friedland, Herrold, Fogarty)	Aerospace & Defense	IS 2016
Definition	Case Study	Creating an A3 Architecture Overview; a Case Study in Subsea Systems (Muller, Wee, Mobarg)	Energy	IS 2015
Definition	Approach	A Layered Requirement Development Model for Railway Infrastructure Development (Maarschalkerweerd, Bosma)	Transportation	IS 2015
Definition	Foundations	Ontology for Systems Engineering as a base for MBSE (van Ruijven)	Industry Agnostic	IS 2015
Definition	Case Study	The Use of MBSE in Infrastructure Projects – An MBSE Challenge Team Paper (Hause, van de Ven, Bulteiaar, Burgers)	Transportation	IS 2015
Definition	Foundations	Model-based Engineering of Emergence in a Collaborative SoS: Exploiting SysML & Formalism (Ingram, Payne, FitzgeraId, Couto)	Transportation	IS 2015
Definition	Best Practices	From Asking Forgiveness to Saying "You're Welcome!" – Introducing Requirements Engineering to Medical Device Development (Medina, Fuenir)	Healthcare	IS 2015
Definition	Approach	Model Based Systems Engineering. Focus on the Initial Stages, "Get it Right in the First Stage" (Walker)	Industry Agnostic	IS 2015
Cross Areas	Foundations	Ontology for Systems Engineering as a base for MBSE (van Ruijven)	Industry Agnostic	IS 2015
Cross Areas	Foundations	SysML Activity Models for Applying ISO 14971 Medical Device Risk and Safety Management Across the System Lifecycle (Malins, Stein, Thukral, Watteplas)	Healthcare	IS 2015
Cross Areas	Approach	Do Teams Using Agile Methodology Need Modeling? (Dovalds, Lempia)	Industry Agnostic	IS 2015
Cross Areas	Foundations	Implementing Model Semantics and a (M)BSE Ontology in Civil Engineering & Construction Sector (Bahlen)	Buildings/Construction	IS 2015
	Best Practices	From initial investigations up to large-scale rollout of an MBSE method and its supporting workbench: the Thales experience (Voirin, Bonnet, Normand, Exertier)	Aerospace & Defense	IS 2015
	Best Practices	Implementing the MBSE Cultural Change: Organization, Coaching and Lessons Learned (Bonnet, Voirin, Normand, Exertier)	Aerospace & Defense	IS 2015
	Approach	Do Teams Using Agile Methodology Need Modeling? (Dovalds, Lempia)	Industry Agnostic	IS 2015
Definition	Analysis	Model-Based operational analysis for complex systems – A case study for electric vehicles (Doufene, Chale, Dauron, Krob)	Automotive	IS 2014
Definition	Approach	Traceable Engineering of Fault-Tolerant SoSs (Andrews, et al.)	Infrastructure	IS 2014
Definition	Analysis	Integrated Toolset and Workflow for Tradespace Analytics in Systems Engineering (Sitterle, Curry, Freeman, Ender)	Aerospace & Defense	IS 2014
Definition	Analysis	Quantifying the Value of Flexibility in Design and Management of Onshore LNG Production System (Cardin, et al.)	Energy	IS 2014
Definition	Best Practices	Increasing the value of model-assisted communication: Modeling for understanding, exploration and verification in production line design projects (Stahlberg, Muller)	Aerospace & Defense	IS 2014
Definition	Foundations	Semantic Platforms for Cyber-Physical Systems (Petrige, Austin)	Transportation	IS 2014
Definition	Approach	Why avoiding how when defining what? Towards an OSLC-based approach to support Model-Driven Requirements Engineering (Rodriguez, et al.)	Industry Agnostic	IS 2014
Cross Areas	Approach	Model Lifecycle Management for MBSE (Fisher, et al.)	Industry Agnostic	IS 2014

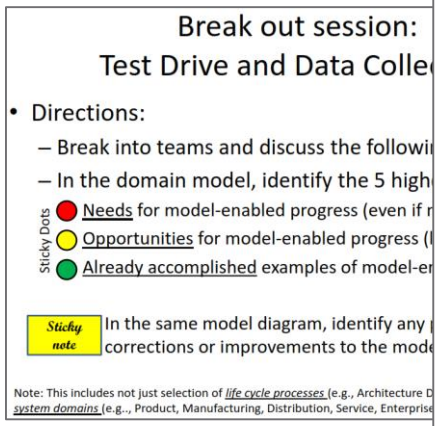


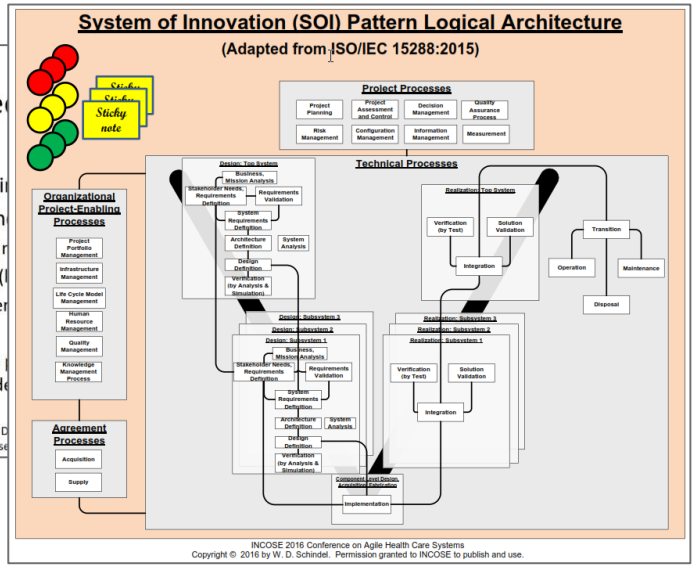


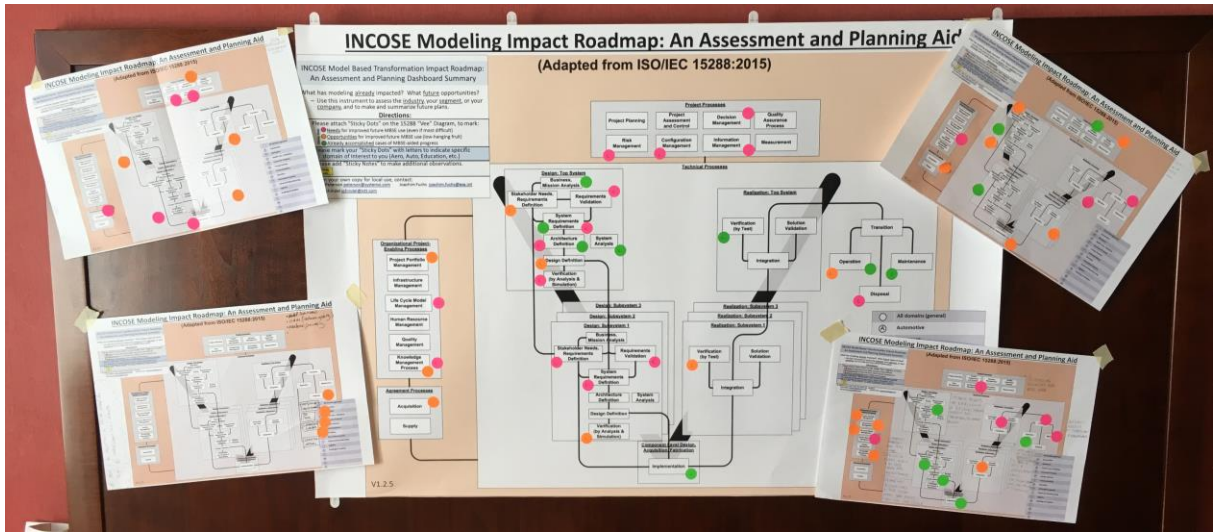


Example Transformation Products, for Beta Test Use:
MB Roadmap Planning and Assessment Tool

- **Product Concept**: Drive “one level below” the declaration that “we want to start using Model-Based Methods” , or the assertion that “we already use Model-Based Methods”:
  - Drills down “one level”, to the granularity level of the ISO15288 processes, but not lower than that
  - Provides a **light-weight tool** for (a) making a plan to incorporate Model-Based Methods, or (b) overviewing the relative perceived extent of Model-Based Method use and its degree of impact, challenge
- Not a detailed maturity model
  - Meant to be easy to use, but more challenging than “we are going to use model based methods”, or “we already do”
  - Resulting display instrument suitable for use in leadership briefings as well as technical audiences.
- **For use by:**
  - An enterprise
  - A project
  - An individual person
  - A multi-company team
  - A trade group
  - And especially by . . . INCOSE members!

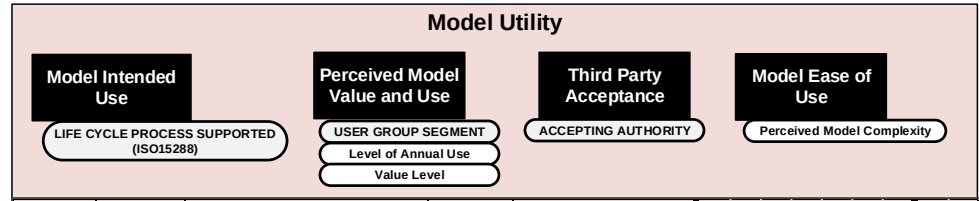




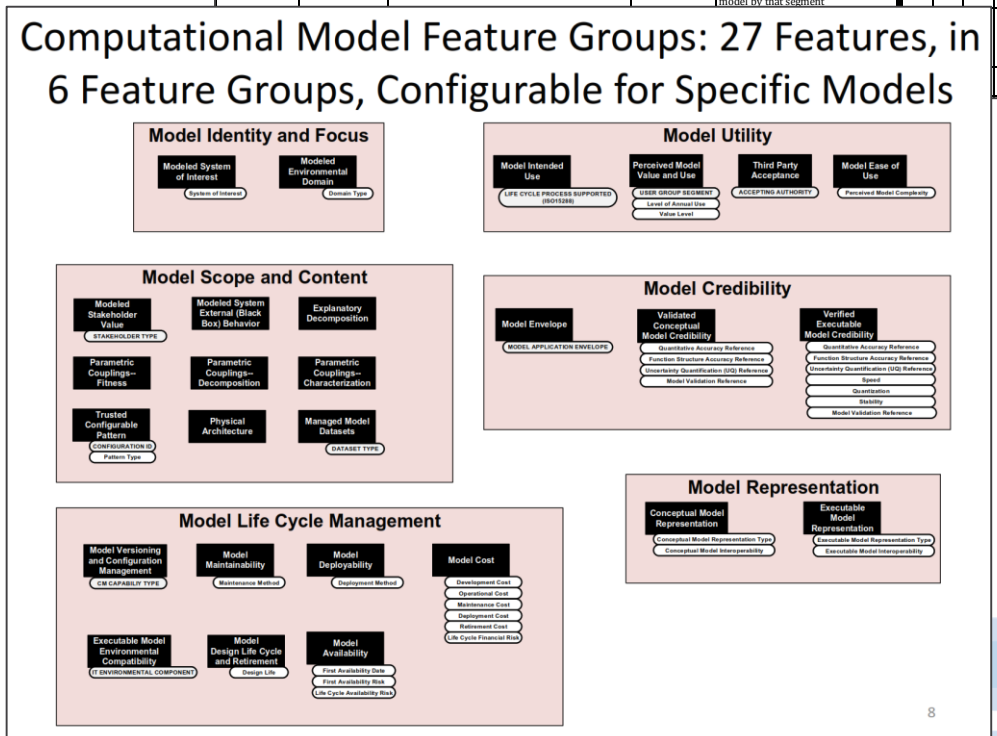


Example Transformation Products, for Beta Test Use:
Model Features Planning and Packaging Framework

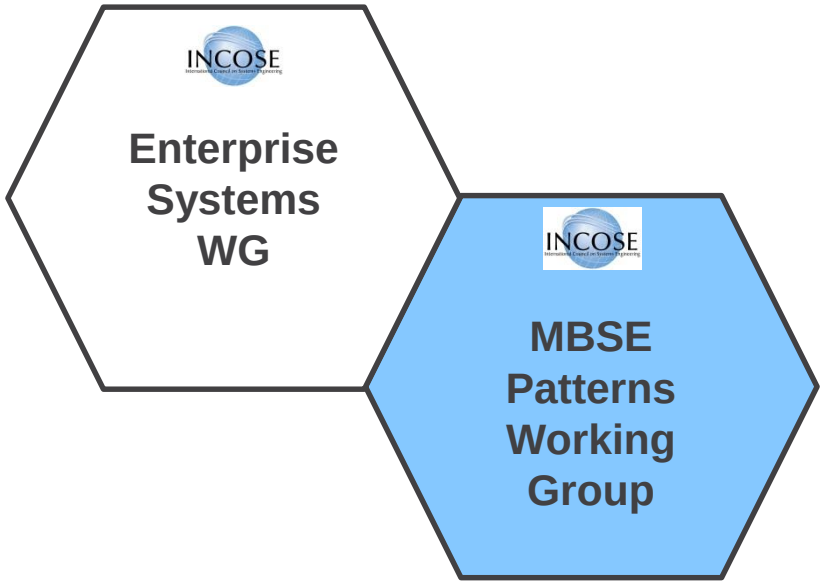
- **Product Concept:** What are the stakeholder features of the model we are planning, the model we are building, the model we are using? Is it fit for its intended use?
- A more detailed, but entirely stakeholder-level, framework for describing the full spectrum of stakeholder issues, expectations,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



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



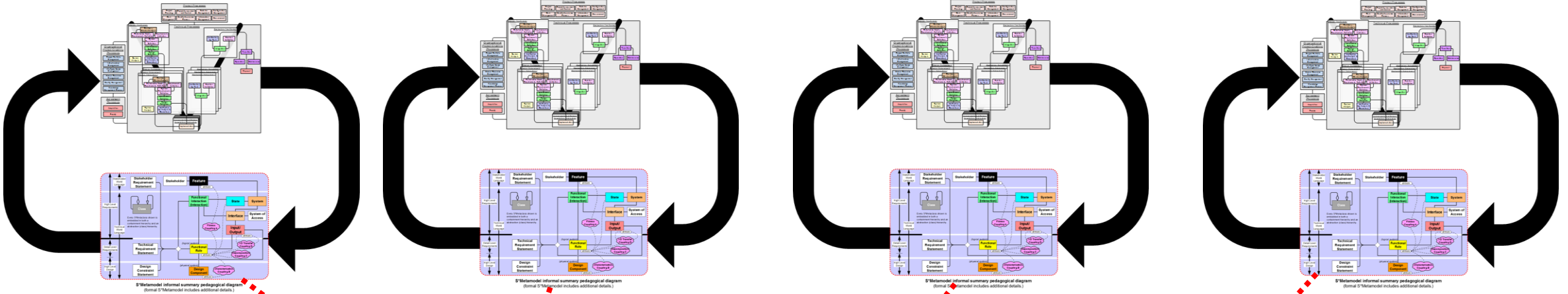
S3 Pattern and INCOSE OCM—Enterprise WG collaboration



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.



LEARN

EXECUTE

LEARN

EXECUTE

3. System of Innovation (SOI)

Learning & Knowledge Manager for LC Managers of Target System

Life Cycle Manager of LC Managers

2. Target System (and Component) Life Cycle Domain System

Learning & Knowledge Manager for Target Systems

LC Manager of Target System

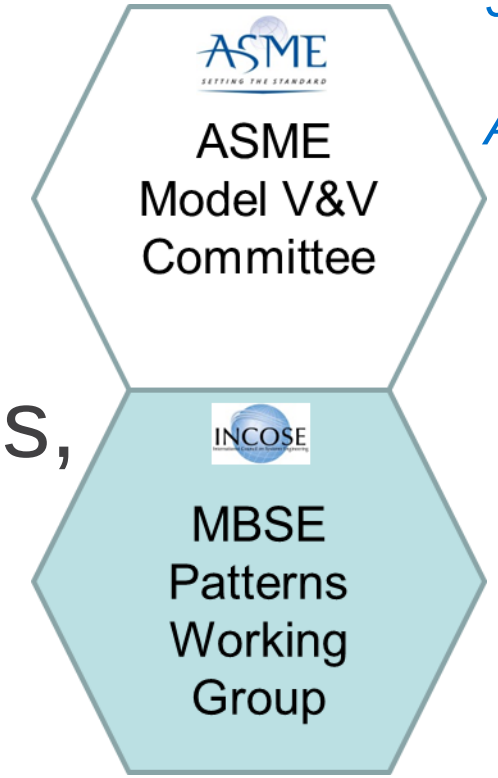
1. Target System

Target Environment

(Substantially all the ISO15288 processes are included in all four Manager roles)

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

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



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

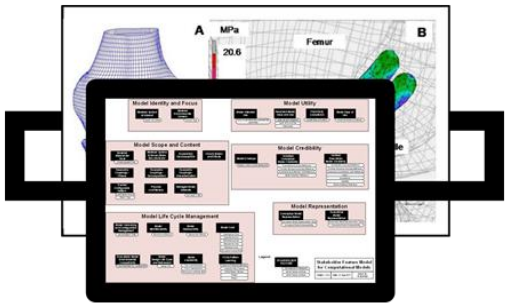
Model VVUQ Project Status Jan 2019

- Member ASME VV50 Standards Committee: Presented related report to IW18 MBSE Workshop on Jan 21, 2018.
- Have generated Model 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.)

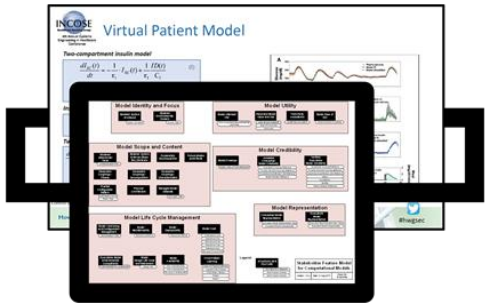
V4I-INCOSE Collab Example: Model VVUQ Pattern

- Uniform model “wrapper” describes all types of computational and representational models.
- Currently being used by INCOSE MBE Transformation to package diverse MBSE models.
- Developed with the INCOSE MBSE Patterns WG.

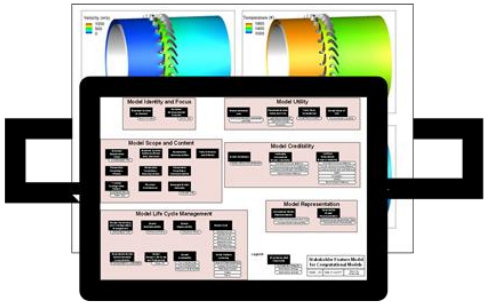
FEA Model



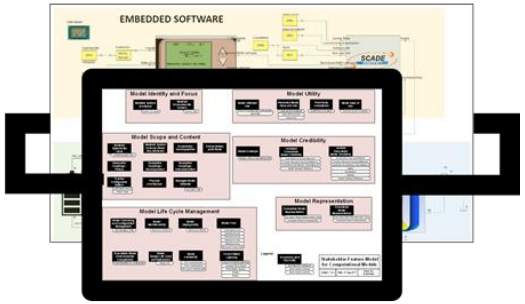
ODE Model

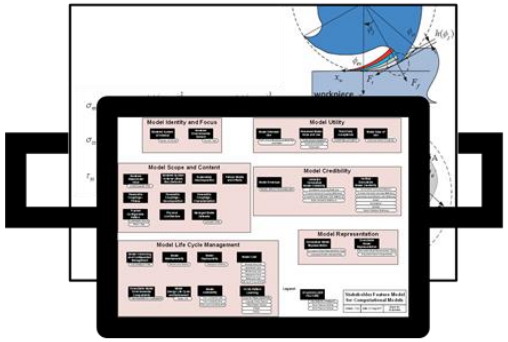


CFD Model

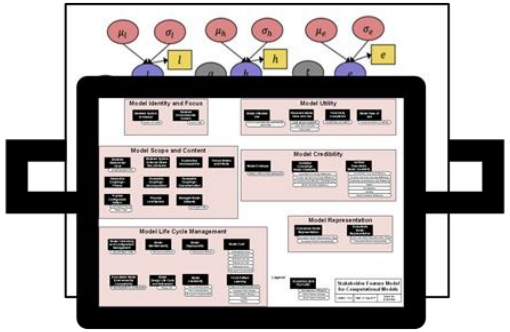


Multi-Domain System Model

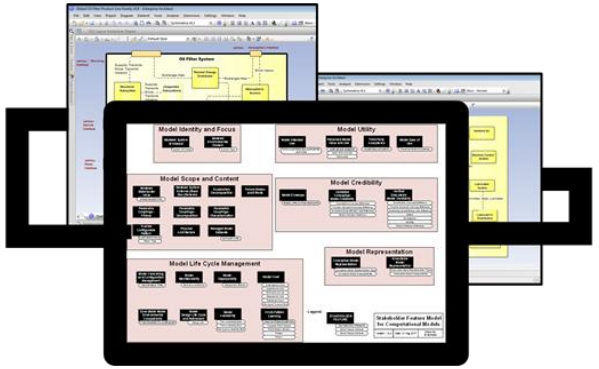




Physics-Based PDE Model



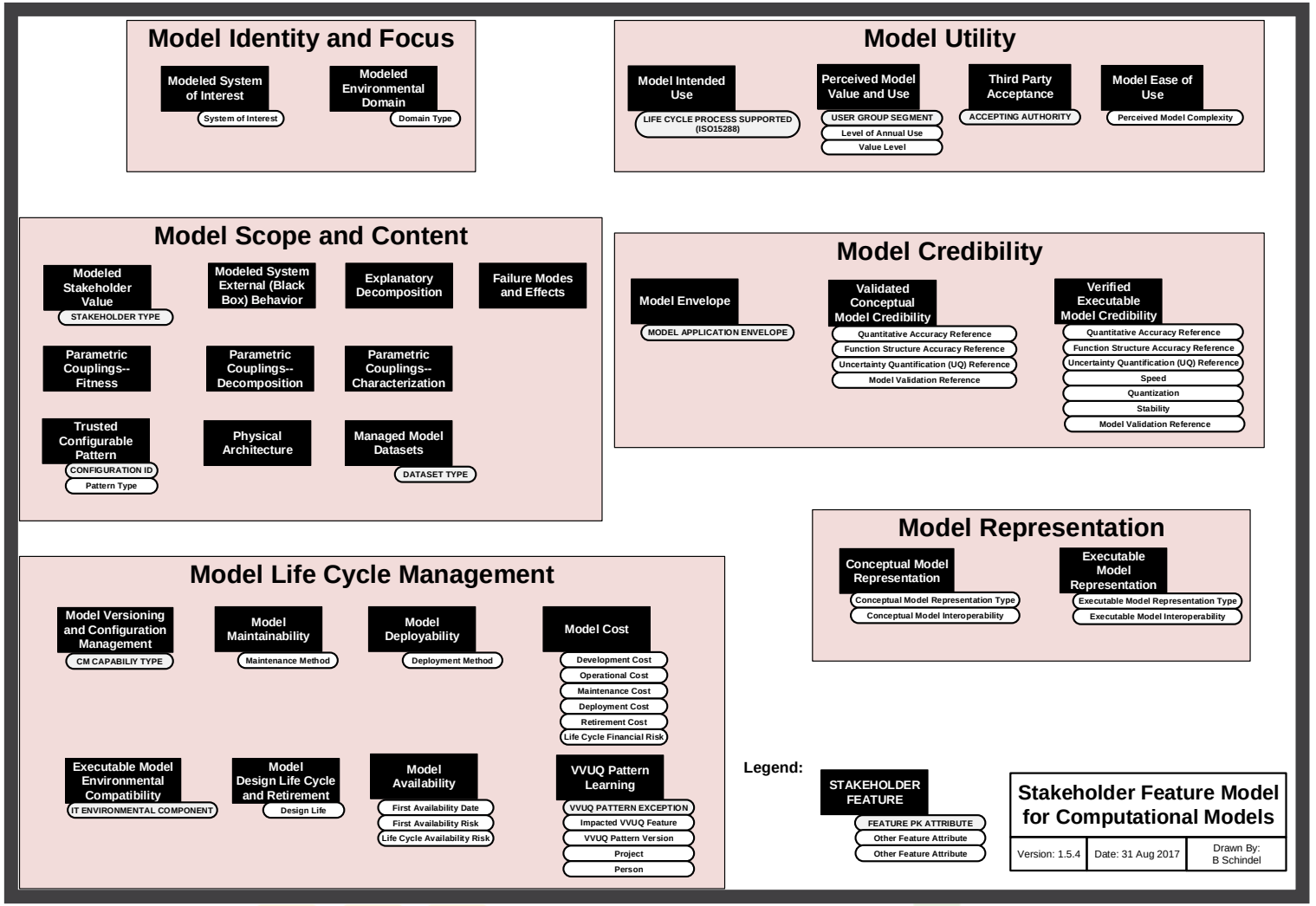
Data-Driven Bayesian Network Model



MBSE Model

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

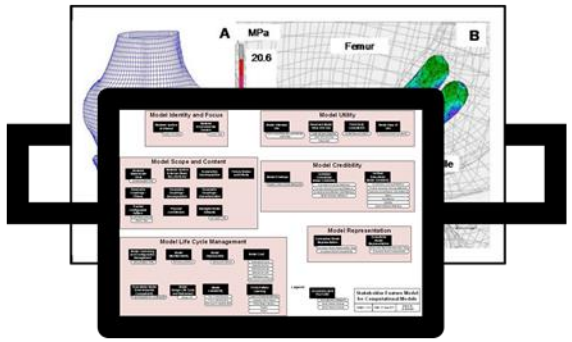
Model VVUQ S*Pattern—Model Metadata "Wrapper" (Configurable Model of the Virtual Models)



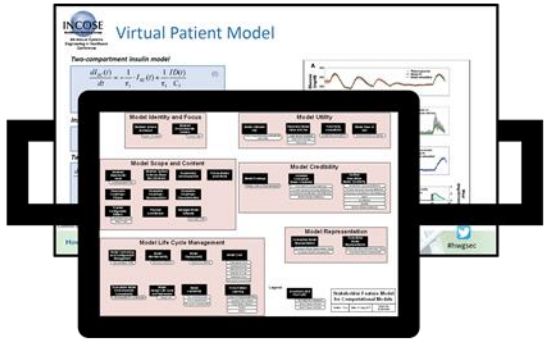
(An S*Pattern, based on S*Metamodel)

Uniform handles/wrappers/metadata for inherently diverse models:

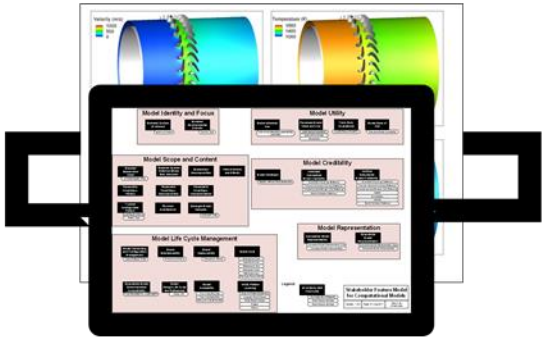
FEA Model



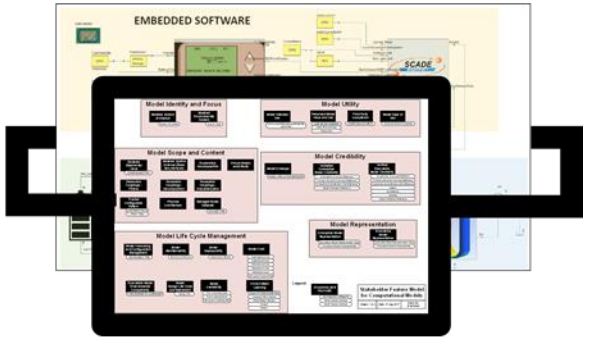
ODE Model

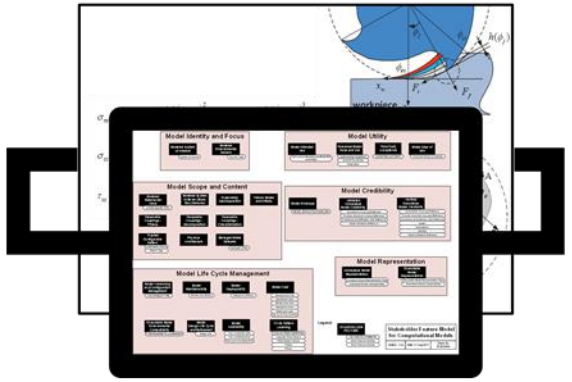


CFD Model

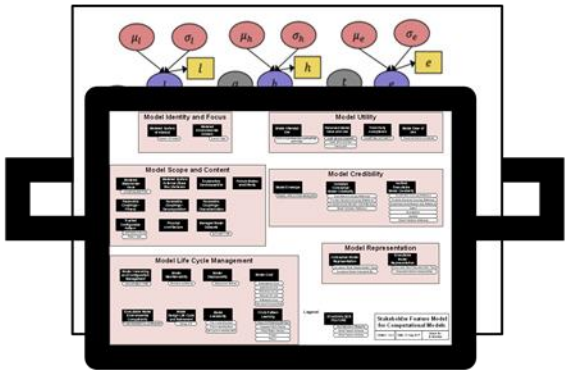


Multi-Domain System Model

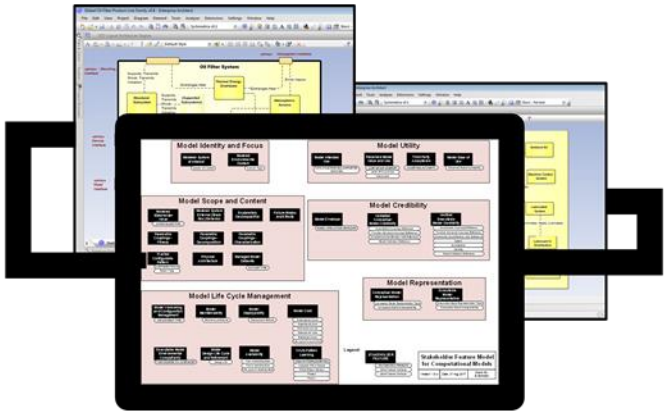




Physics-Based PDE Model

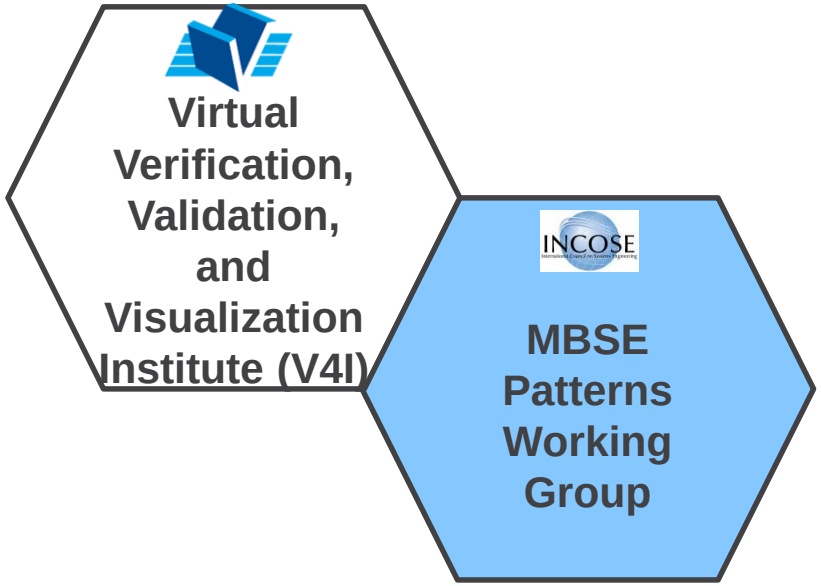


Data-Driven Bayesian Network Model



MBSE Model

V4 Institute Collaboration



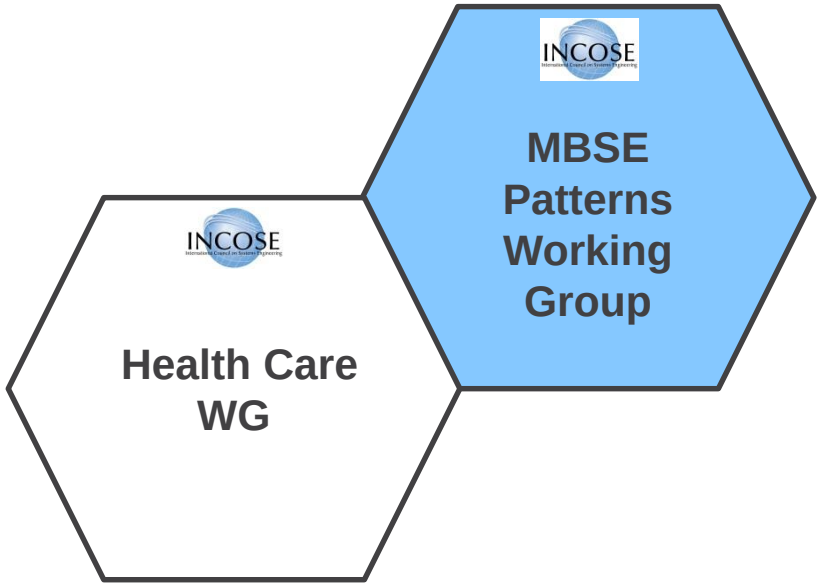
Primary Contacts:
John Matlik, Rolls-Royce, V4 Institute;
Ralph Resnick, NCDMM

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 Health Care WG: Joint Activity Materials

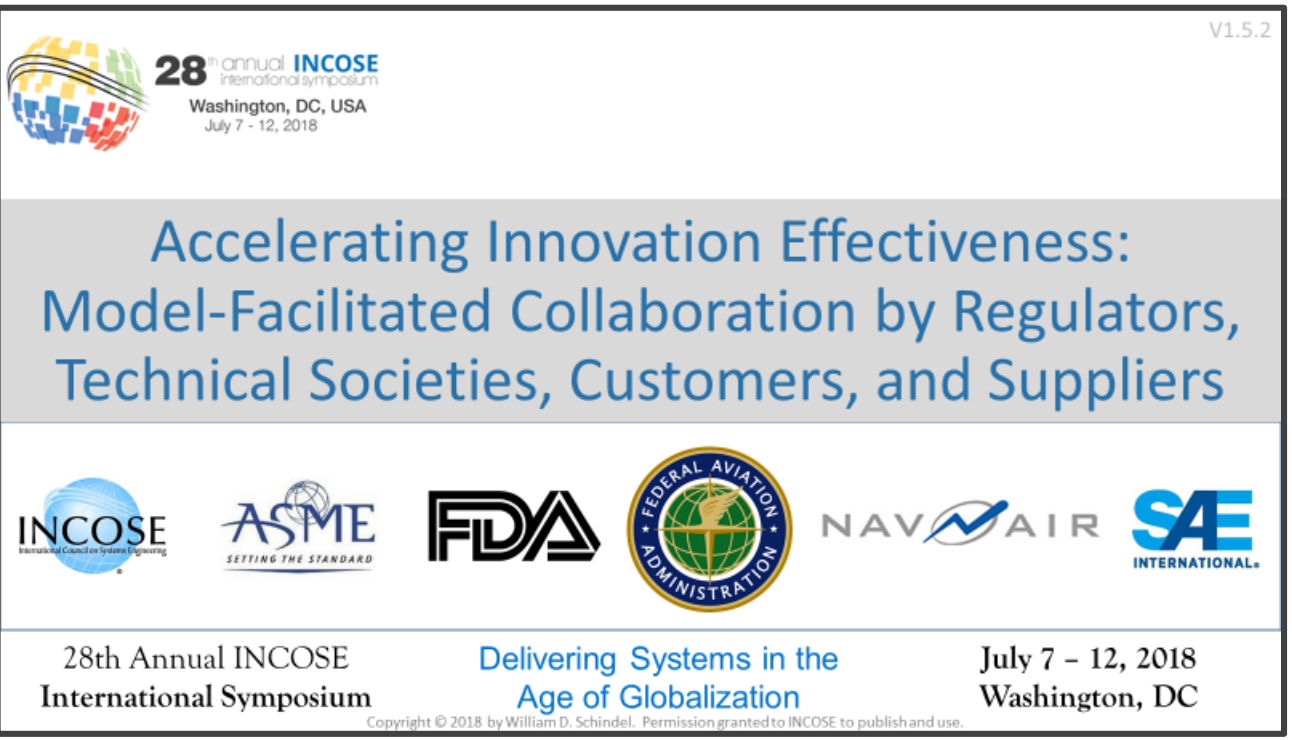
- Supporting the INCOSE Health Care Systems Conference (fourth year), Health Care application of ASELCM Pattern, Medical Device Embedded Controls VVUQ Pattern, and FDA participation in Patterns in the Public Square IS2018 panel.



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

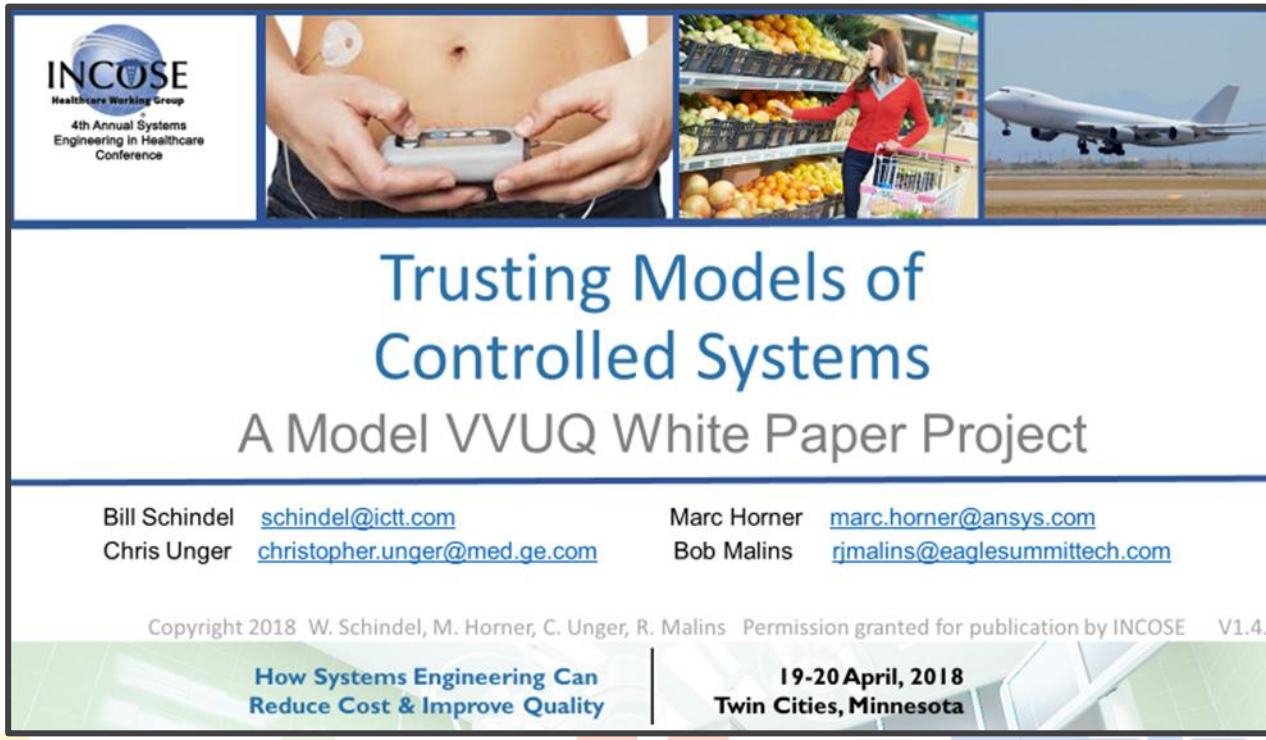
Health Care WG Collab: July 2018 Status

- 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 reported at IS2018.
- Supported ASME AABME first health care conference in 2018.
- Dr. Tina Morrison, FDA, participated in our invited panel at IS2018, “Patterns in the Public Square”.



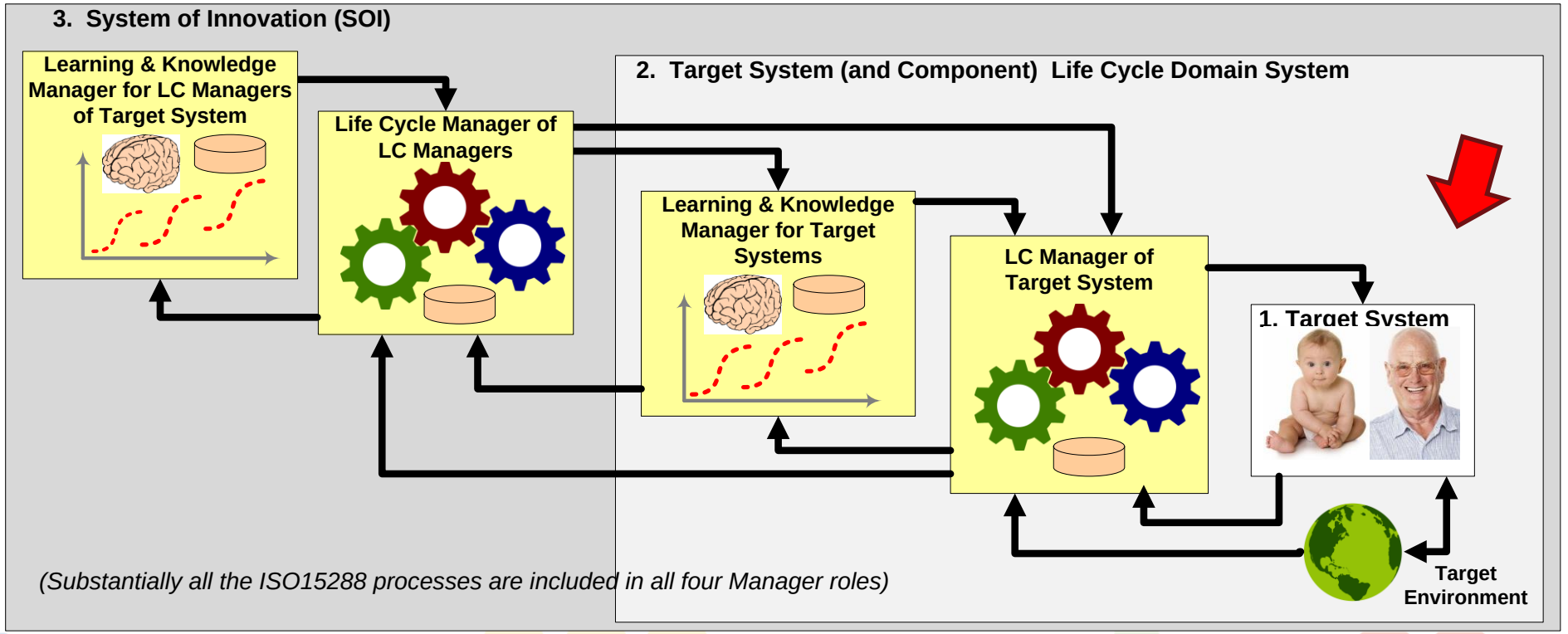
IS 2018 Panel

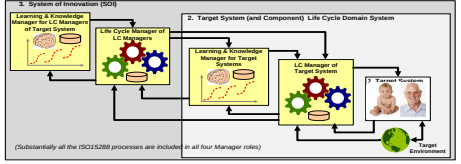
Invited IS2018 session



2016-8 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.)

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)
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1. Target System

Patient
Patient Subsystem
Patient Environment

Observes

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)

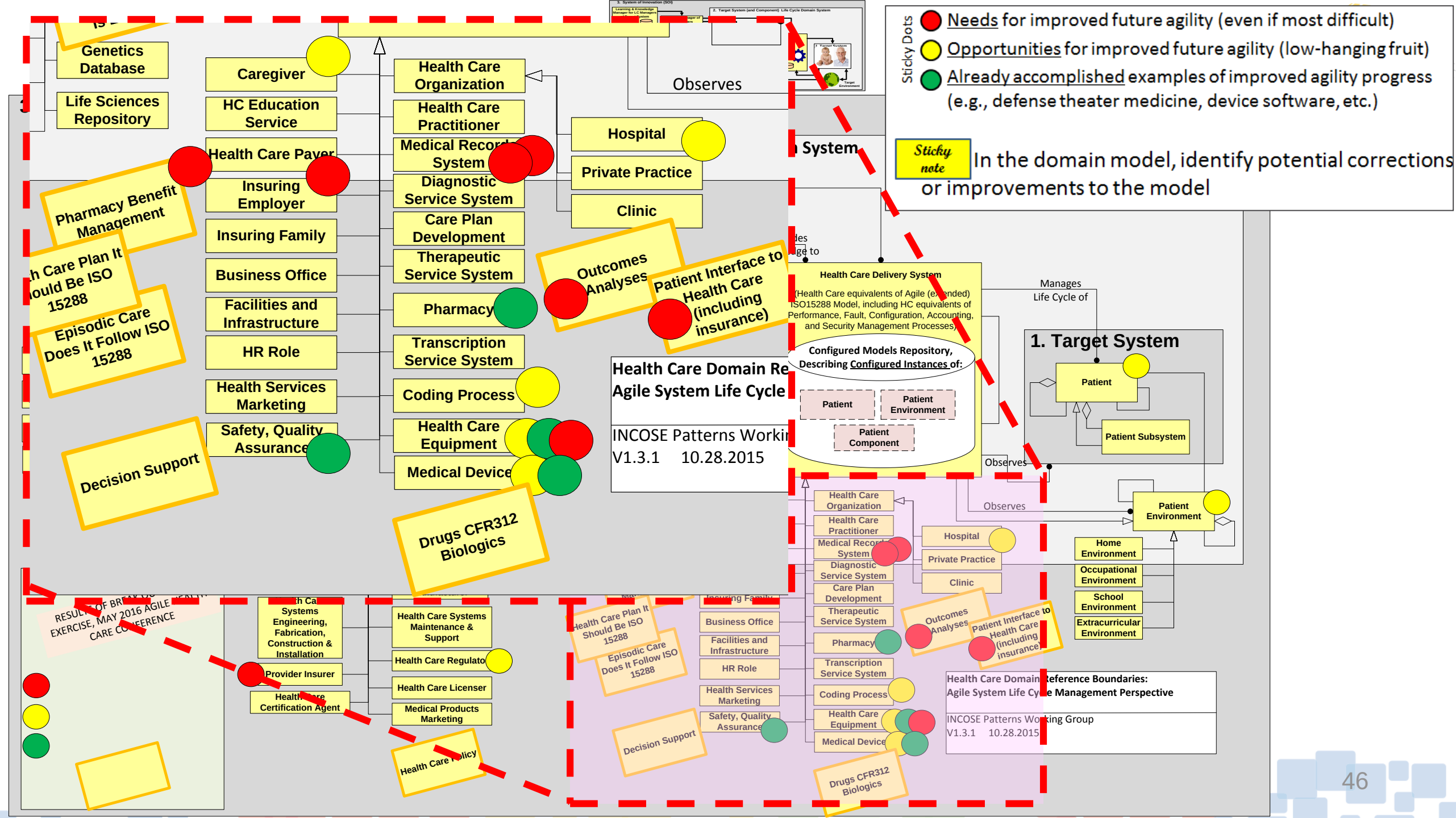
Hospital
Private Practice
Clinic

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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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
Health Care Organization
Health Care Practitioner
Medical Record System
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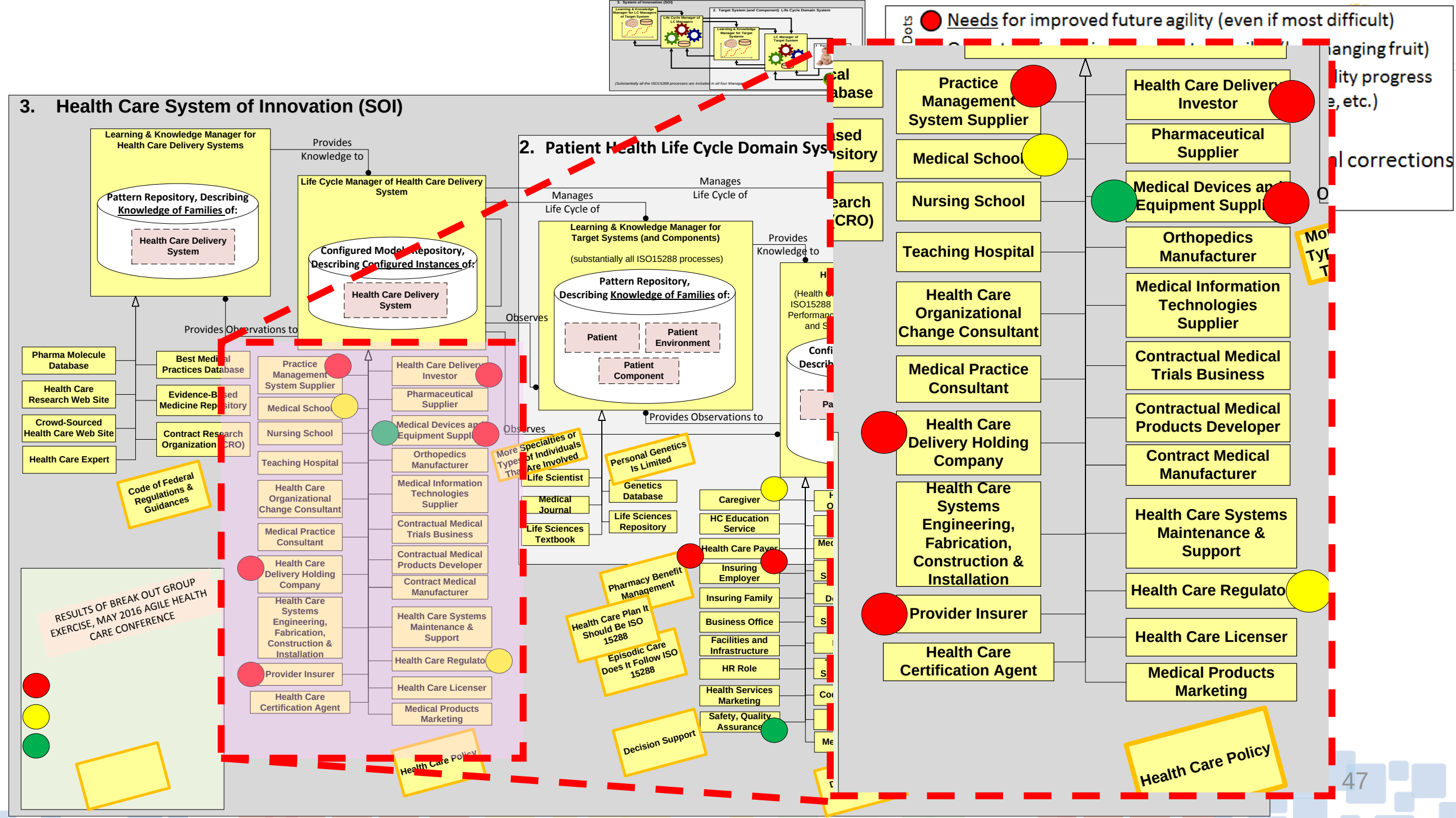
Provider Insurer
Health Care Regulator
Health Care Licenser
Medical Products Marketing
Health Care Policy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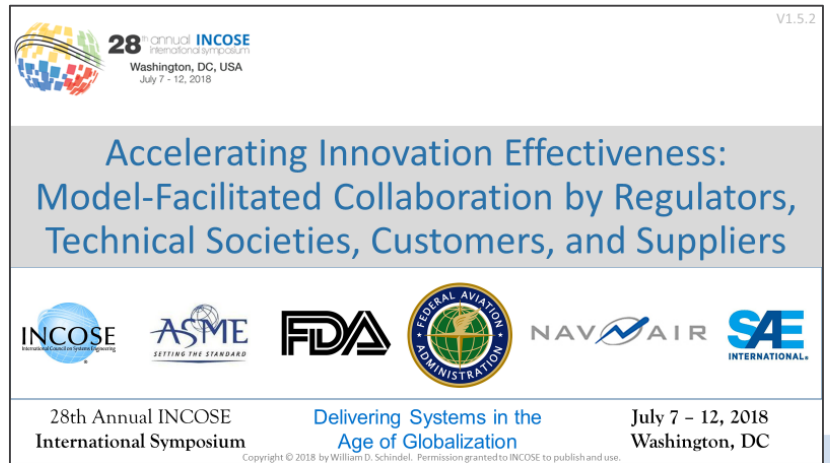
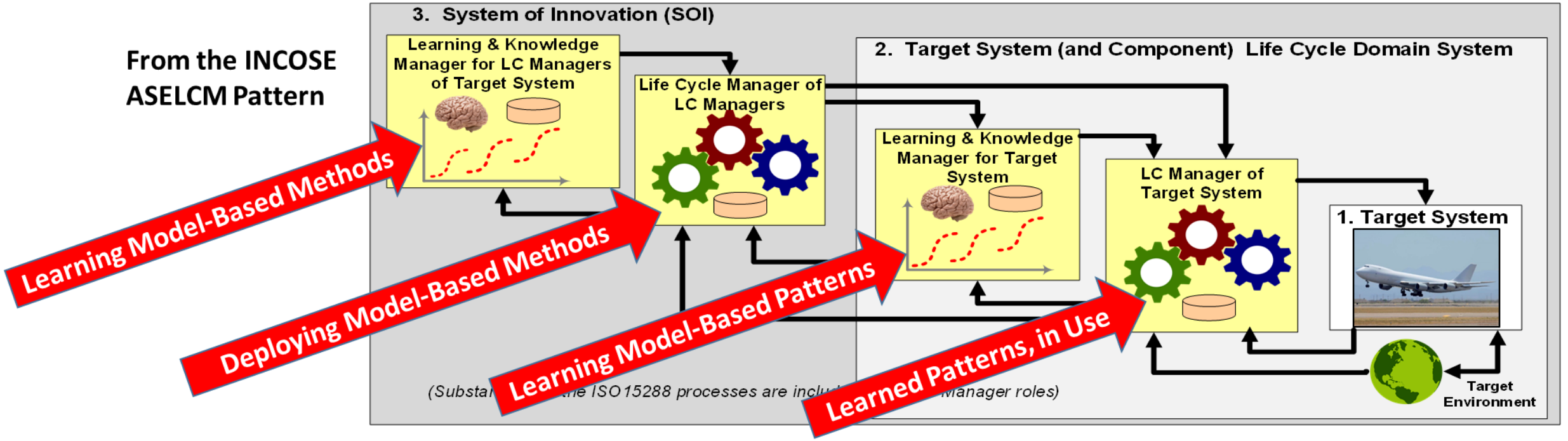
Patterns in the Public Square

- 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



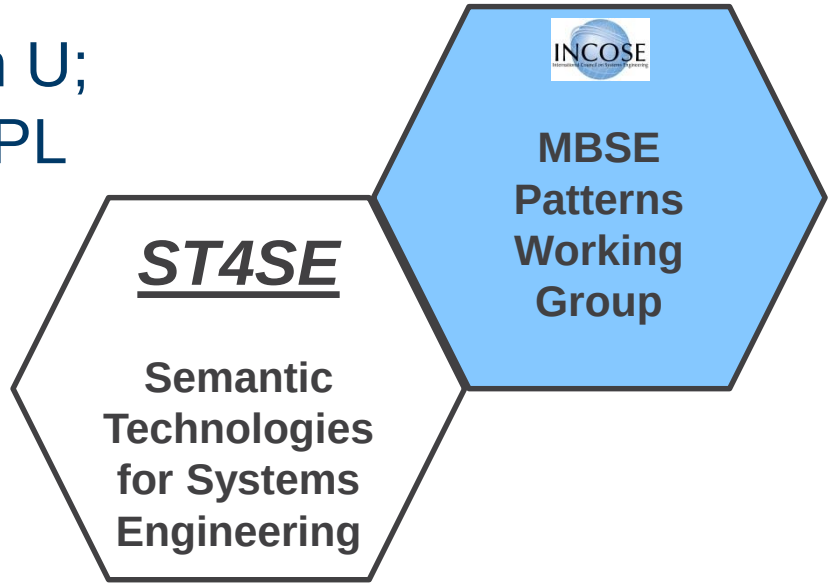
Patterns in the Public Square



Mappings to Frameworks and Tools (suggested by members at IS2018 meeting)

Semantic Technologies for Systems Engineering (ST4SE) Collaboration

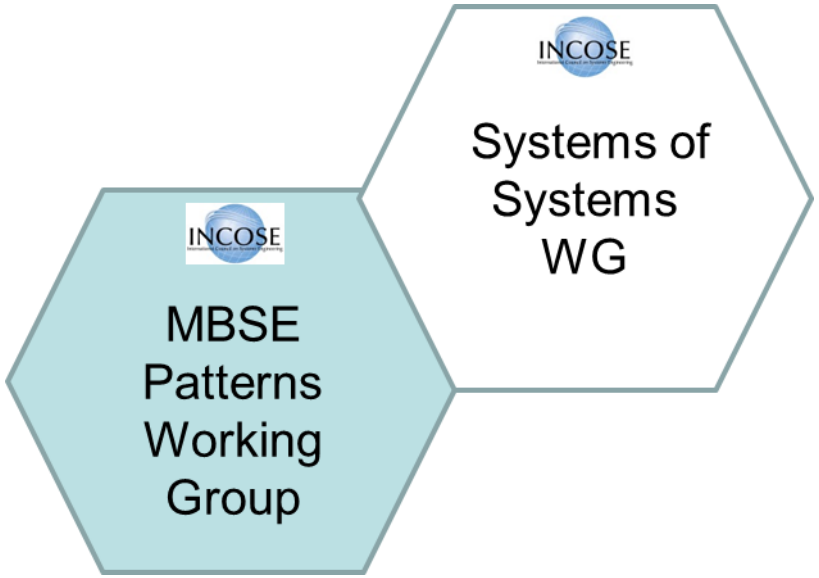
Primary Contacts:
Chris Paredis, Clemson U;
Steve Jenkins, NASA JPL



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

System of Systems (SoS) WG Collaboration



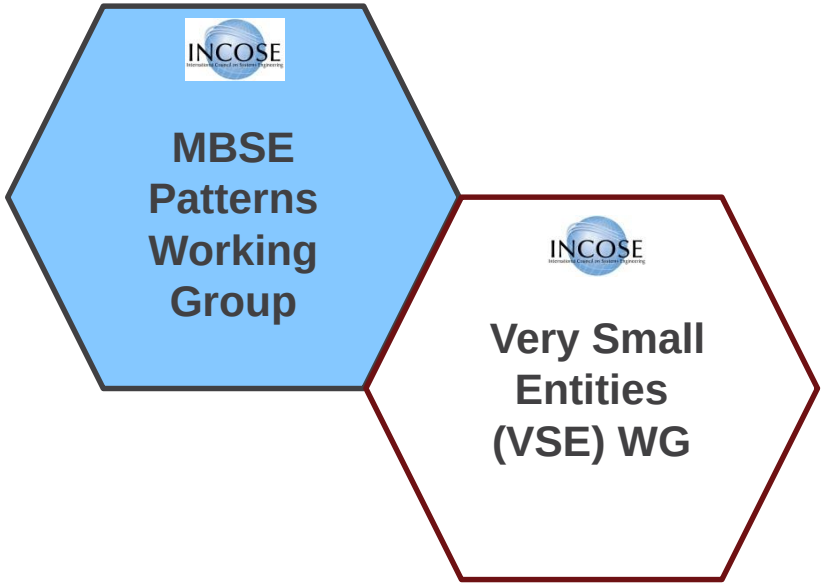
Primary Contact:
Judith Dahman, MITRE, INCOSE SoS WG Lead

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 previous 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



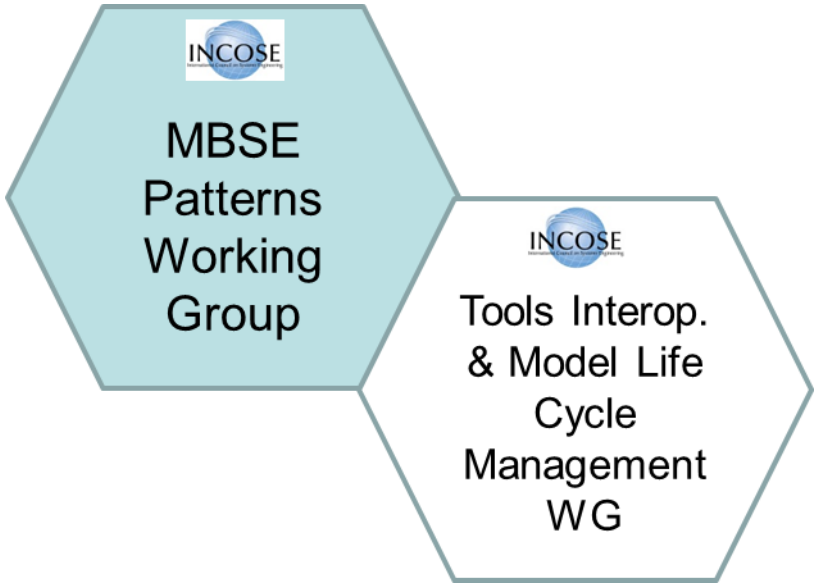
Very Small Entities (VSE) Joint Project: VSE Project Pattern

VSE Working Group: Project Status Jan 2019

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

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

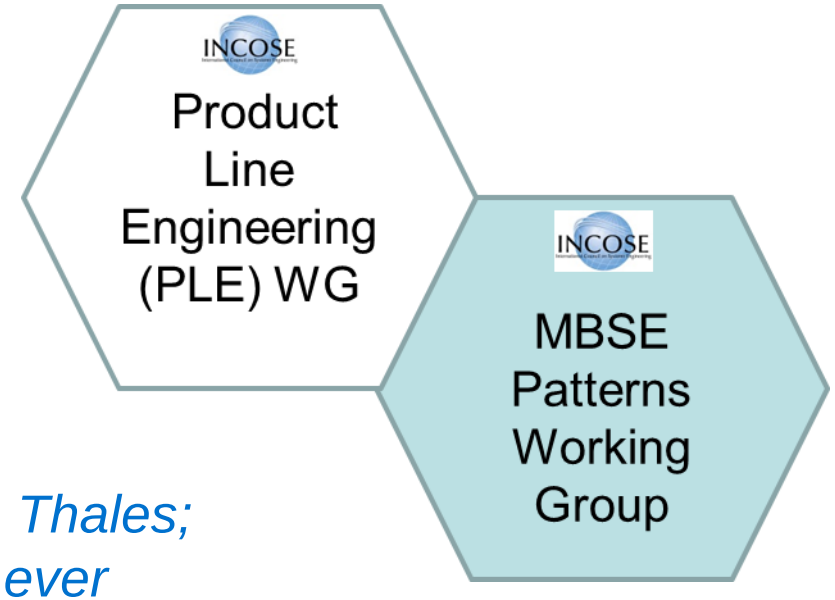


Primary Contact:
Lonnie VanZandt,
John Nallon,
TIMLM WG

TIMLM Patterns Project: Jan 2019 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 2019 Status

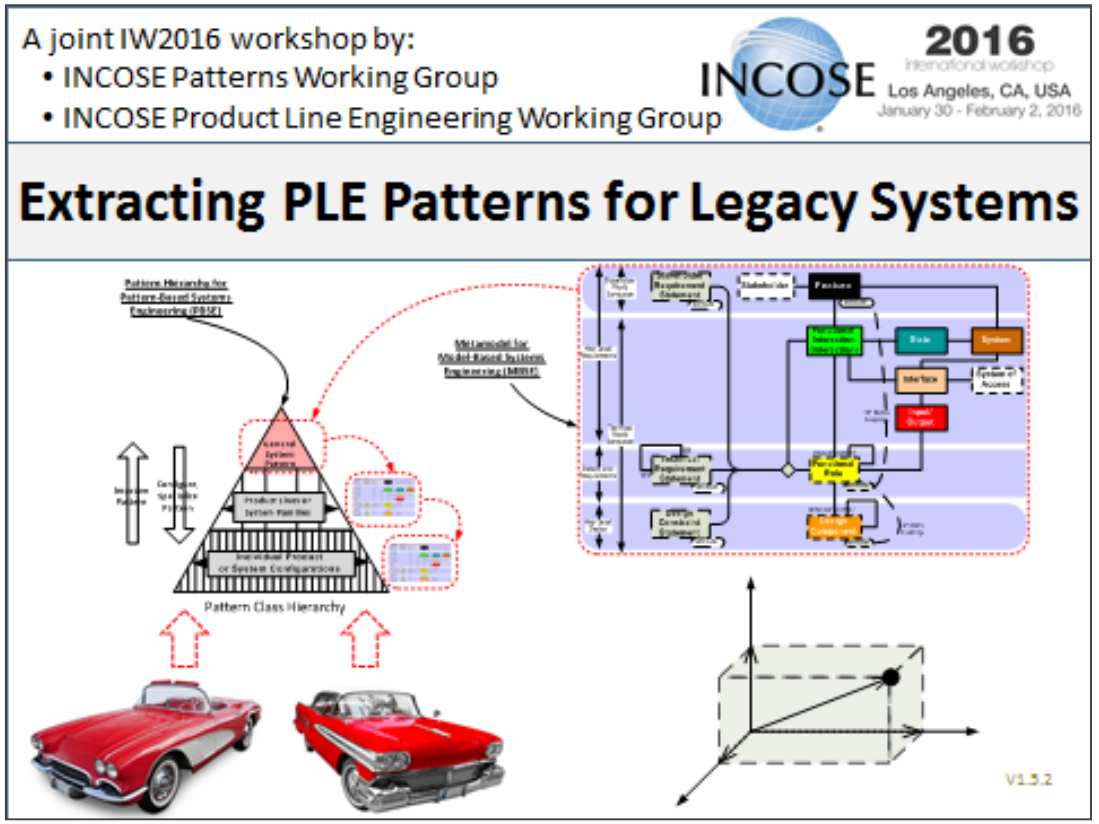
- Sample COTS legacy system document (sanitized) provided by PLE WG, for a legacy pneumatic control system product line
- Projected legacy data onto S*Pattern space, identifying S*Features, S*Interactions, S*Interfaces, S*States, S*Requirements
- Met with PLE WG at IW2018 to confirm next steps and interests

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*

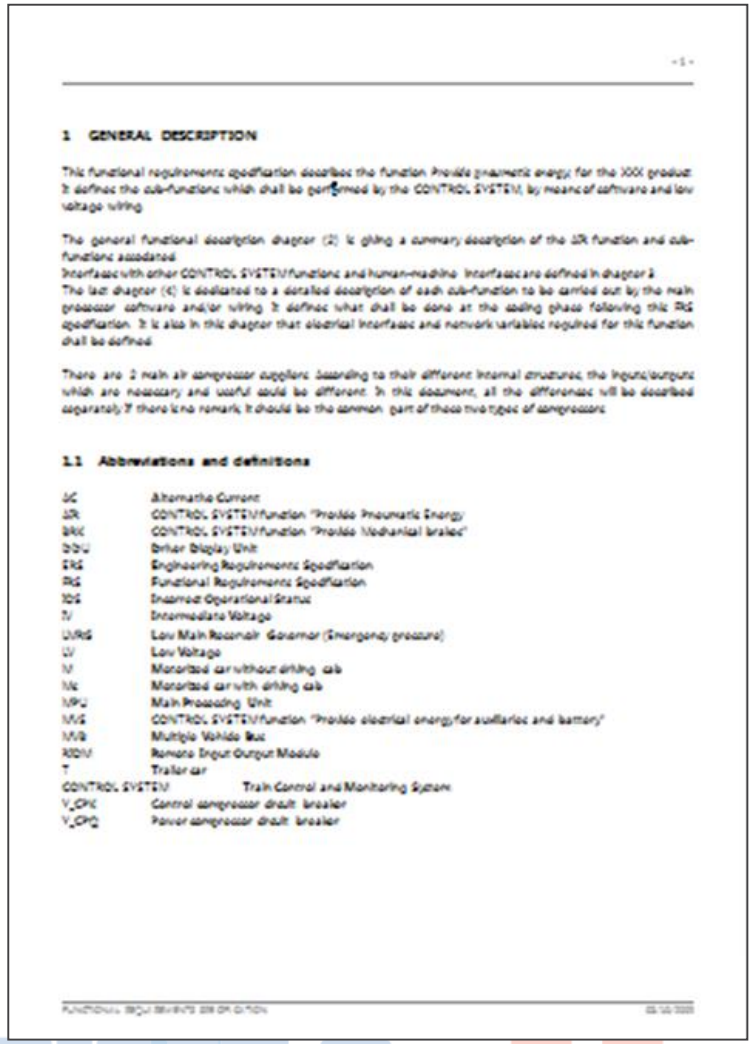
Project 1: Demonstration of Legacy Product Line Pattern Harvest, using Method of Projections



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



1 GENERAL DESCRIPTION

This functional requirements specification describes the function Provide pneumatic energy for the XXX product. It defines the sub-functions which shall be performed by the CONTROL SYSTEM, by means of software and low voltage wiring.

The general functional description chapter (2) is giving a summary description of the EPR function and sub-functions associated.
Interfaces with other CONTROL SYSTEM functions and human-machine interfaces are defined in chapter 3.
The last chapter (4) is dedicated to a detailed description of each sub-function to be carried out by the main processor software and/or wiring. It defines what shall be done at the coding phase following this FRS specification. It is also in this chapter that electrical interfaces and network variables required for this function shall be defined.

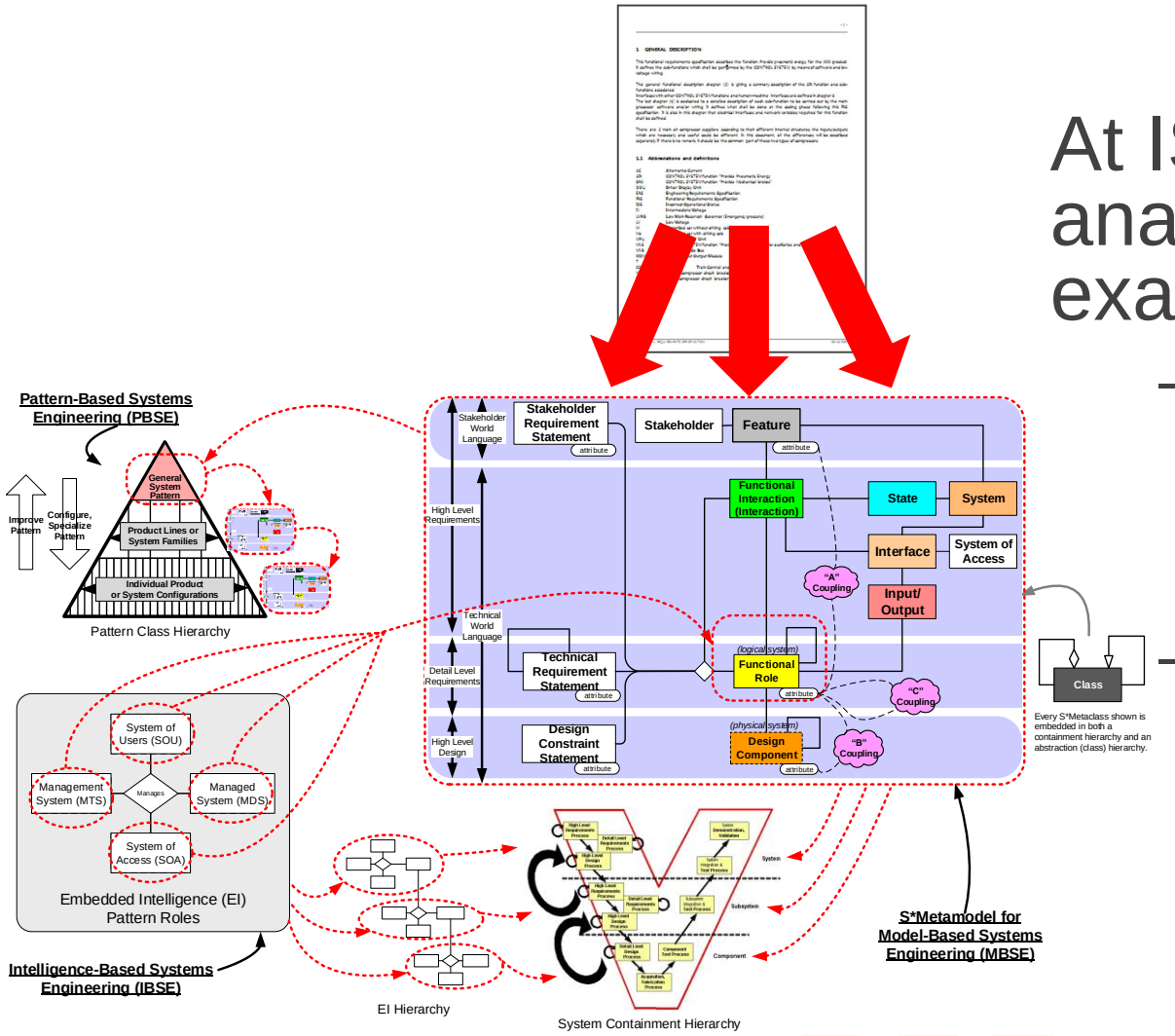
There are 2 main air compressor suppliers. According to their different internal structures, the inputs/outputs which are necessary and useful could be different. In this document, all the differences will be described separately. If there is no remark, it should be the common part of these two types of compressors.

1.1 Abbreviations and definitions

AC	Alternating Current
APR	CONTROL SYSTEM function "Provide Pneumatic Energy"
BRAK	CONTROL SYSTEM function "Provide Mechanical brakes"
DDU	Driver Display Unit
ERS	Engineering Requirements Specification
FRS	Functional Requirements Specification
IOS	Internal Operational Status
IV	Intermediate Voltage
LVRG	Low Main Reservoir Governor (Emergency pressure)
LV	Low Voltage
M	Motorized car without driving cab
Mc	Motorized car with driving cab
MPU	Main Processing Unit
MVS	CONTROL SYSTEM function "Provide electrical energy for auxiliaries and battery"
MVB	Multiple Vehicle Bus
RIOM	Remote Input Output Module
T	Trailer car
CONTROL SYSTEM	Train Control and Monitoring System
V_CPC	Control compressor circuit breaker
V_CPQ	Power compressor circuit breaker

- 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)

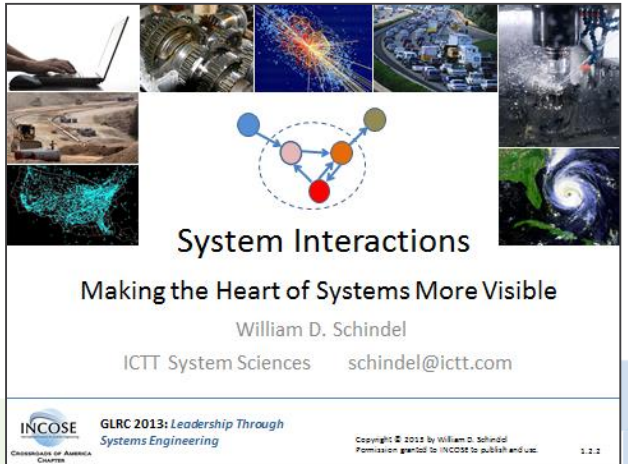
- Product lines, and S*Patterns, have fixed and variable (configurable) aspects
- One view of an analyzed and automation-supported Product Line is that:
  - the variable aspects have been explicated, but . . .
  - the fixed parts, described by information “assets” that may not be model-based, *might*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

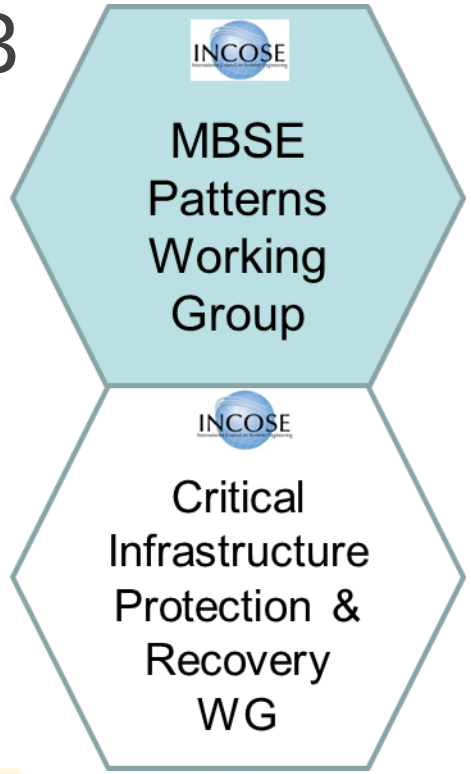
Points of value add we want to emphasize in the example (confirmed at IW2018)

- 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



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

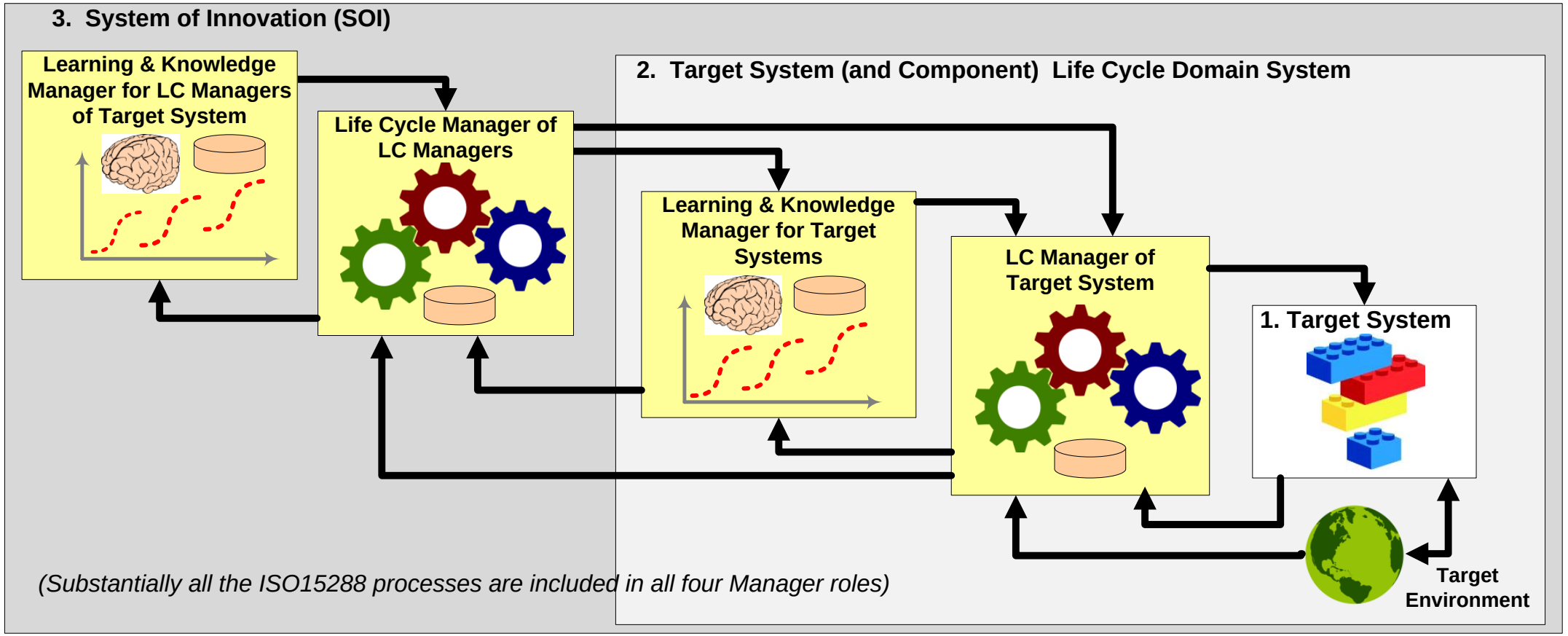


Primary Contact:
Mike DeLamar, Bechtel

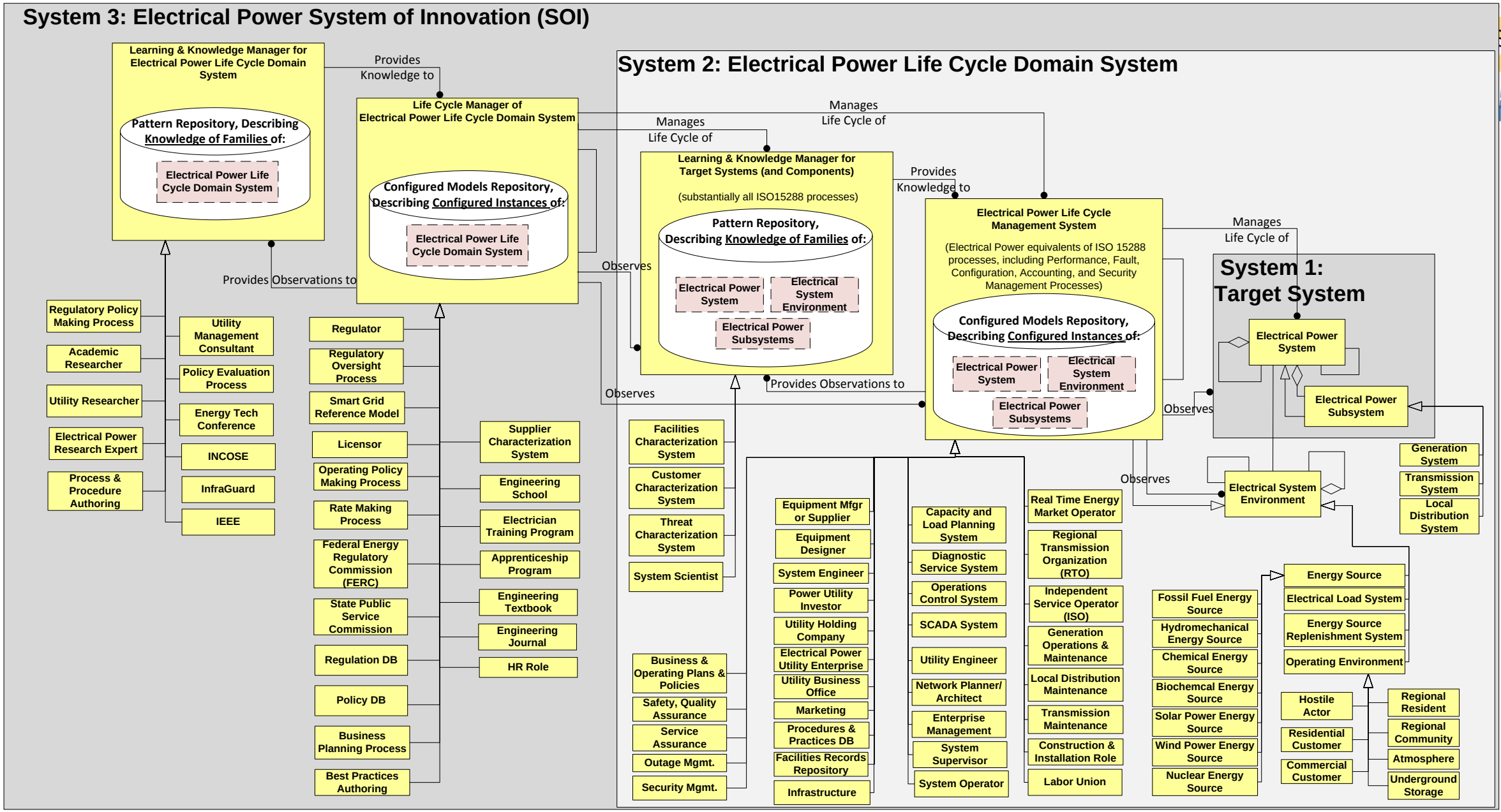
CIPR Pattern Collaboration: Jan 2019 Status

- 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.



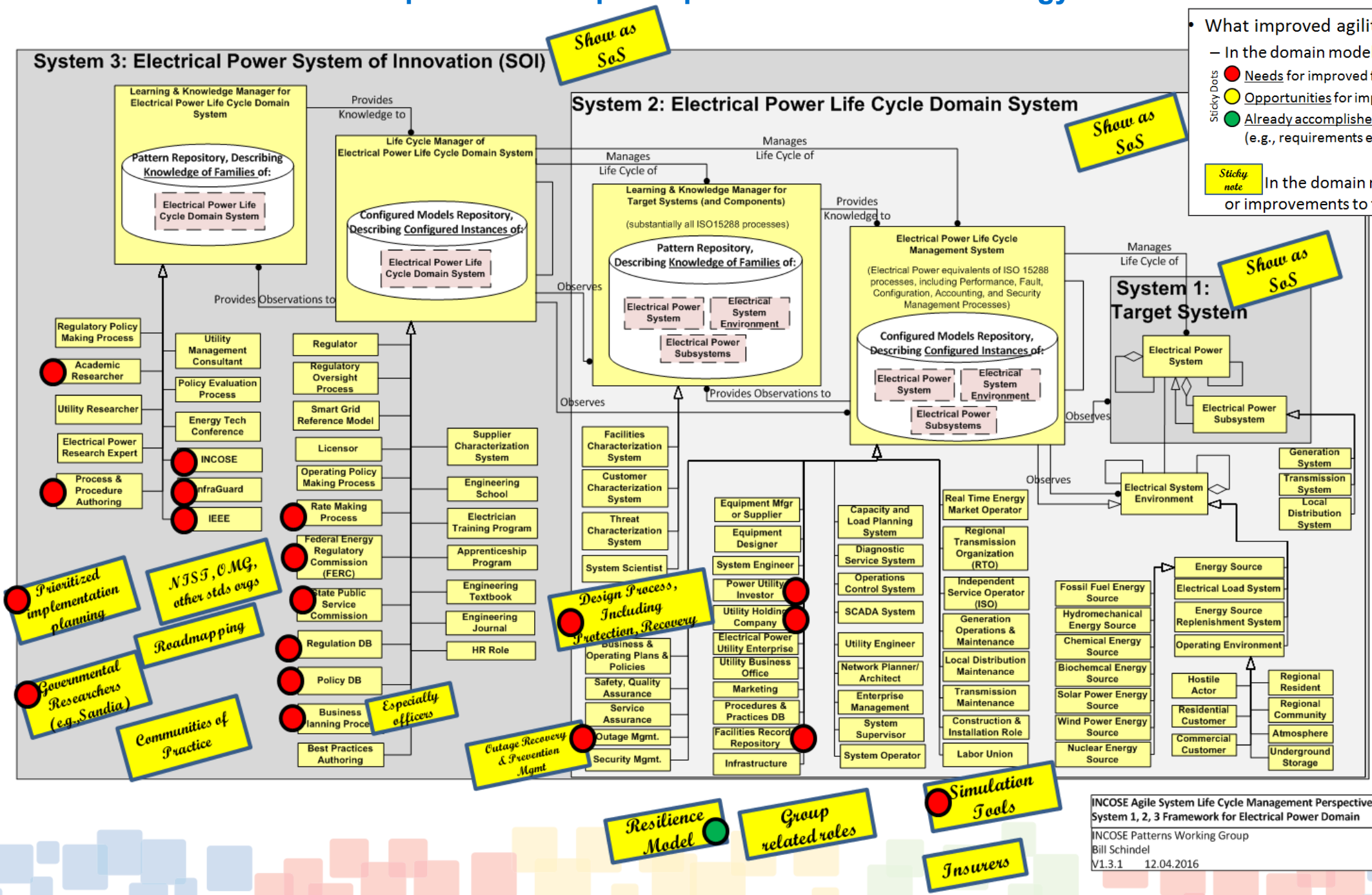
System 2, 3 framework for Electrical Power Grid

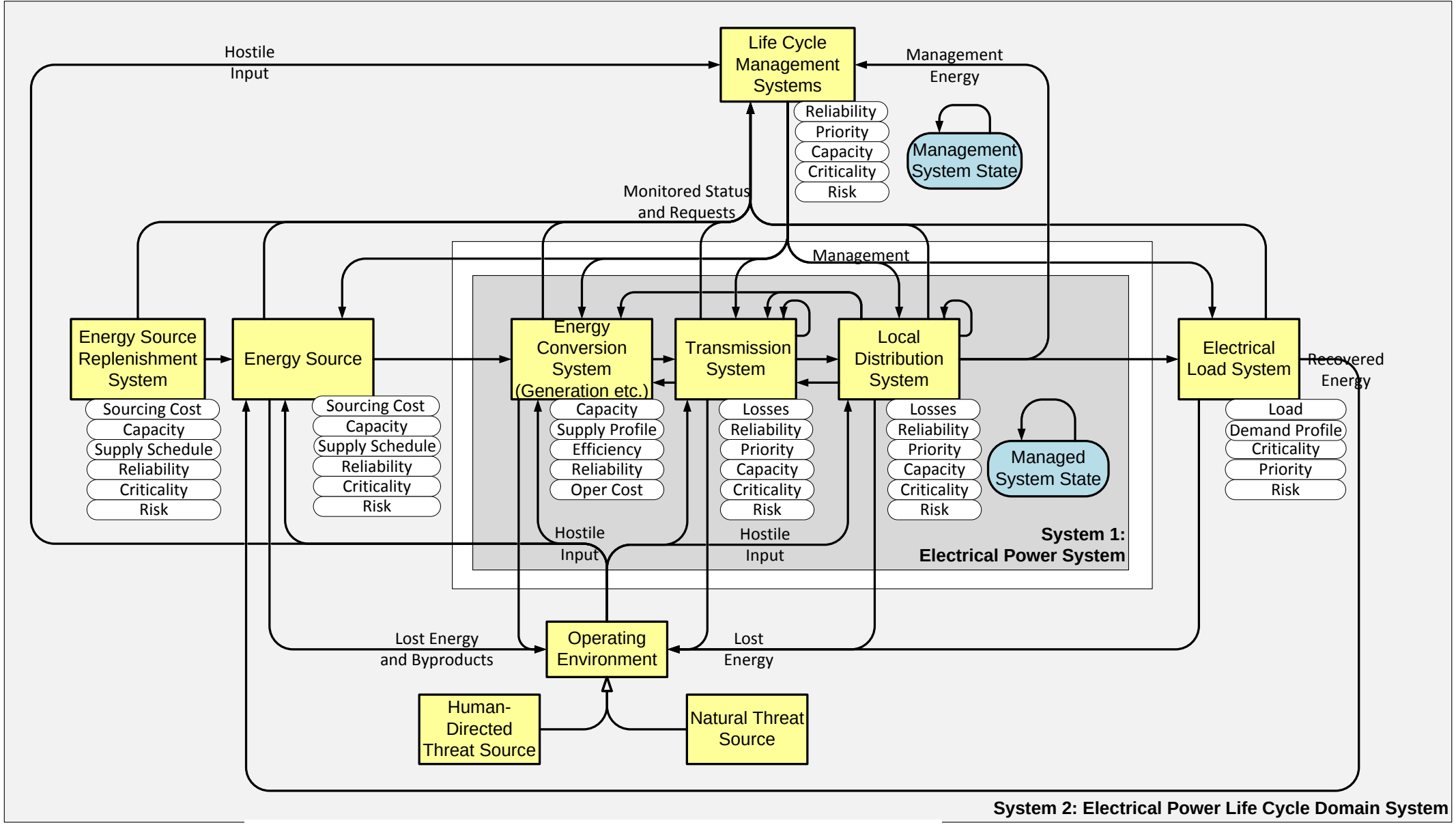
INCOSE Agile System Life Cycle Management Perspective: System 1, 2, 3 Framework for Electrical Power Domain

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:

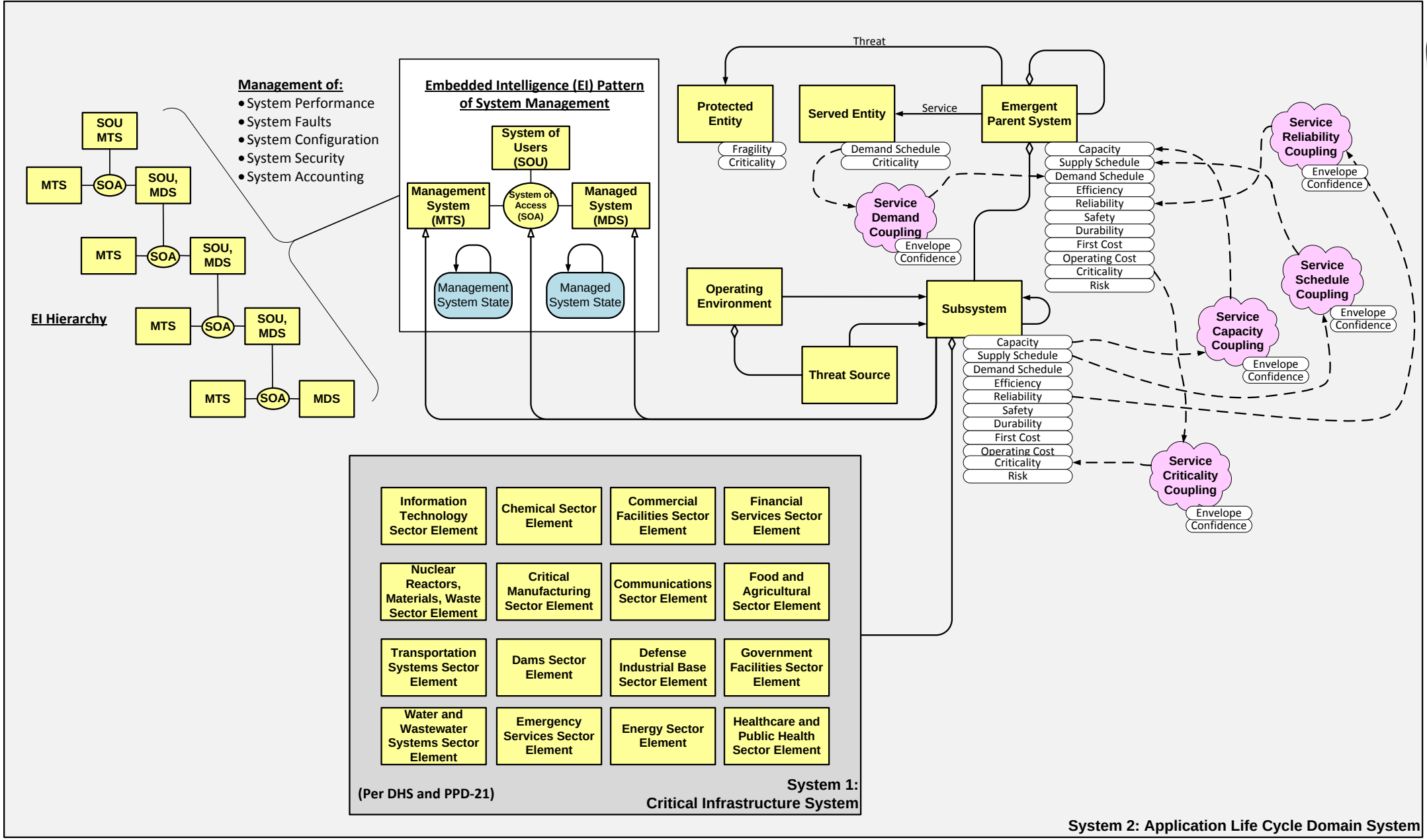




System 1 framework for Electrical Power Grid

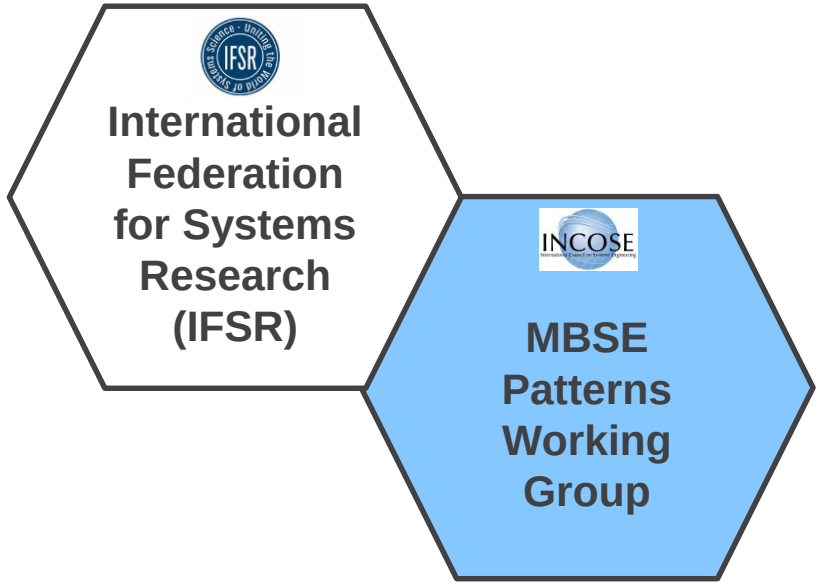
INCOSE Agile System Life Cycle Management Perspective: System 1 & 2 Summary, for Electrical Power Domain

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

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, presented by Ed Carroll at IW2019 MBES Workshop:

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/ MBSE Practice

Dana Grisham
SNL-Data Governance/Agile Methods

Chris Schreiber
Lockheed Martin Space Systems-Systems Engineering Modernization

Bill Schindel
ICTT Systems Sciences-Systems Sciences

Frank Salvatore
Engility Corp-Systems Engineering/ Data Taxonomy

Eliot Rich
Univ at Albany, SUNY-System Dynamics

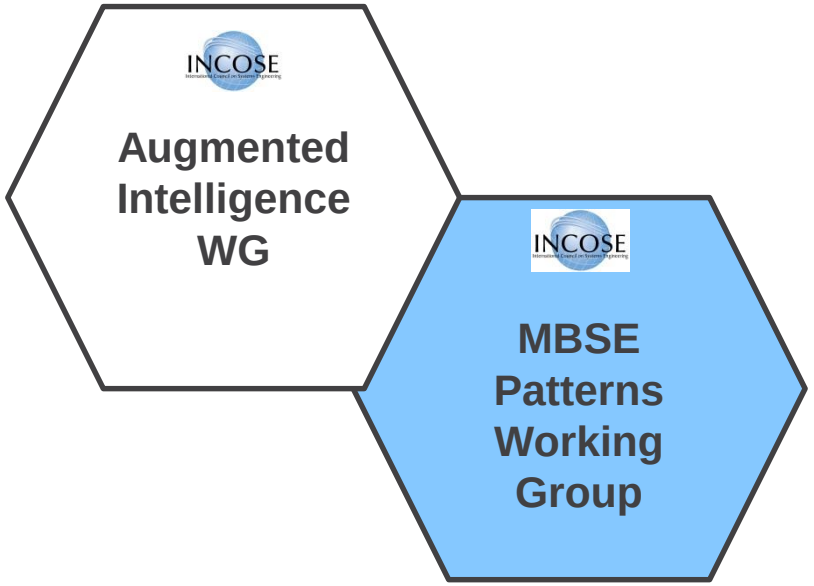
Teleconference participation from:

Steve Jenkins
JPL-Systems Semantics

Anne O'Neil
Anne O'Neil Consultants-Organizational Transformation

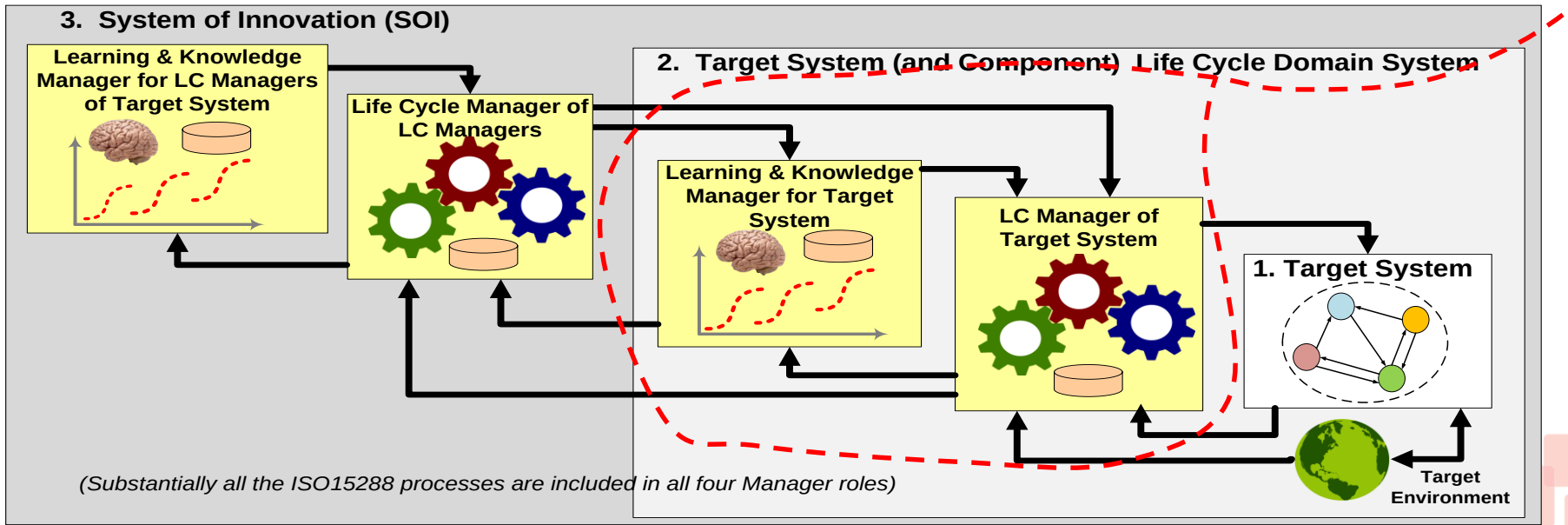
Augmented Intelligence Challenge Team Collaboration

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



WG Project Team:
Jon Torok, Frank Salvatore,
Jason Sherey, Stephen Lewis

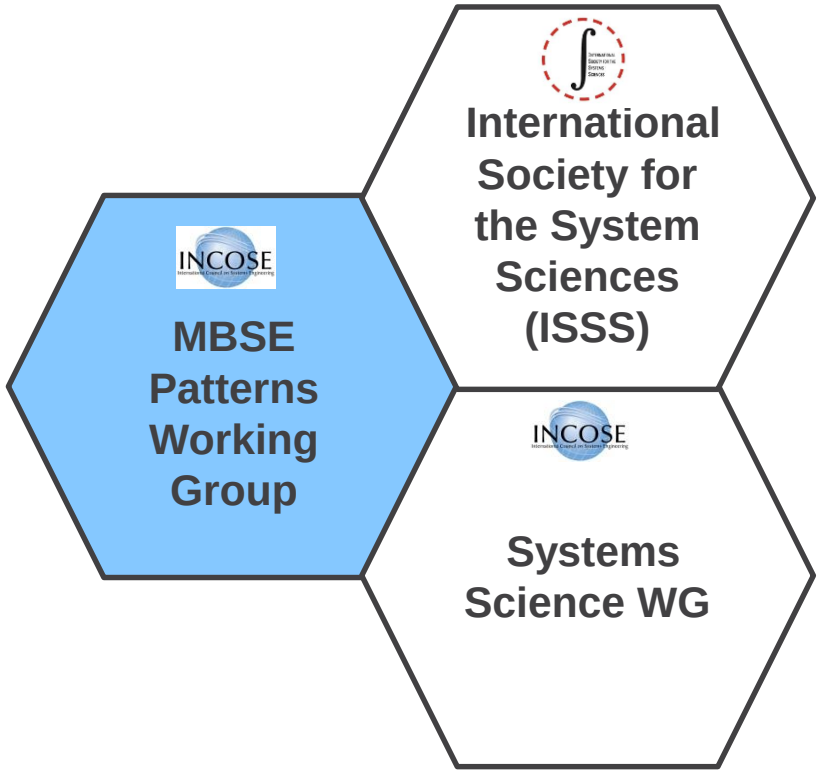
Interface Patterns Project: July 2018 Status

- 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

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 Jan 2019

- 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.
  - Joint sessions with SSWG at IW2018, IS2018, and IW2019
- Summary: We assert that there is an impactful 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),
- Presented invited plenary to ISSS 2018 in Corvallis, OR, USA, July, 2018
- Contributing “System Patterns” chapter of *Handbook of System Science*, Springer.
- IW2019: SSWG seeking collaborations in support of various ISO15288 processes.

INCOSE Outreach to Model Communities

Discussion

Future Projects of Interest to Attendees

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28th Annual INCOSE international symposium

Washington, DC, USA

July 7 - 12, 2018

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