A Few Words First

Courtesy – Please mute your phone (*6 toggle).

Upcoming Meetings – see events on Chapter home page for details:

- Apr 11: Is Systems Engineering Really Engineering? LUNCH MEET 11:45-13:00 Dr. Steve Jenkins, JPL, Chief Engineer of Integrated Model-Centric Engineering
- May 09: Creating Decision Guidance for Applying Agile System Engineering Ron Lyells, Retired Honeywell, Co-Chair INCOSE Agile Systems & SE WG
- May 10-11: Tutorial Model Based Systems Engineering Registration is Open Mathew Hause, PTC, Engineering Fellow; Chair OMG SysML V2 submission team
- Jun 13: Requirements Efficiency Celeste Drewien, Sandia National Labs, National Security Studies Department
- Sep 20-22: Western States Regional Conference, Ogden, Utah Website: <u>https://incose-wsrc.eventbrite.com</u>, Presentation call open all of March

CSEP Courses by Certification Training International: <u>Course details</u> | <u>Course brochure</u> Upcoming Course Schedule (close by, but many more locations and dates): 2018 Apr 02-Apr 6 | Denver, CO 2018 May 21-May 25 | Austin, TX 2018 Oct 15-Oct 19 | Albuquerque, NM Chapter SEP mentors: Ann Hodges <u>alhodge@sandia.gov</u>, Heidi Hahn <u>hahn@lanl.gov</u>

> First slide, not recorded but retained in Library-archived pdf slide file. And Now - Introductions

Enchantment Chapter Monthly Meeting



<u>14 March 2018 – 4:45-6:00 pm:</u>

Systems Engineering Transformation

Troy Peterson, System Strategy, VP; Director INCOSE's Transformation Initiative

Abstract: While complex systems transform the landscape the Systems Engineering discipline is also experiencing a transformation to model based discipline. In alignment with this one of the International Council on Systems Engineering (INCOSE) strategic objectives is to accelerate this transformation. INCOSE is building a broad community that promotes and advances model based methods. This model based transformation is necessary to advance the discipline and handle the seamless integration of computational algorithms and physical components across domains and traditional system boundaries. This presentation will cover current and planned INCOSE activities directed at accelerating this transformation.

Download slides today-only from GlobalMeetSeven file library or anytime from the Chapter website Library at <u>www.incose.org/enchantment</u> **NOTE: This meeting will be recorded**

Today's Presentation

Things to Think About

How can this be applied in your work environment? What did you hear that will influence your thinking? What is your take away from this presentation?

Speaker Bio



Troy Peterson is Vice President and Fellow at System Strategy Inc. a systems consulting business.

Previous to this role Troy was a Booz Allen Fellow and the firm's Chief Systems Engineer responsible for instituting capabilities to manage complexity engineer resiliency and speed innovation. Prior to joining Booz Allen Troy worked at Ford Motor Company as a Lead Manufacturing Engineering and as an entrepreneur operating a design and management consulting business.

Troy has led several international projects and large teams in the delivery of complex systems. His experience spans commercial government and academic environments across all product life cycle phases.

Recent engagements include system projects related to autonomy contingency basing combat and tactical vehicles and developing engineering capability within organizations responsible for research development acquisition and system of systems engineering and integration.

Troy's impact has led to his appointment to six different boards to improve engineering education and method application. He frequently speaks at leading engineering conferences and was recently appointed by INCOSE as the lead for transforming Systems Engineering to model based discipline.

Troy leads the INCOSE Transformational Working Groups, is Co-Chair of the MBSE Patterns Working Group, and is the INCOSE Michigan Chapter Past President.

Troy received his B.S. in Mechanical Engineering from Michigan State University, his M.S. in Technology Management from Rensselaer Polytechnic Institute, and an advanced graduate certificate in Systems Design and Management from the Massachusetts Institute of Technology (MIT).

He holds INCOSE Systems Engineering, PMI Project Management, and ASQ Six Sigma Black Belt certifications



INCOSE: TRANSFORMATION STRATEGIC OBJECTIVE

Troy A. Peterson

INCOSE Assistant Director Systems Engineering Transformation troy.peterson@incose.org

Vice President & Technical Fellow

System Strategy, Inc. (SSI)



INCOSE Webinar 106 November 15, 2017

Systems Engineering

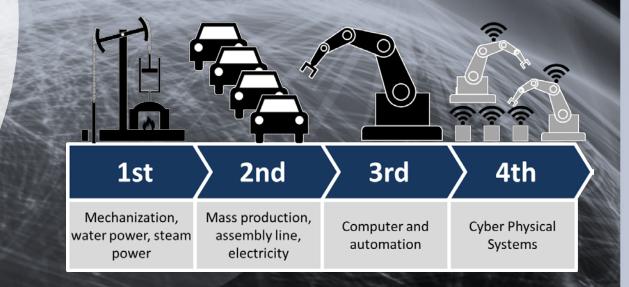
The Essence of the Next Industrial Revolution

"The world is entering the Fourth Industrial Revolution. Processing and storage capacities are rising exponentially, and knowledge is becoming accessible to more people than ever before in human history. The future holds an even higher potential for human development as the full effects of new technologies such as the Internet of Things, artificial intelligence, 3-D Printing, energy storage, and quantum computing unfold."

The Global Information Technology Report Innovating in the Digital Economy World Economic Forum WØRLD ECONOMIC FORUM

Digital Transformation

Industrial Revolution



14 March 2018



Deep Shift Technology Tipping Points and Societal Impact



COMMITTED TO IMPROVING THE STATE OF THE WORLD

The Six Megatrends

As a foundation to its work, the council sought to identify the software and services megatrends which are shaping society, and their associated opportunities and risks.

People and the internet

How people connect with others, information and the world around them is being transformed through a combination of technologies. Wearable and implantable technologies will enhance people's "digital presence", allowing them to interact with objects and one another in new ways.

Computing, communications and storage everywhere

The continued rapid decline in the size and cost of computing and connectivity technologies is driving an exponential growth in the potential to access and leverage the internet. This will lead to ubiquitous computing power being available, where everyone has access to a supercomputer in their pocket, with nearly unlimited storage capacity.

The Internet of Things

Smaller, cheaper and smarter sensors are being introduced – in homes, clothes and accessories, cities, transport and energy networks, as well as manufacturing processes.

Artificial intelligence (Al) and big data

Exponential digitization creates exponentially more data – about everything and everyone. In parallel, the sophistication of the problems software can address, and the ability for software to learn and evolve itself, is advancing rapidly. This is built on the rise of big data for decision-making, and the influence that AI and robotics are starting to have on decision-making and jobs.

The sharing economy and distributed trust

The internet is driving a shift towards networks and platform-based social and economic models. Assets can be shared, creating not just new efficiencies but also whole new business models and opportunities for social selforganization. The blockchain, an emerging technology, replaces the need for third-party institutions to provide trust for financial, contract and voting activities.

The digitization of matter

Physical objects are "printed" from raw materials via additive, or 3D, printing, a process that transforms industrial manufacturing, allows for printing products at home and creates a whole set of human health opportunities.

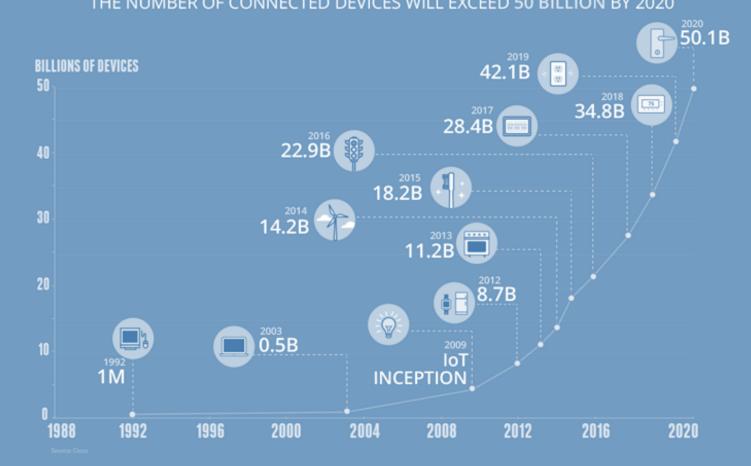


163307/50

Trends: Internet of Things and System Interactions

The interconnection of products is ubiquitous, occurring across domains and with systems we use every day creating a complex web of interdependent systems.

GROWTH IN THE INTERNET OF THINGS





Trends: Data Science



Analytics – Data Science - Visualization/Navigation: Improving Systems and Shared Human Understanding Across Stakeholders



Trends: Cyber Security

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Cyber-Physical Intertwined cyber and physical, vast state space, new vulnerabilities

Dance problems.

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Trends: Artificial Intelligence

Artificial Intelligence Human – Machine interactions solving complex problems (team play)



Trends: Industrial Revolution / Industry 4.0

Industry 4.0 / Industrial Internet Connecting models across the lifecycle



Transforming Systems Engineering



Vision25

Systems engineering will lead the effort to drive out unnecessary complexity through well-founded architecting and deeper system understanding

A virtual engineering environment will incorporate modeling, simulation, and visualization to support all aspects of systems engineering by enabling improved prediction and analysis of complex emergent behaviors.

Composable design methods in a virtual environment support rapid, agile and evolvable designs of families of products. By combining formal models from a library of component, reference architecture, and other context models, different system alternatives can be quickly compared and probabilistically evaluated. **From:** Model-based systems engineering has grown in popularity as a way to deal with the limitations of document-based approaches, but is still in an early stage of maturity similar to the early days of CAD/CAE.

To:Formal systems modeling is standard practice for specifying, analyzing, designing, and verifying and is fully integrated with other systems. engineering models. System models are adapted to application domain, and include a broad the spectrum of models for representing all aspects of systems. The use of internet-driven knowledge representation and immersive technologies enable highly efficient and shared human understanding of systems in a virtual environment that span the full life through development, cvcle from concept manufacturing, operations, and support.



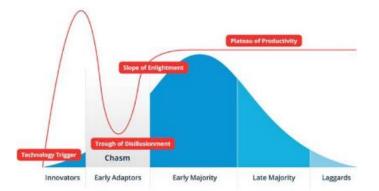
INCOSE's Transformation Strategic Objective

Objective:

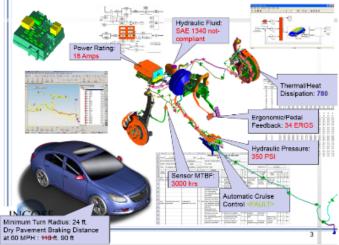
INCOSE <u>accelerates</u> the <u>transformation</u> of systems engineering to a <u>model-based discipline</u>.

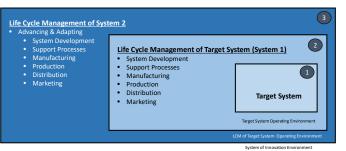
- Accelerates:
 - Understand the hype cycle¹ and bridge the chasm²...
 - Empower others to enlighten and influence adoption
- Transformation:
 - A marked change, as in appearance or character, usually for the better³. e.g. documents to models
 - Lead and support the community in crossing the chasm
- Model Based Discipline
 - System models of all types
 - Modeler Collaboration and Model Integration

Hype Cycle is a branded graphical presentation developed and used by IT research and advisory firm Gartner
 Moore, Geoffrey A. "Crossing the Chasm – and Beyond" Strategic Management of Technology and Innovation Third Edition 1996
 Excerpted from The American Heritage Dictionary of the English Language, Third Edition 1996 by Houghton Mifflin Company
 Friedenthal, Sandy and Sampson, Mark - MBSE Initiative Overview - http://www.omgwiki.org/MBSE/doku.php



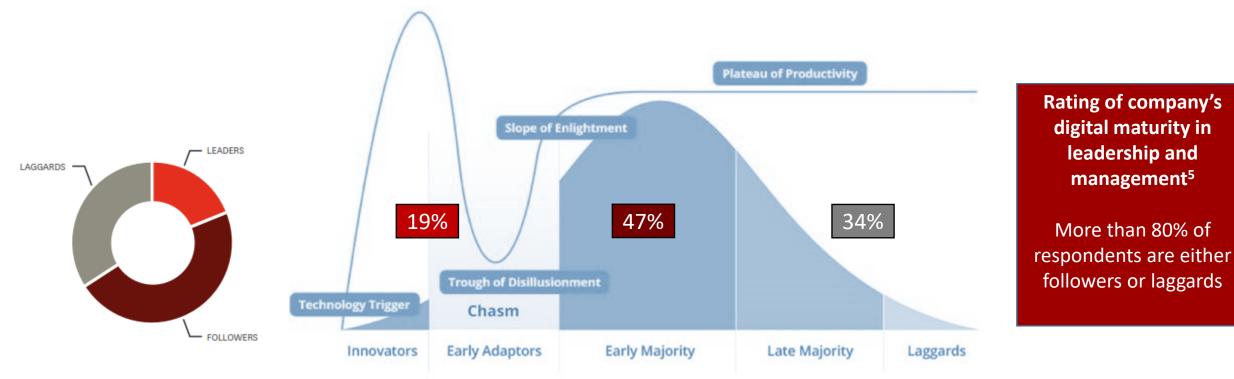
Integrated Systems Engineering Vision







Accelerating: Technology Adoption – Hype and Chasm



Acceleration is very much about sharing, communicating and learning

Where would you plot your organization today?

1. Hype Cycle is a branded graphical presentation developed and used by IT research and advisory firm Gartner

5. Driving Digital Transformation: New Skills for Leaders, New Role for the CIO, Harvard Business Review

^{2.} Hype Cycle Graphic: <u>https://en.wikipedia.org/wiki/Hype_cycle</u>

^{3.} Moore, Geoffrey A. "Crossing the Chasm – and Beyond" Strategic Management of Technology and Innovation Third Edition 1996

^{4.} Hype Cycle, Chasm Combined Graphic: http://www.datameer.com/blog/big-data-analytics-perspectives/big-data-crossing-the-chasm-in-2013.html



Transformation: Change Management and Leadership

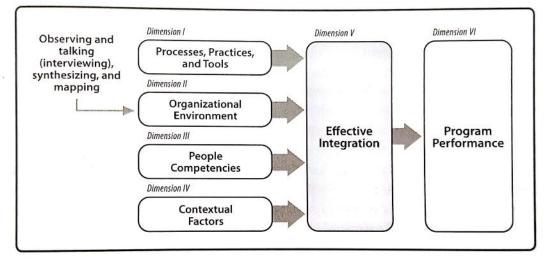


Figure 15-1: The dimension of the Integration Framework in view for initial engagement activities

Consider:

ABP = CM(OE + BPR + IT)

- ABP = Achieving Breakthrough Performance
- OE = Organizational Environment
- BPR = Business Process Reengineering
- IT = Information Technology
- CM = Change Management

Consider key dimensions of change

- People, Process, Technology, and Physical Infrastructure
 - Integrate dimensions of change
 - Addresses dimensions in parallel
 - Leverage concurrency to encourage cross dimension trades
 - Build ownership at the grass-root level

Transformation is very much a people focused endeavor.



Transformation: Driving Digital Transformation¹

Keys to Digital Transformation (HBR Report)

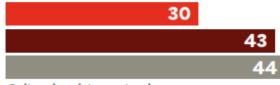
- Start from the customers perspective
- Digital leadership starts at the top
- Engage in a discussion of trends
- Think about agile
- Use examples to make it real
- Need a foundation of trust
- Use KPIs for sharing knowledge
- Break down walls wherever possible
- Need digital coaches or maters
- Create appropriate learning forums

KEY BARRIERS TO DIGITAL BUSINESS DEVELOPMENT

Percentage who said, when it comes to digital business, these are the primary issues holding their organization back. [CHECK UP TO THREE]

LEADERS • FOLLOWERS • LAGGARDS
 44
 41
 36
 Organizational silos
 43
 42
 34





1. Driving Digital Transformation: New Skills for Leaders, New Role for the CIO, Harvard Business Review



Model Based Discipline: The Next Evolutionary Step

Model Based Discipline

- Models are not new to us
- In some ways we're going "back to the future"
- Transformation is not a wholesale change
- Model based is the next evolutionary step
- A transformation whose time has come

Understand the Current State

• Take inventory of current state of transition and progress toward becoming a model based discipline

Envision and define the future state of SE:

• See Vision 2025, what are the business objectives, metrics, stakeholders, technologies, priorities etc.

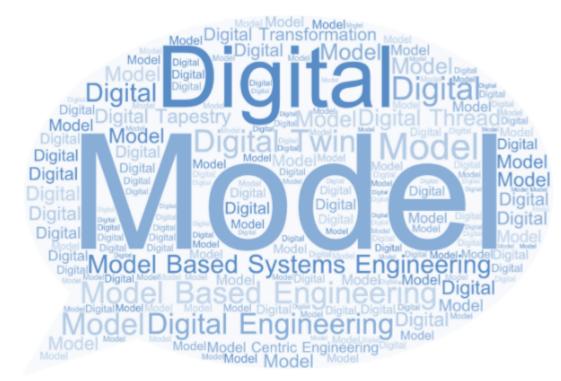


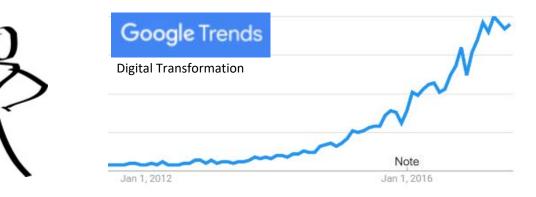
"Make sure that those, 'Ideas whose time has come', get launched today."



Model Based Discipline: What do we mean by MBSE

- What do we mean by:
 - Model Based Systems Engineering
 - Model Based Engineering
 - Model Based Development
 - Model Based Design
 - Model Centric Engineering
 - Model Based Methods
 - Digital Engineering
 - Digital Design
 - Digital Thread
 - Digital Twin
 - Digital Tapestry
 - Et al.







Transformation Strategy Overview

- Vision
- Mission
- Mission Areas
- Goals
- Objectives

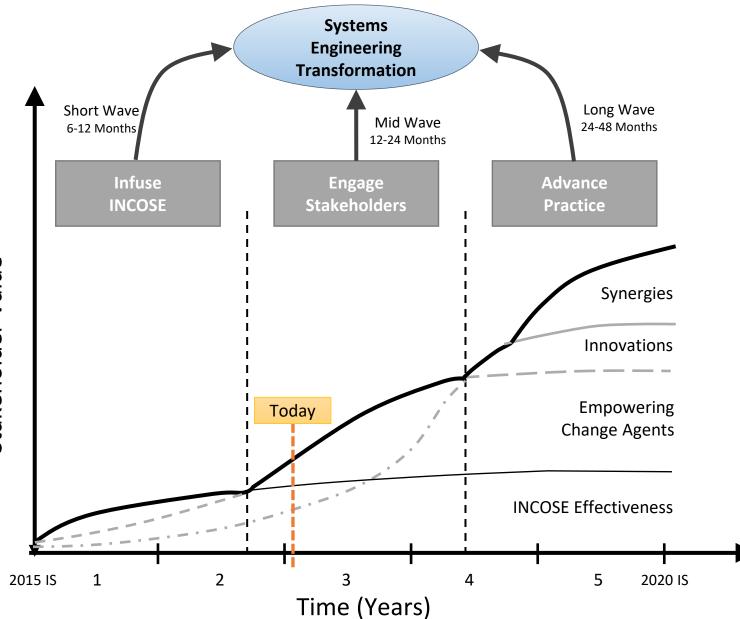
Vision	Systems Engineering is	s acknowledged as a n	nodel based discipline			
Mission	INCOSE accelerates the transformation of systems engineering to a model-based discipline					
Mission Area #	1	2	3			
Mission Area	Infuse INCOSE	Engage Stakeholders	Advance Practice			
Mission Area	What can INCOSE Do?	What is practiced and needed?	What is possible?			
Goals	Infuse model based methods throughout INCOSE products, activities and WGs	Engage stakeholders to assess the current state of practice, determine needs and values of model based methods	Advance stakeholder community model based application and advance model based methods.			
<i>Objective 1</i> Foundations	Inclusion of model based content in INCOSE existing/new products (Vision, Handbook, SEBoK, Certification, Competency Model, etc.)	Define scope of model based systems engineering with MBE practice and broader modeling needs	Advance foundational art and science of modeling from and best practices across academia, industry/gov. and non profit.			
Objective 2 Expand Reach	Expand reach within INCOSE of MBSE Workshop; highlight and infuse tech ops activities with more model based content (products, WGs etc.)	Identify, categorize and engage stakeholders and characterize their current practices, enablers and obstacles	Increase awareness of and about stakeholders outside SE discipline of what is possible with model based methods across domains and disciplines (tech/mgmt)			
Objective 3 Collaborate	Outreach: Leverage MOUs to infuse model based content into PMI, INFORMS, NAFEMS, BIM, ASME and others, sponsoring PhD Students, standardization bodies, ABET	Build a community of Stakeholder Representatives to infuse model based advances into organizations practicing systems engineering.	Initiate, identify and integrate research to advance systems engineering as a model based discipline			
Objective 4 Assessment/ Roadmap	Assess INCOSE's efforts (WG, Objectives, Initiatives etc.) for inclusion of model based methods across the Systems Modeling Assessment/Roadmap	Engage stakeholder community with Systems Modeling Assessment/ Roadmap to better understand the state of the practice of MBSE. Push and pull content from stakeholders (change agents and the "to be convinced")	Provide baseline assessment framework, Systems Modeling Roadmap, to create a concrete measure of current state of the art of what's possible/what's the potential. 20			



• Mission Areas

IW. 14 March 2018

- Internal Short Wave
- External Mid Wave
- Advancing Long Wave
- Waves Run Concurrently
- Activities build on each other
- Important to fully engage stakeholder this next year. Pilot Assessment & Roadmap this CY and kick-off more broadly at 2017



Stakeholder Value



Transformation – Objectives & Initiatives

New/Related Developments

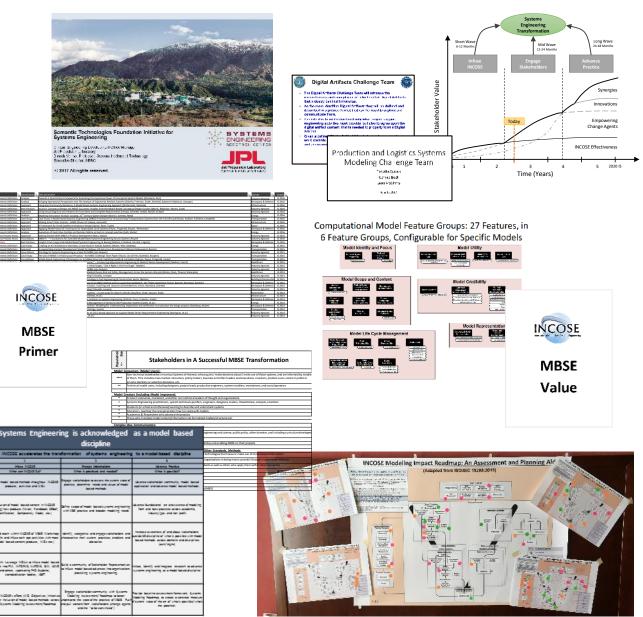
- SE Ontology Effort with SERC, JPL et al.
- MBSE Initiative Challenge Teams for Digital Artifacts, Production & Logistics Systems Modeling
- Collaborative V&V of models in effort with ASME
- 2018 IS MBSE Workshop "TED Talks" & Case Studies

Products Under Development

- Model Based Exemplars
- Assessment Roadmap Model Features
- INCOSE MBSE Primer
- Value Briefing / Case Studies / ROI
- Webinar planned for November

Accomplishments

- Strategy & Action Plan
- Stakeholder List
- Assessment Roadmap
- Enablers & Roadblocks
- Web search improvements
- Transformation website created
- Integration of MBSE throughout IW
- Many professional society and company briefings on Systems Engineering Transformation



Interactions/Integ Interactions/Integ Interactions/Integ Interaction Interacti

Digestion 3 Averal free:



Transformation Stakeholders



- Engineering
 Executives
- Policy Makers
- Academics & Researchers
- Practitioners
- Tool Vendors

This vision will continue to evolve based on stakeholder inputs and on-going collaborations with professional societies.



ation

Stakeholders in A Successful MBSE Transformation

- Model Consumers (Model Users
- Non-technical stakeholders in various Systems of Interest, who acquire / make decisions about / make use of those systems, and are informed by models end of them. This includes mass market consumers, policy makers, business and other leaders and executives, investors, product users, voters in public or private dections or selection decisions, etc. Technical model users, including designers, project leads, production engineers, system installers, maintainers, and users/operators

Model Creators (including Model Improvers):

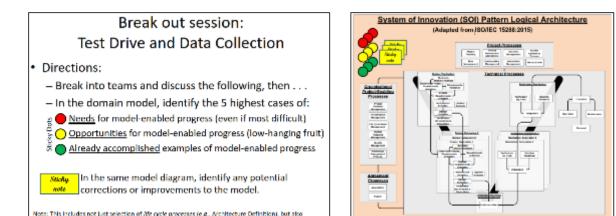
woder ci	reators (including violet improvers):
*	Product visionaries, marketers, and other non-technical leaders of thought and organizations
*	Systems Engineering practitioners, system technical specifiers, engineers, designers, testers, theoreticians, analysts, scientists
*	Students (in school and otherwise) learning to describe and understand systems
*	Educators, teaching the next generation how to create with models
*	Academics & Researchers who advance the practice
*	Those who translate model content/information into formalized models/structures etc.
	Idea Communicators;
**	Marketing professionals
**	Academics/Educators, especially in complex systems areas of engineering and science, public policy, other domains, and including curriculum developers
	as well as teachers
**	Leaders of all kinds
**	Leaders responsible to building their organization's MBSE capabilities and enabling MBSE on their projects
Model In	frastructure Providers, Including Tooling, Language and Other Standards, Methods:
*	Suppliers of modeling tools and other information systems and technologies that house or make use of model-based information
*	Methodologists, consultants, others who assist individuals and organizations in being more successful through model-based methods
•	Standards bodies (including those who establish modeling standards as well as others who apply them within other standards)
INCOSE a	and other Engineering Professional Societies
*	As a deliverer of value to its membership
*	As seen by other technical societies and by potential members
*	As a great organization to be a part of
*	As promoter of a dvance and practice of systems engineering and MBSE

Model Consumers Model Creators Complex Idea Communicators Model Infrastructure Providers INCOSE and other Professional Societies

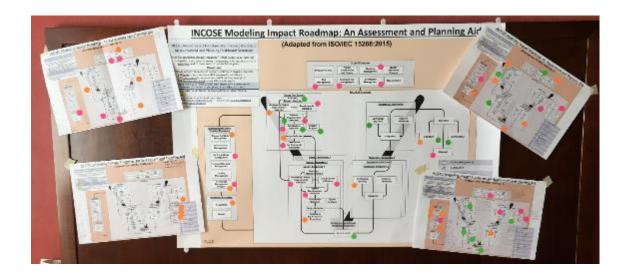


CAB Breakout: Assessment / Roadmap Instrument:

- Intentionally very simple:
 - Focused "one level down" from the intention to apply model-based methods to SE.
 - Level of detail = the individual ISO 15288 life cycle processes.
- Intended to address these <u>important</u> <u>questions</u>:
 - What are you trying to improve? (Which 15288 processes?)
 - Where are the biggest potential gains? The easiest potential gains?
 - What is already improved?
- But <u>not</u>:
 - <u>How</u> will your goals be accomplished?
 - What are the <u>details</u> of your plan?
 - Not a CMMI



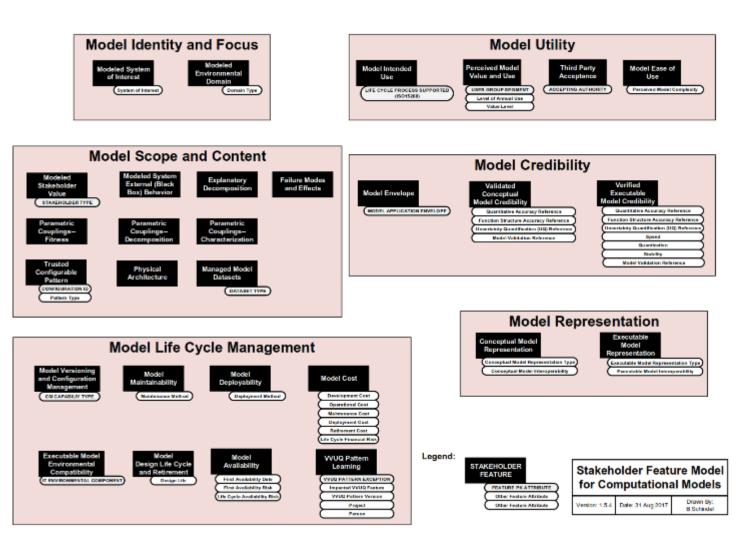
mains (e.g., Product, Manufacturing, Distribution, Service, Enterprise, etc.





INCOSE/ASME Model Stakeholder Features Pattern

- Being created in the INCOSE supported ASME VV50 standards committee project, also in use in the INCOSE Transformation effort.
- Metadata in the form of a model itself, describing "what is in the model" – like a barcode which describes a product.
- 29 Model Features, spread across 6 feature groups

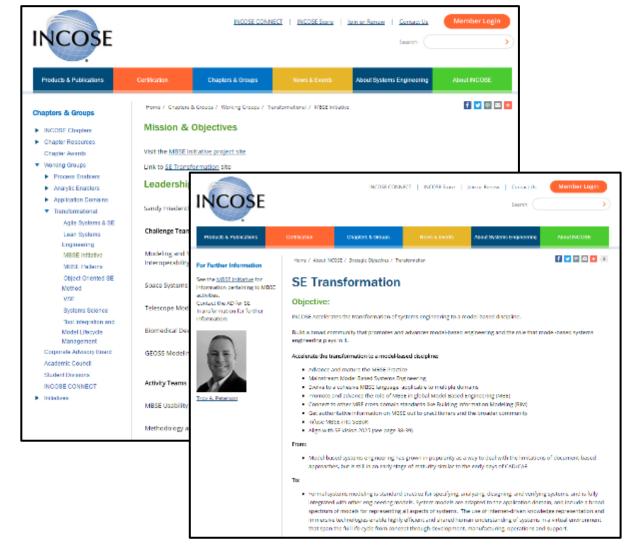




MBSE Wiki and Website

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expand upon the highly successful MBSE Workshop, nov		the state is a second bill as a state of the second				
to the International Workshop (IW) 2016, MBSE will be an	MBS	E Workshop Schedule				
the fWC in alignment with the INCOSE's Systems Enginee locus on current practices, advancements and collaboration	A VEGE I	Noticities Associate are being teld in Store F, with the su-	region whe	MRSE reception on S	antis which u	the held is the Zen Gam
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This page provides an overview of the MBSE related info		exercisions will be added to the agentia terms before as th	NA DECEMPT A	Contraction of the second		
W. Each group is encouraged to maintain a meeting pag	Saturday	y, January 28, 2017				
application, or INCOSE website. Presentations and other	TITE	Agenda Rem/Persentation Link		Presenter		
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 Get authoritative information on MBSE out to pract 	17 45-16:00 HDSE Workshop What up & Look sheed			Mark Sampson (Semena: & Troy Peleroon (SSI)		
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 Engage stakeholders to assess the current state of 	Other gross	pa with MOSE-related topics on Sanday (see group section	below for deta	and .		
 Determine needs and value of model based methols Advance stakeholder community and advance model 	Time(a)	Group				
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W 2017 MBSE Schedule	Sunday,	January 29, 2017				
	Time	Agendu Hem Presentation Link		Presenter		
The following PDF file contains the (GIW 2017 MDSC W	0.00- 0.30	MDSE Initiative & SE Transformation		Mark Sampeon (Sere	ena) & Troy Po	Arron (SSI)
This agenda includes the main MBSE workshop scheduk inked from the tables below as they become available.	0-38- 10-00	Cosing the Design Cycle Loop with Executable Require OSLC		Librene (The Reuse C	(0)	Tammascheit (Mosielor) -
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http://www.incose.org/about/strategicobjectives/transformation



Accomplishments: Website / Discoverability Improvements

Transformational Working Groups (WG)

- Agile Systems and Systems Engineering
- Lean Systems Engineering
- Model Based Systems Engineering Initiative
- Model-based Conceptual Design
- Object-Oriented SE Method
- MBSE Patterns
- Very Small Entities (VSE)
- Systems Science
- Tools Integration & Model Lifecycle Management
- INCOSE-NAFEMS Collaboration
- Ontology

Visit site for WG charters and to learn more

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MBSE Initiative as an Incubator and Transformation Agent

- Digital Artifacts Challenge Team:
 - Identifying and characterizing MBSE digital artifacts across the lifecycle
- Production and Distribution Systems Challenge Team
 - Connecting models across the lifecycle Industry 4.0, Supply Chain, Logistics
- V&V of models (Potential Collaboration ASME, INCOSE, NAFEMS)
 - Verification and Validation of Models tied to ASME VV50 standards project
- Augmented Intelligence in Systems Challenge Team
 - How can machine learning and AI aid systems engineering in the innovation process

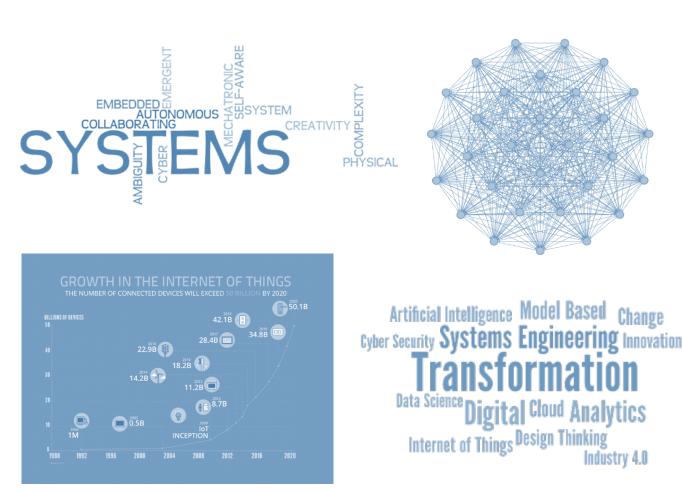


Generic	life cycle	(ISO/IEC/IEEE	15288:2015)	

	Concept stage	Development stage	Production	Utilization stage	Retirement	
			stage	Support stage	stage	



Overcoming the Challenge



...the only simplicity to be trusted is the simplicity to be found on the far side of complexity

Alfred North Whitehead (1861-1947)

Simplicity does not precede complexity but follows it. Alan Perlis (1922 – 1990)

Out of intense complexities intense simplicities emerge Winston Churchill (1874 – 1965)

Simplicity is complexity resolved.

Constantin Brancusi (1876-1957)

Fools ignore complexity. Pragmatists suffer it. Some can avoid it. Geniuses remove it.

Alan Perlis (1922 – 1990)

Any intelligent fool can make things bigger and more complex... It takes a touch of genius – and a lot of courage to move in the opposite direction.

Albert Einstein (1879 – 1955)

A genius! For 37 years I've practiced fourteen hours a day, and now they call me a genius!

Pablo de Sarasate (1844 - 1908)

Lesson: Endure complexity, add tireless effort, and a touch of genius...

"It is not necessary to change. Survival is not mandatory."

W. Edwards Deming





INCOSE's Transformation Strategic Objective:

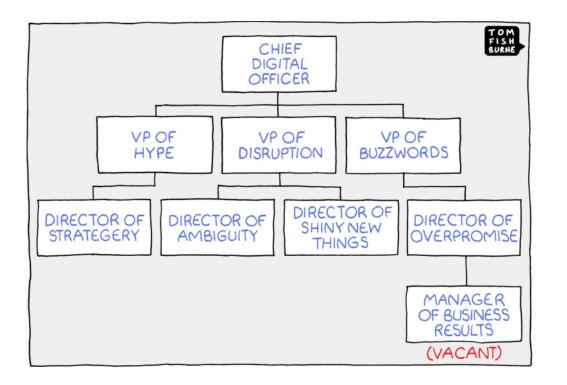
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Q&A





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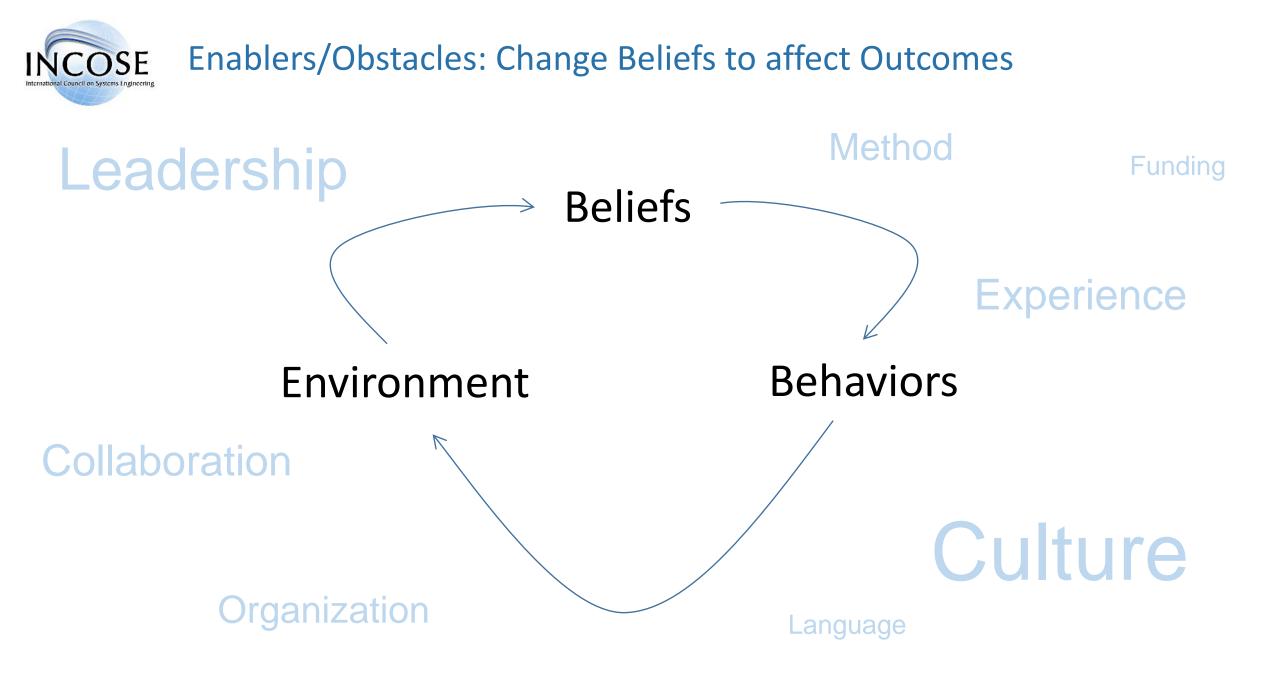
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