

INCOSE: TRANSFORMATION STRATEGIC OBJECTIVE

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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

OF THE WORLD

Digital Transformation

Industrial Revolution



24 October 2017



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 (AI) 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.



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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: Analytics and Data Science



Analytics – Data Science - Visualization: Improving Systems and Shared Human Understanding

24 October 2017



Trends: Industrial Revolution / Industry 4.0



Industry 4.0 / Industrial Internet Connecting data/models across the lifecycle – Agile Enterprises – Adaptable Systems

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Trends: Cyber Physical System Security

Dance problems.

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

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Trends: Artificial Intelligence

Augmented & Artificial Intelligence Human – machine interactions solving complex problems



Smart, Interconnected, Complex, Dynamic...









Nodes = 5

Potential Links = 10

Networks = 2^{10} or 1024



Nodes = 30, potential links = 435, unique configurations = 2^{435}

Number of known atoms in the universe ~ 2^{158 and} 2²⁴⁶



Quote on System Challenges Today

"Today more and more design problems are reaching insoluble levels of complexity."

"At the same time that problems increase in quantity, complexity and difficulty, they also change faster than before."

"Trial-and-error design is an admirable method. But it is just real world trial and error which we are trying to replace by a symbolic method. Because trial and error is too expensive and too slow."

> Christopher Alexander, Notes on the Synthesis of Form¹,

1. Christopher Alexander, "Notes on the Synthesis of Form" Harvard University Press, Cambridge Massachusetts, 1964



Rethinking Systems Conceptualization

- The rapid increase in Cyber-Physical Systems is changing the way we develop, manage and interact with systems.
- The National Science Foundation (NSF) describes Cyber-Physical Systems (CPS) as "engineered systems that are built from, and depend upon, the seamless integration of computational algorithms and physical components"
- They tightly intertwine computational elements with physical entities across domains
- The NSF notes that CPS challenges and opportunities are both significant and farreaching.
- To address these challenges the <u>NSF is calling</u> for methods to conceptualize and design for the deep interdependencies inherent in Cyber-<u>Physical Systems</u>.





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 the application domain, and include a broad 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 cycle from concept through development, 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





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

^{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

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



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



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



Transformation: Change Management and Leadership



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

Transformation is all about changing peoples environment, beliefs and behavior. Consider key dimensions of change

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





Transformation: Digital impact on Change Management

Changing Change Management:

- 70% of Change Management programs fail to achieve their goals largely due to employee resistance and lack of management support
- When people are truly invested in change it is 30% more likely to stick
- Mastering the art of changing quickly is now a critical competitive advantage
- Competitive advantage will accrue to companies with the ability to set new priorities and implement new processes quicker than their rivals.

Five key areas to make internal change efforts more effective:

- 1. Provide just in time feedback right information at the right time
- 2. Personalize the experience tailor information to the user
- 3. Sidestep hierarchy network, open, short circuit long chains of communication
- 4. Build community & shared purpose dashboards, visuals and gamification
- 5. Demonstrate Progress Communicate progress and status, move forward

Ref: Changing Change Management - McKinsey & Company, July 2015



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







Model Based Discipline: Systems Engineering Domains

Model based methods apply to more than models of the Target System...





Transformation Strategy Overview

- Vision
- Mission
- Mission Areas
- Goals
- Objectives

Vision	Systems Engineering i	s acknowledged as a n	nodel based discipline
Mission	INCOSE accelerates the trans	formation of systems engineering	g 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.
Objective 1 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. 23

24 October 2017



- Mission Areas
- 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 Team for Digital Artifacts
- MSE Challenge team for Production & Logistics Systems Modeling
- MBSE Initiative for V&V of models in collaboration 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





MBSE Wiki and Website

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expand upon the highly successful MESE Workshop, nov						
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 Promote and advance the role of MASE in globally Oct authoritative information on MASE out to start 	17.00-17.45 MBSE & SysML Education			Russel Peak (Georgia Tech)		
 Infuse model based methods throughout INCOSE 	17:45-163	6 MDSE Workshop Wrap-up & Look alread	Mark Sampson (Slense	a) & Troy Pelemon (SSI)		
Engage stakeholders to assess the current state c	Other group	a with MDSE-related topics on Sunday (see group a	ection below for details)			
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IW 2017 MBSE Schedule	Sunday,	January 29, 2017				
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			• Model bear	al systems engineering has an	own in popularity as a	way to deal with the limitation	s of document based

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

http://www.incose.org/ChaptersGroups/WorkingGroups/transformational

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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:

http://www.incose.org/about/strategicobjectives/transformation

Engage as a Transformation Stakeholder Representative, visit:

http://www.incose.org/about/strategicobjectives/transformation



Q&A





HSPIRED BY ODT AT #E205 BY OVOINONEN

Digital Denial

Digitally Zealous



Troy Peterson Bio



Troy Peterson

Vice President tpeterson@systemxi.com 313.806.3929 Troy Peterson is Vice President and co-founder of 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.

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 Contingency Basing, the Ground Combat Vehicle (GCV), Mine Resistant Ambush Protected (MRAP) vehicle 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.

Prior to joining Booz Allen, Troy worked at Ford Motor Company and as an entrepreneur operating a design and management consulting business. 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.



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