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Transformation of Systems Engineering into a Model Based Discipline

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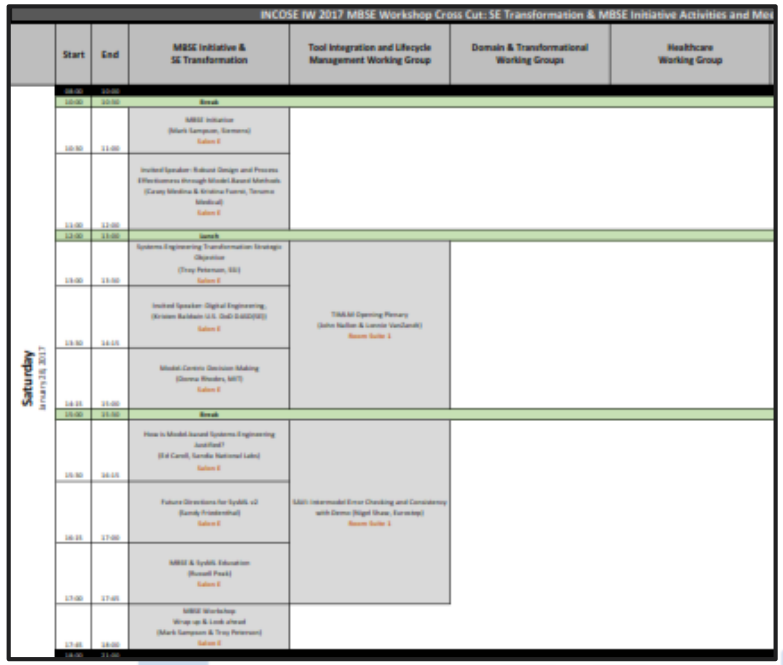
2017 IW MBSE Workshop… Embedded

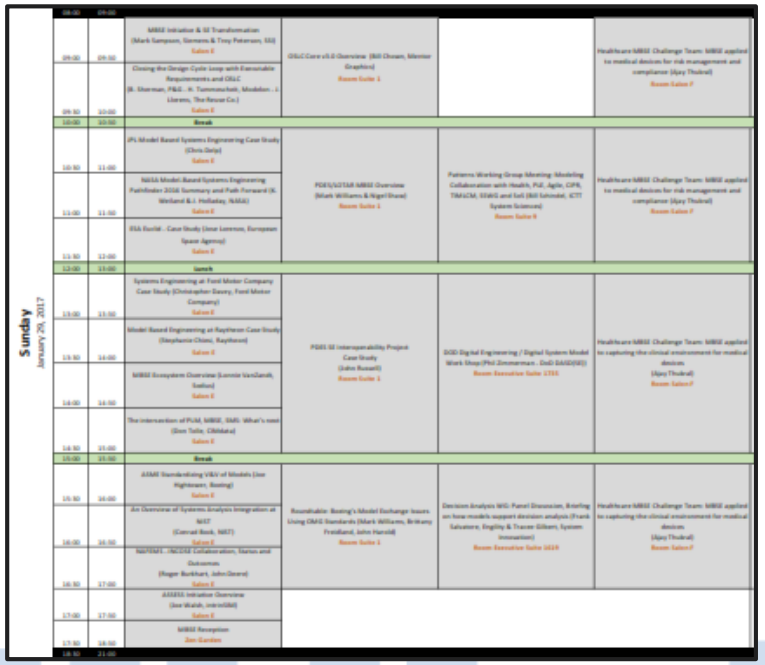
MBSE: practicing, advancing, researching, educating, standardizing…

- More than 20 presentations here in Salon E (Sat & Sun) with most linked to working group activities
- At least 17 different Working Groups/Initiatives involved in MBSE related meetings
- 7 case studies from across medical, consumer products, automotive, space and defense
- 5 external views on analysis modeling, tool integration, verification and validation
- 10 different collaboration efforts internal and external to INCOSE

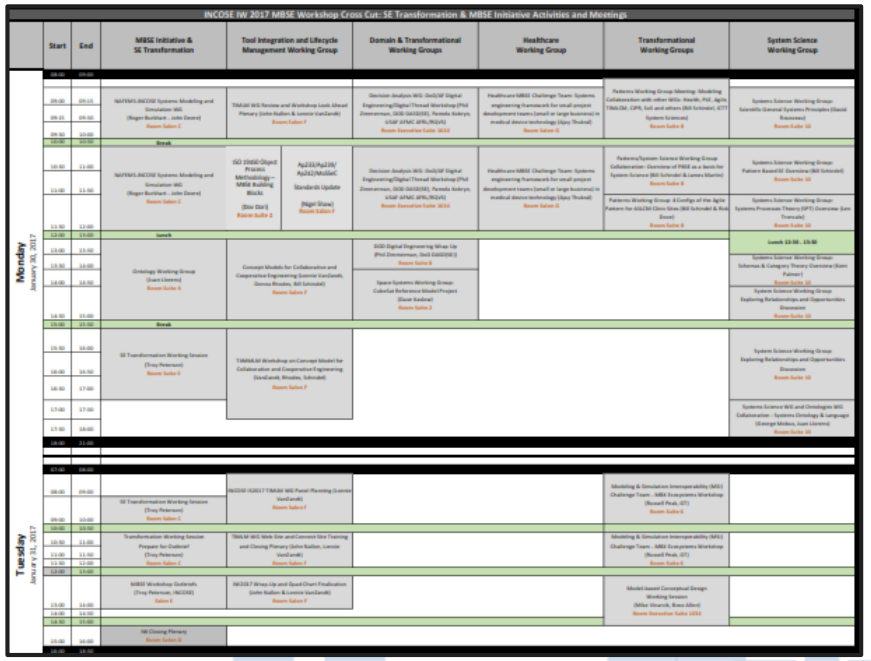
SATURDAY



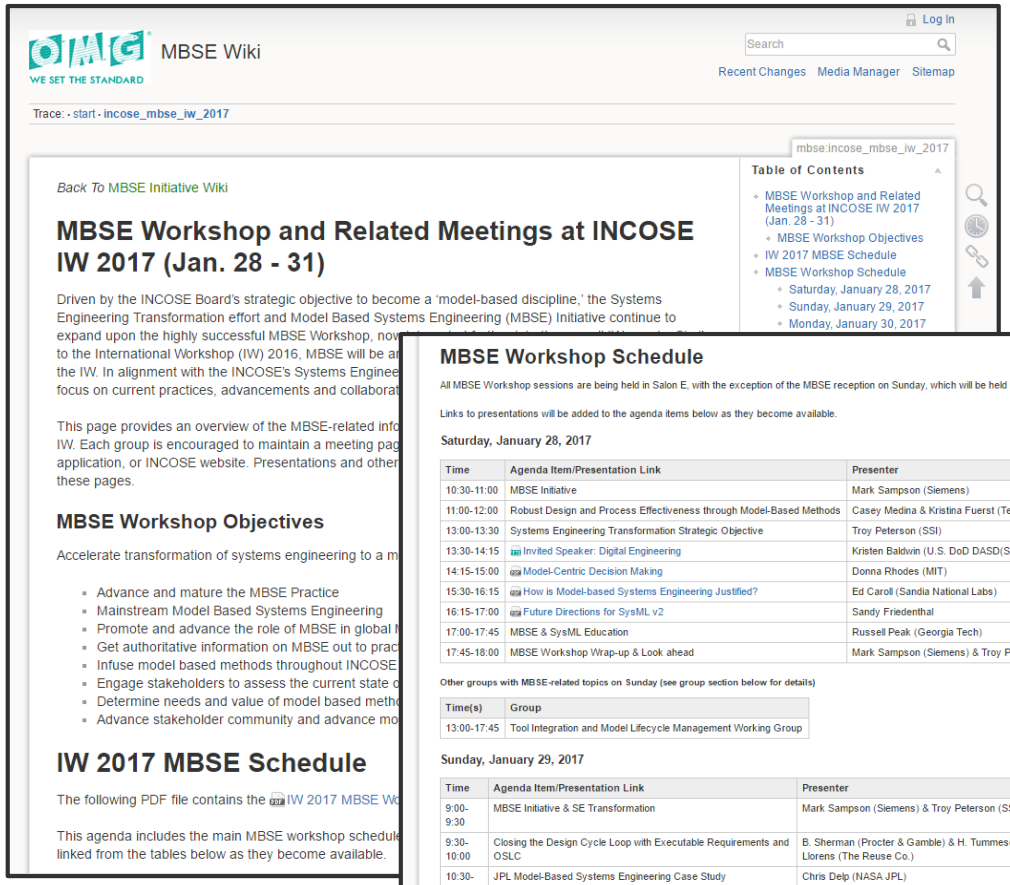
SUNDAY

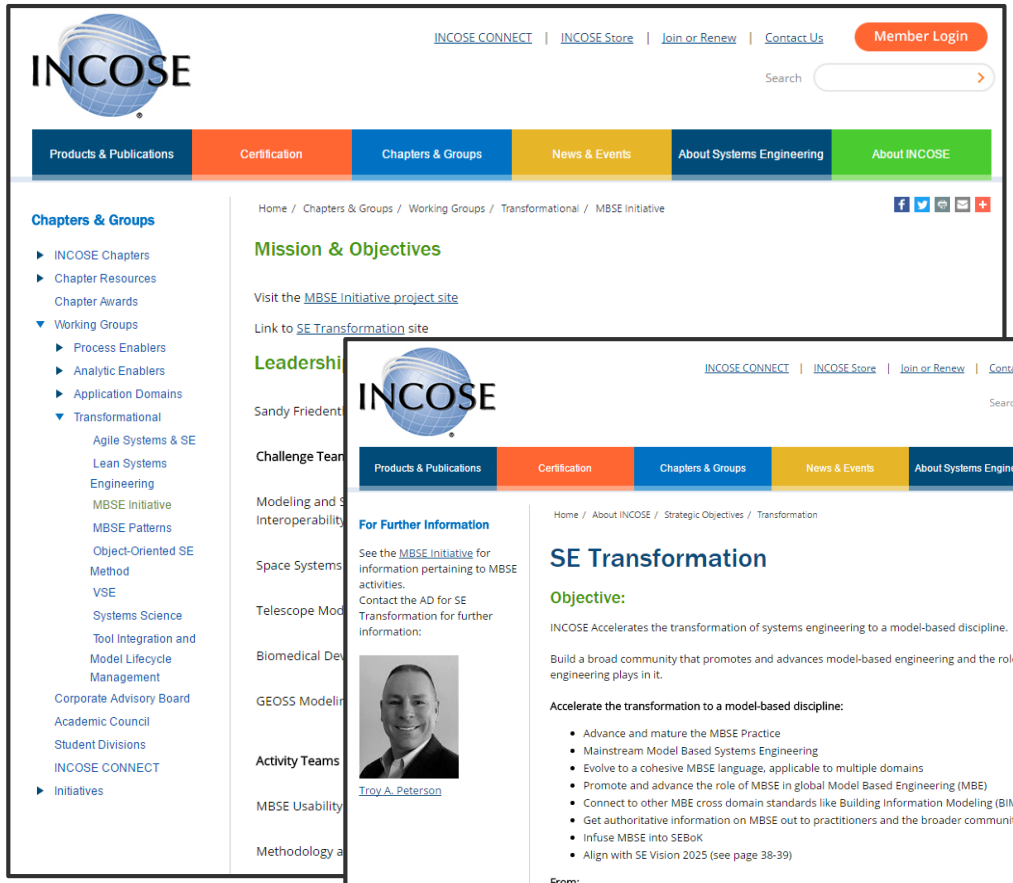


MONDAY & TUESDAY



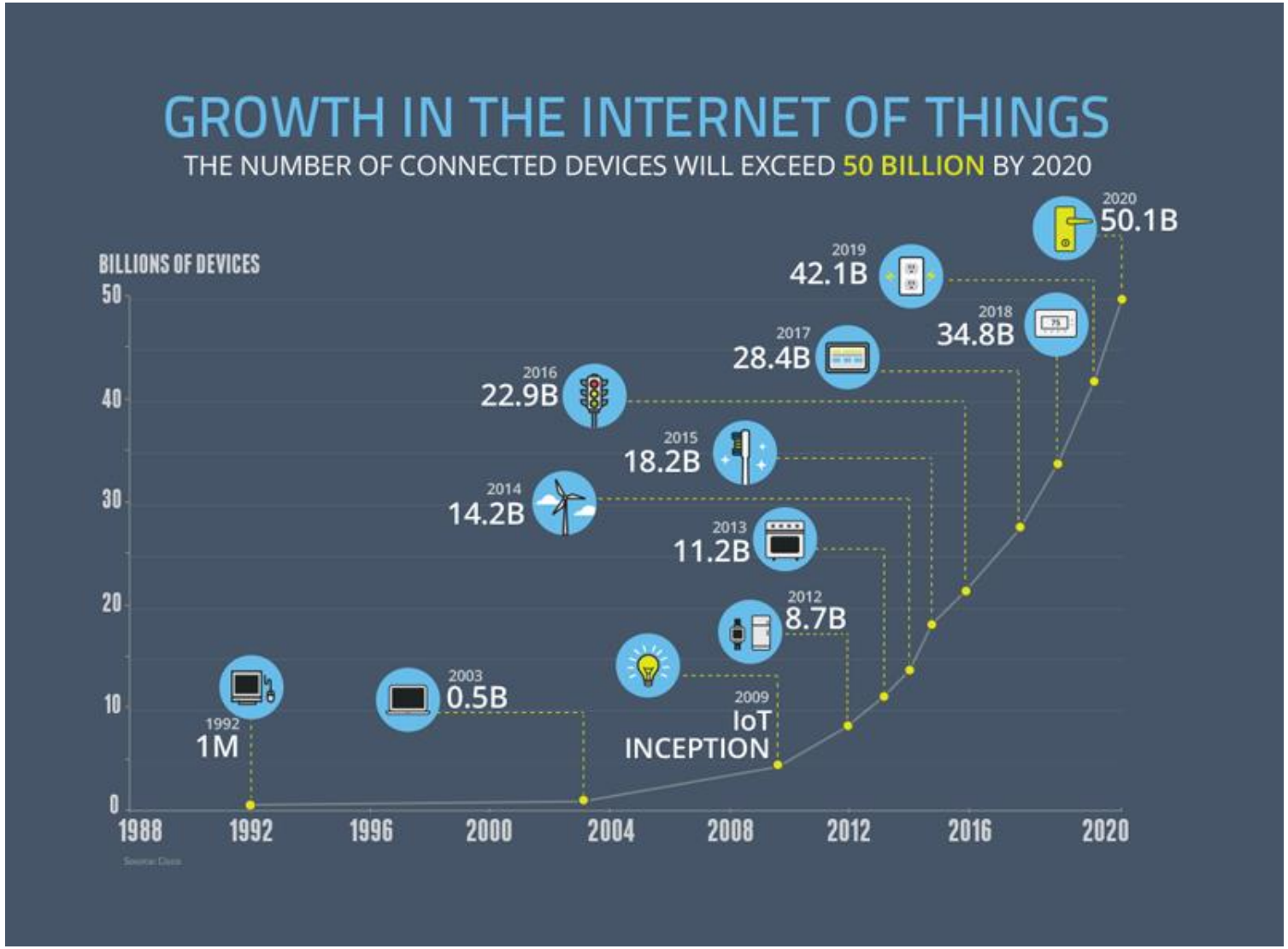
MBSE Wiki and INCOSE Website



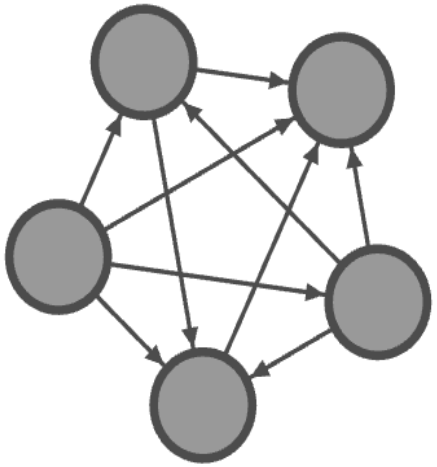


Why Transformation

IoT – Connectedness - Systems



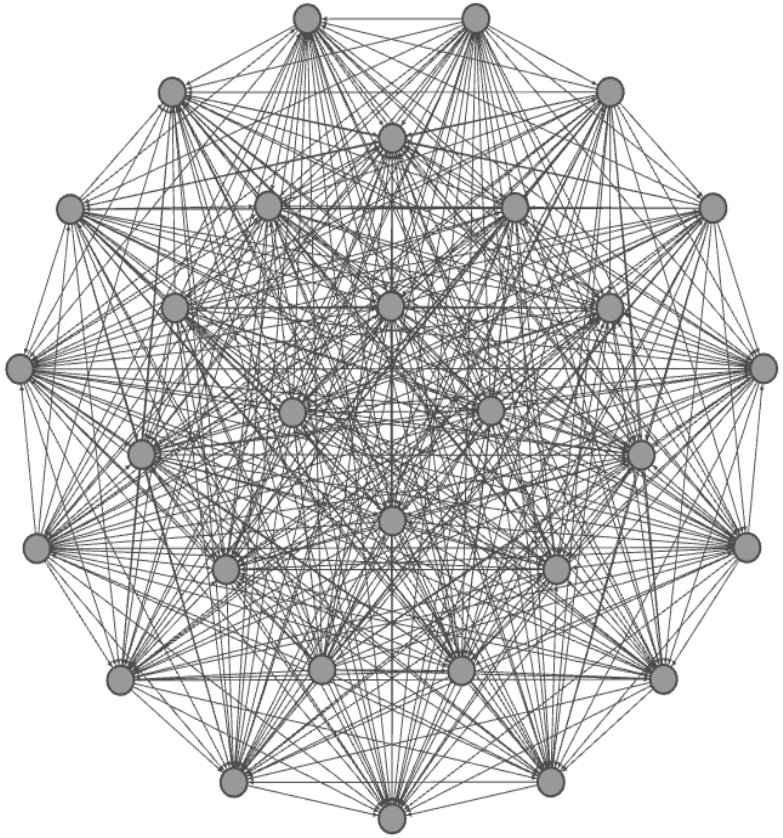
Interactions Drive Complexity



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 2^{246}

Rethinking System Conceptualization

- Interconnectedness and the rise of Cyber Physical 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 rapid increase in Cyber-Physical Systems is changing the way we develop, manage and interact with systems.
- The NSF notes that CPS challenges and opportunities are both significant and far-reaching. To address these challenges the NSF is calling for methods to conceptualize and design for the deep interdependencies inherent in Cyber-Physical Systems.

We must transform systems engineering to manage the current and coming complexity

Transformation to a Model-Based Discipline

Objective: *INCOSE accelerates the transformation of systems engineering to a model-based discipline*

- Advance and mature the MBSE Practice **(MA3)**
- Mainstream Model Based Systems Engineering **(MA3)**
- Evolve to a cohesive MBSE language, applicable to multiple domains **(MA3:O1)**
- Promote and advance the role of MBSE in global Model Based Engineering (MBE) **(MA2:O1)**
- Connect to other MBE cross domain standards like Building Information Modeling (BIM) **(MA1:O3)**
- Get authoritative information on MBSE out to practitioners and the broader community **(O3)**
- Infuse MBSE into SEBoK **(MA1:O1)**
- Align with SE Vision 2025 (see page 38-39) **(All)**

Transformation Considerations

- Key considerations
  - Change management is essential and it's focus is on the human dimension
  - The broader stakeholder community that must be reached for transformation
  - Must lead the value proposition and coordinate the technical activity
  - It's much more than just advancing the technical dimension

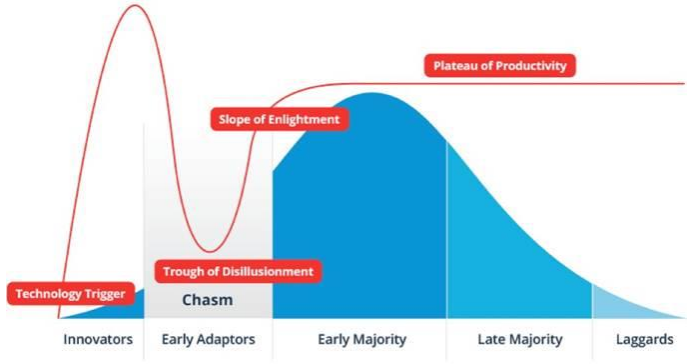
- Other relevant background
  - Great work has been done on the Transformation front – Need to accelerate
  - Transformation is required to manage the current and coming complexity
  - Model based is the next evolutionary step – not an all new or radical change
  - INCOSE must lead the effort and move the needle

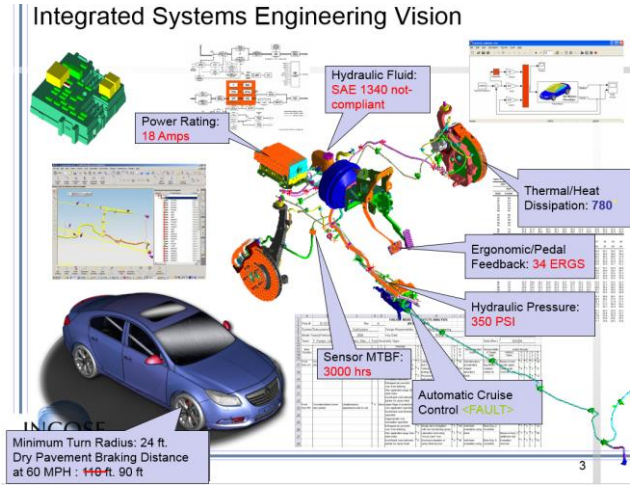
SE Transformation Overview

Objective:

INCOSE accelerates the transformation of systems engineering to a model-based discipline.

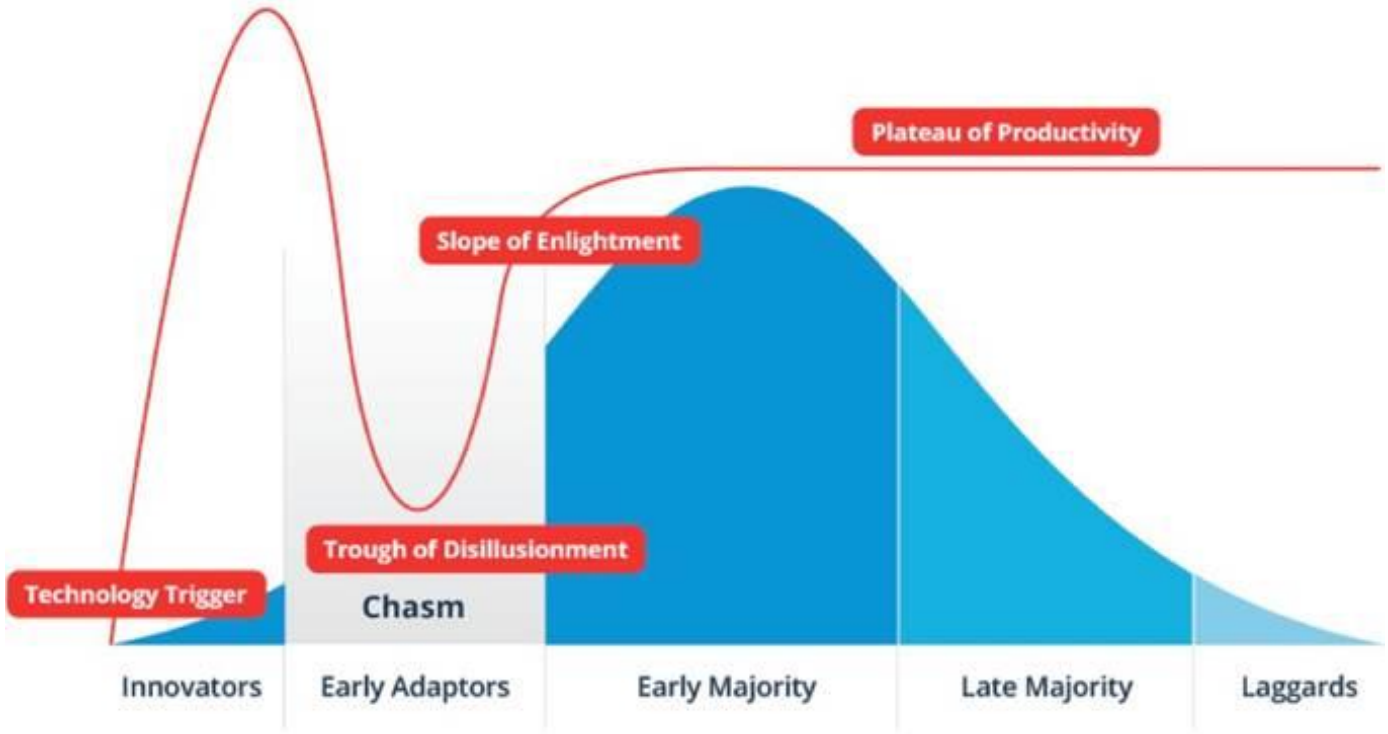
- Accelerates:
  - Understand the hype cycle[1] and bridge the chasm[2]…
  - Empower others to enlighten and influence adoption
- Transformation:
  - A marked change, as in appearance or character, usually for the better[3]. e.g. documents to models
  - Lead and support the community in crossing the chasm
- Model Based Discipline
  - System models of all types
  - Modeler Collaboration and Model Integration





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

Transformation: Hype Cycle and Chasm

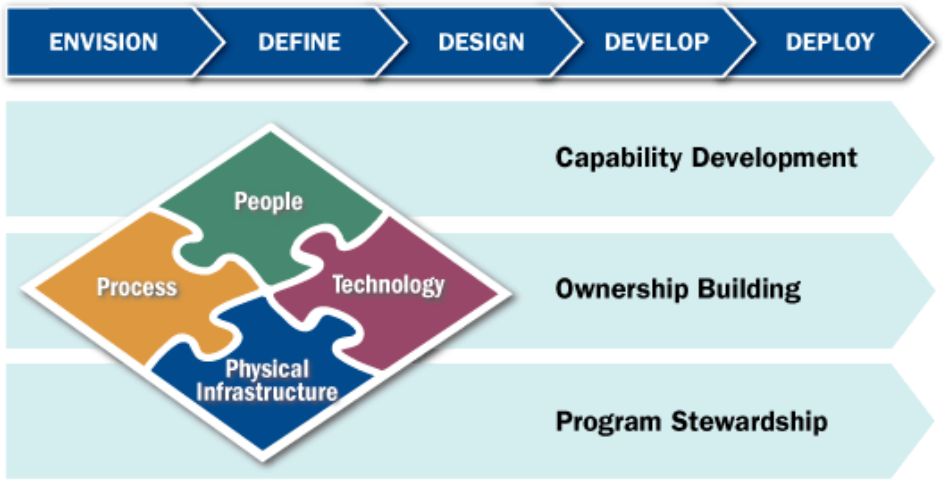


Acceleration is very much about sharing, communicating and learning

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: https://en.wikipedia.org/wiki/Hype_cycle
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



Transformation Life Cycle™ (TLC): Booz Allen Hamilton

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

Consider:

ABP = CM(OE + BPR + IT)

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

Transformation is a people focused endeavor.

Transformation: What to expect and what do we need

…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)

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)

We must endure complexity

add tireless effort and a touch of genius

If only it were that easy…

SE Transformation Products: Stakeholders

Population Size <--	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 a re informed by models of them. This includes mass market consumers, policy makers, business and other leaders and executives, investors, product us ers, voters in public or private elections or selection decisions, etc.
**	Technical model users, including designers, project leads, production engineers, system installers, maintainers, and users/op erators
Model Creators (including Model Improvers):	
*	Product visionaries, marketers, and other non-technical leaders of thought and organizations
*	Systems Engineering practitioners, system technical specifiers, engineers, designers, testers, theoreticians, analysts, scien tists
*	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.
Complex Idea Communicators:	
**	Marketing professionals
**	Academics/Educators, especially in complex systems areas of engineering and science, public policy, other domains, and includ ing 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 Infrastructure 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 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 advance and practice of systems engineering and MBSE

The purpose of the Vision 2025 is to *inspire and guide* the direction of systems engineering across diverse stakeholder communities, which include:

- **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.

Strategy Overview

- Vision
- Mission
- Mission Areas
- Goals
- Objectives

Vision	**Systems Engineering is acknowledged as a model 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.
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.

Strategy Detail

- Objectives have MOEs
- Objectives have traceable Activities / Task level actions to accomplish objective
- Baseline Assessment of current state will need to be completed.
- Objective 4: Assessment & Roadmap will enable baseline assessment by ISO 15288 process areas

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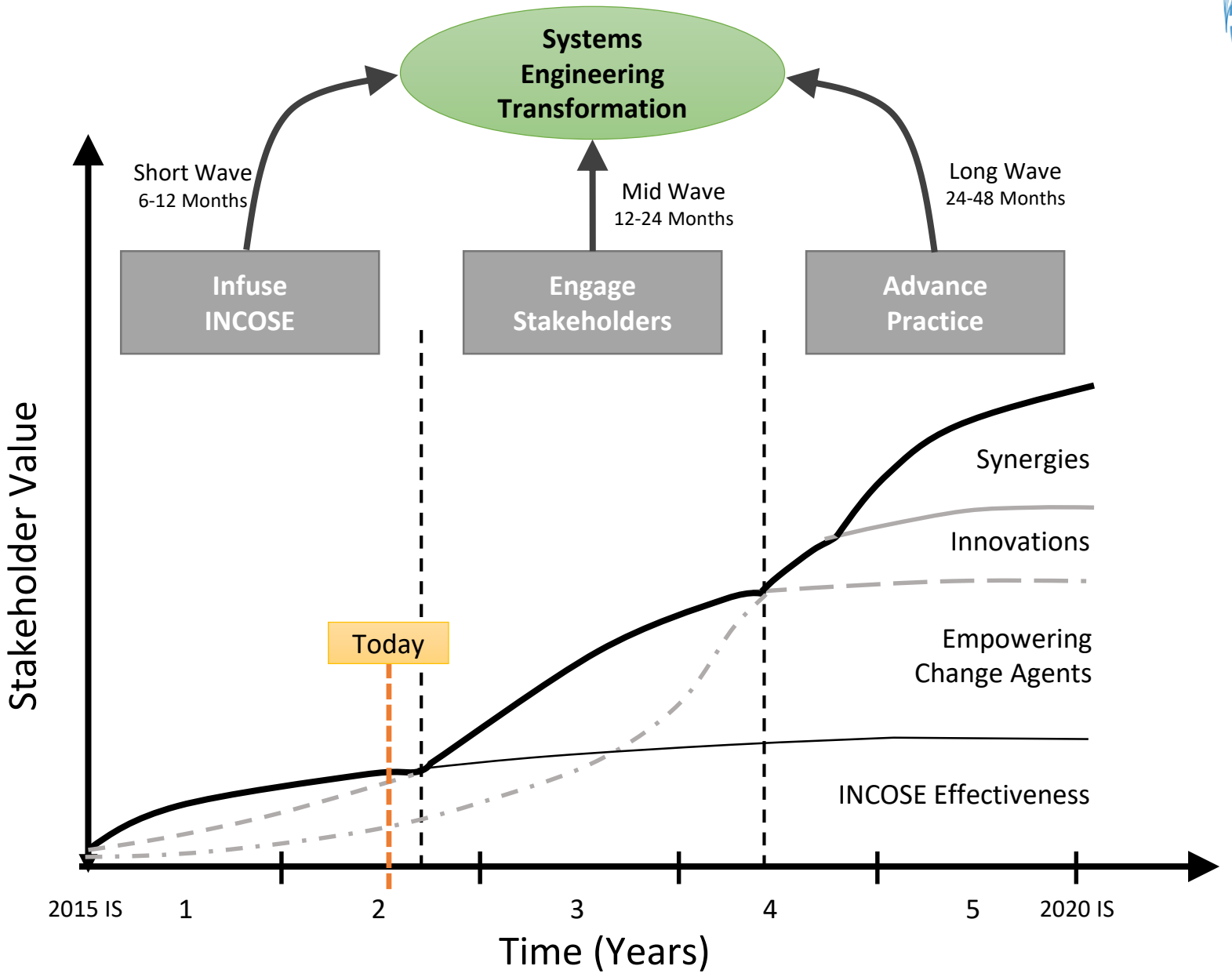
Objective Measures of Effectiveness (MOEs)	O1: % of INCOSE products including model based content O1: # of sections in existing products with model based content weighted by significance (L, M, H); Marking these assessments into the SE Transformation Roadmap (by ISO 15288 process area). O1: Inclusion of Model Based content into certification (SEP would signify an understanding of MBSE) O2: # of domains represented within MBSE Workshop O2: Stakeholders breadth in INCOSE and activities O2: % WG/Activity teams including model based content O2: % of model based content in IW and IS O2: # of WG's that are including model-based content weighted by the impact on the practice (L, M, H); Marking these assessments into the SE Transformation Roadmap (by ISO 15288 process area).; O2: # of models included in products, or used to describe products (SEBoK for example) O3: # of joint products with model based content O3: #of MOU's which help infuse model based content O4: # of gaps identified O4: % of content missing MBSE O4: Progress in inclusion of model based methods on the Assessment & Roadmap for INCOSE	O1: Is MBSE and MBE defined across modeling community O2: % and quantity of stakeholder types across domains engaged O2: Use Xfrmation A-R to characterize current state and obtain E&O O3: # of stakeholders, O3: # of domains represented, O3: Stakeholder Representative meeting attendance O3: Stakeholder feedback on A-R progress in organizations O4: Pilot completed and feedback positive, neutral or negative	O1 & O3: Trend % of SE publications with model based content - note by domain O1: Use Xfrmation A-R to assess ease of model based activities (creation, communication, level of automation et al.) O2: # of non-SE stakeholders in stakeholder representative list engaged O2: Targeted questionare toward non SE stakeholders on perception of value of model based methods O2: Increased hits on MBSE content on INCOSE website, ...measures global buzz... O2: Trend % of SE Academic programs include model based methods
Imperatives / Actions / Activities	O1: Engage product providing groups for assessments noted in O1 MOEs O4: Internal application of MBSE Assessment & Roadmap	O1: Leverage relationship and efforts with NAFEMS for model definitions and model taxonomy O2: Create stakeholder model in a modeling tool O2: Run A-R pilot and aggregate results; refine A-R from Pilot, Run A-R across Stakeholder community (CAB, Stakeholder Reps etc.), Aggregate results and publish O4: Pilot Assessment & Roadmap to obtain initial Feedback O4: Expand A&R activity to CAB & Stakeholder Reps. Provide change agents success stories/ value of MBSE implem. from across domains	(standards, ontology, visualization, methods etc.).

Refining MOEs

Mapping and building out tasks level with POCs and Funding

Strategy Notional Timeline

- 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 IW.



Transformation Assessment & Roadmap

- Our team has been discussing “instruments” or “dashboards” for showing current state and opportunities for progress.
- Views below are adapted from a recent INCOSE Conference on Agile Health Care Systems:

Break out session:
Test Drive and Data Collection

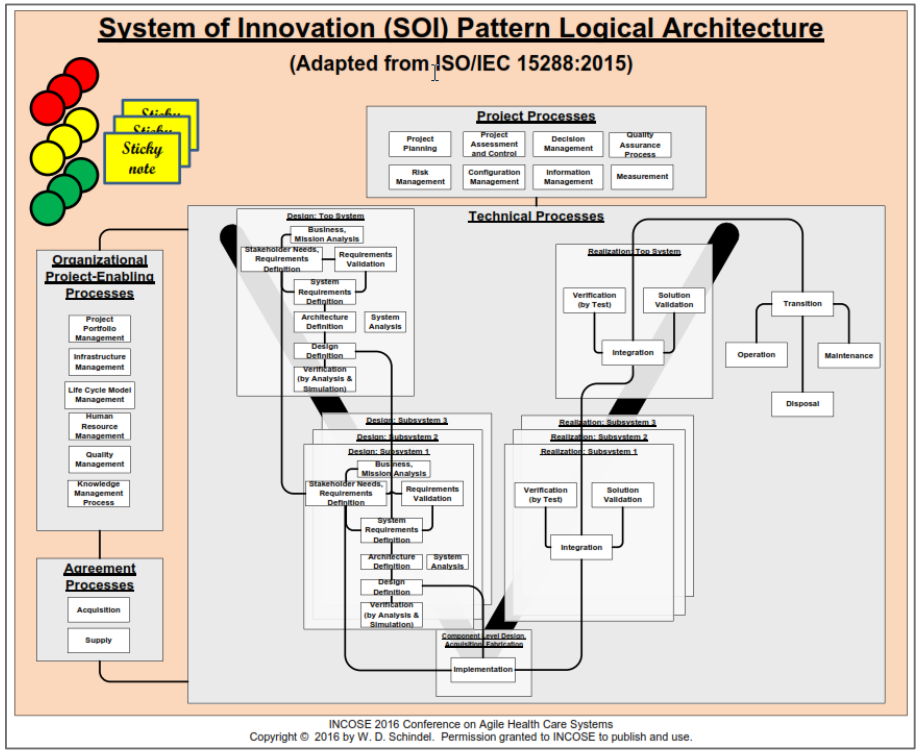
- Directions:
  - Break into teams and discuss the following, then . . .
  - In the domain model, identify the 5 highest cases of:

Sticky Dots

- Needs for model-enabled progress (even if most difficult)
- Opportunities for model-enabled progress (low-hanging fruit)
- Already accomplished examples of model-enabled progress

Sticky note — In the same model diagram, identify any potential corrections or improvements to the model.

Note: This includes not just selection of *life cycle processes* (e.g., Architecture Definition), but also *system domains* (e.g.., Product, Manufacturing, Distribution, Service, Enterprise, etc.)



INCOSE Vision 2025

Transforming Systems Engineering

- 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.

Trending Influencers on Systems Engineering Transformation

MBSE Imitative as an MBSE Incubator

- Analytics – Data Science - Visualization/Navigation:
  - Improving Shared Human Understanding Across Stakeholders
- Industry 4.0 / Industrial Internet
  - Connecting models across the lifecycle
- Artificial Intelligence
  - *Human – machine interactions solving complex problems (match play)*
- Cyber-Physical
  - *Intertwined cyber and physical dimensions, vast state space, new vulnerabilities*

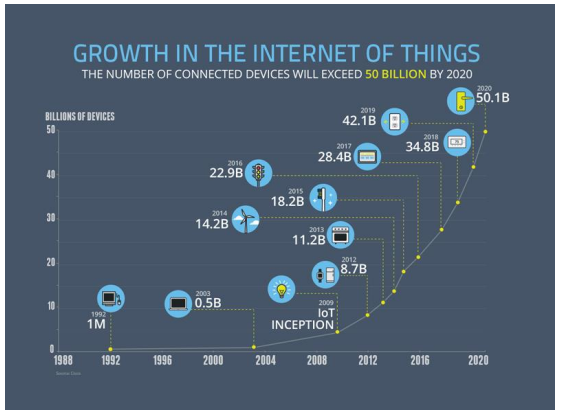



Change

Rapid rates of change and matched agility

“When the rate of external change exceeds the rate of internal change, the end of your business is in sight.”

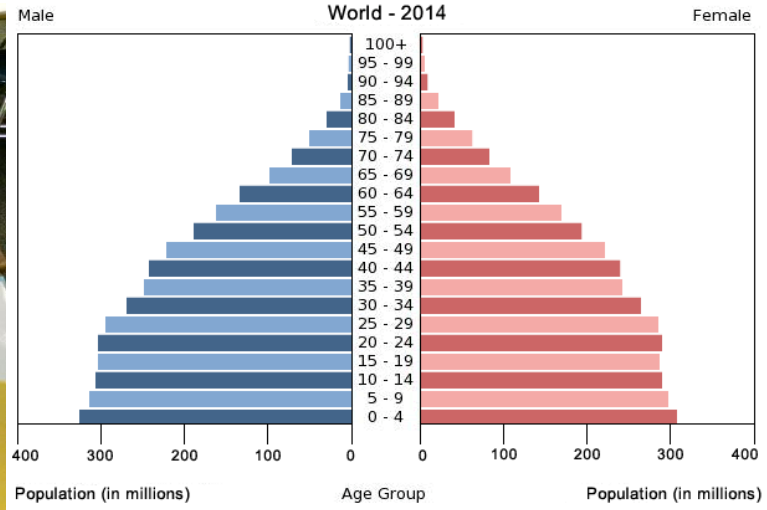
Jack Welch

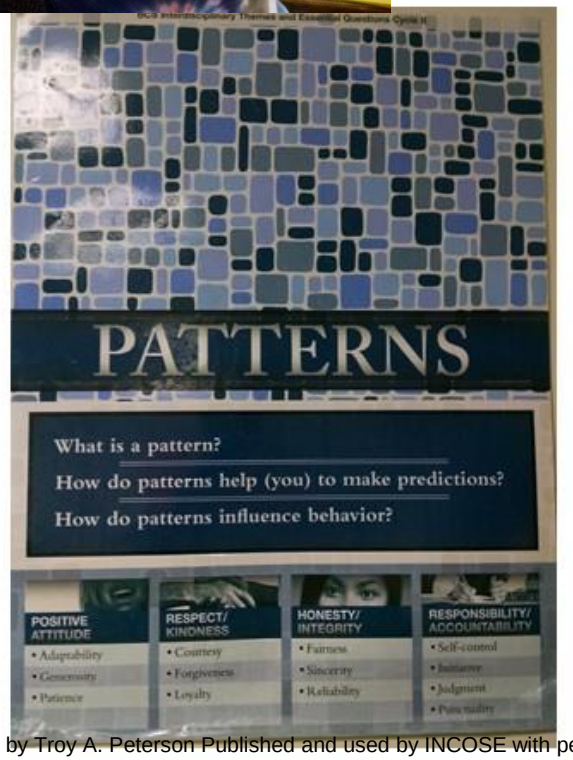


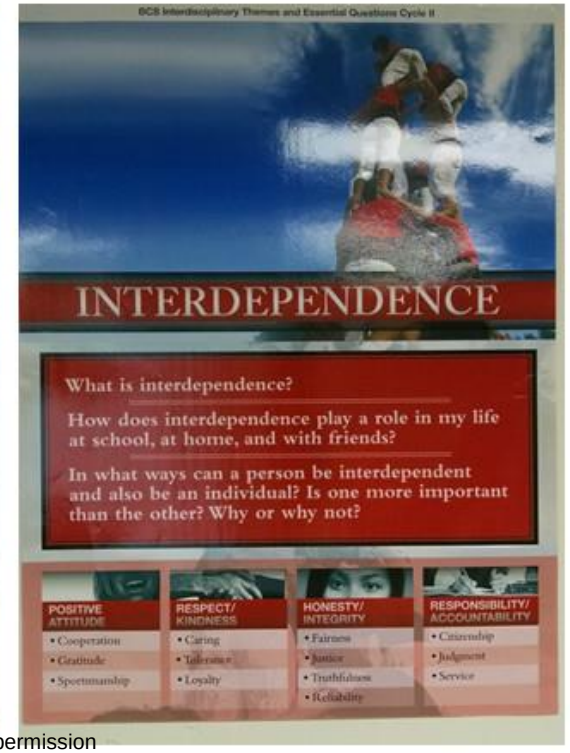
“It is not necessary to change. Survival is not mandatory.”

W. Edwards Deming

Future Generations







Questions

Troy Peterson Bio

Troy Peterson

System Strategy, Inc.

Vice President & Fellow

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Troy Peterson is a Vice President with System Strategy, Inc. A consulting firm instituting model based systems and strategies to manage complexity 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 System Strategy, Inc. Troy was a Booz Allen Fellow and Chief Engineer, He 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.