



**2017**  
annual **INCOSE**  
international workshop  
**Los Angeles, CA, USA**  
January 28 - 31, 2017

## **Transformation of Systems Engineering into a Model Based Discipline**

# 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

	Start	End	INCOSE IW 2017 MBSE Workshop Cross Cut: SE Transformation & MBSE Initiative Activities and Meetings	
	MBSE Initiative & SE Transformation	Tool Integration and Lifecycle Management Working Group	Domain & Transformational Working Groups	Healthcare Working Group
Saturday January 28, 2017	08:00	09:00	Break	
	09:00	11:00	MBSE Initiative & SE Transformation (Mark Sampson, Siemens & Troy Peterson, INCOSE)	
	11:00	12:00	Invited Speaker - Robust Design and Process Effectiveness through Model-Based Methods (Gary Moore, INCOSE, Terence McNamee, INCOSE)	
	12:00	13:00	Break	
	13:00	14:00	Systems Engineering Transformation Strategy (Troy Peterson, INCOSE)	
	14:00	15:00	Invited Speaker - Digital Engineering (Koenraad Baeten, UGent & GMD)	
	15:00	16:00	Model-Centric Decision Making (Gemma Weller, INCOSE)	
	16:00	17:00	Break	
	17:00	18:00	How to Model Inert Systems Engineering (Mark Sampson, INCOSE)	
	18:00	19:00	Failure Reduction for Safety v2 (Sandy Frischknecht)	
	19:00	20:00	MBSE: Intermodal Error Checking and Consistency with Demos (Digital Sheet, Eurostep)	
	20:00	21:00	MBSE & Spoke Education (Howard Eberle)	
	21:00	22:00	MBSE Workshop Wrap-up & Look-ahead (Mark Sampson & Troy Peterson)	

### SUNDAY

	Start	End	INCOSE IW 2017 MBSE Workshop Cross Cut: SE Transformation & MBSE Initiative Activities and Meetings	
	MBSE Initiative & SE Transformation	Tool Integration and Lifecycle Management Working Group	Domain & Transformational Working Groups	Healthcare Working Group
Sunday January 29, 2017	08:00	09:00	MBSE Initiative & SE Transformation (Mark Sampson, Siemens & Troy Peterson, INCOSE)	
	09:00	10:00	Closing the Garage Cycle Loop with Executable UML (Mark Sampson, INCOSE, Troy Peterson, INCOSE)	
	10:00	11:00	INCOSE Core v1.0 Overview (Allan Chouin, Mentor Graphics)	
	11:00	12:00	INCOSE Core v1.0 Overview (Allan Chouin, Mentor Graphics)	
	12:00	13:00	Break	
	13:00	14:00	INCOSE Model-Based Systems Engineering Case Study (David Denehy)	
	14:00	15:00	INCOSE Model-Based Systems Engineering Case Study (David Denehy)	
	15:00	16:00	INCOSE Model-Based Systems Engineering Case Study (David Denehy)	
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	23:00	24:00	INCOSE Model-Based Systems Engineering Case Study (David Denehy)	
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# MBSE Wiki and INCOSE Website



**OMG® MBSE Wiki**

Trace: · start · incose\_mbse\_iw\_2017

[Back To MBSE Initiative Wiki](#)

## MBSE Workshop and Related Meetings at INCOSE IW 2017 (Jan. 28 - 31)

Driven by the INCOSE Board's strategic objective to become a 'model-based discipline,' the Systems Engineering Transformation effort and Model Based Systems Engineering (MBSE) Initiative continue to expand upon the highly successful MBSE Workshop, now added to the International Workshop (IW) 2016. MBSE will be an integral part of the IW. In alignment with the INCOSE's Systems Engineering Transformation effort, the focus is on current practices, advancements and collaborations.

This page provides an overview of the MBSE-related information available at the IW. Each group is encouraged to maintain a meeting page on their application, or INCOSE website. Presentations and other materials can be found on these pages.

### MBSE Workshop Objectives

Accelerate transformation of systems engineering to a model-based discipline:

- Advance and mature the MBSE Practice
- Mainstream Model Based Systems Engineering
- Promote and advance the role of MBSE in global engineering
- Get authoritative information on MBSE out to practitioners and the broader community
- Infuse model based methods throughout INCOSE
- Engage stakeholders to assess the current state of the discipline
- Determine needs and value of model based methods
- Advance stakeholder community and advance modeling standards

### IW 2017 MBSE Schedule

The following PDF file contains the [IW 2017 MBSE Workshops](#).

This agenda includes the main MBSE workshop schedule linked from the tables below as they become available.

#### MBSE Workshop Schedule

All MBSE Workshop sessions are being held in Salon E, with the exception of the MBSE reception on Sunday, which will be held in the Zen Garden.

Links to presentations will be added to the agenda items below as they become available.

**Saturday, January 28, 2017**

Time	Agenda Item/Presentation Link	Presenter
10:30-11:00	MBSE Initiative	Mark Sampson (Siemens)
11:00-12:00	Robust Design and Process Effectiveness through Model-Based Methods	Casey Medina & Kristina Fuerst (Terumo Medical)
13:00-13:30	Systems Engineering Transformation Strategic Objective	Troy Peterson (SSI)
13:30-14:15	Invited Speaker: Digital Engineering	Kristen Baldwin (U.S. DoD DASD(SE))
14:15-15:00	Model-Centric Decision Making	Donna Rhodes (MIT)
15:30-16:15	How is Model-based Systems Engineering Justified?	Ed Carroll (Sandia National Labs)
16:15-17:00	Future Directions for SysML v2	Sandy Friedenthal
17:00-17:45	MBSE & SysML Education	Russell Peak (Georgia Tech)
17:45-18:00	MBSE Workshop Wrap-up & Look ahead	Mark Sampson (Siemens) & Troy Peterson (SSI)

Other groups with MBSE-related topics on Sunday (see group section below for details)

Time(s)	Group
13:00-17:45	Tool Integration and Model Lifecycle Management Working Group

**Sunday, January 29, 2017**

Time	Agenda Item/Presentation Link	Presenter
9:00-9:30	MBSE Initiative & SE Transformation	Mark Sampson (Siemens) & Troy Peterson (SSI)
9:30-10:00	Closing the Design Cycle Loop with Executable Requirements and OSCL	B. Sherman (Procter & Gamble) & H. Tummeschiet (Modecon) & J. Llorens (The Reuse Co.)
10:30-11:00	JPL Model-Based Systems Engineering Case Study	Chris Delp (NASA JPL)
11:00-11:30	NASA Model-Based Systems Engineering Pathfinder 2016 Summary and Path Forward	K. Weland & J. Holladay (NASA)
11:30-12:00	ESA Euclid - Case Study	Jose Lorenzo (European Space Agency)
13:00-13:30	Systems Engineering at Ford Motor Company Case Study	Christopher Davey (Ford Motor Company)
13:30-14:00	Model-Based Engineering at Raytheon Case Study	Stephanie Chiesi (Raytheon)
14:00-14:30	MBSE Ecosystem Overview	Lonnie VanZandt (Sodius)

[http://www.omgwiki.org/MBSE/doku.php?id=mbse:incose\\_mbse\\_iw\\_2017](http://www.omgwiki.org/MBSE/doku.php?id=mbse:incose_mbse_iw_2017)

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**Chapters & Groups**

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  - Application Domains
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  - Agile Systems & SE
  - Lean Systems Engineering
  - MBSE Initiative
  - MBSE Patterns
  - Object-Oriented SE Method
  - VSE
  - Systems Science
  - Tool Integration and Model Lifecycle Management
  - Biomedical Development
  - GEOSS Modeling
- Corporate Advisory Board
- Academic Council
- Student Divisions
- INCOSE CONNECT
- Activity Teams
- Initiatives
  - MBSE Usability
  - Methodology and Standardization

**Mission & Objectives**

Visit the [MBSE Initiative project site](#)

Link to [SE Transformation site](#)

**Leadership**

Sandy Friedenthal

**Challenge Team**

**Modeling and Simulation Interoperability**

**Space Systems**

**Telescope Monitoring**

**Biomedical Development**

**GEOSS Modeling**

**Activity Teams**

**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 systems, and is fully integrated with other 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.

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**SE Transformation**

**Objective:**

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

Build a broad community that promotes and advances model-based engineering and the role that model-based systems engineering plays in it.

**Accelerate the transformation to a model-based discipline:**

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

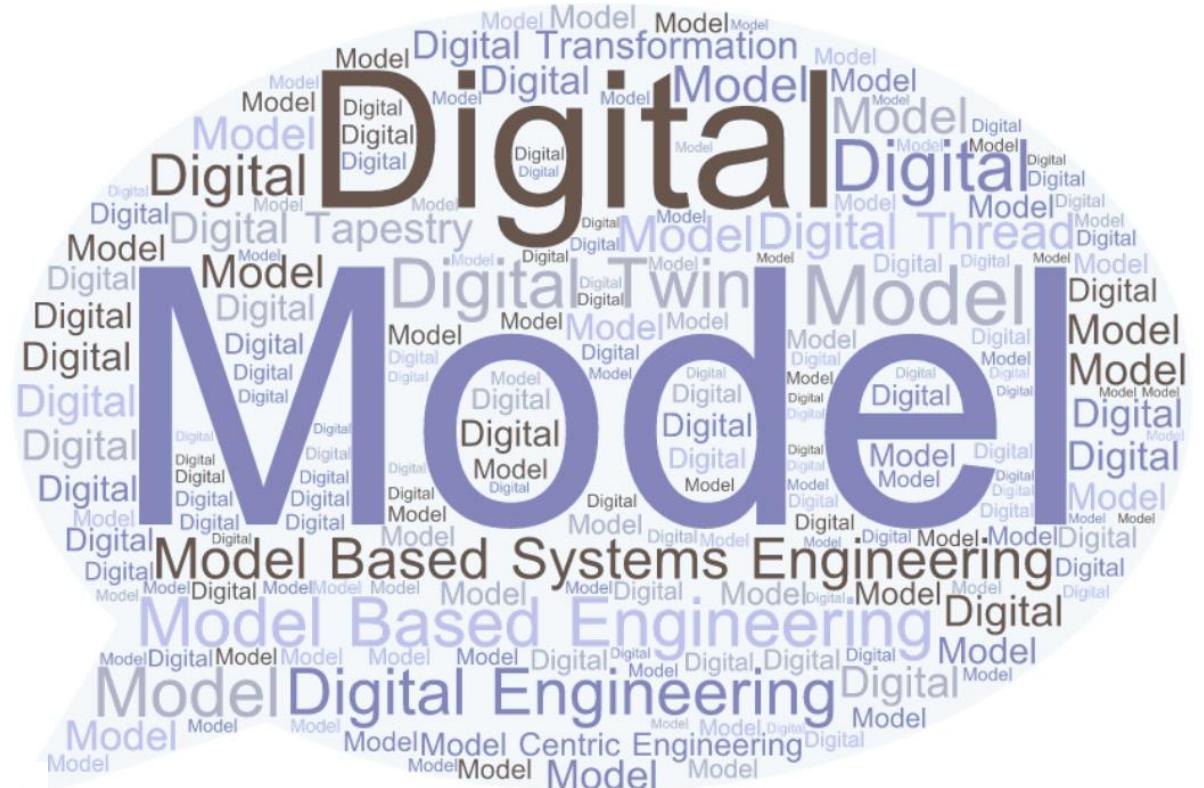
<http://www.incose.org/about/strategicobjectives/transformation>

# Our Hope for the MBSE Workshop





- 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





## High Priority Products to be Worked

1. Definitions and Terms
2. Digital Artifacts
3. MBSE Primer
4. Value Briefing / Case Studies / ROI

## Other Products to be Worked

1. Detailed assessment / roadmap, maturity model
2. Viewpoints/Products for specific stakeholders for products (stakeholders, Acquisition/Contracts)
3. Training plan / Resources / Education
4. Model Libraries

## Products Worked

1. Stakeholder List
2. Strategy & Action Plan
3. Assessment Roadmap
4. Enablers & Roadblocks

# MBSE Propeller Hat Award



## MBSE Propeller Hat Award

One of the INCOSE Curmudgeons (Noun: bad-tempered, surly person) criticized the MBSE Initiative as a “bunch of propeller hats in the basement”. He was challenging us to bring MBSE exercised by a few modeling nerds out of the basement to make it widely available and commonly practiced by all systems engineers (and for that matter by all engineers). This award is a recognition to those individuals or working groups who have done the most in bringing “MBSE out of the basement” through:

- Democratization of modeling
- Simplifying complex problems through models
- Educating upcoming generations of engineers on MBSE
- Automating complex systems engineering practices
- Advancing the practice of systems modeling



JPL for Open MBEE and  
MBSE Workshop Contributions



Bill Schindel for Patterns  
Collaborations and  
Transformation Contributions



# Artificial Intelligence Model Based Change Cyber Security Systems Engineering Innovation **Transformation** Data Science Digital Cloud Analytics Internet of Things Design Thinking Industry 4.0



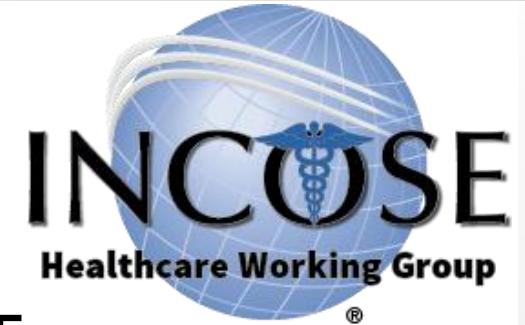
# MBSE Initiative as an MBSE Incubator

- **Digital Artifacts:**
  - Identifying and characterizing MBSE digital artifacts
- **Manufacturing Modeling & Industry 4.0**
  - Connecting models across the lifecycle – Manufacturing, SC, Logistics
- **V&V of models (Potential Collaboration ASME, INCOSE, NAFEMS)**
  - *Human – machine interactions solving complex problems (match play)*





- **SE Transformation Working Session**
- **Healthcare Working Group**
- **SysML v2 Working Group Meeting**
- **Tool Integration and Model Lifecycle Management Working Group**
- **Decision Analysis Working Group /DoD Digital Engineering**
- **M&S Interoperability Challenge Team - MBX Ecosystems Workshop**
- **NAFEMS-INCOSE Systems M&S Working Group**
- **Patterns Working Group**
- **Assessment Instrument**



## Biomedical-Healthcare MBSE Challenge Team Technical Track

Sunday, January 29, 2017 – Morning Session

SE/MBSE Methods for Medical Device Compliance and Compliance Review

Sunday, January 29, 2017 – Afternoon Session

SE/MBSE Methods to Capture the Clinical Environment for Device Developers



Bob Malins

Co-Lead, Healthcare Working Group

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# Problem Statements for Challenge Team 2016 Efforts



- **Question 1:**
  - Can SE methods and MBSE techniques help device developers achieve safe and effective devices and facilitate (including speed up) the regulatory review and approval process?
    - Focus on applicable standards
    - Focus on FDA review process and issues therein
    - Outcomes – Sunday morning session
- **Question 2:**
  - Can SE methods and MBSE techniques capture critical characteristics of the clinical environment in a form device developers can use as part of developing safe and effective devices?
    - Focus on how clinicians use devices
    - Focus on process, interfaces, usability, interoperability
    - Outcomes – Sunday afternoon session

SCOPE: Infusion pump devices and technology



# Outbrief from IW2017



- **MBSE for medical device compliance, regulatory submission, safety analyses**
  - MBSE tools offer a significant capability for performing the work needed to address FDA concerns
    - The model will not likely ever be part of the submission
    - But the model can be a critical tool for driving the design, organizing the evidence, packaging the submission
  - Tool vendors are providing new, highly relevant capabilities
    - Standards tracking and reporting
    - FMEA, FTA, and other hazard and safety analysis
  - Relevant libraries of standards and regulatory requirements would be very useful
- **MBSE for capturing the critical characteristics of the clinical environment**
  - Device developer perspective ...
    - The critical elements of the clinical environment driving usability can be captured
    - Much of the usability analysis requirement can be performed in the tool
  - Clinician and hospital director perspective ...
    - Still very unclear where MBSE can contribute
    - Approaches such as Lean, Value-Stream mapping, clinical simulation offer immediate tangible benefits
    - While the MBSE model faces significant challenges communicating to clinicians
    - But there could be utility for large-scale projects (e.g., information architecture, clinician friendly EMR, etc.)



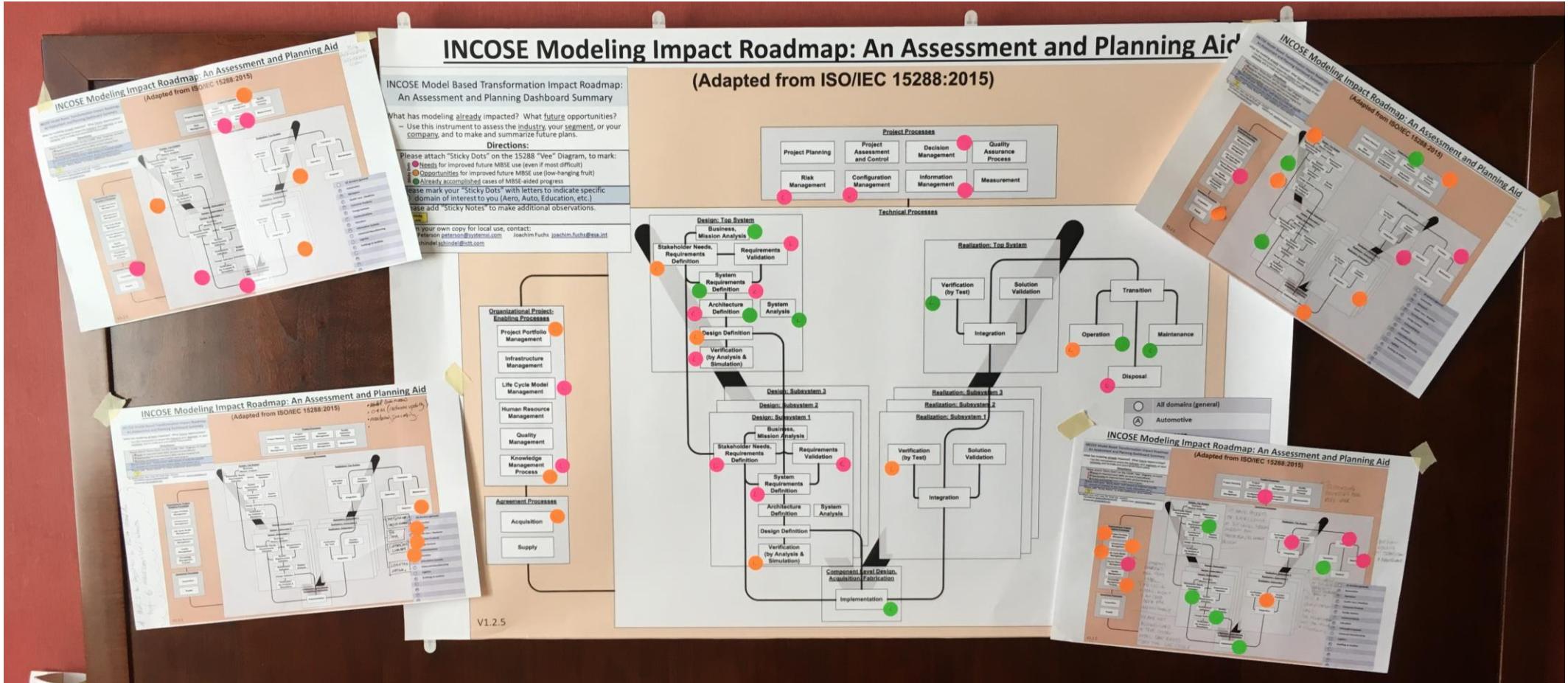


# CAB Breakout: Assessment / Roadmap Instrument: A simple instrument

- 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 important questions:
  - What are you trying to improve? (Which 15288 processes?)
  - Where are the biggest potential gains? The easiest potential gains?
  - What is already improved?
- But not:
  - How will your goals be accomplished?
  - What are the details of your plan?
  - Not a CMMI



# Breakout session





## Main takeaways

- Good instrument to start the discussion and highlight areas
- Very big differences between organisations / sectors
  - Avoid accumulation without this parameter
- Need for further improvement
  - Two functions: Assessment (status quo) and future (gap analysis)
  - Representation very design centric
  - Some aspects difficult to "locate", e.g.
    - Links between boxes (at model level)
    - Contract relations (only acquisition...?)
- Potential feedback also on process standard, if driven by model-based



# Open Mic

What can we do better?  
What are your needs?  
What did you like?



# Questions

# 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) [\(All\)](#)



# SE Transformation Products: Stakeholders



Population Size ↓	Stakeholders in A Successful MBSE Transformation
<b>Model Consumers (Model Users):</b>	
**** Non-technical stakeholders in various Systems of Interest, who acquire / make decisions about / make use of those systems, and are informed by models of them. This includes mass market consumers, policy makers, business and other leaders and executives, investors, product users, voters in public or private elections or selection decisions, etc.	
**	Technical model users, including designers, project leads, production engineers, system installers, maintainers, and users/operators
<b>Model Creators (including Model Improvers):</b>	
*	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.
<b>Complex Idea Communicators:</b>	
**	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
<b>Model Infrastructure Providers, Including Tooling, Language and Other Standards, Methods:</b>	
*	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)
<b>INCOSE and other Engineering Professional Societies</b>	
*	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?	
<b>Goals</b>	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.	
<b>Objective 1 Foundations</b>	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.	
<b>Objective 2 Expand Reach</b>	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)	
<b>Objective 3 Collaborate</b>	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	
<b>Objective 4 Assessment/Roadmap</b>	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.	21

# 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

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
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<b>Objective 4 Assessment &amp; Roadmap</b>	Assess INCOSE's efforts (WG, Objectives, Initiatives etc.) for inclusion of MBSE across the Systems Modeling 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.
<b>Objective Measures of Effectiveness (MOEs)</b>	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 etc.) O2: # of non-SE stakeholders in stakeholder representative list engaged O2: Targeted questionnaire 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
<b>Imperatives / Actions / Activities</b>	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.

