

International Workshop 28 Jan – 2 Feb 2011 Phoenix, AZ, USA

#### Model-based Systems Engineering (MBSE) Initiative

#### Mark Sampson, Sanford Friedenthal Opening Plenary 29 January 2011







#### **MBSE** Initiative Charter

- Supports MBSE Component of the SE Vision 2020
- Promote, advance, and institutionalize the practice of MBSE through broad industry/academic involvement
  - Research
  - Standards
  - Processes, Practices, & Methods
  - Tools & Technology
  - Outreach, Training & Education





#### Integrated Systems Engineering Vision

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### INCOSE MBSE Roadmap







- Reorganized to Focus Initiative
  - Monthly telecons with expanded Leadership Team
- Monthly MBSE Webinars
  - Well attended and generally high quality
- Established MBSE Wiki
  - http://www.omgwiki.org/MBSE/doku.php
  - Hosted by the OMG
  - Populated by MBSE Activity and Challenge Teams
  - Provides open forum to foster industry collaboration
- MBSE Workshop at IW 2011







- Continued broad interest in MBSE
  - Broad company participation and initiatives
  - DoD NDIA MBE Report and Systems 2020
- INCOSE has opportunity to foster collaboration and maintain leadership role to advance the practice of MBSE
  - Webinars
  - Workshops
  - Wiki







#### **MBSE Leadership Team**

#### Management

- Chair Mark Sampson
- Co-Chair Sandy Friedenthal
- Webinars and Communications Ray Jorgensen
- MBSE Wiki Support David Lempia

#### Challenge Teams

- Modeling and Simulation Interoperability Russell Peak
- Space Systems Modeling Chris Delp
- <u>Telescope Modeling</u> Robert Karban
- GEOSS Modeling Larry McGovern

#### Activity Teams

- MBSE Usability Scott Workinger
- Methodology and Metrics Jeff Estefan
- Model Management Mark Sampson
- Modeling Standards Roger Burkhart
- Ontology Henson Graves
- <u>System of Systems/Enterprise Modeling</u> Ron Williamson







- Objectives
  - Learn about the latest MBSE activities
  - Contribute to MBSE Roadmap and Plans
- Agenda
  - Saturday, January 29 Leadership Team Meeting
  - Sunday, January 30 Presentations
  - Monday January 31 Breakout Sessions





#### MBSE Presentations Sunday, January 30 Agenda

08:00 - 12:00

- Introduction Sandy Friedenthal / Mark Sampson (30 min)
- Methodology and metrics Jeff Estefan (30 min)
- SoS/Enterprise Modeling Ron Williamson (50 min)
- MBSE Usability Scott Workinger / David Lempia (50 min)
- Challenge Team Telescope Modeling Robert Karban (50 min)
  13:00 17:30
- Model Management Mark Sampson (50 min)
- Ontology Henson Graves (50 min)
- Challenge Team Space Systems Modeling Bjorn Cole (50 min)
- Challenge Team M&S Interoperability Russell Peak (50 min)
- Modeling Standards Roger Burkhart (30 min)







MBSE Breakout Sessions Monday, January 31 Agenda

08:00 - 11:00

- SoS/Enterprise Modeling Ron Williamson (3 hrs)
- MBSE Usability Scott Workinger / David Lempia (3 hrs)
- Ontology Henson Graves (3 hrs)
- Challenge Team Telescope Modeling Robert Karban (1.5 hours)
- Model Scaling Issues (1.5 hr)
- 11:00 12:00 Team Outbriefs

13:00 - 16:00

- Methodology and metrics Jeff Estefan (3 hrs)
- Model Management Mark Sampson (3 hrs)
- Modeling Standards Roger Burkhart (14:45 15:45)
- Challenge Team Joint Session SysML/STK integration (1 hr)
- Challenge Team M&S Interoperability Russell Peak (2 hrs)

600 E 17:00 Team Outbriefs

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#### DRAFT Final Report Model Based Engineering (MBE) Subcommittee Jeff Bergenthal (Subcommittee Lead)

#### NDIA Systems Engineering Division M&S Committee

December, 2010







#### MBE Subcommittee Charter

- Assess and promote Model Based Engineering (MBE) practices in support of the DOD capability acquisition life cycle\*
  - Define Model Based Engineering (MBE)
  - Define how MBE is related to M&S
  - Identify the potential costs, risks, and benefits of MBE
  - Identify the potential limitations of MBE
  - Identify how MBE practices can be used in capability acquisition with a primary focus on Systems Engineering to include concept engineering, concurrent design, development, and manufacturing
  - Identify MBE approaches to assess and mitigate risks throughout the capability acquisition life cycle
  - Identify the issues and challenges with using MBE practices across the capability acquisition life cycle
  - Identify where/how existing policy, guidance and contracting mechanisms support/hinder Model Based collaboration across program/capability boundaries



**G**F Provide recommendations:

\* - Acquisition Life Cycle: All phases of the capabilities life cycle including research, development, Test & Evaluation, production, deployment, operations and support, as well as evolution of deployed systems in response to changes in their environment over time. 12



#### MBE Subcommittee Membership

- Jeff Bergenthal (LM; MBE subcommittee lead)
- Eileen Bjorkman (SAF/A6W; former AMSWG chair)
- Jim Coolahan (JHU/APL; SISO)
- Bill Espinosa (USN)
- Sandy Friedenthal (LM; INCOSE MBSE)
- Tony Pandiscio (Raytheon)
- Lou Pape (Boeing)
- Greg Pollari (Rockwell Collins; AVSI SAVI)
- Hans Polzer (LM; NCOIC)
- Jennifer Rainey (JHU/APL)

- David Redman (AVSI; AVSI SAVI)
- Mark Rupersburg (GDLS)
- Frank Salvatore (HPTI)
- Don Schneider (Foxhole Technology)
- Dennis Shea (CNA)
- Roddey Smith (NGC)
- Charlie Stirk (CostVision; PDES, Inc.)
- Steve Swenson (Aegis Technologies; SISO)
- Bill Tucker (Boeing)
- Mike Truelove (Army CAA)





#### **MBE** Definition

- Model-Based Engineering (MBE): An approach to engineering that uses models as an integral part of the technical baseline that includes the requirements, analysis, design, implementation, and verification of a capability, system, and/or product throughout the acquisition life cycle
- Model: A physical, mathematical, or otherwise logical representation of a system, entity, phenomenon, or process. (DoD 5000.59 -M 1998)
- Preferred MBE Practices:
  - Models are scoped to purpose/objectives
  - Models are appropriate to the context (e.g., application domain, life cycle phase)
  - The models represent the technical baseline that is delivered to customers, suppliers, and partners
  - Models are integrated or interoperable across domains and across the lifecycle
- Core to MBE is the integration of descriptive/design models with the computational models







#### Characteristics of Models Used in MBE

- Models apply to a wide range of domains (e.g., systems, software, electrical, mechanical, human behavioral, logistics, manufacturing, business, socioeconomic, regulatory)
- Computer-interpretable computational model
  - Time varying (e.g., performance simulations, structural dynamic analysis)
  - Static (e.g., reliability prediction model)
  - Deterministic or stochastic (e.g., Monte Carlo)
  - May interact with hardware, software, human, and physical environment
  - Includes input/output data sets
- Human-interpretable descriptive models (e.g., architecture/design such as UML, SysML, UPDM, IDEF, electrical schematic, 3D CAD geometry, DODAF 2.0)
  - Symbolic representation with defined syntax and semantics
  - Repository based (i.e., the model is stored in structured computer format)
- Supporting metadata about the models including assumptions, versions, regions of validity, etc.
- MBE can also include the use of physical models (e.g., scale models for wind tunnels or wave tanks)







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# Potential MBE Benefits, Costs, Risks

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#### High-Level MBE Benefits

- Reduce time to acquisition of first article for systems and solutions
  - More complete evaluation of the trade space
  - Earlier risk identification and mitigation
  - Concurrent and collaborative engineering
  - Design reuse
  - Accelerated development
- Reduce the time to implement planned and foreseen changes in systems
  - Design reuse
  - Rapidly evaluate changing threats and explore trade space
- Enhance Reliability
  - Earlier and continuous requirements and system verification
  - Identify and resolve errors / issues earlier  $\rightarrow$  fewer post-fielding issues
- Enhance Interoperability
  - Inclusion of the operating environment and external interfaces in system models

Early and continuous interface and interoperability verification



... and Each of These Benefits Enhance Affordability



- Initiating an MBE approach will require investment in tools, training, and infrastructure
  - MBE must be institutionalized to be cost effective
  - The initial investment may be prohibitive if only used on one project
- MBE approaches and tools will not replace strong, rigorous, and disciplined enterprise processes
   They must be integrated with the processes
- Training is necessary, but not sufficient
- Must address stove-piped responsibilities
  - Model artifacts will cross organizational / discipline boundaries

Requires a strong interdisciplinary team to support Eoncurrent engineering processes and practices





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# **Objective MBE Framework**

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- Poor integration of models across the life cycle
- Limited reuse of models between programs
- Variation in modeling maturity and integration across Engineering Disciplines (e.g., systems, software, mechanical, electrical, test, maintainability, safety, security)
  - Mechanical/Electrical CAD/CAE fairly mature
  - Systems/Software/Test fairly immature
- Many MBE related activities across Industry, Academia, and Standards Bodies
- Evolving modeling standards (e.g., CMSD, Modeling Languages such as SysML, UPDM, Modelica, AADL)
- Tools are evolving towards an MBE paradigm and progressing towards greater tool to tool interoperability







#### MBE To-Be State

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#### Primary Gaps That Must Be Closed

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- Policy
  - Policy / contracting mechanisms
  - Business model(s) that incentivize MBE adoption
- Processes/Methods
  - Currently, models (other than CAD) are not part of the Technical Baseline
  - Model / data/ tools management (GOTS and COTS)
  - Information management
  - Model-based methods
- Tools/Technologies/Standards
  - Domain specific language and data standards
  - Formal semantics
  - Data rights protection in an open architecture environment
  - Model interconnect and interchange
    - Potential to leverage efforts by INCOSE, AVSI, SISO, STEP PDES, OMG, NIST







#### Primary Gaps That Must Be Closed (cont.)

- People
  - Workforce gaps across stakeholder communities
  - Acceptance of the use of models as a business practice
  - Model validation and confidence (reputation management; evidence based credibility)
- Infrastructure/Environment
  - Easy access to models / content developed by others
    - Inseparable from the business model
    - Potential to leverage the developing Defense Meta Data Standard and M&S Catalogue
  - Lack of common, shared Operational Scenarios
- The Business Case for MBE





#### To restate the obvious...

- Complex systems are everywhere...
- They are becoming the norm, not the exception
- They require systems/cross-domain thinking to be successful
- Existing processes can't handle the complexity, magnitude, etc.
- Models are becoming the master, not drawings, not documents,...
- Model-based systems world is coming...





~5000 sensors, ECU's, etc. communicating over 9000 connections via 1,000,000+ types of messages, performing 2000+ functions in triple-redundant, physically separated fashion with each tail number a different configuration 24





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#### Organizational SDB's...

# How prepared is your organization for the change?

# Culture change vs. getting lucky...



**Buckminster Fuller's Magic Log** 

SE tool management acceptance checklist	Y	Ν
Did the tool support group help with the proposal?		
Has the manger forecast time & money for tool usage?		
Did the project manager help get the tools for his project?		
Has the manager forecast time & money for tool training?		
Is the manager willing to let the tools be upgraded mid		
project or are we stuck at this tool version?		
Is the manager willing to let his tool power users share		
lessons learned, be involved with user groups, etc.?		
Is the manager active in convincing his customer or the		
benefits of the tools?		
Are the tools used during customer reviews?		
Is there a development process being followed on the		
project?		
Is there a mechanism for doing something with the results		
of the tools?		
Is the manager involved with defining requirements?		
Does the manager see "one or two" engineers managing		
the product requirements?		
Does the manager have a "lets get something built" before		
requirements are defined mentality?		
Does the manager think the value of the tool is in its		
paper generation capability?		
Does he want/let the engineering automation support his		
project?		

Cows drink...

