

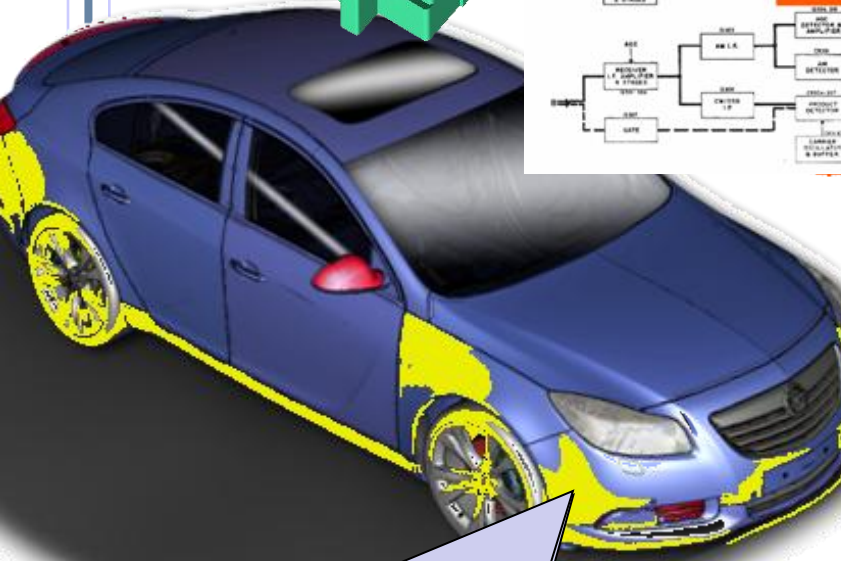
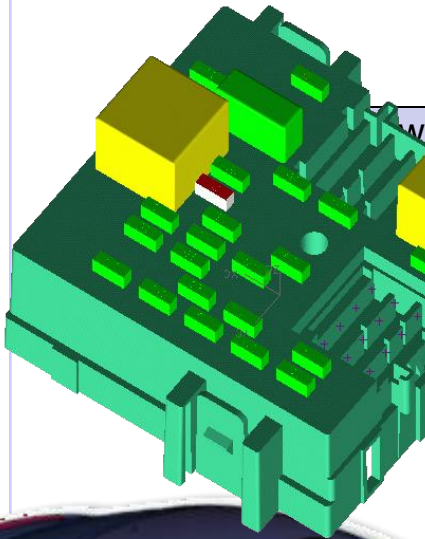


MBSE Initiative Charter

- 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

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



Minimum Turn Radius: 24 ft.
Dry Pavement Braking Distance
at 60 MPH : ~~110~~ ft. 90 ft

Hydraulic Fluid:

SAE
comp

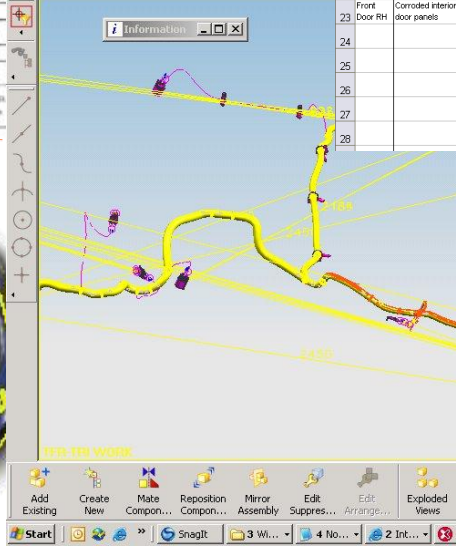
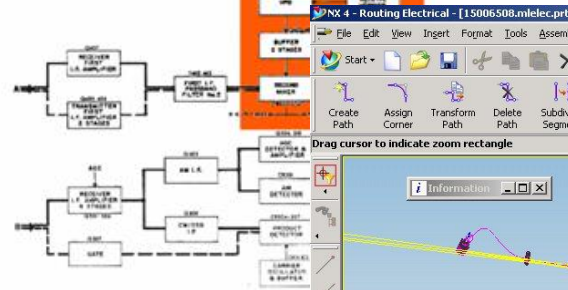
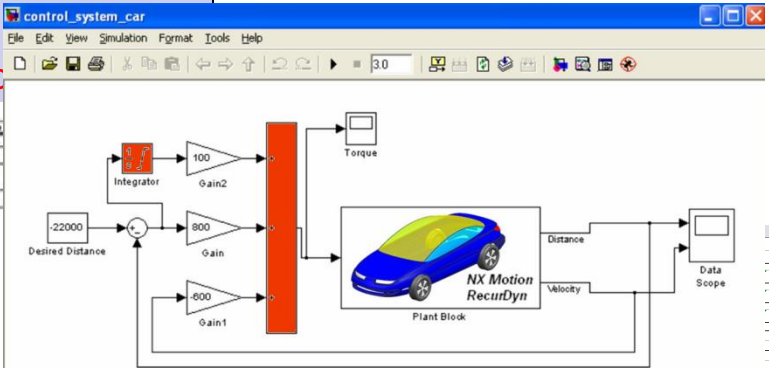
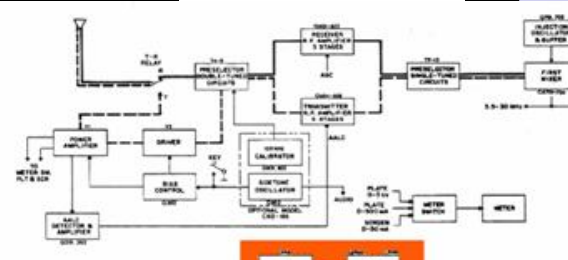


Table II.—Ordinary Joint Life and Last Survivor Annuities—Two Lives—Expected Return Multiples

Ages		35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52
Male	Female	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57
35	40	46.2	45.7	45.3	44.8	44.4	44.0	43.6	43.3	43.0	42.6	42.3	42.0	41.7	41.4	41.1	40.8	40.5	40.2
36	41	44.8	44.3	43.9	43.5	43.1	42.7	42.3	42.0	41.7	41.4	41.1	40.7	40.4	40.1	39.8	39.5	39.2	38.9
37	42	43.4	42.9	42.5	42.1	41.7	41.4	41.0	40.6	40.3	40.0	39.7	39.3	39.0	38.7	38.4	38.1	37.8	37.5
38	43	42.0	41.5	41.1	40.7	40.3	39.9	39.5	39.2	38.8	38.5	38.2	37.9	37.6	37.3	37.0	36.7	36.4	36.1
39	44	40.6	40.1	39.7	39.3	38.9	38.5	38.2	37.8	37.5	37.2	36.9	36.6	36.3	36.0	35.7	35.4	35.1	34.8
40	45	39.2	38.7	38.3	37.9	37.5	37.2	36.8	36.5	36.2	35.9	35.6	35.3	35.0	34.7	34.4	34.1	33.8	33.5
41	46	37.8	37.3	36.9	36.5	36.2	35.8	35.5	35.2	34.9	34.6	34.3	34.0	33.7	33.4	33.1	32.8	32.5	32.2
42	47	36.4	35.9	35.5	35.1	34.8	34.5	34.2	33.9	33.6	33.3	33.0	32.7	32.4	32.1	31.8	31.5	31.2	30.9
43	48	35.0	34.5	34.1	33.7	33.3	32.9	32.6	32.2	31.9	31.6	31.3	31.0	30.7	30.4	30.1	29.8	29.5	29.2
44	49	33.6	33.1	32.7	32.3	31.9	31.5	31.2	30.8	30.5	30.2	29.9	29.6	29.3	29.0	28.7	28.4	28.1	27.8
45	50	32.2	31.7	31.3	30.9	30.5	30.1	29.8	29.5	29.2	28.9	28.6	28.3	28.0	27.7	27.4	27.1	26.8	26.5
46	51	30.8	30.3	29.9	29.5	29.1	28.7	28.4	28.1	27.8	27.5	27.2	26.9	26.6	26.3	26.0	25.7	25.4	25.1
47	52	29.4	28.9	28.5	28.1	27.7	27.3	27.0	26.7	26.4	26.1	25.8	25.5	25.2	24.9	24.6	24.3	24.0	23.7
48	53	28.0	27.5	27.1	26.7	26.3	26.0	25.7	25.4	25.1	24.8	24.5	24.2	23.9	23.6	23.3	23.0	22.7	22.4
49	54	26.6	26.1	25.7	25.3	24.9	24.5	24.2	23.9	23.6	23.3	23.0	22.7	22.4	22.1	21.8	21.5	21.2	20.9
50	55	25.2	24.7	24.3	23.9	23.5	23.2	22.9	22.6	22.3	22.0	21.7	21.4	21.1	20.8	20.5	20.2	19.9	19.6
51	56	23.8	23.3	22.9	22.5	22.1	21.8	21.5	21.2	20.9	20.6	20.3	20.0	19.7	19.4	19.1	18.8	18.5	18.2
52	57	22.4	21.9	21.5	21.1	20.7	20.4	20.1	19.8	19.5	19.2	18.9	18.6	18.3	18.0	17.7	17.4	17.1	16.8
53	58	21.0	20.5	20.1	19.7	19.3	19.0	18.7	18.4	18.1	17.8	17.5	17.2	16.9	16.6	16.3	16.0	15.7	15.4
54	59	19.6	19.1	18.7	18.3	17.9	17.6	17.3	17.0	16.7	16.4	16.1	15.8	15.5	15.2	14.9	14.6	14.3	14.0
55	60	18.2	17.7	17.3	16.9	16.5	16.2	15.9	15.6	15.3	15.0	14.7	14.4	14.1	13.8	13.5	13.2	12.9	12.6
56	61	16.8	16.3	15.9	15.5	15.1	14.8	14.5	14.2	13.9	13.6	13.3	13.0	12.7	12.4	12.1	11.8	11.5	11.2
57	62	15.4	14.9	14.5	14.1	13.7	13.4	13.1	12.8	12.5	12.2	11.9	11.6	11.3	11.0	10.7	10.4	10.1	9.8
58	63	14.0	13.5	13.1	12.7	12.3	12.0	11.7	11.4	11.1	10.8	10.5	10.2	9.9	9.6	9.3	9.0	8.7	8.4
59	64	12.6	12.1	11.7	11.3	10.9	10.6	10.3	10.0	9.7	9.4	9.1	8.8	8.5	8.2	7.9	7.6	7.3	7.0
60	65	11.2	10.7	10.3	9.9	9.5	9.2	8.9	8.6	8.3	8.0	7.7	7.4	7.1	6.8	6.5	6.2	5.9	5.6



INCOSE MBSE Roadmap

MBSE Capability Reduced cycle times System of systems interoperability Design optimization across broad trade space
Cross domain effects based analysis

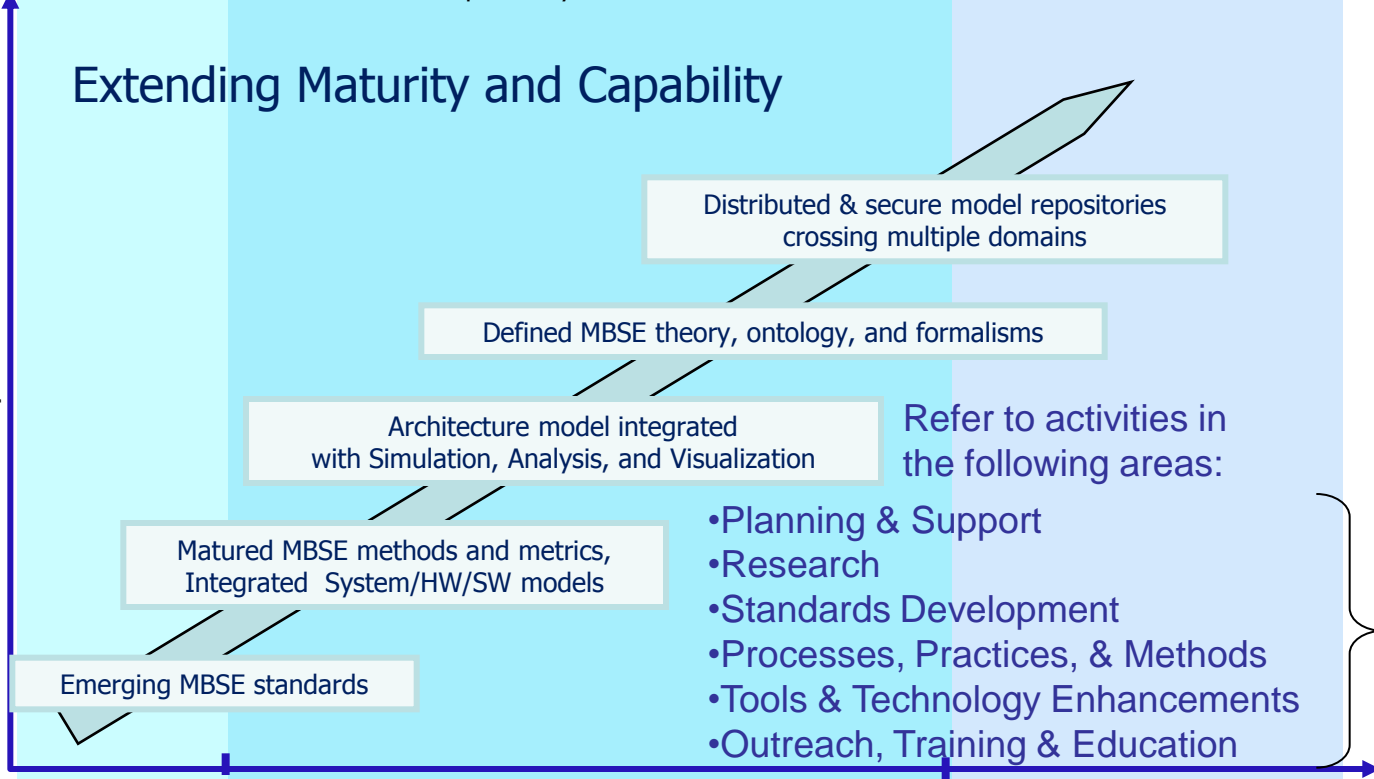
Extending Maturity and Capability

Institutionalized MBSE across Academia/Industry

Well Defined MBSE

Ad Hoc MBSE Document Centric

Maturity



Refer to activities in the following areas:

- Planning & Support
- Research
- Standards Development
- Processes, Practices, & Methods
- Tools & Technology Enhancements
- Outreach, Training & Education

2010

2020

2025





MBSE Initiative Status

- 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



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
- [Telescope Modeling](#) 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
- [System of Systems/Enterprise Modeling](#) Ron Williamson



MBSE Presentations

Sunday, July 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, July 31 Agenda

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

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 (3 hours)

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 (2 hrs)
- Challenge Team Joint Session – SysML/STK integration (1 hr)
- Challenge Team – M&S Interoperability - Russell Peak (2 hrs)

16:00 – 17:00 Team Outbriefs

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

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)

- 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, socio-economic, 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)

Potential MBE Benefits, Costs, Risks

Final Report

Model Based Engineering Subcommittee
INCOSE
International Council on Systems Engineering

- 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 → fewer post-fielding issues
- Enhance Interoperability
 - Inclusion of the operating environment and external interfaces in system models

Early and continuous interface and interoperability verification

Potential MBE Costs and Risks

- 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 concurrent engineering processes and practices

Objective MBE Framework

Final Report

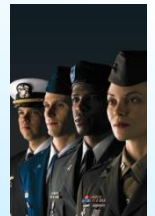
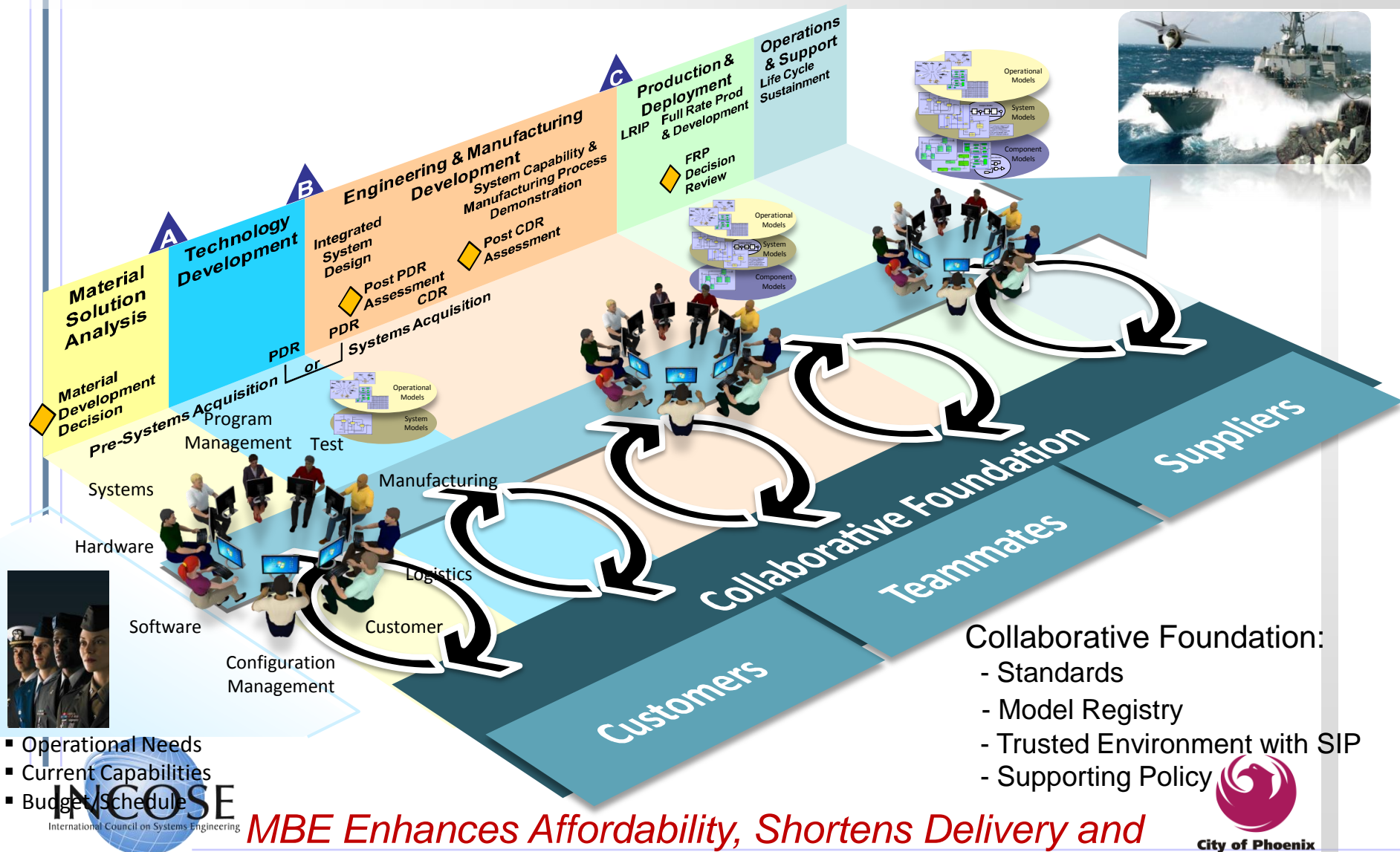
Model Based Engineering Subcommittee
INCOSE
International Council on Systems Engineering



City of Phoenix

- 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



MBE Enhances Affordability, Shortens Delivery and Reduces Risk Across the Acquisition Life Cycle



Primary Gaps That Must Be Closed

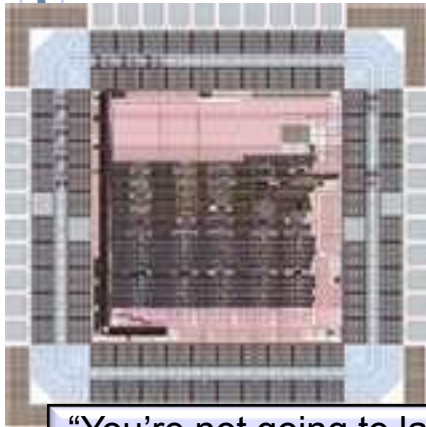
- Policy
 - Policy / contracting mechanisms
 - Business model(s) that incentivize MBE adoption
- Processes/Methods
 - Currently, models (other than CAD) are not part of the Technical Baseline
 - Model / data/ tools management (GOTS and COTS)
 - Information management
 - Model-based methods
- Tools/Technologies/Standards
 - 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...



“You’re not going to lay out a billion-gate integrated circuit by hand in your life-time” 1972 Dr. Charles Rose at TI (Inventor of HDL’s)



“...no two BMW 5 series sold last year were the same. “



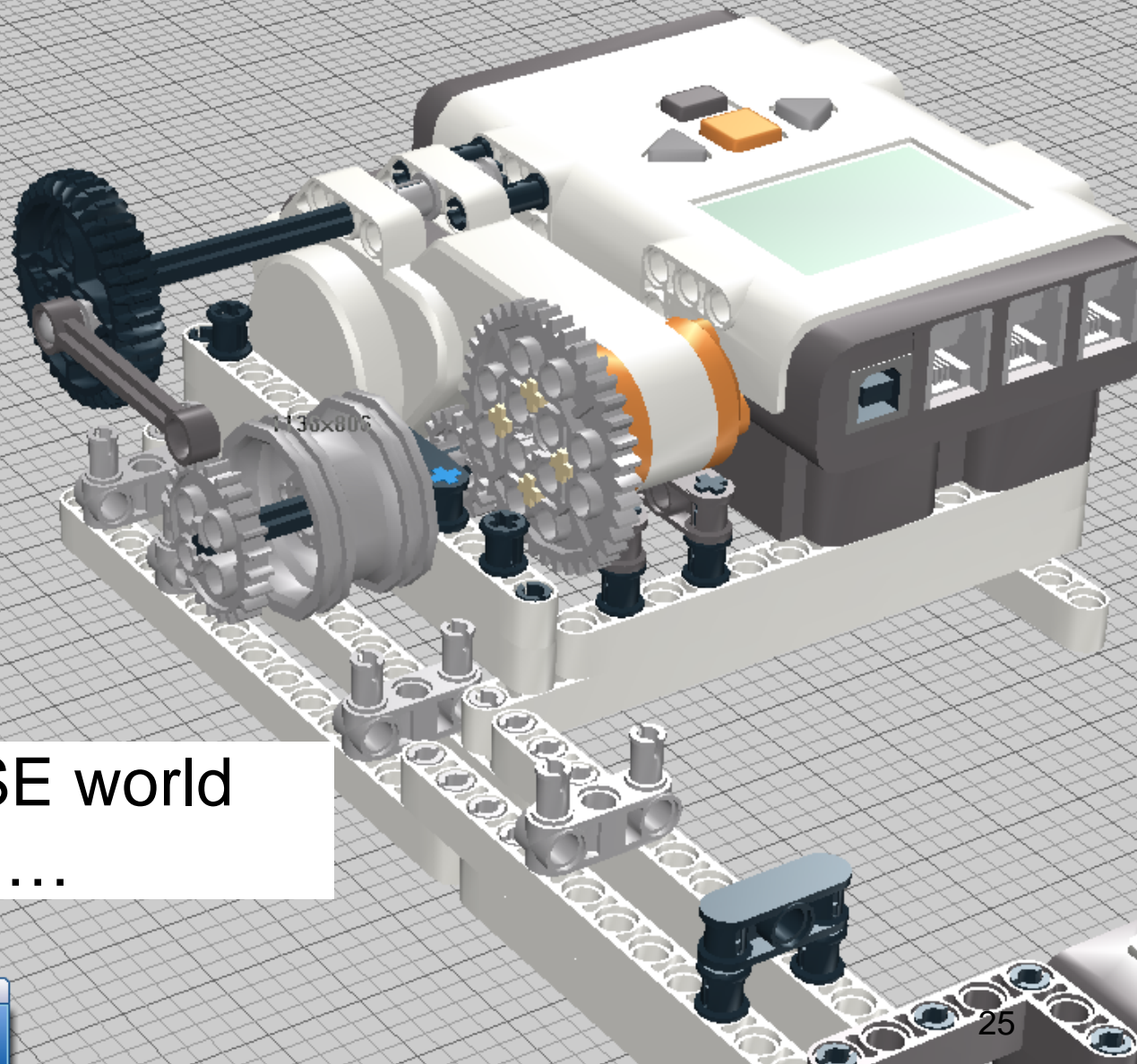
~5000 sensors, ECU's, etc. communicating over 9000 connections via 1,000,000+ types of messages, performing 2000+ functions in triple-redundant, physically separated fashion with each tail number a different configuration



Brick Palette

Bricks Starter Models

Mindstorms

The Brick Palette window displays a grid of 12 LEGO parts, including gears, axles, and connectors, each with a plus sign in the bottom right corner. The window also features a search bar and several icons for navigation and selection.

Model-based SE world is coming...





Backup

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	N
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...

