National Defense Industrial Association
Systems Engineering Division
Modeling and Simulation Committee

Model Based Engineering Subcommittee

Interim Report

October 2010

Agenda

- Background / Charter / Subcommittee Membership
- MBE Definition and Model Characteristics
- Current State
- Elements of MBE “To Be” State
- Potential Benefits of MBE
- Initial Findings on Policy/Guidance and Contracting Mechanisms
- Next Steps

Grow engineering capabilities to address emerging challenges (con't)

Identify opportunities to leverage Model-based engineering practices to improve systems engineering productivity and completeness

- Do existing policies, guidance and contracting mechanisms hinder model-based collaboration?

Reinvigorate exploration and exploitation of Modeling and Simulation Systems Engineering enablers to assess and mitigate acquisition program risks

- Modeling & Simulation Committee to lead the initial investigation
- Coordinate work schedule with new Committee chair

Model-Based Engineering 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
  - Provide recommendations:
    - For changes in policy, guidance, and contracting mechanisms that could further support Model Based collaboration
    - For near-term opportunities to leverage MBE in capability acquisition
    - For areas of MBE research & development that may have high potential pay-off

* - 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.

Model-Based Engineering Subcommittee

- Jeff Bergenthal (LM; 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, 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), but this is not the central focus.

MBE Current Activities

- Government
  - Systems 20/20 Initiative
  - DARPA META Projects
  - Navy, Army, Air Force all have programs and internal initiatives to deliberately drive engineering practices in the MBE direction
  - Air Force ICE project
  - Army MATREX
  - NIST MBE projects
  - OSD Mantech MBE projects
  - JPL
- Academia
  - Stevens, USC, Penn State, SERC
  - GTRI
  - GMU
  - JMU
  - JHU-APL

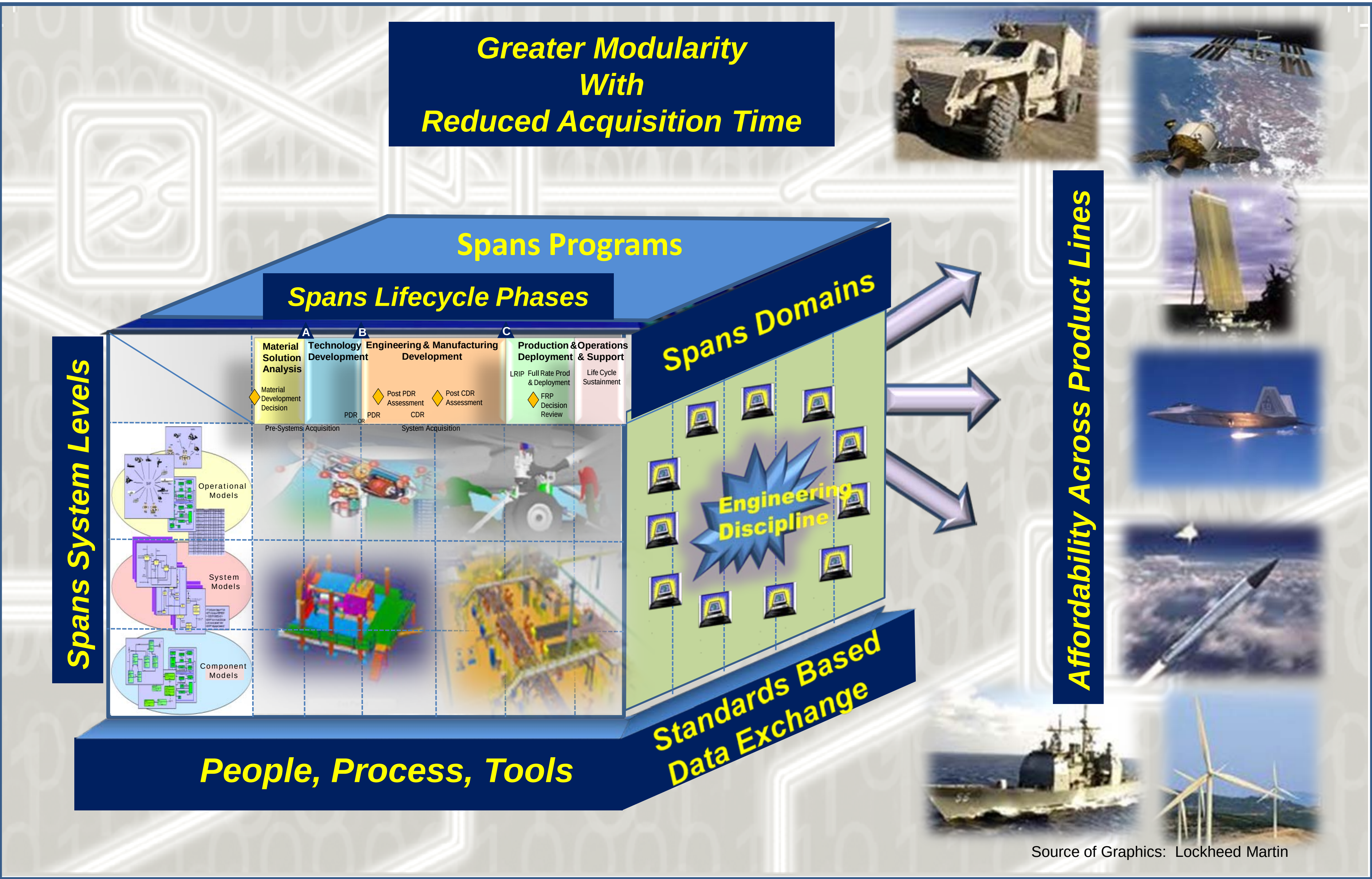
MBE Current Activities (cont.)

- Professional Organizations
  - INCOSE MBSE Initiative
- Standards Bodies
  - SISO Core Manufacturing Simulation Data Standard
  - PDES Data Interchange with STEP
  - OMG SysML
- Industry
  - AVSI SAVI Project in Aircraft Industry (Integration and Test)
  - All major players have various environment in use; even the best of these has limited collaboration capabilities.
- Tool Vendors
  - SysML/UML/UPDM/IDEF/ADL/BPML
  - CAD/CAE/CAM
  - Analysis
  - PLM/PDM
  - Etc….

MBE Current State

- Poor integration of simulations across the life cycle
- Limited reuse of simulation 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 making progress towards greater tool to tool interoperability

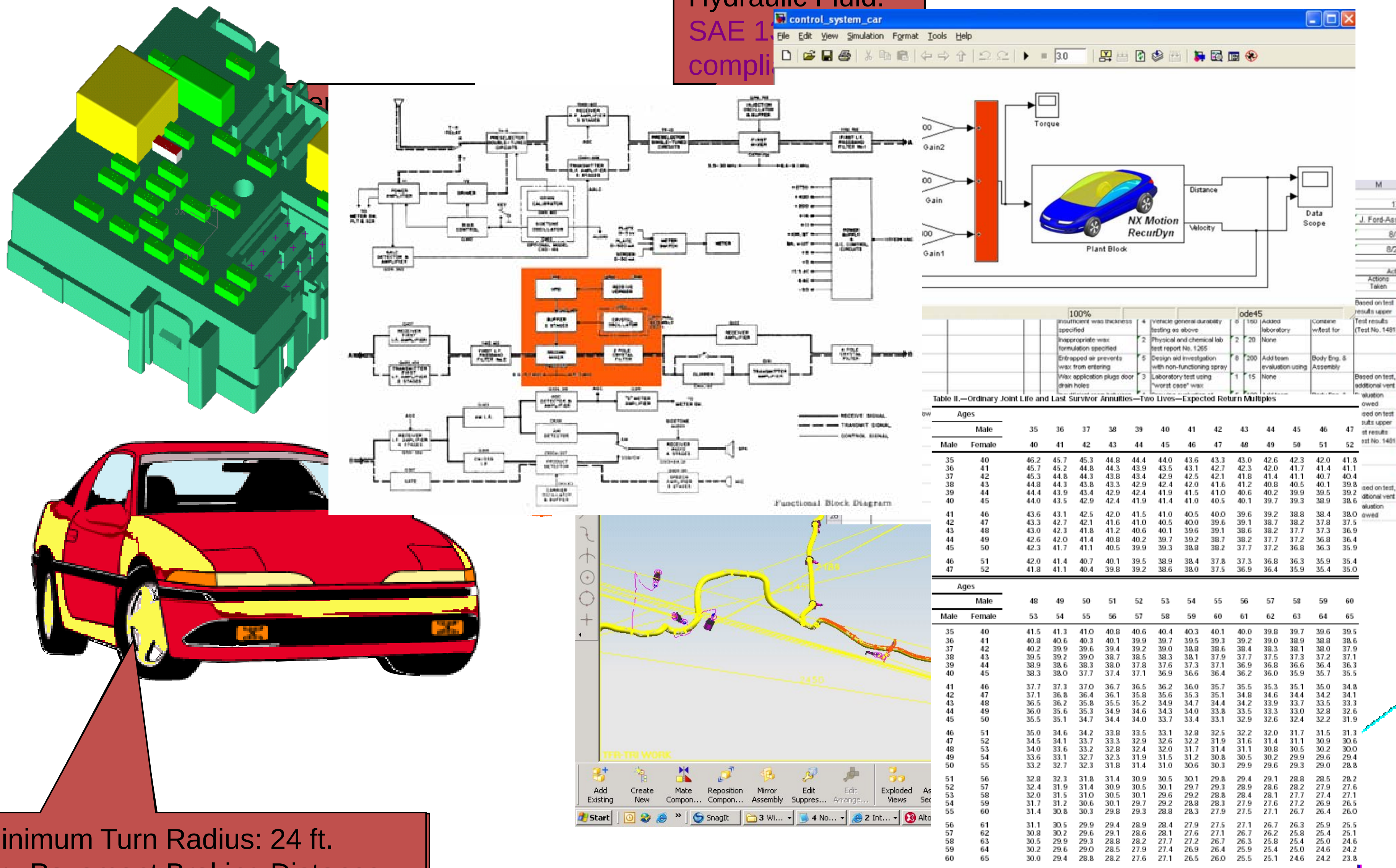
A Conceptual View of MBE "To Be" State



Source of Graphics: Lockheed Martin

Example From INCOSE MBSE Initiative

Hydraulic Fluid:
SAE 1
compli



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

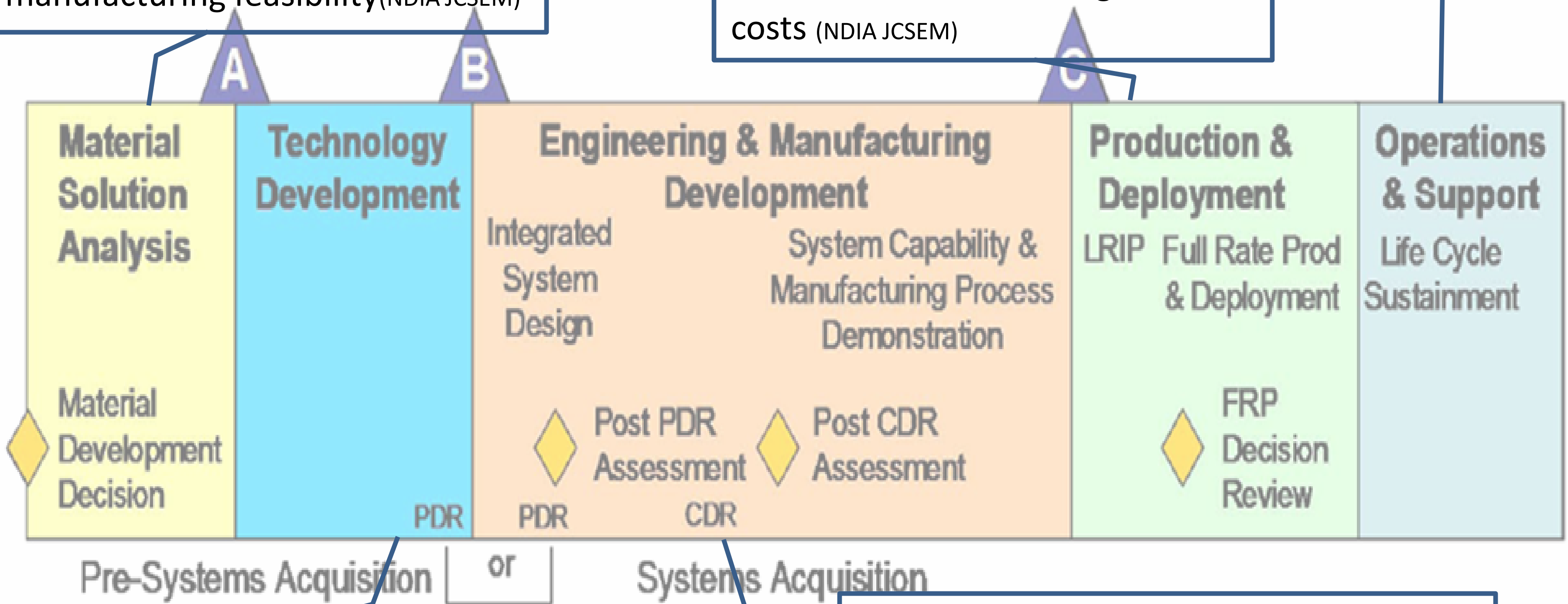
Provided by Mark Sampson

Potential Benefits of MBE

- Increased trade space (Boeing 787)
- Earlier evaluation of manufacturing feasibility(NDIA JCSEM)

- Reduced costs associated with complex product families (SWFTS)

- Reduced manufacturing related costs (NDIA JCSEM)



- Improved requirements (NRC, NRAC)
- Earlier risk identification and mitigation (NRC, NDIA JCSEM)
- Early evaluation of manufacturing processes (NDIA JCSEM)
- Increased trade space (Boeing 787)

- Earlier risk identification and mitigation (NRC, NDIA JCSEM)
- Concurrent and collaborative engineering (NRC, NRAC, NDIA JCSEM)
- Reduced defects and re-work costs (AVSI SAVI, NRAC, NRC)

Elements of MBE "To-Be" State

- Model-centric approach to engineering
  - Models are an integral part of the technical baseline
  - Models are explicit about their sources of "ground" truth
- Full life cycle application
  - Acquisition life cycle
  - For example: … -> Requirements → early validation → virtual integration → build/support
- Depth and breadth of the models
  - From SoS (System of Systems) down to component including the environment / context
  - Interoperable across User and Platform domains and engineering disciplines
  - Supply chain integration/exchange (global): customers, suppliers, partners
  - Potentially available for wider cross-enterprise use
- Implementation
  - Models based on descriptive metadata (model assumptions, versions, properties, validity ranges etc.)
  - Decentralized models that are stored and accessed with secure, reliable data exchange
  - Easier ability to find, access, and reuse models
  - Modeling languages based on formal semantics
  - Integrated model management (configuration, synchronization, change impact, etc.)
  - Modeling related standards that, as a minimum, support model interoperability
- Organizational / cultural
  - Knowledge, skills, ability
  - The way we do work and the value proposition(s) – individual and organizational
  - Breaking tradition

Gaps Identified That Will Need To Be Closed

- Policy/Processes/Methods
  - Policy / contracting mechanisms
  - Currently, models (other than CAD) are not part of the Technical Baseline
  - Model-based methods
- Tools/Technologies/Standards
  - Robust technology program for developing and transitioning technology to close specific gaps
  - Formal semantics
  - Model interconnect and interchange
    - Leverage efforts by INCOSE, AVSI, SISO, STEP PDES, OMG
- People
  - Workforce gaps across stakeholder communities
  - Acceptance of the use of models as a business practice
  - Model validation and confidence
- Infrastructure/Environment
  - Easy access to models / content developed by others
    - Inseparable from the business model
    - May be able to leverage the developing Defense Meta Data Standard
  - Lack of common, shared Operational Scenarios
  - Business model(s) that integrate the piece parts into a whole
  - Will take time to build up the set of available models that can be shared / reused across programs

Initial Policy Findings

- Existing OSD policies do not appear to pose any barriers to the implementation and use of MBE but does not appear to incentivize MBE. Guidance as referenced in the Defense Acquisition Guidebook is stronger and is supportive of the MBE concept.
- Army Acquisition Policy and Procedures has wording in place for "Simulation and Modeling for Acquisition, Requirements & Training" which is considered by some as a forerunner to MBE. Existing Army policy appears to be ready to accept MBE.
- Review of Air Force Policy found nothing that would preclude MBE from being implemented. Current Air Force policies will encourage MBE as a best practice.
- Review of Navy policy found no barriers to an increased use of M&S or the adoption of MBE concepts in the acquisition of Navy systems. Navy policy appears to be forward leaning in encouraging the use of MBE concepts and tools.
- There does appear to be more policy and guidance needed to address Model Based Contracting. Although there does not appear to be any explicit barriers to MBE within OSD or Services' policies and guidance, there are issues to be resolved with respect to contracting for MBE to ensure open and adequate competition and to protect the government from potential legal challenges.

MBE Subcommittee Next Steps

- Finalize analysis of potential MBE benefits, costs and risks
- Complete gap analysis
  - Policy / guidance / contracting mechanisms
  - Technical
  - Workforce
- Develop recommendations:
  - For changes in policy, guidance, and contracting mechanisms that could further support Model Based collaboration
  - For near-term opportunities to leverage MBE in capability acquisition
  - For areas of MBE research & development that may have high potential pay-off
- Prepare and brief final report in December 2010