Model-Based Systems Engineering (MBSE) Panel

Annual SERC Research Review

October 6, 2011

Sanford Friedenthal
safriedenthal@gmail.com

Copyright © 2011 Sanford Friedenthal All Rights Reserved

MBSE and MBE Definitions

"Model-based systems engineering (MBSE) is the *formalized application of modeling* to support system requirements, design, analysis, verification and validation activities beginning in the conceptual design phase and continuing throughout development and later life cycle phases."

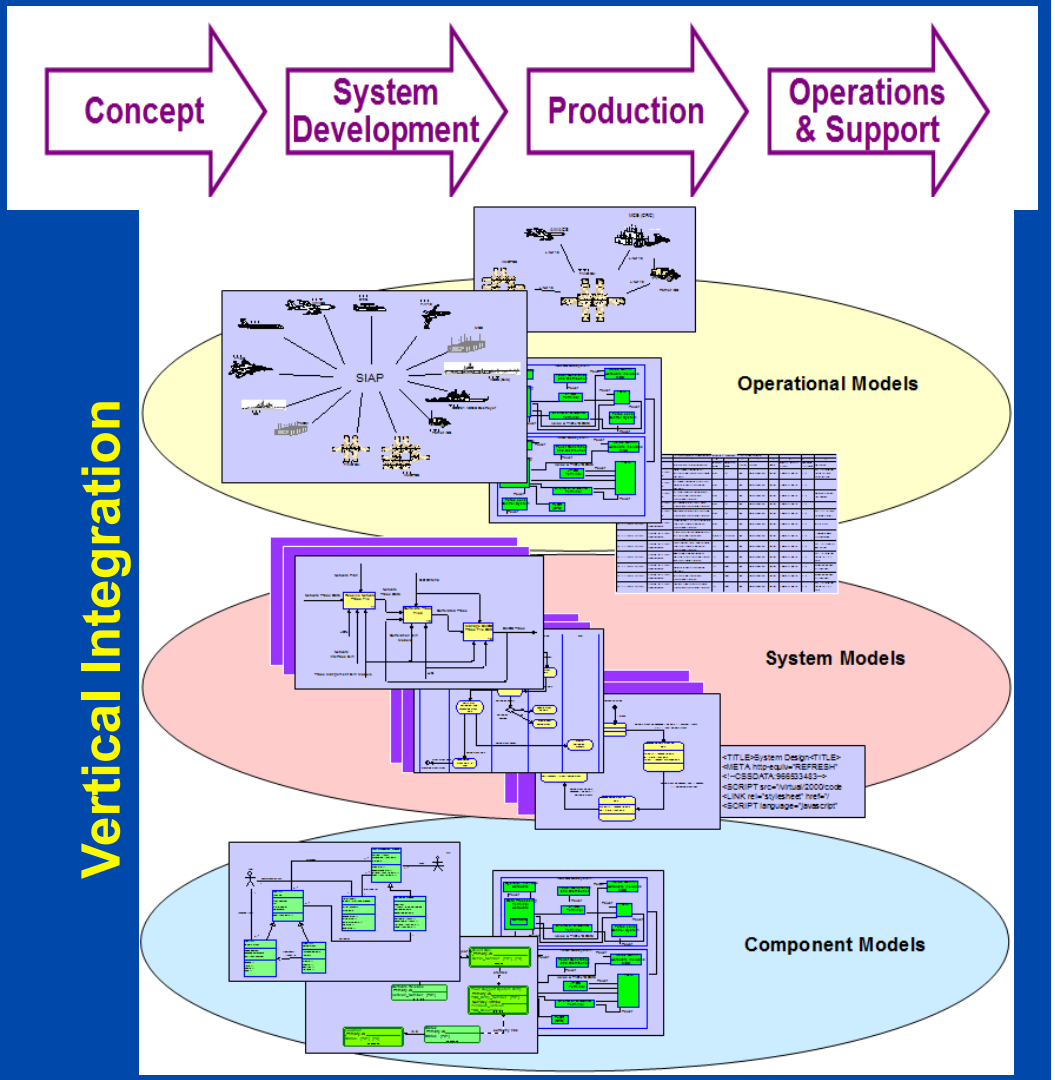
INCOSE SE Vision 2020 (INCOSE-TP-2004-004-02), Sept 2007

"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."

Final Report, Model-Based Engineering, NDIA M&S, Feb. 2011

Model-based Systems Engineering (MBSE)

- **Formalizes the practice of systems development through use of models**
- **Broad in scope**
  - Integrates with multiple modeling domains across life cycle from system of systems to component
- **Results in quality/productivity improvements & lower risk**
  - Rigor and precision
  - Communications among system/project stakeholders
  - Management of complexity



© Copyright Lockheed Martin Corporation All Rights Reserved

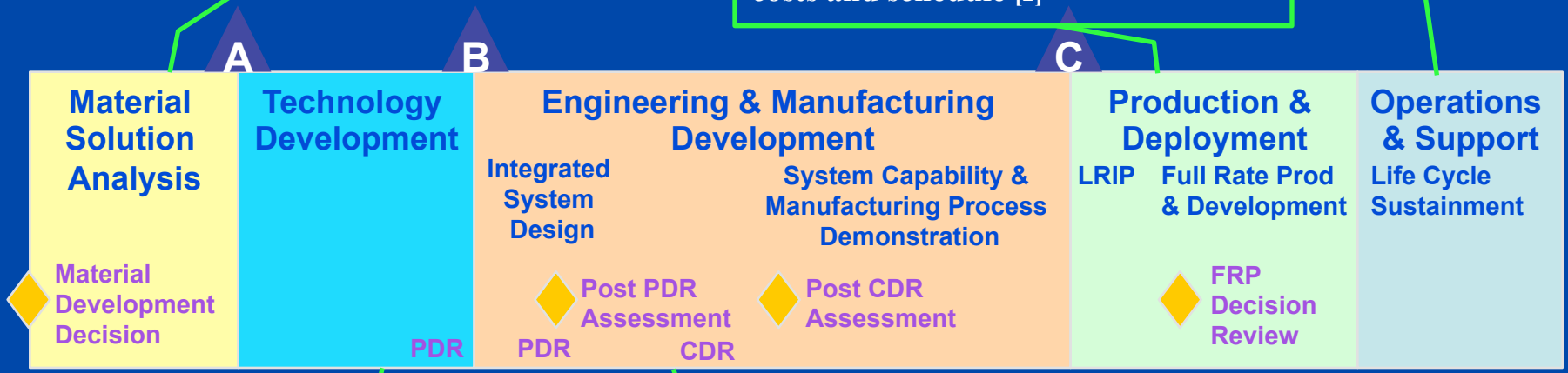
MBE Benefits Across the Acquisition Life Cycle

Source: NDIA MBE Final Report dated February 2011

- More complete evaluation of trade space [8, Boeing 787]
- Improved communications across stakeholders [6, 8]
- Earlier evaluation of manufacturing feasibility [2]

- Rapidly evaluate changing threats and explore solution space [8]
- Design Reuse [6, 7]
- Lower costs with complex product families [5]

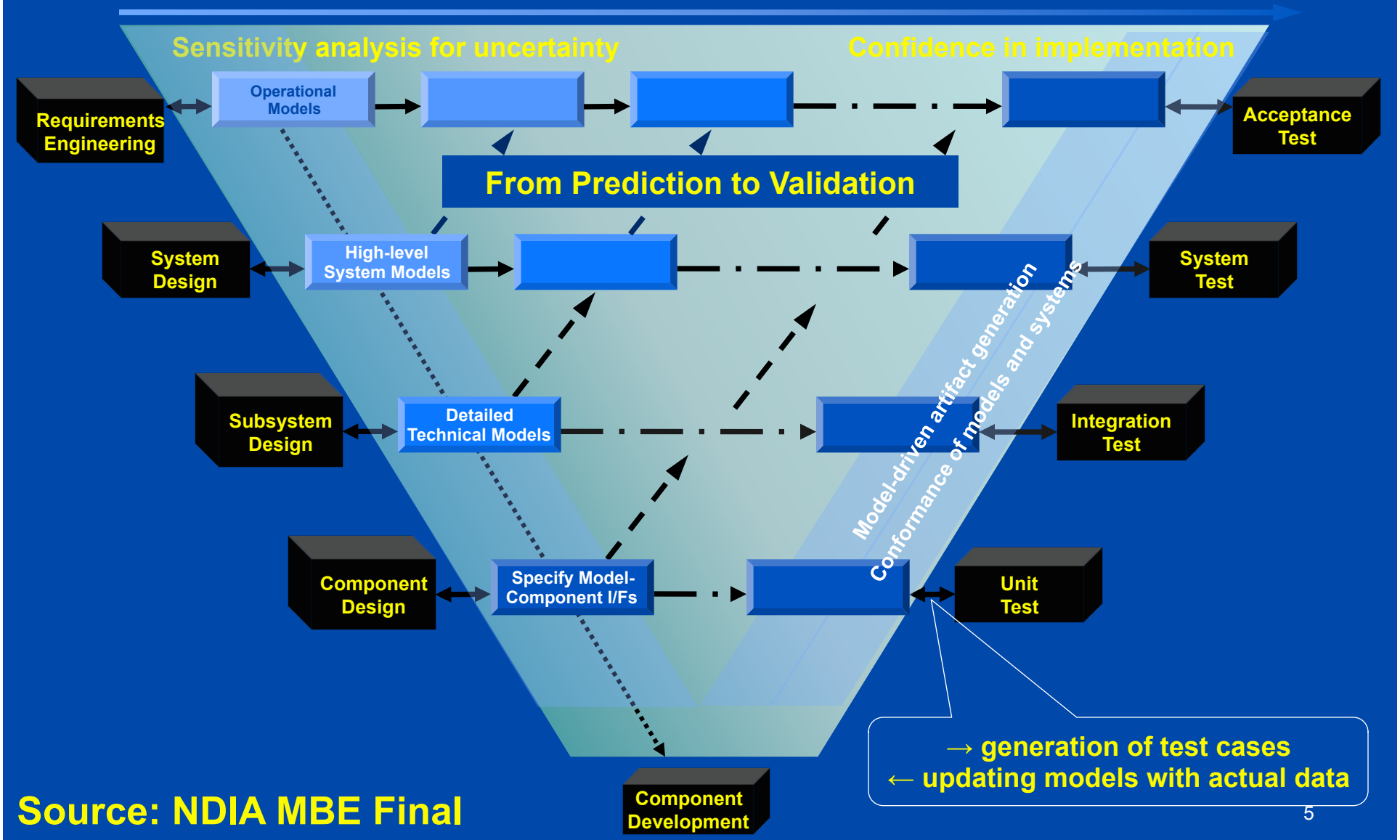
- Reduced manufacturing related costs and schedule [2]



- Improved requirements [3, 4, 6, 7]
- Earlier risk identification and mitigation [2, 4, 7]
- Early evaluation of manufacturing processes [2]
- More complete evaluation of trade space [8, Boeing 787]

- Earlier risk identification and mitigation [2, 4, 7]
- Concurrent and collaborative engineering [2, 3, 4, 7]
- Reduced defects and re-work costs [1, 3, 4, 7])
- Accelerated development schedule [1, 6, 7]
- Improved system and software reliability and quality [6, 7, 8]
- Design reuse [6, 7]

Virtual Integration to Manage Risk Throughout The Life Cycle



Source: NDIA MBE Final Report dated February 2011

MBE Current State

Source: NDIA MBE Final Report dated February 2011

- **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

Source: NDIA MBE Final Report dated February 2011

- Operational Needs
- Current Capabilities
- Budget/Schedule

Collaborative Foundation:

- Standards
- Model Registry
- Trusted Environment with SIP
- Supporting Policy

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

Primary Gaps That Must Be Closed

Source: NDIA MBE Final Report dated February 2011

- **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
- **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
  - Lack of common, shared Operational Scenarios
- **The Business Case for MBE**