Modeling and Simulation in Defense Systems Acquisition:

Pathways to Success

Committee on Modeling and Simulation Enhancements For 21st Century Manufacturing and Acquisition

Board on Manufacturing and Engineering Design
Division on Engineering and Physical Sciences
National Research Council

Sponsored by:
Defense Modeling and Simulation Office
United States Department of Defense

Virtual Analysis from Lust to Dust:

What will it take?

Committee

Modeling and Simulation Enhancements for 21st Century Manufacturing and Acquisition

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- Dr. Erik Antonsson, California Institute of Technology
- Mr Denis Clements, GRC International
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- Dr. Yu-Chi Ho, Harvard University
- Ms. Mary Ann Horter, Lockheed - Martin Aeronautics
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- Dr. Jay Lee, University of Wisconsin, Milwaukee
- Dr. John Mitchiner, Sandia National Laboratories
- Dr. Mikel Petty, Old Dominion University
- Dr. Stuart Starr, The Mitre Corporation
- Dr. Charles Wu, Ford Motor Company
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NRC Staff

Patrick J. Doyle and Toni Maréchaux, BMAED Director

Sponsor's Task Statement

From the Defense Modeling and Simulation Office

- Investigate next generation evolutionary and revolutionary M&S capabilities that will support enhanced defense systems acquisition
- Identify specific emerging design, testing, and manufacturing/process technologies that can be enabled by advanced M&S capabilities
- Relate these emerging technologies to long-term DoD requirements
- Assess on-going efforts to develop advanced M&S capabilities; identify gaps that must be filled to make the emerging technologies a reality
- Identify lessons learned from industry
- Suggest specific government actions to expedite development and enable maximum DoD and US commercial advantage from these advanced capabilities

Government Presenters

Modeling and Simulation Enhancements for 21st Century Manufacturing and Acquisition

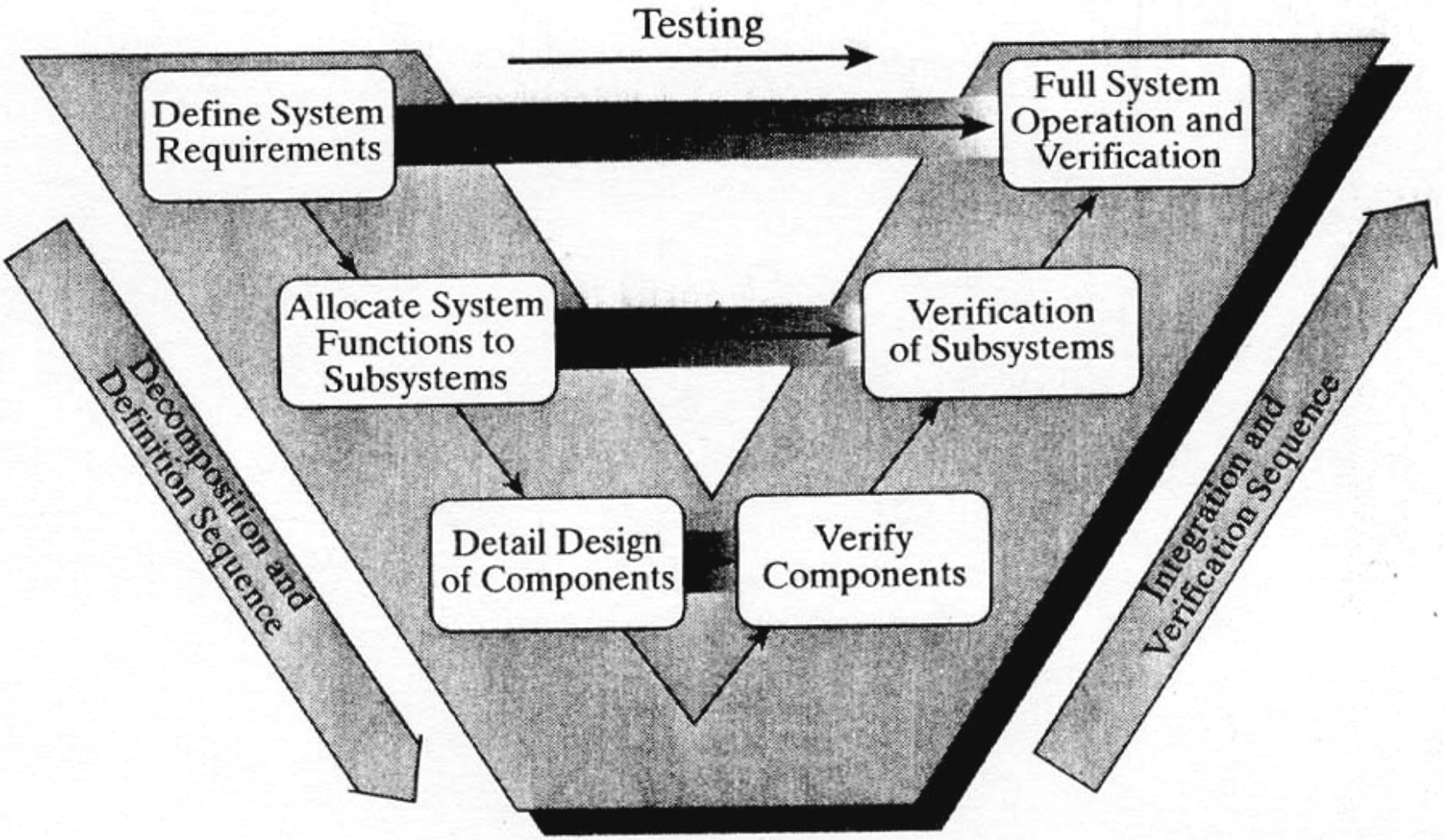
- Delores Etter, Deputy Under Secretary of Defense (Science & Technology)
- Ric Sylvester, Office of Deputy Undersecretary of Defense (Acquisition Reform)
- James Poindexter, Air Force Research Laboratory
- William McQuay, Air Force Research Laboratory
- MAJ Emily Andrew, USAF, Air Force Electronic Systems Center
- Steve Wall, Jet Propulsion Laboratories
- Walter Hollis, Deputy Under Secretary of the Army (Operations Research)
- Ellen Purdy, U.S. Army
- Charles McLean, NIST
- Randy Zittel, Defense Systems Management College

Industry and Academic Presenters

Modeling and Simulation Enhancements for 21st Century Manufacturing and Acquisition

- Mike Wendel, Coleman Research Corporation
- Matt Landry, Lockheed-Martin - Fort Worth
- Steve Hall, Lockheed-Martin Space Systems
- Stephen Keeler, Boeing
- Mike Kamrowski, Raytheon
- Ernie Blood, Caterpillar Corporation
- Jim Korris, Institute for Creative Technologies, University of Southern California

"Vee" Process Model



Source: Benjamin Blanchard, Wolter Fabrycky, Systems Engineering and Analysis, Prentice Hall, New Jersey, 1998

TABLE 1-1. Breakdown of Activities and Phases in the New Defense Acquisition Framework. Source: DOD, 2000.

Activities	Phases
Pre-Systems Acquisition	User Need Assessment Material Acquisition Requirements Analysis Technological Opportunity Activities Analyze Alternatives Develop Concepts and Technologies
Systems Acquisition	Begin Development Develop and Demonstrate Systems Low-Rate Production and Deployment Full-Rate Production and Deployment
Sustainment	Sustain Systems Evolutionary Sustainment (Block Development) Dispose of Systems

EIA 632 can be mapped onto this structure

User Needs

- Fast response (reduced cycle time)
- More sophisticated products and systems
- Viable & effective in the field
- Customizable to satisfy increasingly sophisticated demands
- Life-cycle costs determined
- …

All before ‘metal is cut’!!

Questions:

- Will the envisioned system (product) perform as needed?
- What architectures will permit permit building the system?
- Which architecture is ‘best’?
- What subsystems are specified by the architecture?
- What are the subsystem specifications?
- What are the risks?
- …

Answers come from:

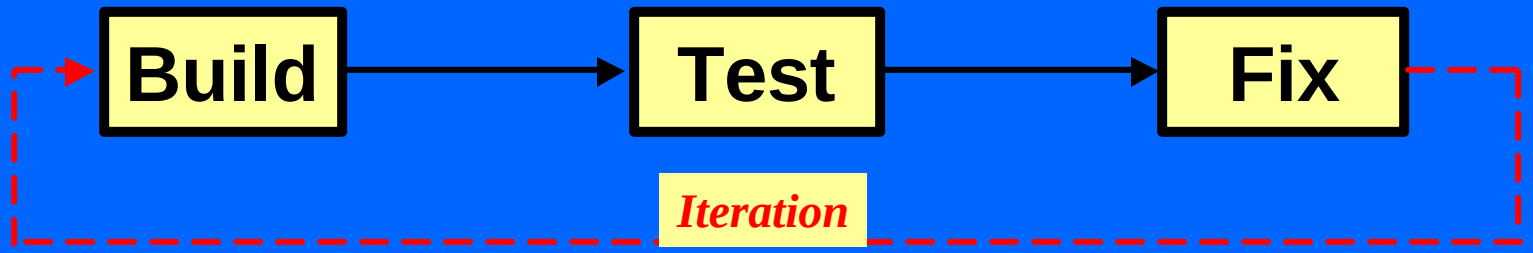
- WAG
- Build – Test - Fix
- SWAG
- Solid scientific estimation

We must turn WAG, B-T-F, and SWAG

into

Solid Scientific Estimation!

Traditional Product Development Process:



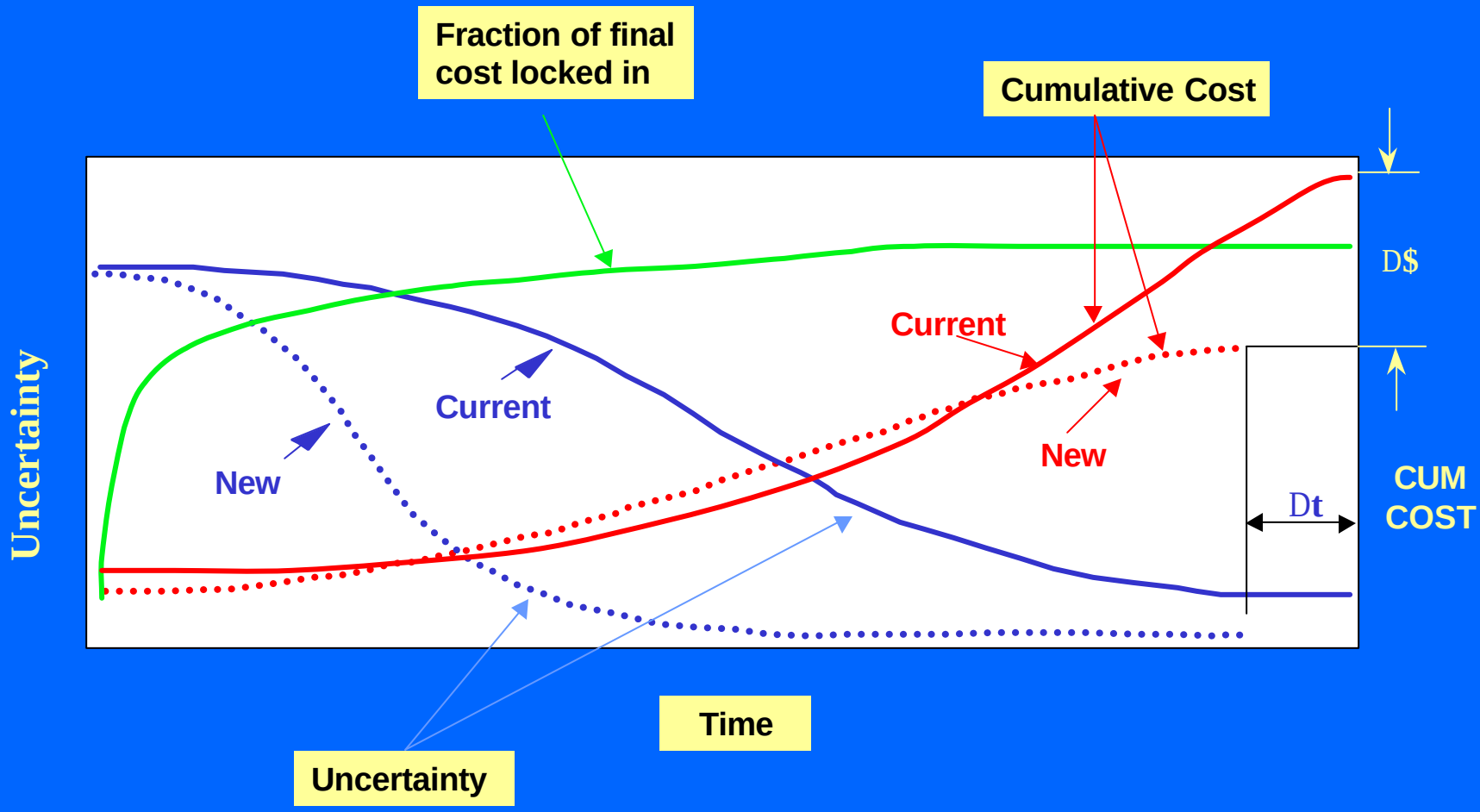
FOR COMPLEX PRODUCTS:

- Cycle Time Too Long
- Facility Intensive
- Cost High
- Convergence Not Assured

Proposed Product Development Process:

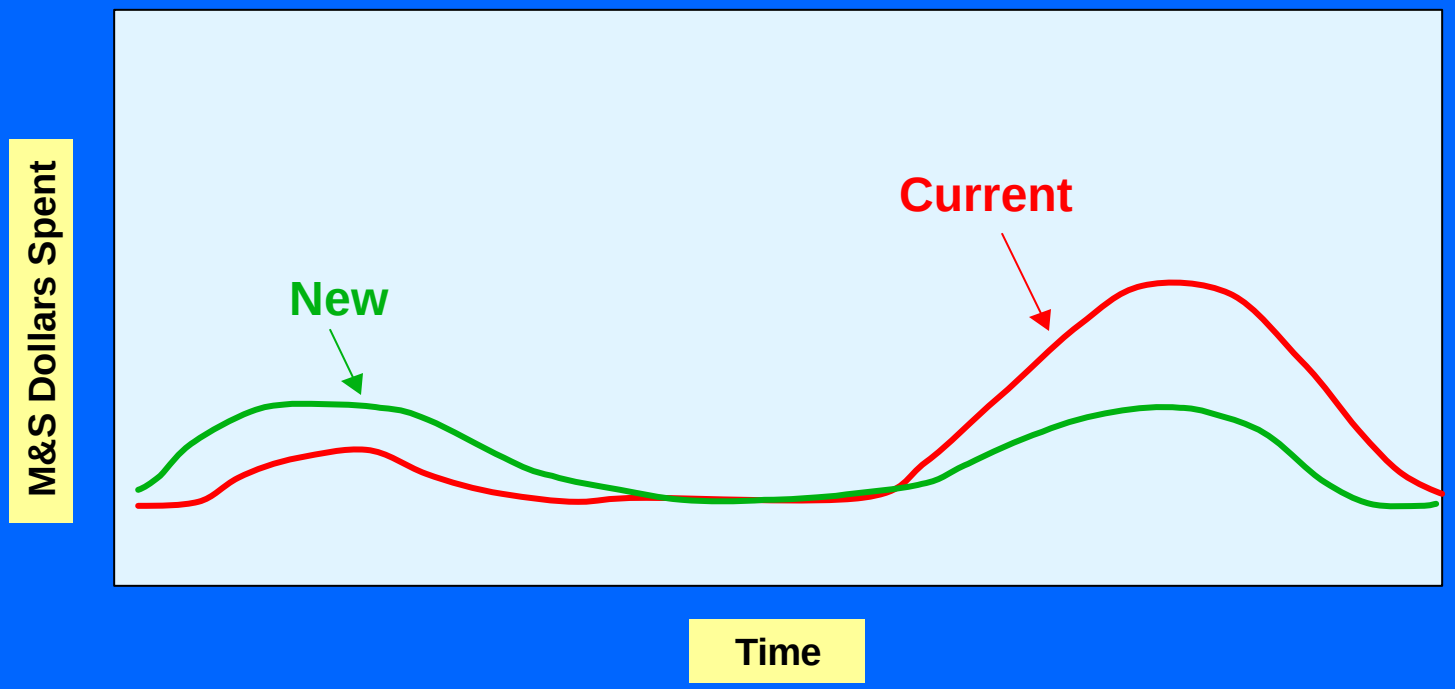
FOR COMPLEX PRODUCTS:

- Cut Cycle Time
- Compute Intensive
- Cost Reduced
- Quality Improved



SOURCE: Defense Science Board Task Force Report, "Engineering in the Manufacturing Process", Mar 93 (with modifications)

Forensic Modeling and Simulation



Why is it so #@!$*# difficult?

Stephen Keeler
Boeing

Because, among many other things, it is

A change in the way we do business!!

Auto catalytic Process

Development of M&S ‘system’ for application to manufacturing and acquisition must be guided by experience in applying M&S to manufacturing and acquisition.

Systems Engineering for M&S

Needs for M&S in Manufacturing and Acquisition

- Robust, reusable, interoperable, model building blocks (atoms)
- Multi-scale, multi-view modeling capability
- Fundamental science enhancement
- Modeling science enhancement
- IT infrastructure
- M&S infrastructure
- Standards
- Culture of M&S acceptance and use
- …

Recommendations

Three groups:

- **Technology development**
- **Infrastructure development**
- **Acquisition of experience**

Set against a background of people and culture

M&S Research & Technology Development

Fund, conduct, apply long term R&D to enhance the science and technology base relevant to M&S in manufacturing and acquisition.

M&S Research & Technology Development

- Modeling methodology:
  - Scalability
  - Multi resolution, multi viewpoint
  - Agent-based models
  - Semantic consistency
  - Complexity
  - Fundamental limits of modeling and computation
  - Characterization of uncertainty and risk

M&S Research & Technology Development

- **Model integration:**
  - **Interoperability**
  - **Composability**
  - **Integration of heterogeneous simulations**
  - **Linking engineering & effectiveness simulations**
- **Model correctness:**
  - **Domain knowledge**
  - **Physics based knowledge**
  - **Human behavior modeling**
  - **Verification, Validation, & Accreditation methodology**

M&S Research & Technology Development

- **Standards:**
  - **Interoperability**
  - **General software standards**
  - **Higher layer standards, including engineering enterprise**
- **Methods & Tools to assist in translation of system requirements into system functionality**
- **Domain specific models, including emerging areas such as information operations and OOTW**

M&S Research & Technology Development

- **Enhance M&S capabilities for systems-of-systems to have the following capabilities:**
  - **Contain and make available a library of composable sensor, weapon, and C4ISR models**
  - **Support analytic and optimization usage modes with visualization, experiment definition, and statistical analysis capabilities**
  - **Ability to represent possible design variations, operational utilization patterns, and engagement scenarios**

M&S Research & Technology Development

- Create a research initiative at multiple universities to attract academic interest in M&S as needed by manufacturing and acquisition.

- Plan and execute transition of research to application as an integral part of development process.

M&S Infrastructure Development

Invest in “common good” activities to encourage adequate standards and a strong infrastructure for M&S.

M&S Infrastructure Development

- Develop a common infrastructure capable of supporting consistency and interoperability across programs.
  - Common repositories
  - Knowledge base
  - Trained M&S work force
  - IT infrastructure
- Stimulate a collaborative effort among DOD, industry, and the academic community to advance the emergence of standards for performance simulation and product modeling.

M&S Experience Development

Invest in process improvements to better support integration of M&S into manufacturing and acquisition.

M&S Experience Development

- Expand M&S use in the concept phase (build the right thing as well as build the thing right)
- Develop guidelines for ownership
- Define how M&S is to be integrated into process
- Create and implement incentives for use of M&S throughout life cycle
- Pilot projects undertaken to advance M&S use

M&S People and Culture Development

Provide leadership to initiate, support, and sustain a cultural change for manufacturing and simulation to be enabled by M&S.

M&S People & Culture

- Take concerted actions to fundamentally change the manufacturing and acquisition cultures: Reward structure, Best practices; Education and training; Conferences

- Build intellectual capital:
  - Centers of excellence
  - Degree programs
  - MURI
  - Mentoring programs
  - Career long learning

Change the way we do business!!

- **Risk of Overestimating Capability**
  - Known shortfalls
  - Unable to model unkonwn unknowns
  - Not error free until verified
- **Substantiate M&S with Test --- Validate**
- **Keys to SBA success**
  - Work on specifics
  - Prudent application for best value

Boeing hasn't given up

Major investment in design process and tools at the corporate level

Near- term approach: "standard" CAD product

Effort is { complemented / challenged } by product divisions' programs

Ongoing development, implementation and support of Boeing-owned software

Applied research and development

Stephen Keeler
Boeing

Design-related applied R& D

Geometry
Optimization
Computational Physics
Computational Mathematics and Linear Algebra
Engineering Modeling and Analysis
Expert and Neural Systems
Visualization and Interaction Technology
Software Technology

Information Management
Human-Computer Interaction
Enterprise and Distributed Systems
Collaborative Technologies
Performance and Scalability Modeling
Intrusion Detection and System Health
Architecture Applications and Infrastructure
Design Automation

Stephen Keeler
Boeing

Modeling and Simulation Enhancements for 21st Century Manufacturing and Acquisition

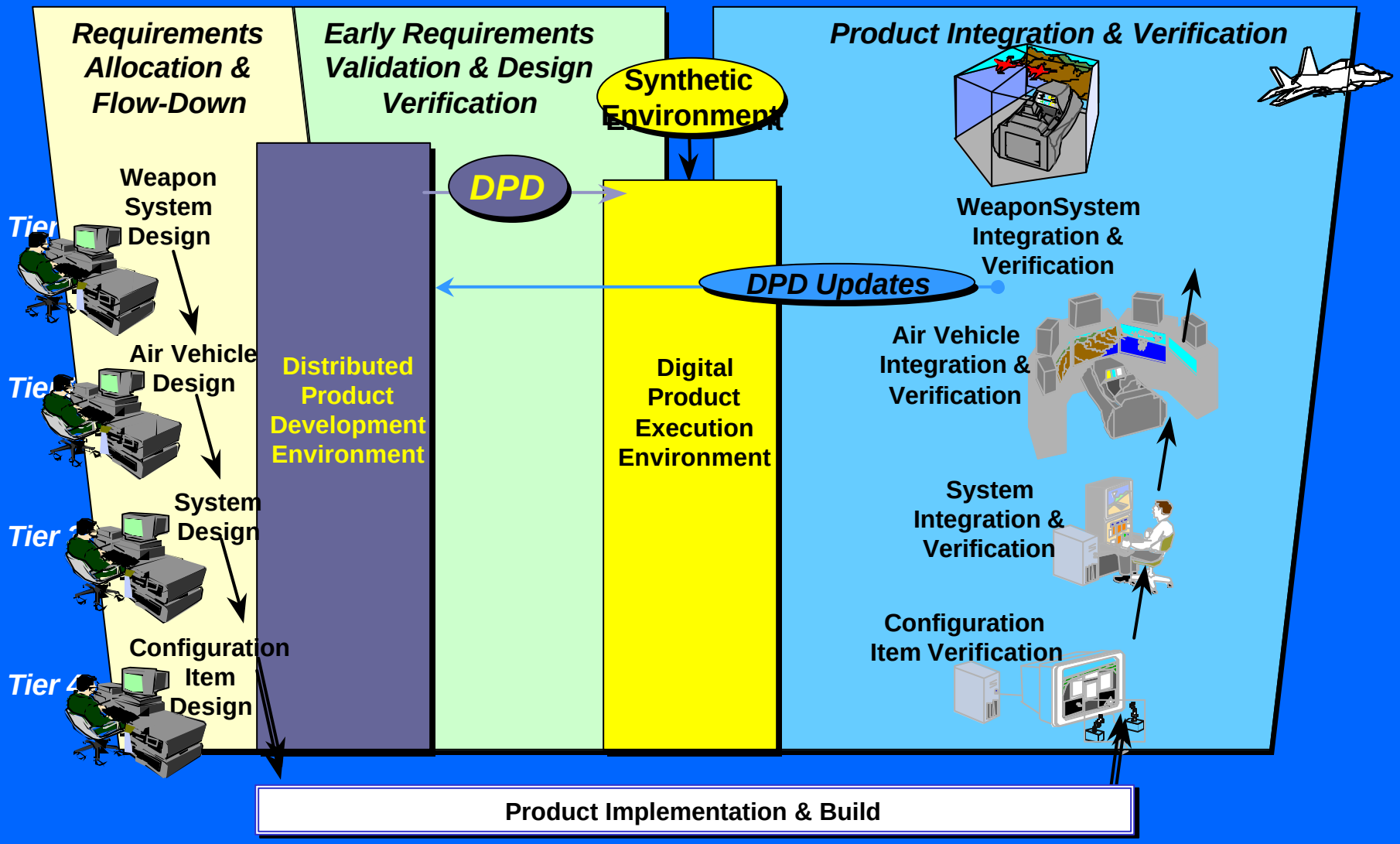
- **M&S will change the way defense systems are acquired**
  - **product design, testing, and manufacturing**

- **DoD initiatives to increase use of M&S throughout system life cycle**
  - **Simulation-Based Acquisition (SBA)**
  - **From initial concept to final disposal**
  - **Integrate the various layers of models and simulations into a distributed, collaborative environment**
    - **Engineering Simulations - used in design**
    - **Performance Simulations - used in war games and planning**

Modeling and Simulation Enhancements for 21st Century Manufacturing and Acquisition

- **Goal: better fulfill the warfighter's needs**
  - **reduce acquisition cycle time and total ownership cost**
  - **providing basis for enhanced performance and manufacturing flexibility**

Natural Development of Distributed Product Description



Matt Landry
Lockheed - Martin