Practical Implementation of Model Based Systems Development

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Biography

Dr. Yvonne Bijan

Systems Engineer Senior Staff
Engineering and Technical Operations- Systems Engineering Directorate

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- 15 years at Lockheed Martin developing SysML models, UML models, and Interoperability Architectures on F-35, Harvest Hawk, and SBIRS
- Certified Enterprise Architect, Certified Systems Engineering Professional, Certified SysML Model Builder Advanced, SAFe Agilist, and QFD Greenbelt
- LM Aero MBSE POC
- PhD Systems Engineering
- MS Computer Science
- BS Physics
Biography

Thomas F. ‘Rick’ Landers

Systems Engineer Principle
Engineering and Technical Operations- Systems Engineering Directorate

Lockheed Martin Aeronautics
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- 35 Years SE and Systems Development experience, through all phases of Product Development Life Cycle.
- Certifications/Awards: LM SEDQP – Advanced Level, NASA Mission Success Honoree
- Key Programs: NASA Space Shuttle, X-33 Venture Star, UK MoD, F-35, MI5 & MI6
- Education: BS Aerospace Engineering
- Hobbies Interests; Tennis, Football
In theory, there is no difference between theory and practice. In practice, there is.
- Yogi Berra

Systems Thinking
Approach to problem solving

“Problems” are part of a system
View systems in a holistic manner
Not a science, but a “frame of mind”
Why consider MBSD?

**Problem**
- Long development time
- Integration issues
- Defects not found until downstream lifecycle phases. E.g. Flight Test, product support

**Current state**
- Individual domain models – Systems Engineering, Software IPTs, Flight Controls, Wiring, and Loads, etc.
- **Framework for Product Development**

**Future work**
- Integrated set of models
- Digital Air Vehicle
Current MBSD across the lifecycle

- Model based concepts in practice
- Changes in one are not propagated to others
- Applied across various domains, i.e. Air System, Flight Controls, etc.
- Not integrated within or across domains
Vision/Needs – MBSD Requirements across lifecycle

- Increase customer value through a Model Based Systems Design (MBSD) approach
- Provide engineering expertise needed throughout an aircraft's lifecycle, beginning with the design phase, ensuring production success and sustainment of the aircraft.
Foundation & Pillars for MBSD Implementation

Processes/Standards   Guideline/Best practices   Tools   Community of support

MBSD

Framework for Product Development
Systems Engineering Principles
Dual V-Model As A High Level Framework

System V-Model

Start

System Development

1. System User and Stakeholder Requirements
2. System Concept
3. AGILE Open Model Planning

Lowest Configuration Items

4. Architecture Development & Definition

Entity V-Models

5. System Development, Coding, and Verification

1 System

2 Subsystems

4 Lowest Configuration Items

System Realization

End

15. System Validation
16. System Validation Preparation

17. System Build, Code, and Integration
18. System Integration

Dual V-Model Copyright 2005 by The Center for Systems Management (CSM) Inc.,
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Product Development Hierarchy

Scope of Work

Configuration Hierarchy of Prime Equipment

Air System

- Air Vehicle
  - Airframe
  - Mission Sys
    - Vehicle Sys
    - Training Sys
    - Support Sys
    - Logistics Infrastructure

Logistics Sys

Supporting Developments

- Wind Tunnel
- Flight Test Control Room
- Avionics Integration Lab
- Structural Test Lab

Standard Technical Development Framework

- Air Frame Structural Development
- Mission Systems Development
- Avionics Integration Laboratory Development
Attributes of Framework for Product Development

This is the foundation for identifying related
• Standards and Processes
• Guidelines / Best Practices
• Tools
• SMEs / POCs

The WBS is modeled in the Framework

The OBS is modeled in the Framework

Workflow Modules

1:1 Correspondence

Product Development Hierarchy (PDH)

Modules are built from the surrounding elements

WBS

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System components are modeled in the Product Development Hierarchy (PDH)

Work Products are contained in the Framework in an “Object Data Library (ODL) synchronized with the Work Product Standard (WPS)

OBS (IPTs) (Program Only)

Disciplines

Core Competencies and their technical disciplines are modeled in the Framework
Example: Workflow – Requirements to Verification

**Development Work Flow For Each Component**
(e.g. Air Vehicle, Landing Gear, Wing, Antenna, Integration Lab)

- Supplier Sourcing
- If Development Is To Be Procured
- Requirements Development
- Architectural Design
- Preliminary Design
- Detailed Design
- Implementation
- Integration & Test
- Verification

**  Each Component Development Flow May Reflect Specific Terminology Associated With The Best Practice Development For That Component; However, They Must All Follow The Systems Engineering Process (See Examples On The Following Slide)
Work Products are key Handoffs

**Notional Examples**

**Mission Systems / Avionics Development**

1. **Core Avionics (in-house) Subsystem Development**
   - Conduct Procurement
   - Requirement Definition
   - Preliminary & Detail Design
   - Implement Design
   - Integrate & Test Subsystem
   - Perform SOF Testing
   - Perform Environ Qual Tests
   - Perform System Integ & Test
   - Install System
   - Deliver A/C Units
   - Install Unit in SWBS

2. **Procured Subsystem Development**
   - Conduct Procurement
   - Requirement Definition
   - Preliminary & Detail Design
   - Implement Design
   - Integrate & Test Subsystem
   - Perform SOF Testing
   - Perform Environ Qual Tests
   - Perform System Integ & Test
   - Install System
   - Deliver A/C Units
   - Install Unit in SWBS

**Training System Development**

1. **Requirements Definition**
2. **Define Functional Architecture**
3. **Conduct Procurement**
4. **Develop Initial Cadre Courseware**
5. **Develop Training Simulator**
6. **Integration & Test of Simulator**
7. **Small & Large Group Tryouts**
8. **Perform Initial Cadre Training**
9. **Perform Initial Cadre Training**
10. **Deliver Formal Training**
Technical Plan Integrates Work Product Standard

- Work products are defined from the work product standard
<table>
<thead>
<tr>
<th>Work Product Consumers-</th>
<th>WP Template</th>
<th>WP Dependencies</th>
<th>Manuals/Examples/etc.</th>
<th>Format</th>
<th>Version #</th>
<th>Tool</th>
<th>Language</th>
</tr>
</thead>
<tbody>
<tr>
<td>WP Unique Name</td>
<td>Domain</td>
<td>SE Phase</td>
<td>WP Description</td>
<td>WP Maturity Required</td>
<td>WP Dependencies</td>
<td>Manuals/Examples/etc.</td>
<td>Format</td>
</tr>
</tbody>
</table>
Product Development Standard

- Incorporate MBSD into PDS
- Identify products that should use MBSD approach
- Develop interface among products

Representative Complexity
Candidates for inclusion in MBSD environment
Candidate products for Modeling

**Selection Guidelines**
- Analysis required
- Trade space investigation
- Highly integrated work products
- Traceability is needed
- High complexity

**Candidates (Subset)**
- Maintenance Task Analysis
- Sortie Generation Rate Analysis
- Availability Analysis
- Life-Cycle Management Analysis
- Logistics Footprint Analysis
- Electromagnetic Environmental Effects Analysis
- Reliability Centered Maintenance Analysis
- Failure Mode, Effects and Criticality Analysis (FMECA)
- Spares Analysis
- Integrated Systems Health Management Analysis
Benefits of MBSD

- Formalizes the practice of systems development
  - Includes industry accepted standards
  - Includes tools
  - Includes command media
  - Provides single source of truth

- Increases integration
  - Includes multiple domains
  - Supports handoffs in the product hierarchy from SoS to component
  - Defines data needs

- Improves quality & productivity, Reduces schedule & risk
  - Increases rigor and precision of definition
  - Communicates to stakeholders
  - Manages complexity
  - Automates labor intensive activities (document generation)
Practical Implementation of MBSD

It’s a ‘FRAME of Mind’