

Practical Implementation of Model Based Systems Development

NDIA 17th Annual Systems Engineering Conference



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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





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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, and QFD Greenbelt
- LM Aero MBSE POC
- PhD Systems Engineering
- MS Computer Science
- BS Physics





In theory, there is no difference between theory and practice. In practice, there is.
- Yogi Berra

Systems Thinking

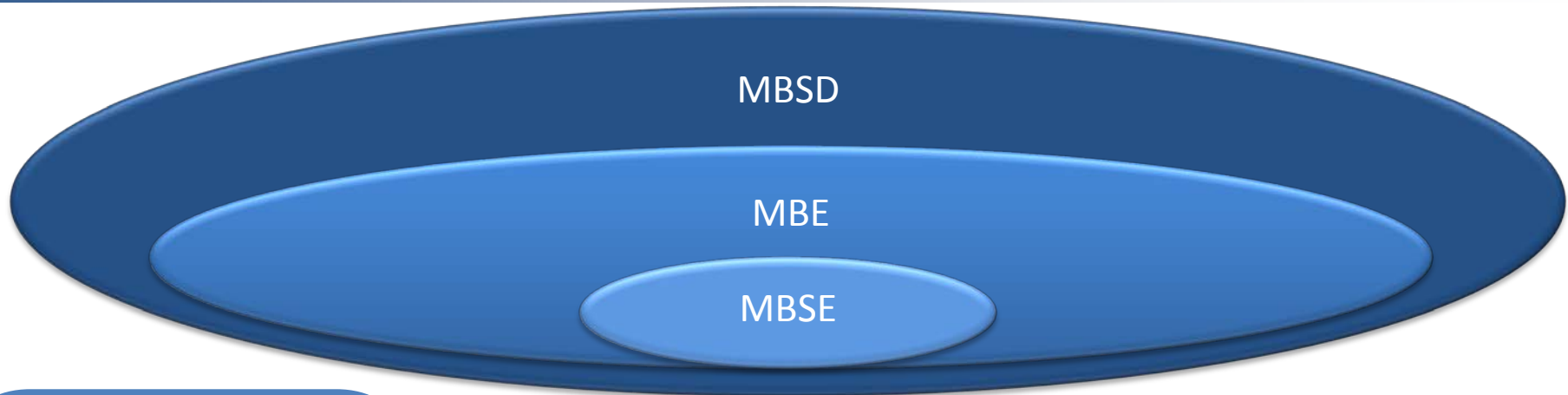
Approach to problem solving



Peter Michael Senge
(social scientist)
1947-

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





Model Based Systems Development (MBSD)

- Model-based approach to develop products across the product life cycle. Includes model-based systems, software, hardware, test engineering, and supporting simulation and analysis.

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 Based Systems Engineering (MBSE)

- Those aspects of MBSD associated with Systems Engineering. Includes analysis, system architecture, simulation, test, and other areas.



Why consider MBSD?

Problem

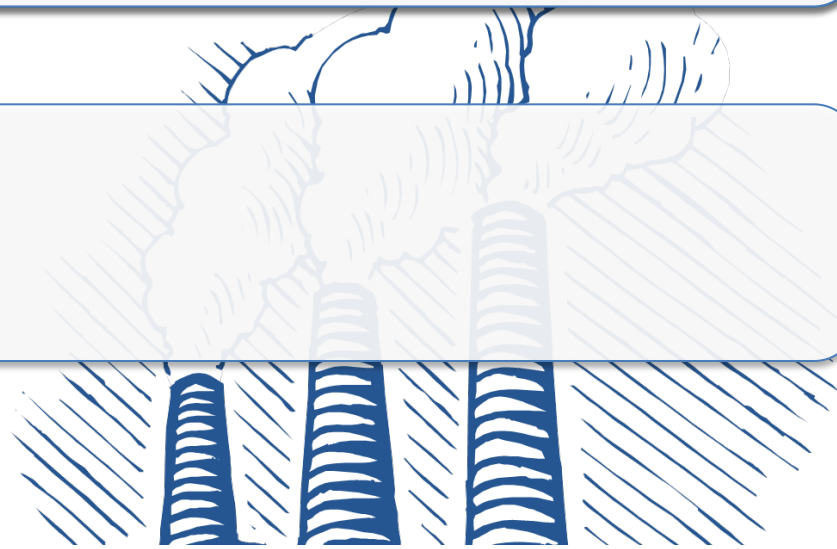
- Long development time
- Integration issues
- Defects not found until downstream lifecycle phases. E.g. Flight Test, product support

Current state

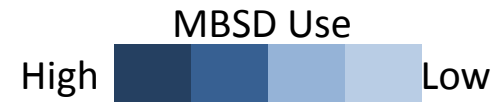
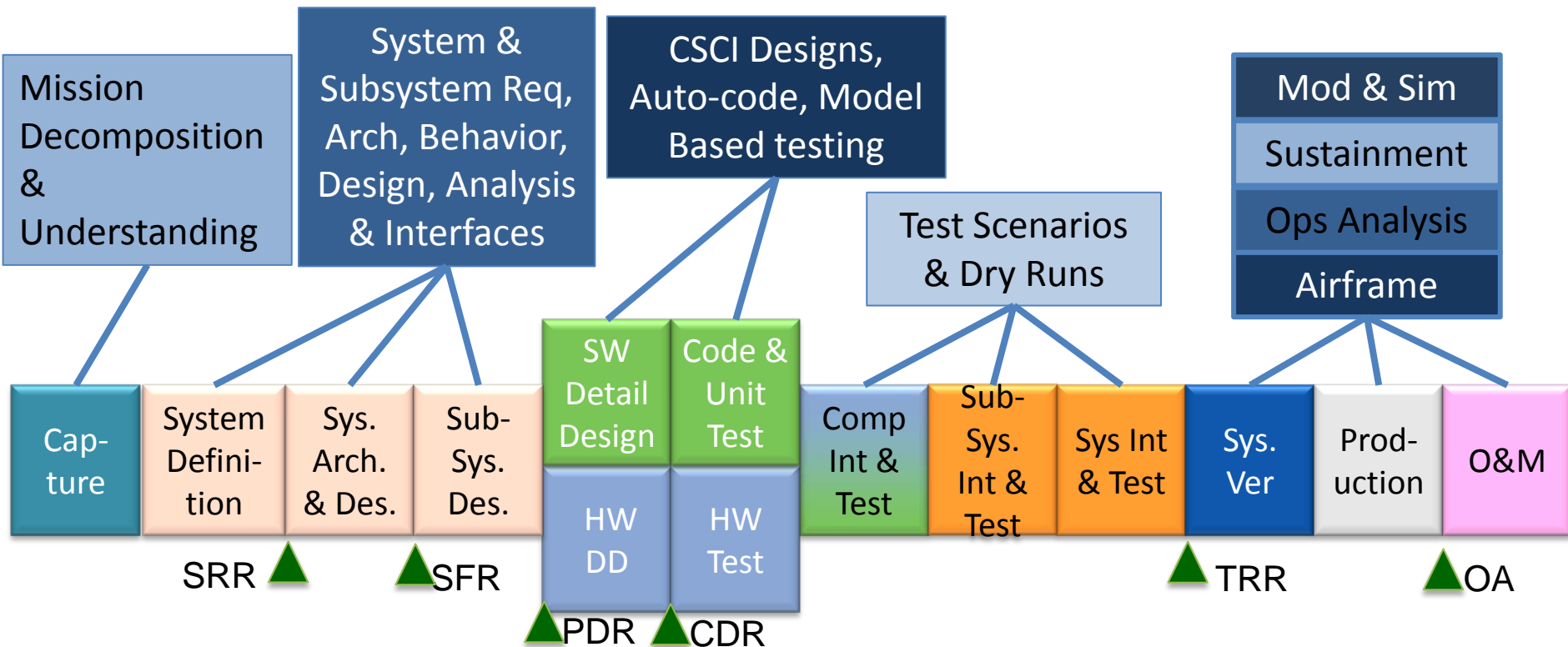
- Individual domain models – Systems Engineering, Software IPTs, Flight Controls, Wiring, and Loads, etc.
- **Framework for Product Development**

Future work

- Integrated set of models
- Digital Air Vehicle



Current MBSD across the lifecycle

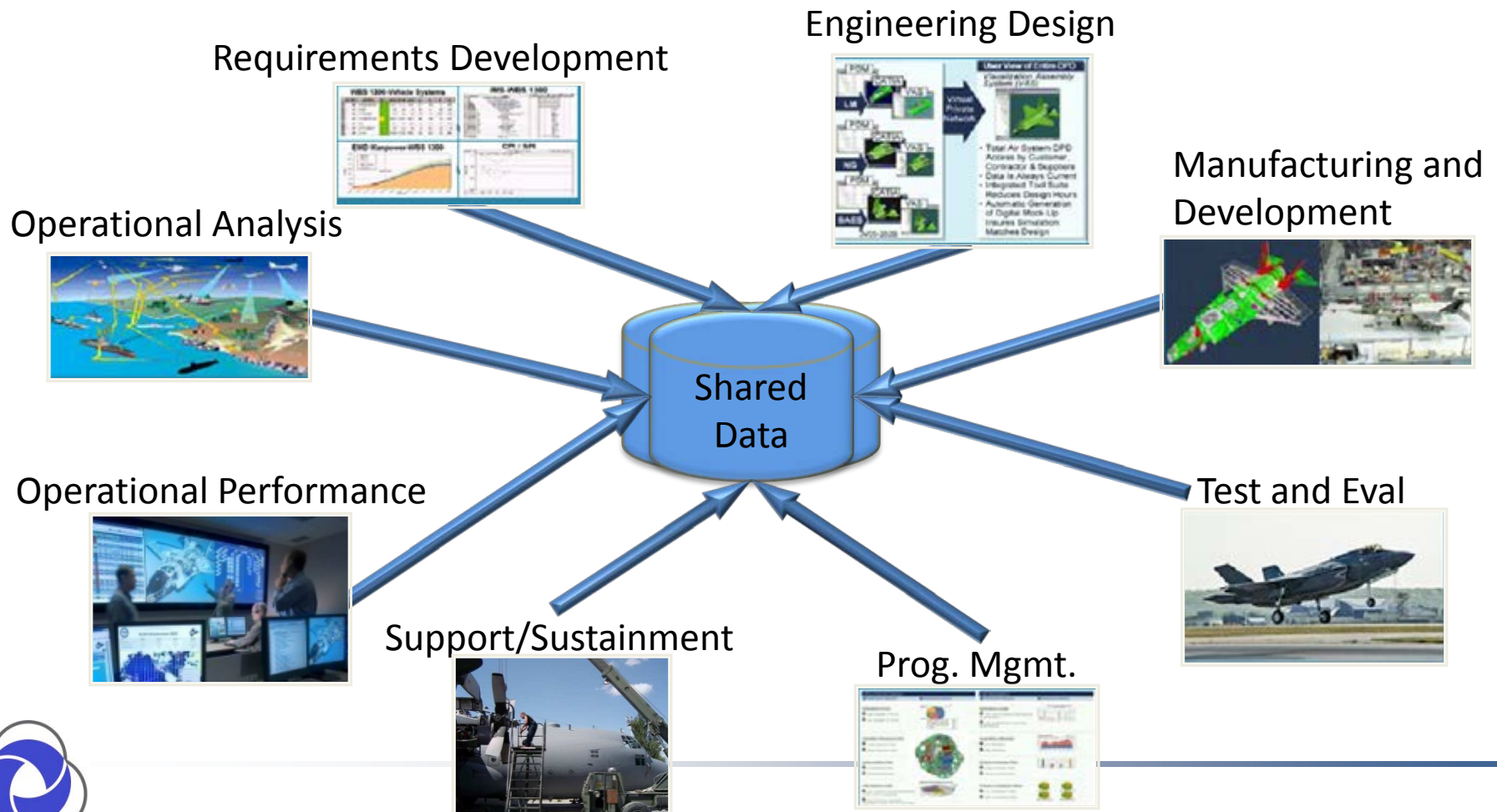


- **Model based concepts in practice**
- **Changes in one are not propagated to others**
- **Applied across various domains, i.e. Air System, Flight Controls, etc.**
- **Not integrated within or across domains**



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.





Challenge

Develop highly integrated model-based environment in which the model and associated data set is the technical baseline

Institutionalize advanced technologies and methods

Increase relevancy to our customer through superior product development, production and deployment





Foundation & Pillars for MBSD Implementation

MBSD

**Processes/
Standards**

**Guideline/
Best
practices**

Tools

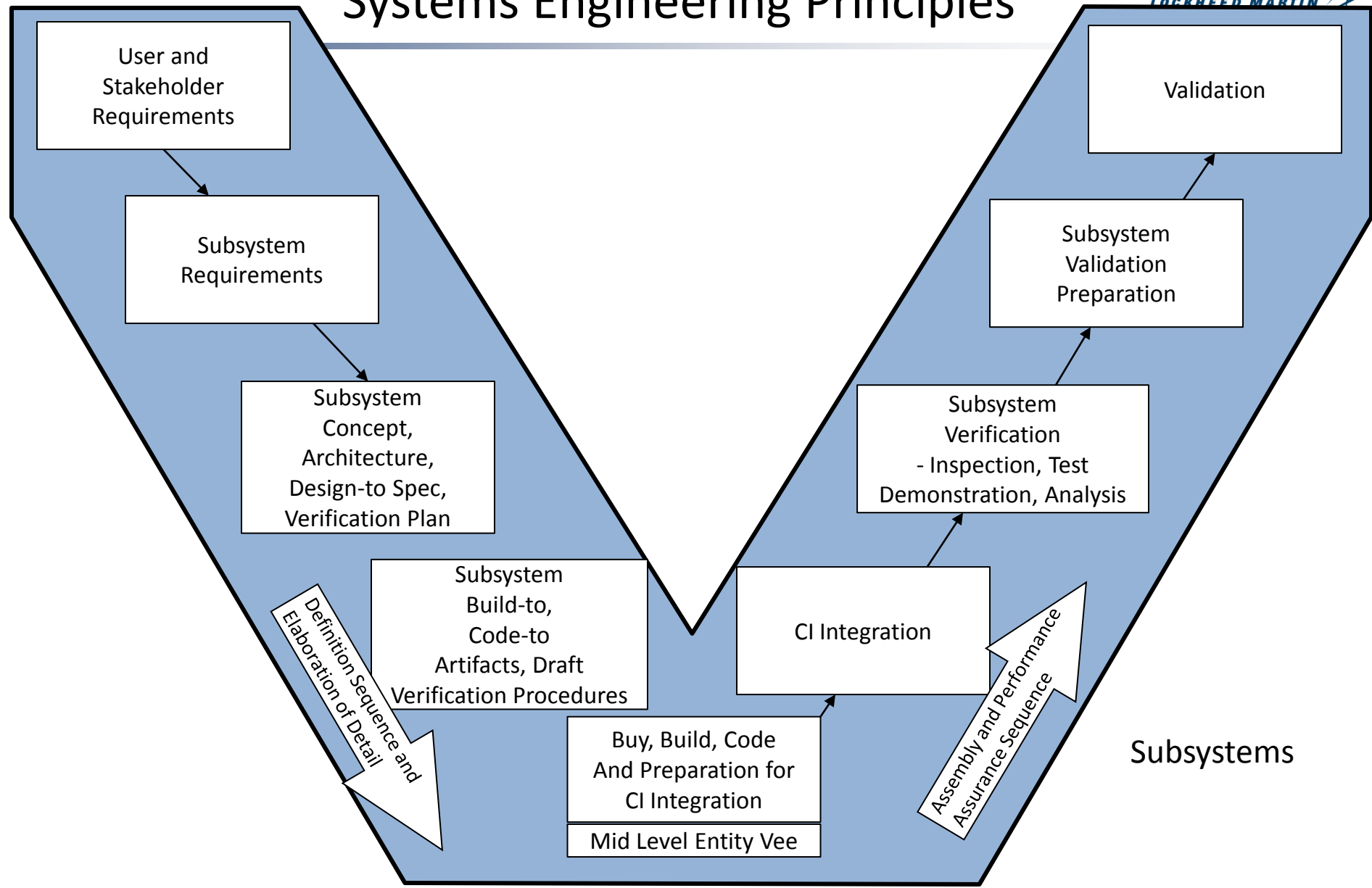
**Community
of support**

Framework for Product Development

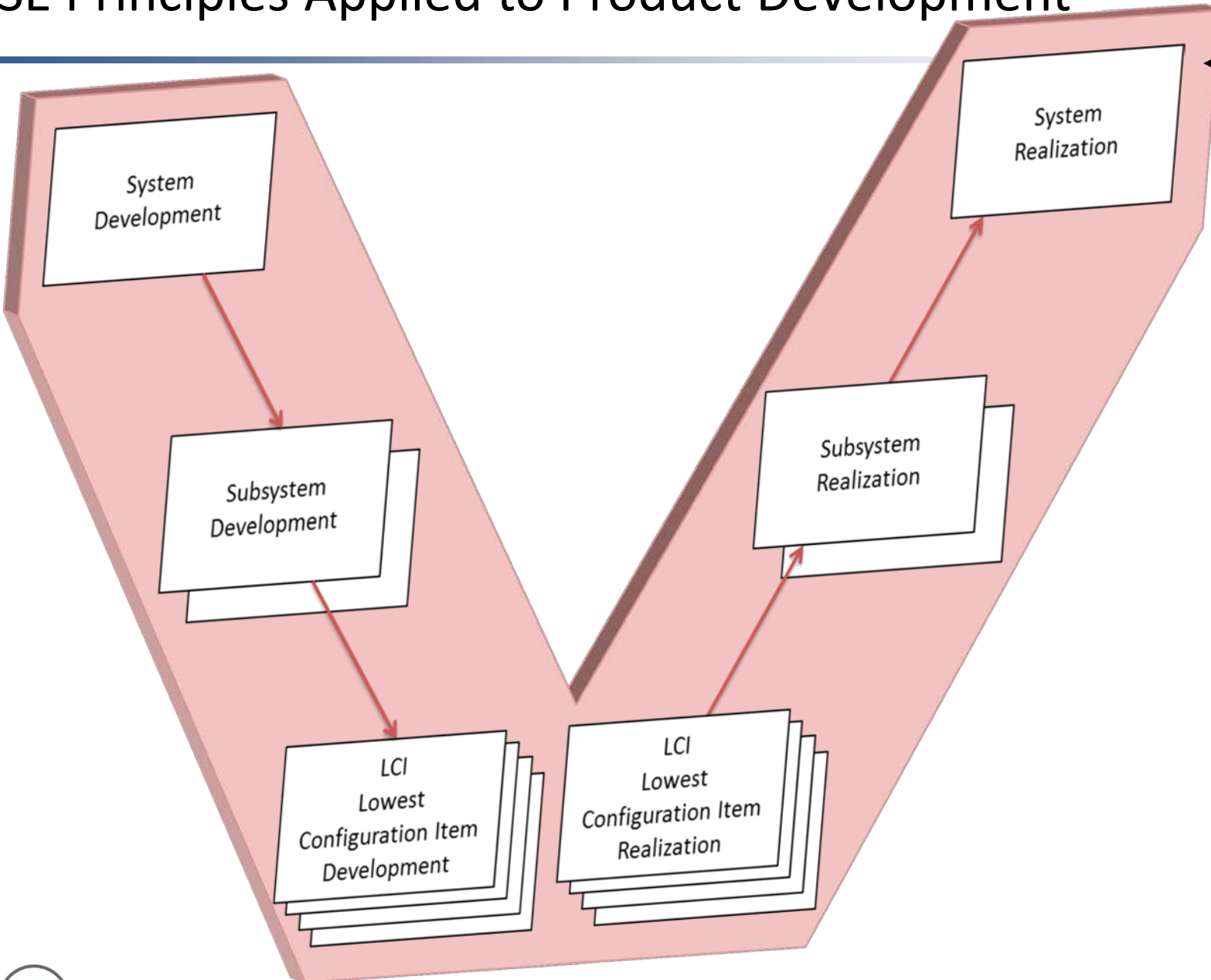
Systems Engineering Principles



Systems Engineering Principles



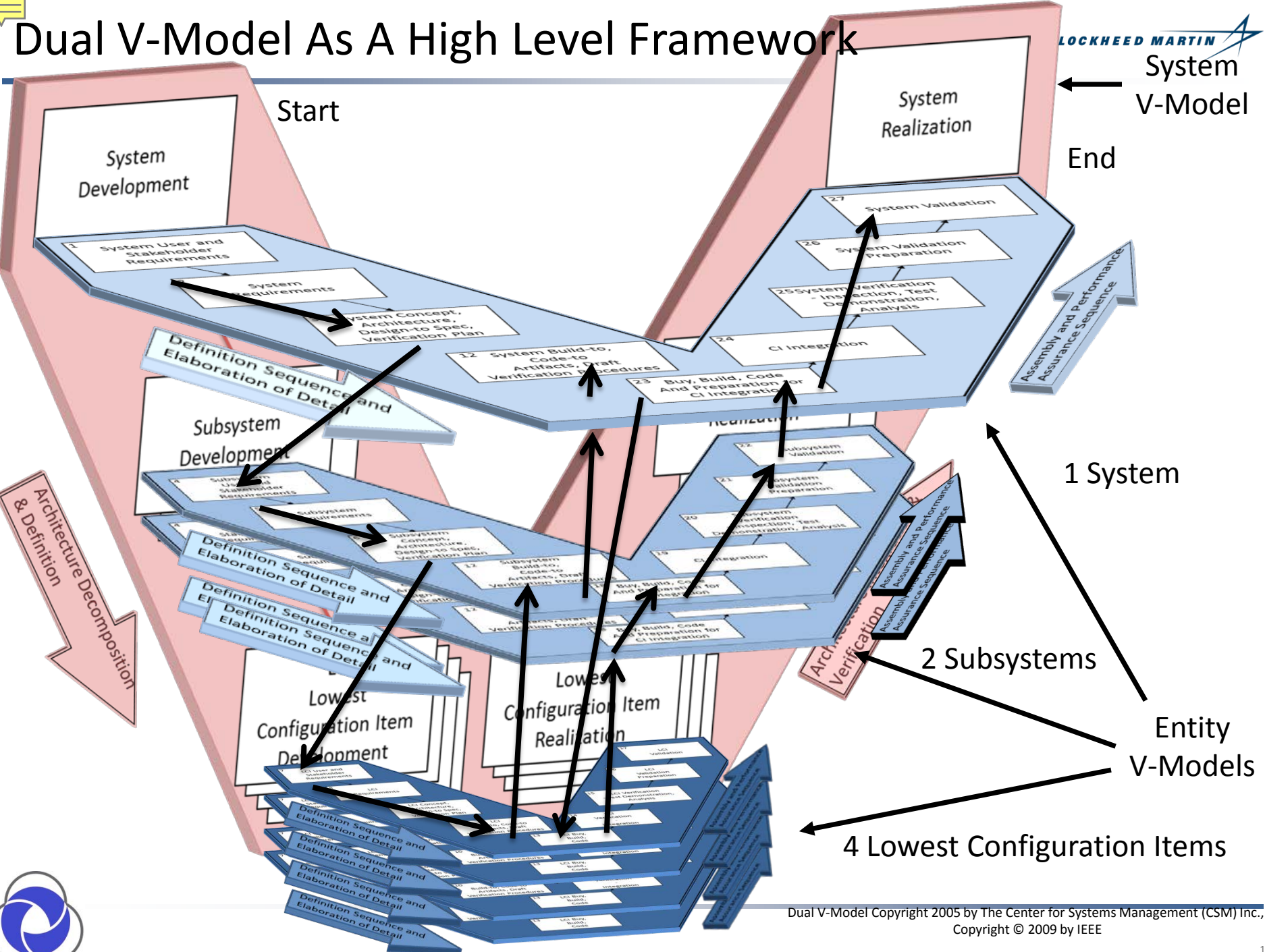
SE Principles Applied to Product Development



Dual V-Model Copyright 2005 by The Center for Systems Management (CSM) Inc.,
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Dual V-Model As A High Level Framework



Product Development Hierarchy

Scope of Work

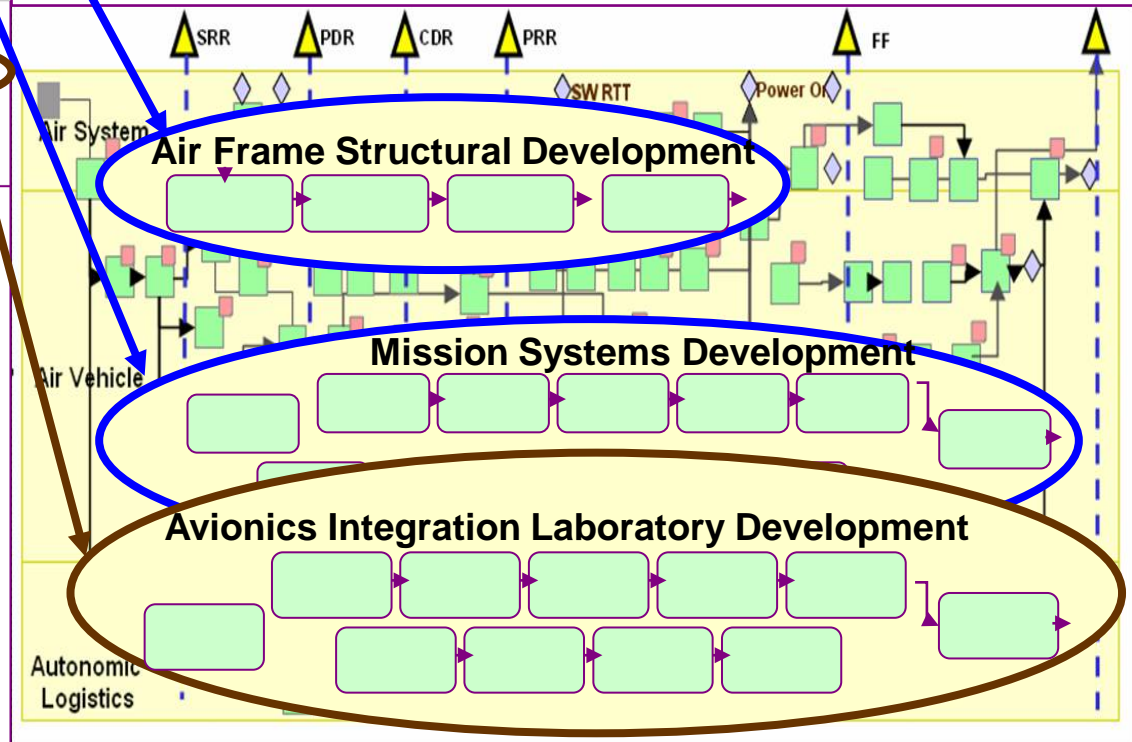
Configuration Hierarchy of Prime Equipment



Supporting Developments



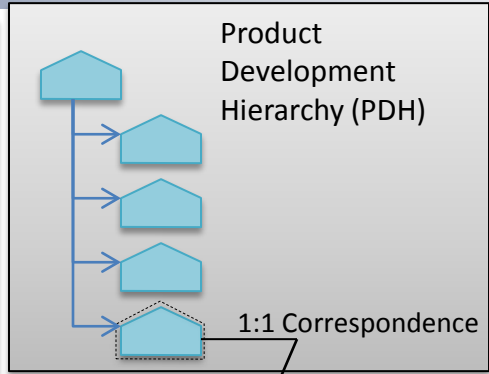
Standard Technical Development Framework



Attributes of Framework for Product Development

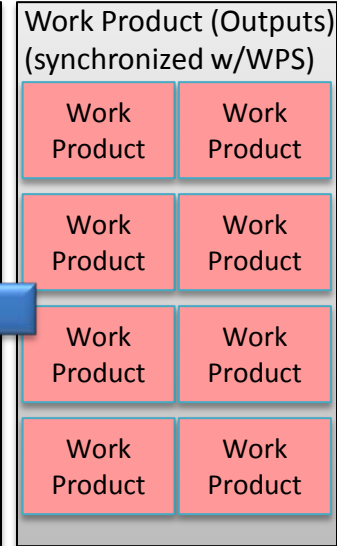
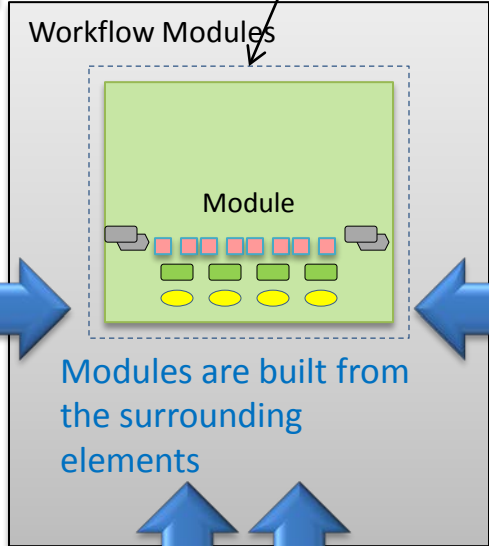
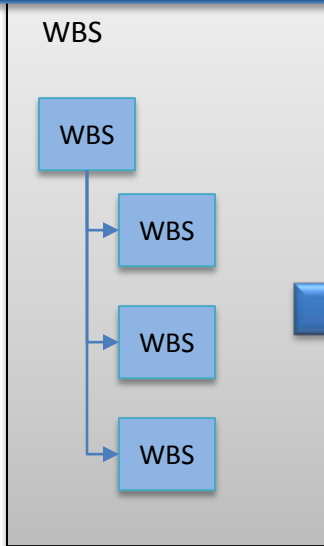
This is the foundation for identifying related

- Standards and Processes
- Guidelines / Best Practices
- Tools
- SMEs / POCs



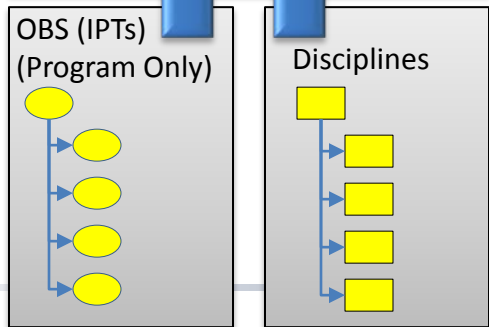
System components are modeled in the Product Development Hierarchy (PDH)

The WBS is modeled in the Framework



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

The OBS is modeled in the Framework



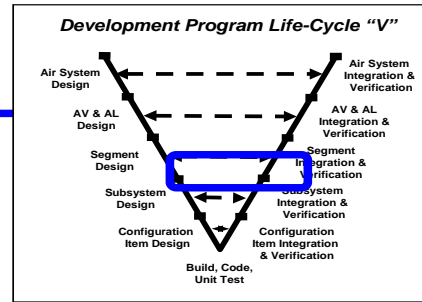
Core Competencies and their technical disciplines are modeled in the Framework



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

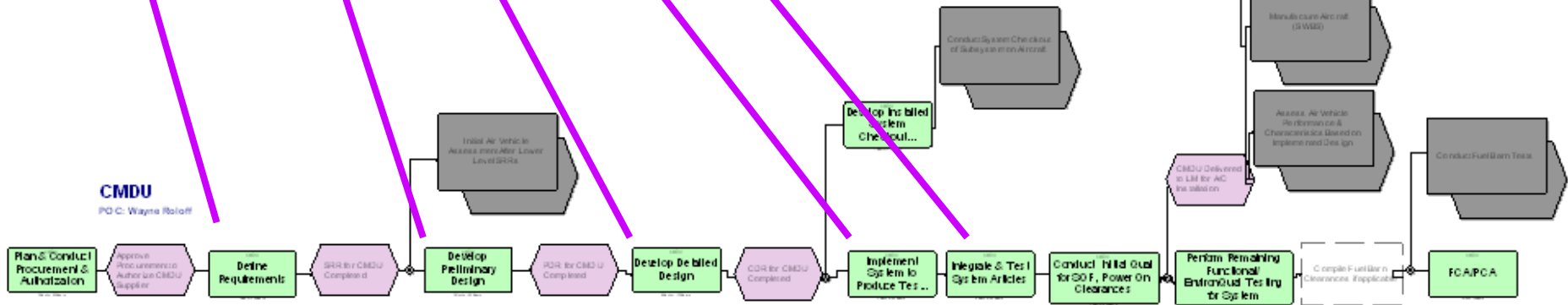
Implementation

Integration & Test

Verification

Handoff to Next Level of Integration

** 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)

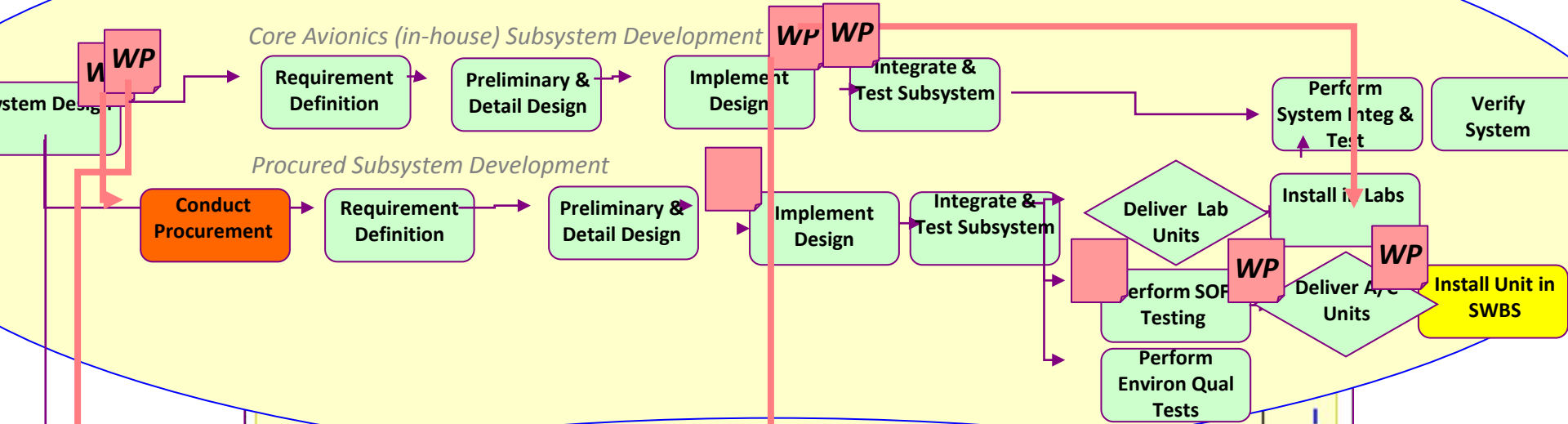


Work Products are key Handoffs

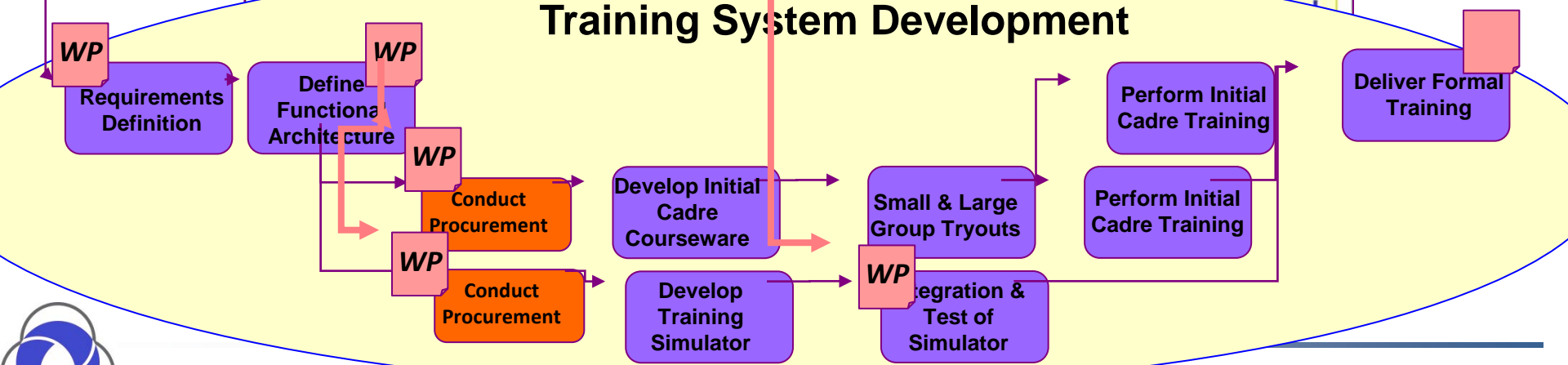
Notional Examples

- █ Engineering
- █ Material Management
- █ Global Sustainment
- █ Production Operations

Mission Systems / Avionics Development



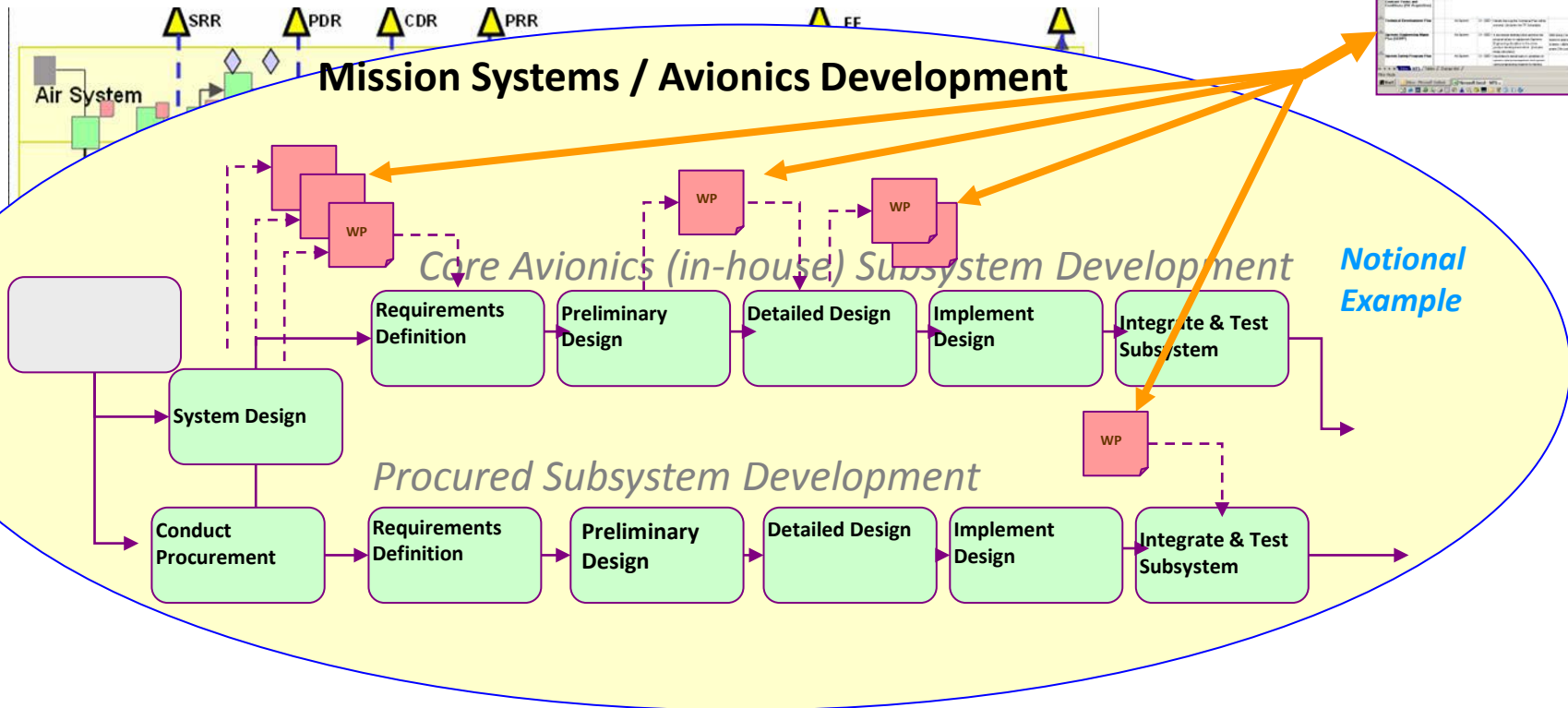
Training System Development



Technical Plan Integrates Work Product Standard

- Work products are defined from the work product standard

Technical Plan



Work Product Standard -- Attributes

Microsoft Excel - WPS Worksheet - (Enable Macros) !!! LMPI !!!.xls [Read-Only] [Shared]

File Edit View Insert Format Tools Data Window Help

Type a question for help

Arial 16 B I U

SnagIt Window

WORK PRODUCTS	DOMAIN	PHASE	DESCRIPTION	MATURITY	PROCESSES
Software Acquisition Management Plan	Air System	3.1-SDD	The description contractually requires the customer, including approval requirements, and pertinent information.	SAMP and other applicable plans, e.g.	PM-4001
Contract Data Requirements List	Air System	3.1-SDD	A descriptive list of technical data for software products contractually required to be provided by a supplier for LM Aero to manage the software acquisition, use the acquired software,		4001
Supplier Data Requirements List	Air System	3.1-SDD	A contractual document with a software supplier that defines the tasks the software supplier is to perform, including scope of work, standards and specifications to be invoked, required	This document is developed and managed by Program Management input from the software team. Program Management should assure appropriate work product verification, management	
Supplier Statement of Work (SSOW) (SW Acquisition)	Air System	3.1-SDD	A list of supplier documentation produced to accomplish a contractual task as outlined in the Supplier Statement of Work but is not contractually required to be delivered in accordance with the	This is a software-related component included in the contract.	4001
Software Data Accession List (SW Acquisition)	Air System	3.1-SDD	A legal agreement between LM Aero and a supplier setting forth the obligations and responsibilities of each party.	This is a software-related component included in the contract.	
Contract Terms and Conditions (SW Acquisition)	Air System	3.1-SDD	Details the way the Technical Plan will be executed. (includes the TP Schedule)		
Technical Development Plan	Air System	3.1-SDD	A document defining products and their development process. SRR Entry Criteria - SEMP available for review & approval including... SRR Exit Criteria - SEMP approved and placed under CM control		
Systems Engineering Mgmt Plan (SEMP)	Air System	3.1-SDD	Describe system safety		SUBP-2453.5(Structural Analysis)
System Safety Program Plan	Air System	3.1-SDD			

100% 8:52 AM

8:49 AM

WP Unique Name

Domain

Work Product Consumers-

SE Phase

WP Template

WP Description

WP Maturity Required

WP Dependencies

Manuals/Examples/etc.

Format

Version #

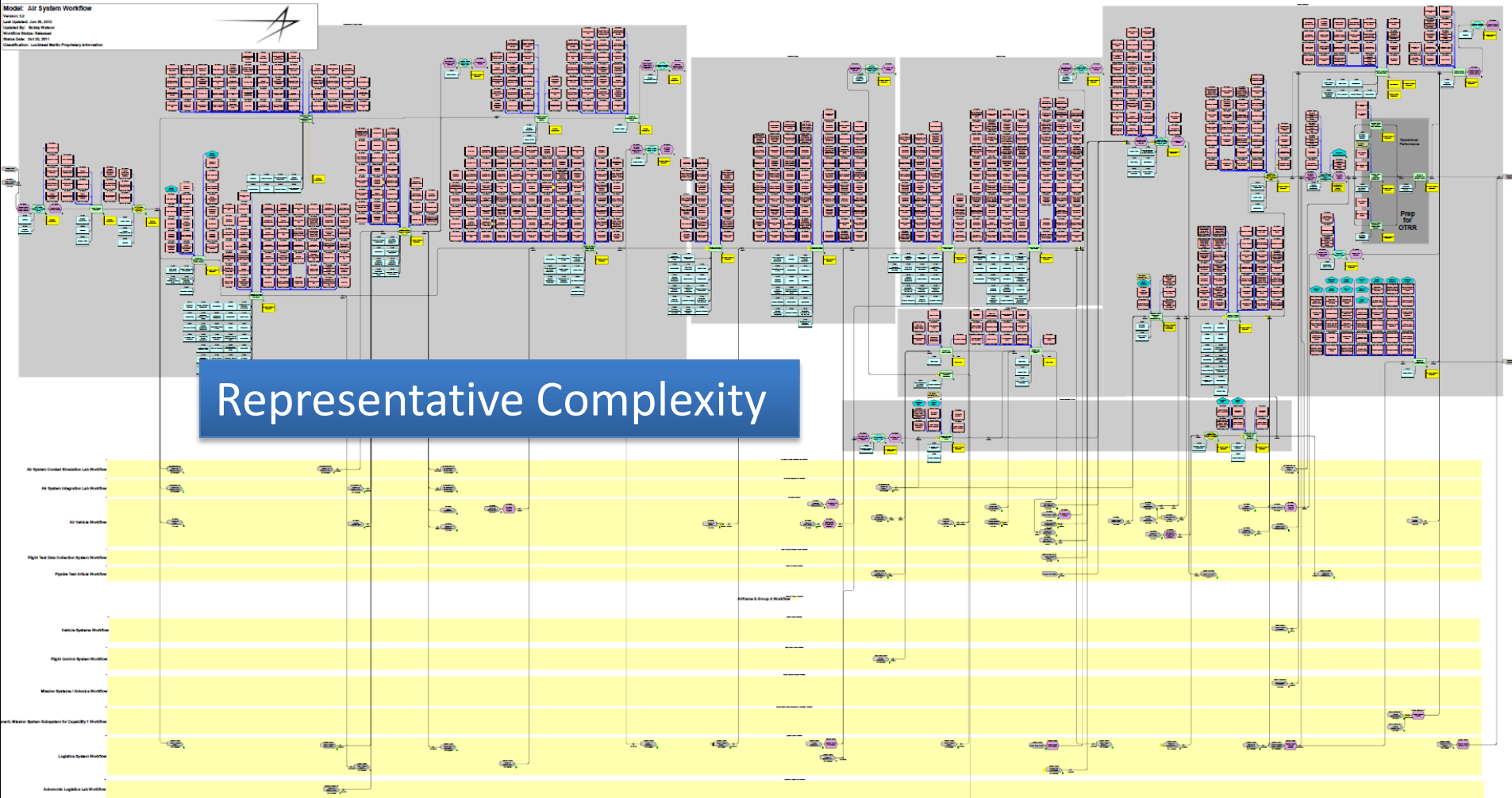
Tool

Language

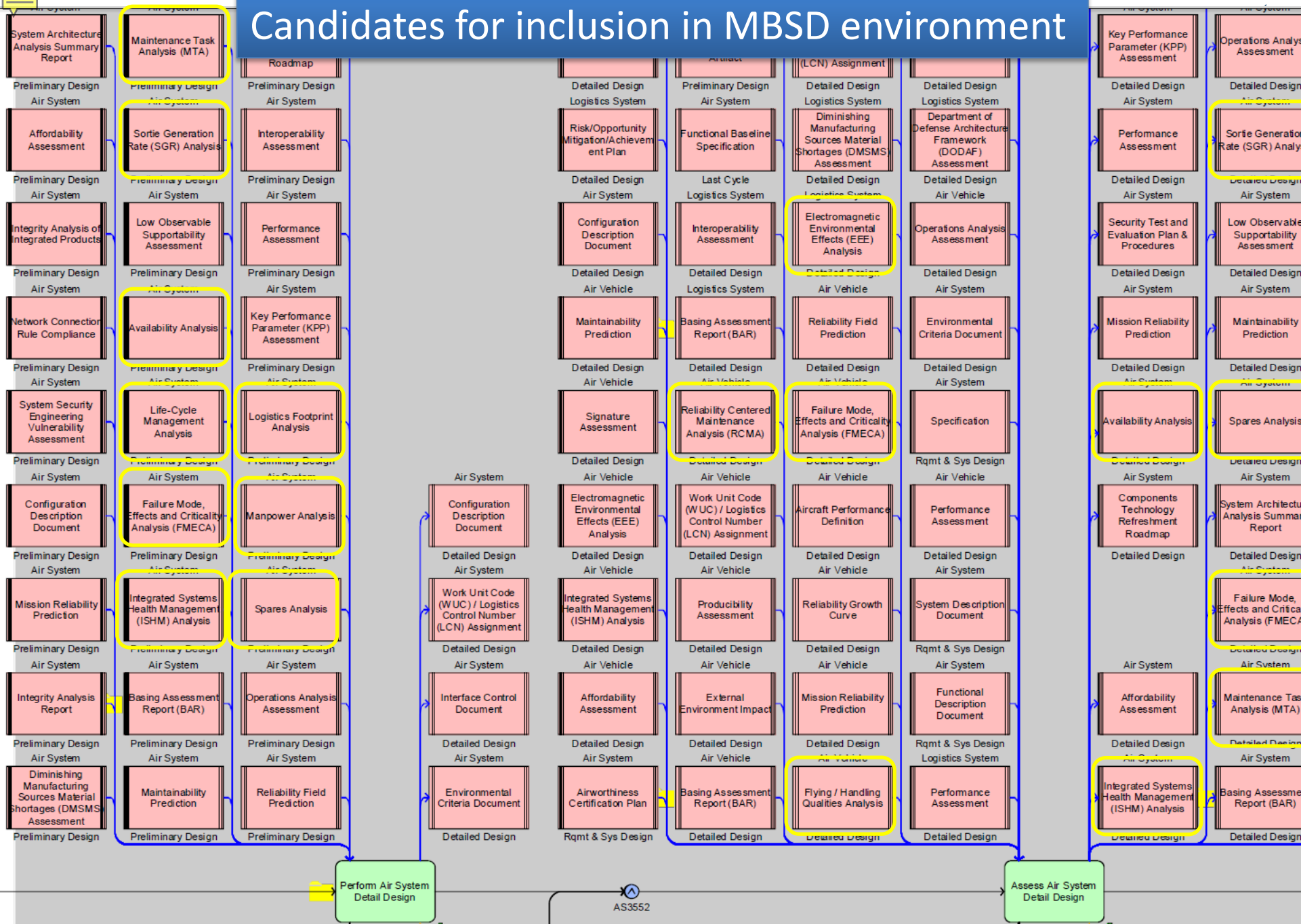


Product Development Standard

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



Candidates for inclusion in MBSD environment



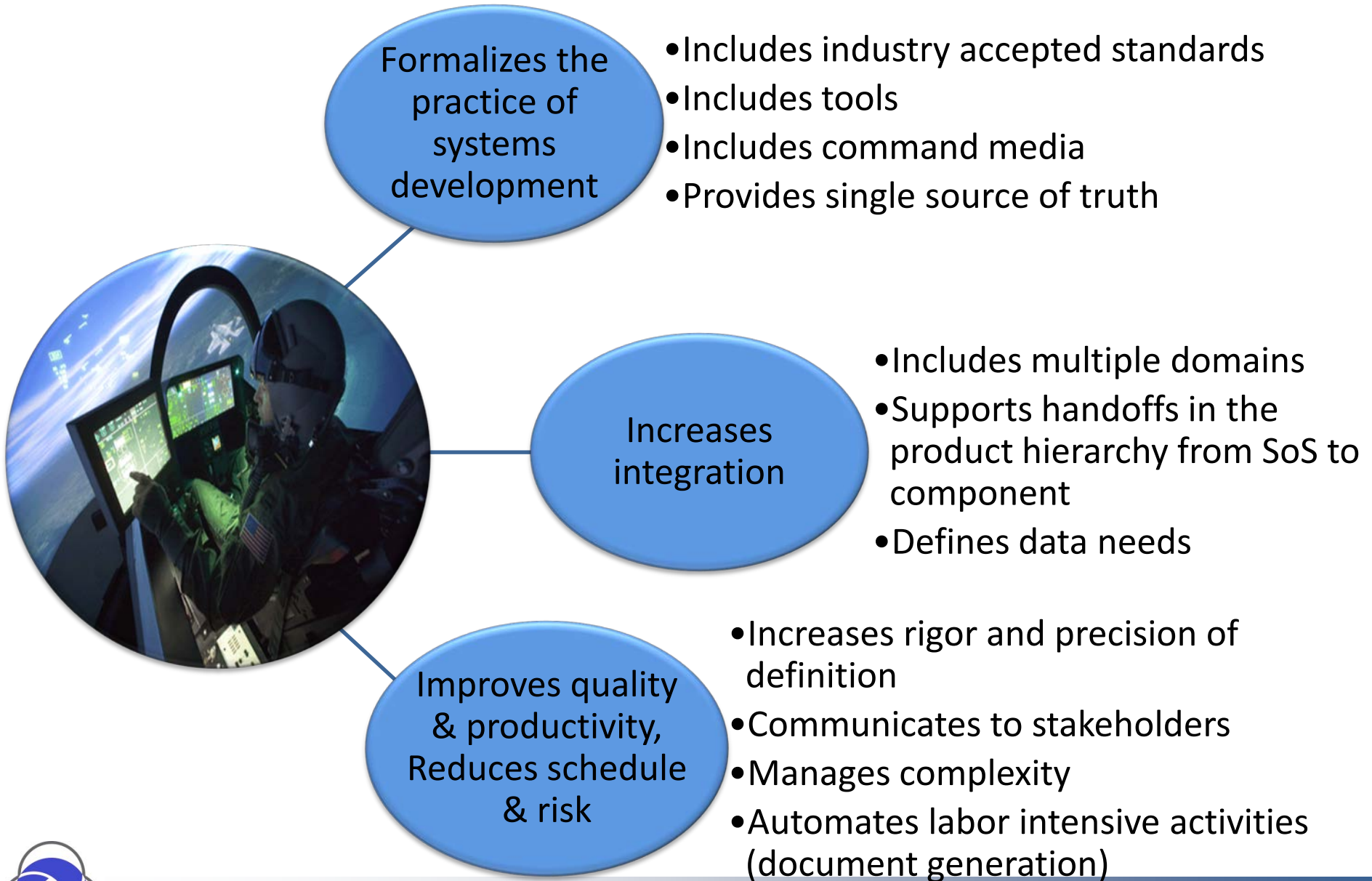
Selection Guidelines

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

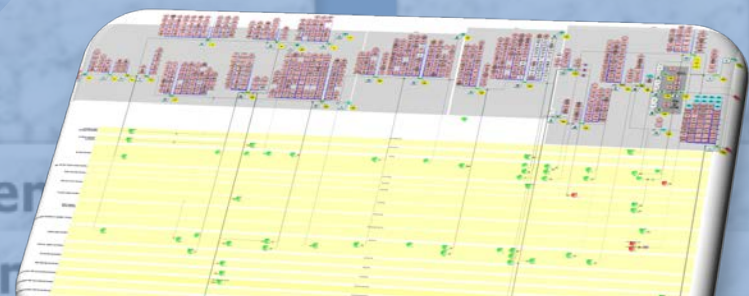
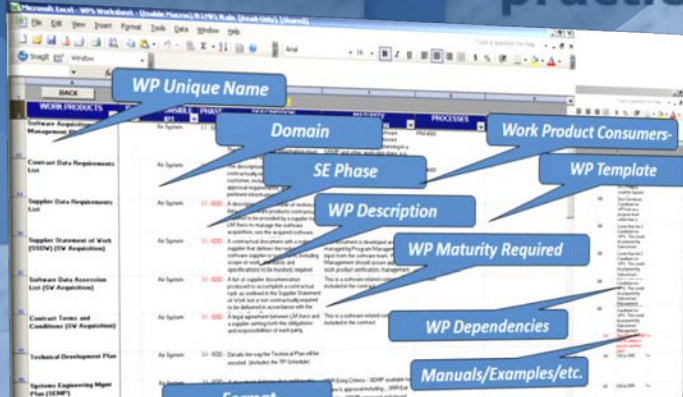
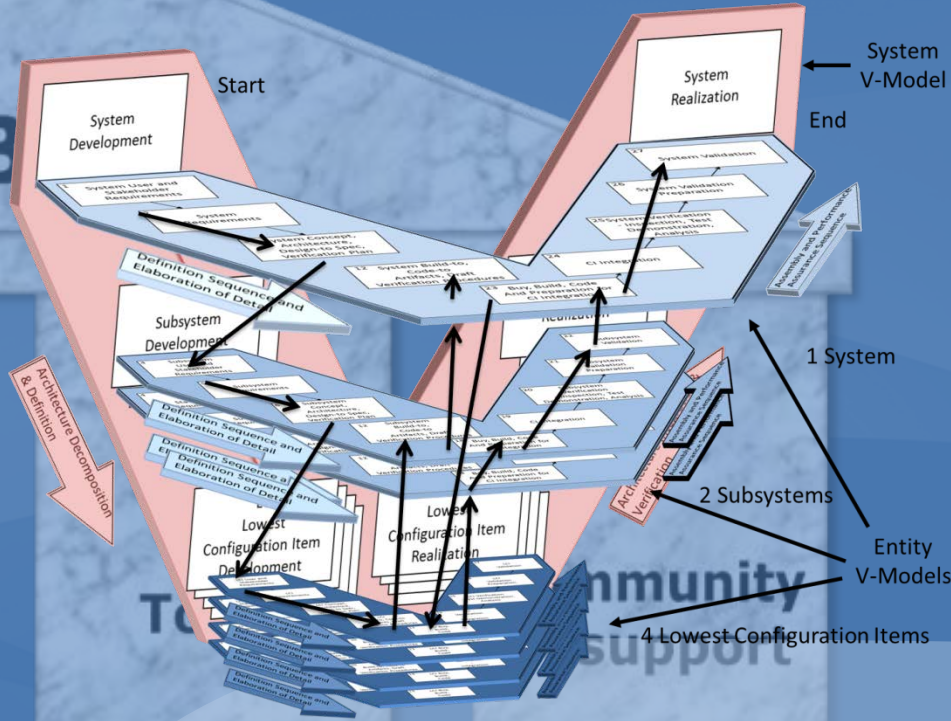
Candidates (Subset)

- 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





Practical Implementation of MBSD



It's NOT Scientific, it's a 'FRAME of Mind'

