The System Engineering “V” - Is It Still Relevant In the Digital Age?

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- 35 years at Boeing
- Senior Manager in PLM at Boeing Defense, Space & Security in St. Louis MO
- Working Digital Transformation and Model Based Engineering
- Lead Boeing Immersive Development (ImDev) activity leveraging the Digital Thread and Digital Twin to drive step change improvements
- Former functional manager in Systems Engineering
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The Fourth Industrial Revolution is Underway

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1st Industrial Revolution
MECHANICAL
Use of mechanical production powered by water and steam

2nd Industrial Revolution
ELECTRICAL
Use of mass production powered by electrical energy

3rd Industrial Revolution
INFORMATION TECHNOLOGY
Use of electronics and IT to further automation

4th Industrial Revolution
DIGITAL
Use of a digitally connected end-to-end enterprise


(1991) Systems Engineering “V” Model

TODAY Digital Engineering (DE)

Model-Based Systems Engineering (MBSE)

Simulation Based Acquisition (SBA)

Traditional Models and Simulations (M&S)

Graphic: Elysium, Parker, Northrop Grumman, BOEING, GPDIS 2018
The Digital Engineering Transformation

Source: Boeing
The SE “V” symbol is an intuitive and instructive framework for depicting product development.

However, this linear representation fails to depict the real-time interchange of data and information in a DE / MBE Environment.

A new symbol is needed to better reflect the increased complexity of an MBE ecosystem.

SOURCE: US Department of Transportation Federal Highway Administration
Background - The Traditional SE “V” Symbol

- **Product** focused development
- Implies a **sequential** process
- “**Document-centric**” focus
- Fails to depict **integrative & iterative** nature of product development
- Historical attempts to update the “V” symbol increased complexity
- A **new symbol** is needed that better represents the complex interactions of an MBE ecosystem

**SOURCE:**
- The Boeing Company
- US DOT Federal Highway Administration

**The Systems Engineering “Engine”**
Tenets for Depicting the SE Process in an MBE Environment

- Represent MBE as a multi-dimensional, iterative process encompassing both physical and virtual implementations
- Reflect the integrated nature of MBE, linked with feedback to related lifecycle elements
- Show relationships spanning business domains (e.g. Product, Production, Service & Support)
- Communicate how SE process is different by using MBE
- Easy to understand, but flexible and tailorable

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Evolution from SE to MBE

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NEEDS
AS-NEEDED

AS-OFFERED

AS-SPECIFIED

AS-DESIGNED

AS-PLANNED

AS-BUILT

DESIGN

PHYSICAL SYSTEMS

DELIVERY

AS-CERTIFIED

AS-TESTED

AS-DELIVERED

AS-SUPPORTED

SOLUTIONS

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Evolution from SE to MBE

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DIGITAL TWINS

MODEL BASED PRODUCTION PLANNING

VIRTUAL PRODUCTION SYSTEM

MODEL BASED DEFINITION

VIRTUAL QUALIFICATION

MODEL BASED SYSTEMS ENGINEERING

VIRTUAL CERTIFICATION

BUSINESS MODEL

VIRTUAL OPERATIONS

MARKET (MISSION) MODEL

VIRTUAL ECOSYSTEM

NEEDS

SOLUTIONS

PHYSICAL SYSTEMS

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Digital Twins

Model Based Production Planning
Model Based Definition
Model Based Systems Engineering
Business Model
Market (Mission) Model
Needs

AS-Planned

AS-Specified

AS-Designed

AS-Offered

AS-Needed

Solutions

Physical Systems
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DIGITAL TWINS

VIRTUAL PRODUCTION SYSTEM

VIRTUAL QUALIFICATION

VIRTUAL CERTIFICATION

VIRTUAL OPERATIONS

VIRTUAL ECOSYSTEM

NEEDS

SOLUTIONS

AS-BUILT

AS-TESTED

AS-CERTIFIED

AS-DELIVERED

AS-SUPPORTED

PHYSICAL SYSTEMS

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Evolution from SE to MBE
Proposed MBE “Diamond” Symbol

DIGITAL TWINS

NEEDS

MODELING

SIMULATION

DESIGN

DELIVERY

PHYSICAL SYSTEMS

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Proposed MBE “Diamond” Symbol - Talking Points

The top-half of the diamond represents the Digital Twins (i.e. the virtual representation of the physical systems).

The bottom-half of the diamond represents the physical systems (retaining the traditional SE “V” flow).

The interior of the diamond represents the Digital Thread linking models or simulations (Digital Twins) to the design of the physical systems.

The circle represents the integrated development of the platform product, production system, and services and support systems.

The Digital and Physical Twins are concurrent paths that inform each other across the lifecycle.

Integrated physical and virtual development is represented from left to right.
Transitioning from a document-focused mindset to a digital engineering mindset that leverages information flow across the lifecycle.

**1990s SE V**

**2020s MBE Diamond**

Source: Boeing


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Questions?

Model Based Engineering is just a fad