The System Engineering Vee - is it Still Relevant in the Digital Age?

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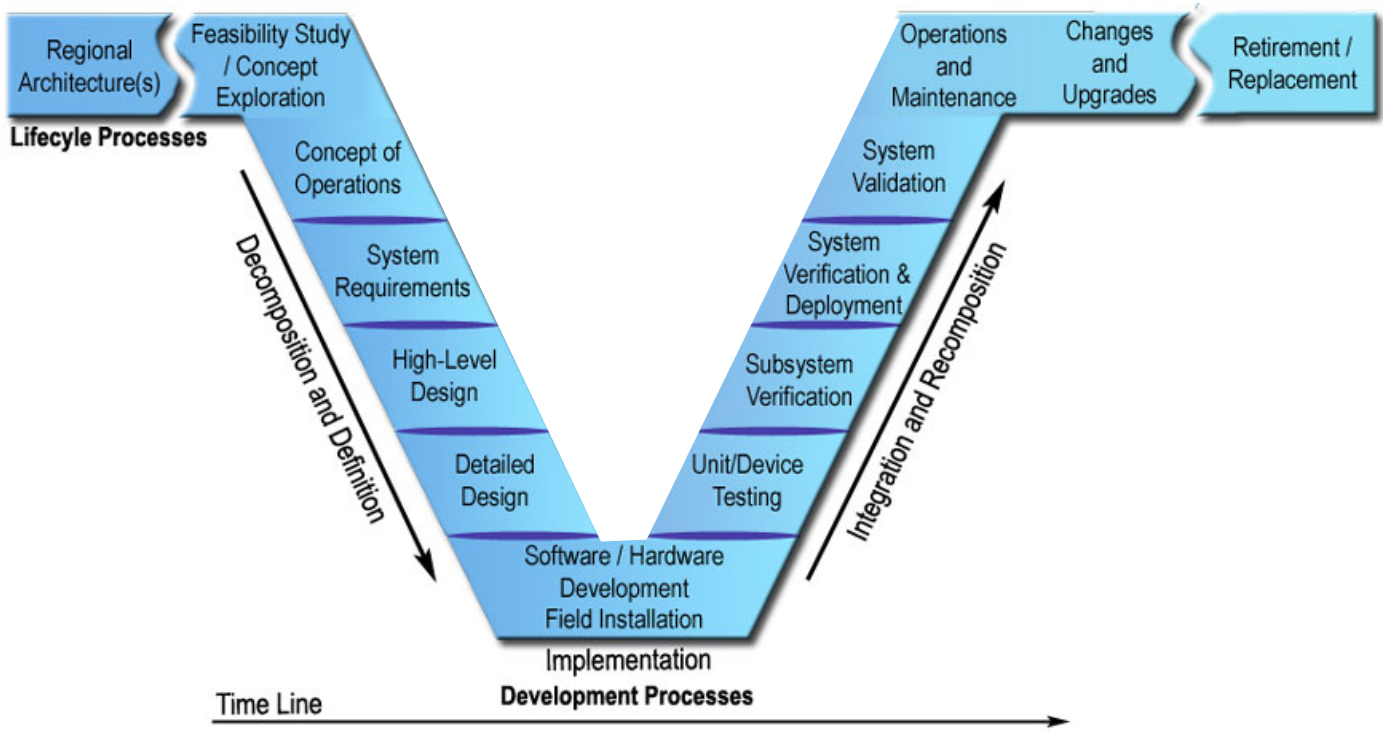
April 4, 2018

Approved for Public Release (RROI 18-00101-BDS)

Summary

- **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 Model Based Enterprise (MBE)**

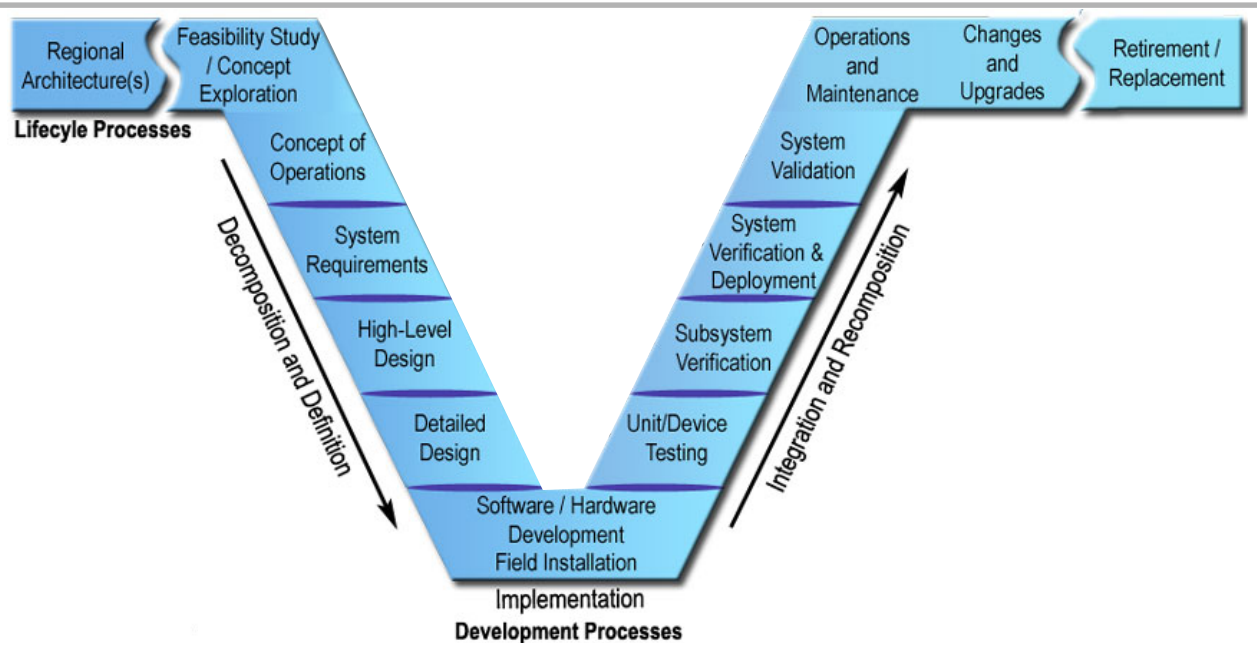
SOURCE: US Department of Transportation Federal Highway Administration
https://ops.fhwa.dot.gov/publications/seitsguide/section3.htm

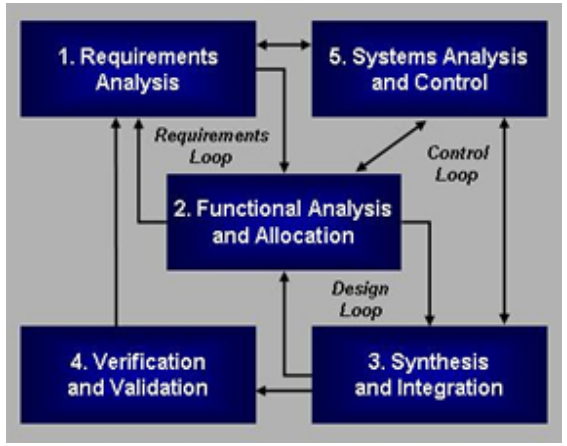


A new symbol is needed to better reflect the increased complexity of an MBE ecosystem.

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**





The Systems Engineering "Engine"

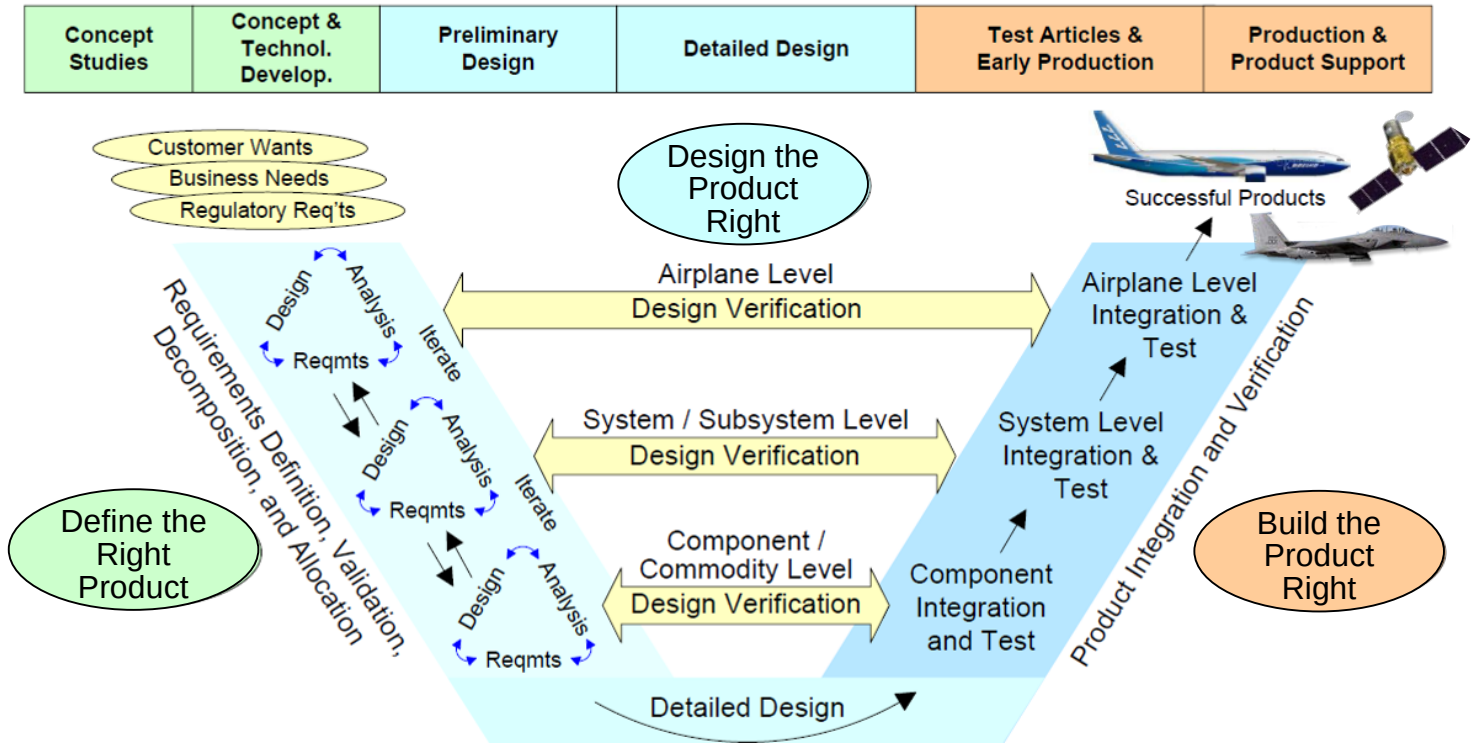
SOURCE:
The Boeing Company

Tenets for Depicting the SE Process in an MBE

- **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**

Option 1 - Time-Based SE with Feedback Across “V”

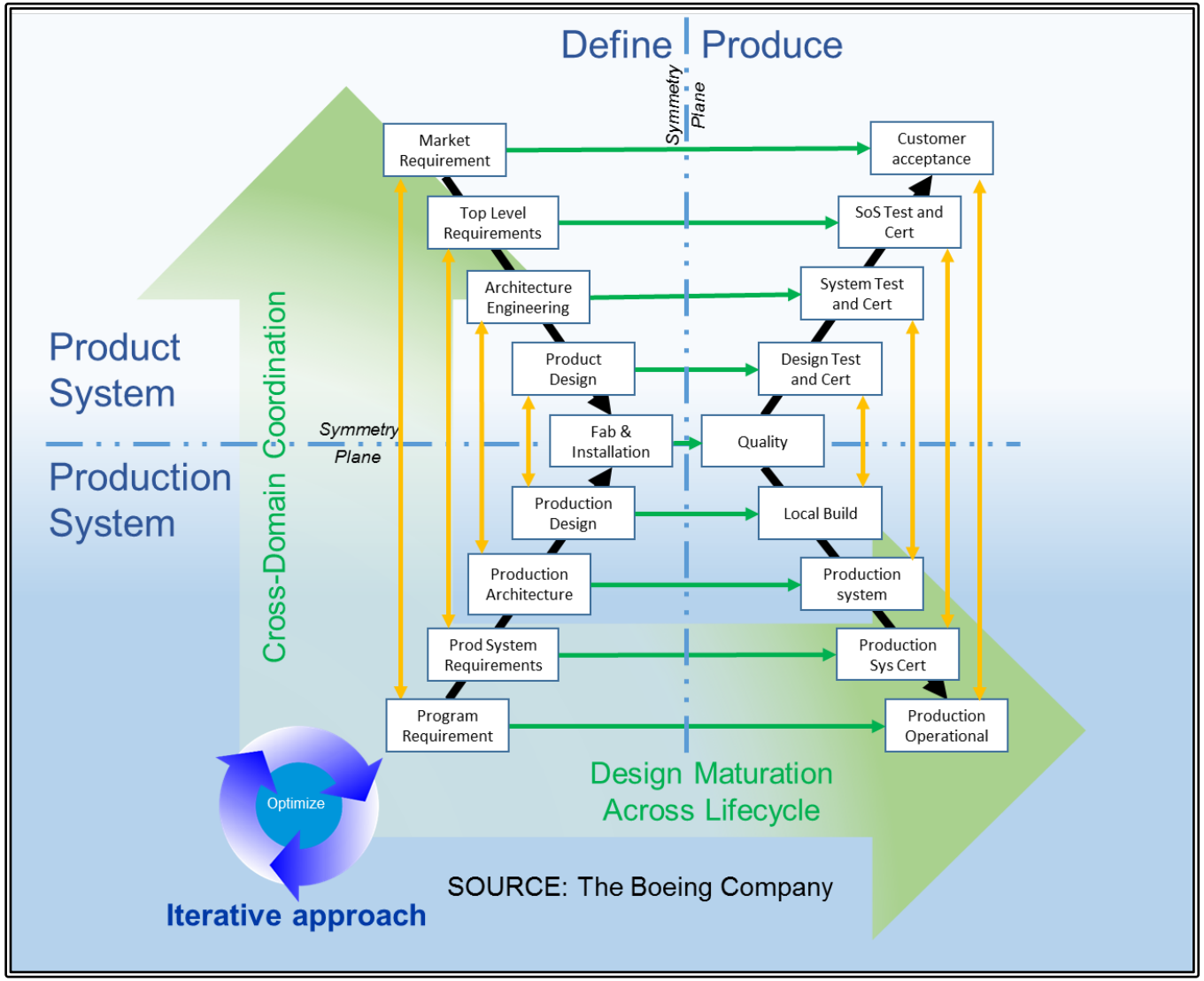
- Increased level of detail, to identify specific processes, products and prescribed timing
- Doesn't address known weaknesses of SE “V” symbol to represent MBE
- Introduces several additional issues related to complexity



SOURCE: The Boeing Company

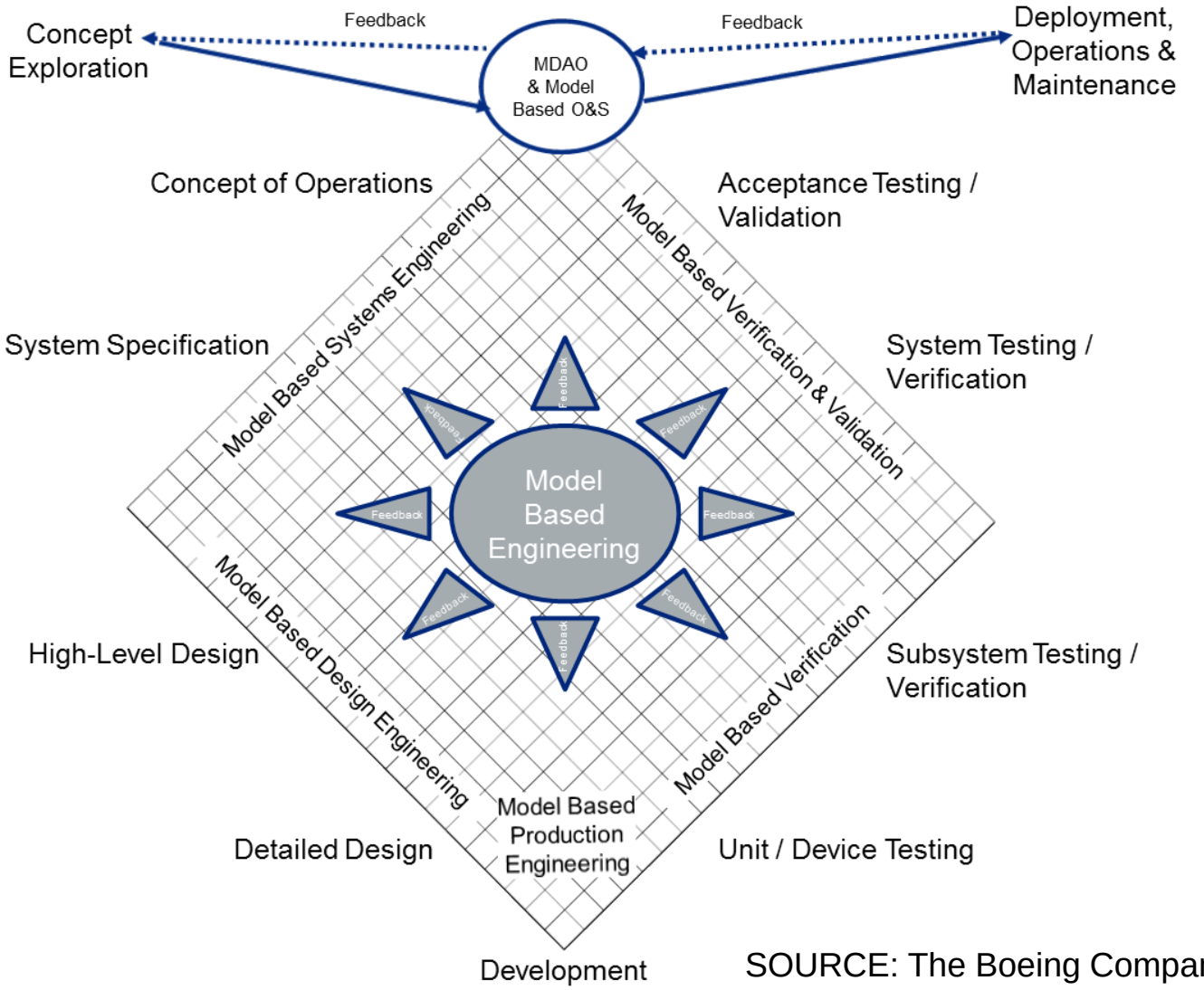
Option 2 - SE of Product and Production System

- **Illustrates Product Domain and Production Domain in context to each other over the development lifecycle**
- **Circular arrows indicate iterative approach**
- **Depiction of additional domains** (e.g. Services & Support) **is challenging**



Option 3 - System and Detailed Design in MBE

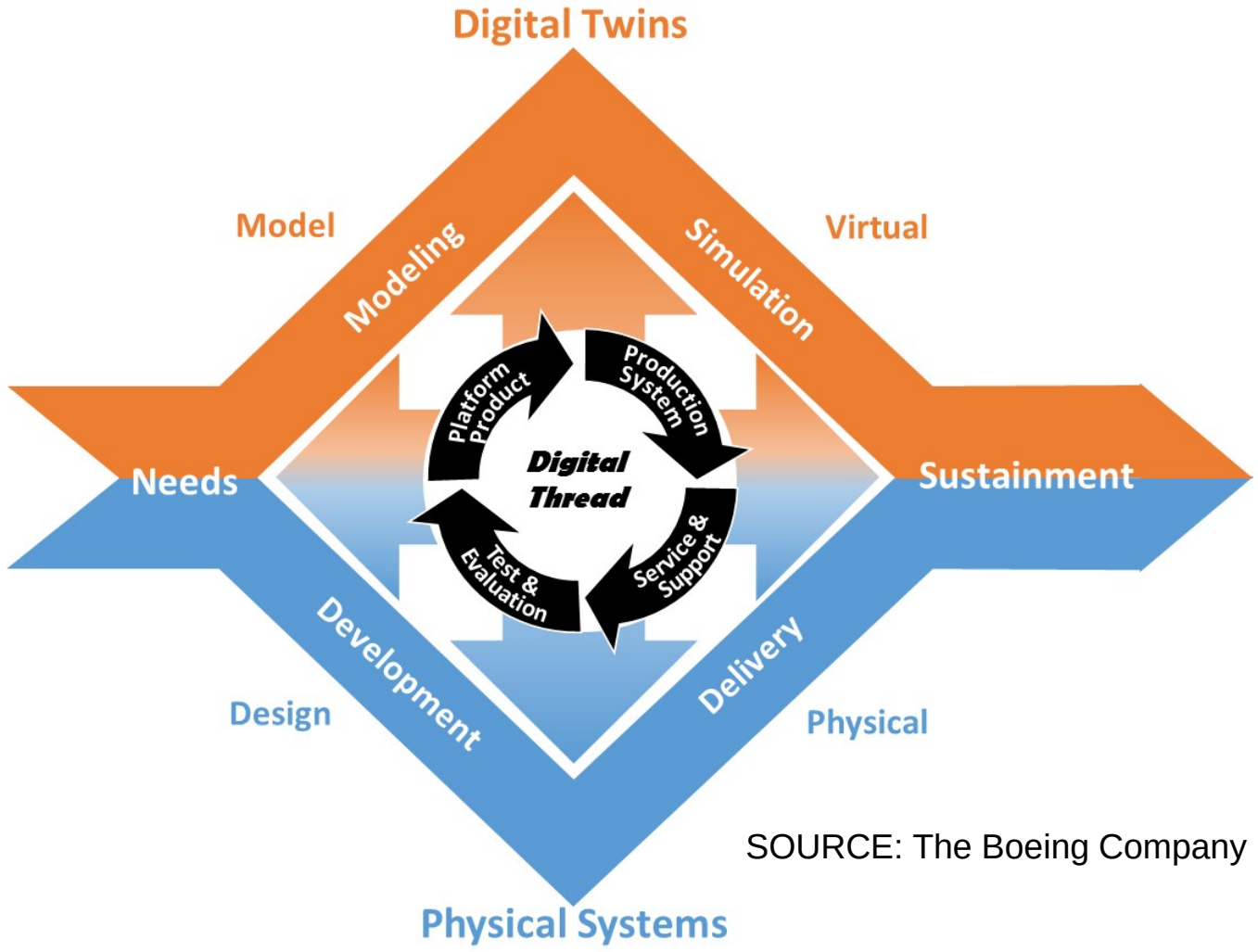
- **Describes MBE process, similar to the SE "V"**
- **Emphasis on central MBE linking information/design throughout the lifecycle**
- **MBE links all development states around outside of the Diamond**



SOURCE: The Boeing Company

Option 5 - Cyber-Physical MBE

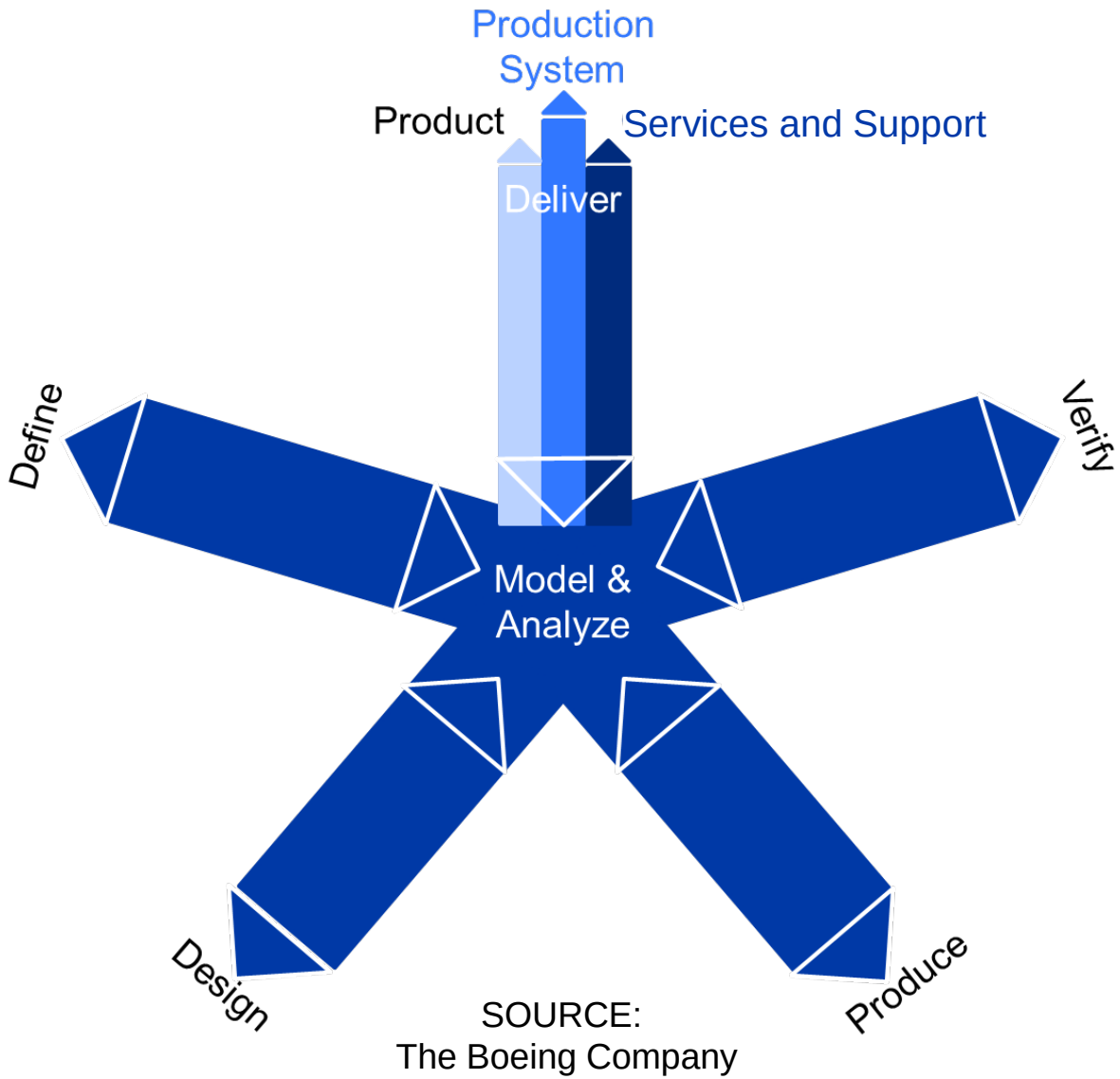
- **The bottom-half of the Diamond represents Physical System** (retaining traditional SE "V" flow)
- **The top-half of the Diamond represents the "Digital Twins"** (i.e. the virtual representation of the physical systems)
- **The interior of the Diamond represents the "Digital Thread" linking models/simulations (Digital Twins) to the design of the physical systems**



SOURCE: The Boeing Company

Option 6 - Model-Centric Product Realization

- **Depicts MBE as a series of 2-way arrows radiating from a central "Model and Analyze" activity**
- **Each spoke represents a major activity in the product lifecycle starting with definition and proceeding through delivery and operations**



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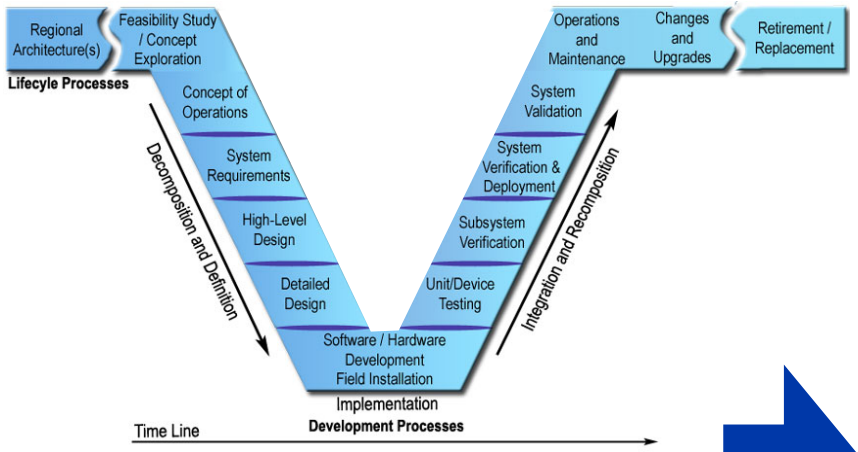
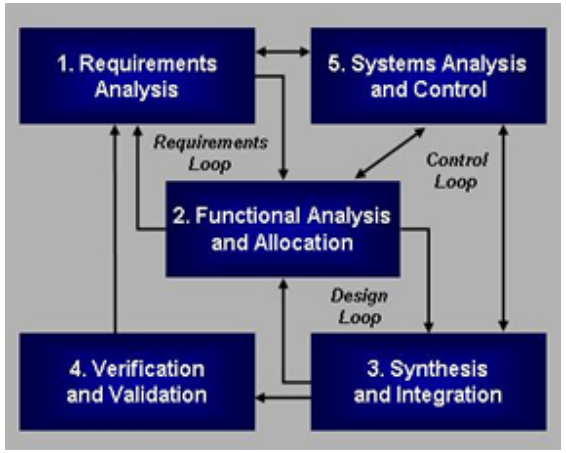
Summary

SE "V" Symbol





Proposed MBE Tenets

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MBE "Symbol" Options