The Imperative for Collaborative Digital Ecosystems in Advanced Production

GLOBAL PRODUCT DATA
INTEROPERABILITY
SUMMIT 2025

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Presentation released under 25-726758 RROI

Presenters Bio

Presenter: Carlos Walker
Company: The Boeing Company
Position: Technical Fellow – Mfg Engineer: PS Architecture & Design Development
Key Technical Field: Production System Design, Production Engineering Tools & Processes
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Education
- MS Technical Management, Embry-Riddle Aeronautical University, 2012
- BS Mechanical Engineering, North Carolina State University, 1998

Fun Facts
- Enjoy 3D Printing & Woodworking to tinker & make toys for my daughters
- Always have a DIY Home Improvement project in-work for much longer than it should take

Career Interest
- Product System Design Development Methods
- Developing tools & process for the next-Gen of Production Engineers.

Years of Service: 27 years

Current Role:

BCA Product Development – Senior Manufacturing Engineer
- Model Based Production System – Architect/Lead Engineer
- Developing MBSE and Model-Based Definition methods for PS Design
- Based in Everett, WA (just outside of Seattle, WA)

Previous Experience:

Boeing Commercial Aircraft (BCA):
- Fabrication Division
- 787 Program
- 737 Program
- BCA Product Development Studies

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Objective

- Highlight the strategic importance of inter-company data interoperability for production systems, quality, cost reduction, and supply chain stability from an industry leader's perspective.
- Establish the "why" for the workshop to tackle the complexities of Model-Based Systems Engineering (MBSE) in manufacturing.

Abstract

- Production Systems (PS) are complex system of systems defined, implemented and operated within the context of the product(s) the Production System manufactures to satisfy the needs of stakeholders and/or customers. Utilization of MBSE for Production System development is not widespread as MBSE usage in the development of products. Production System designs require data interoperability to ensure **digital data exchanges**, **interface management**, and **digital thread connections**. Enabling Production System MBSE data interoperability ensures a robust PS is integrated across collaborating companies, is implemented & sustained cost effectively, and capable of manufacturing high quality products.

Production System – Scope & Context

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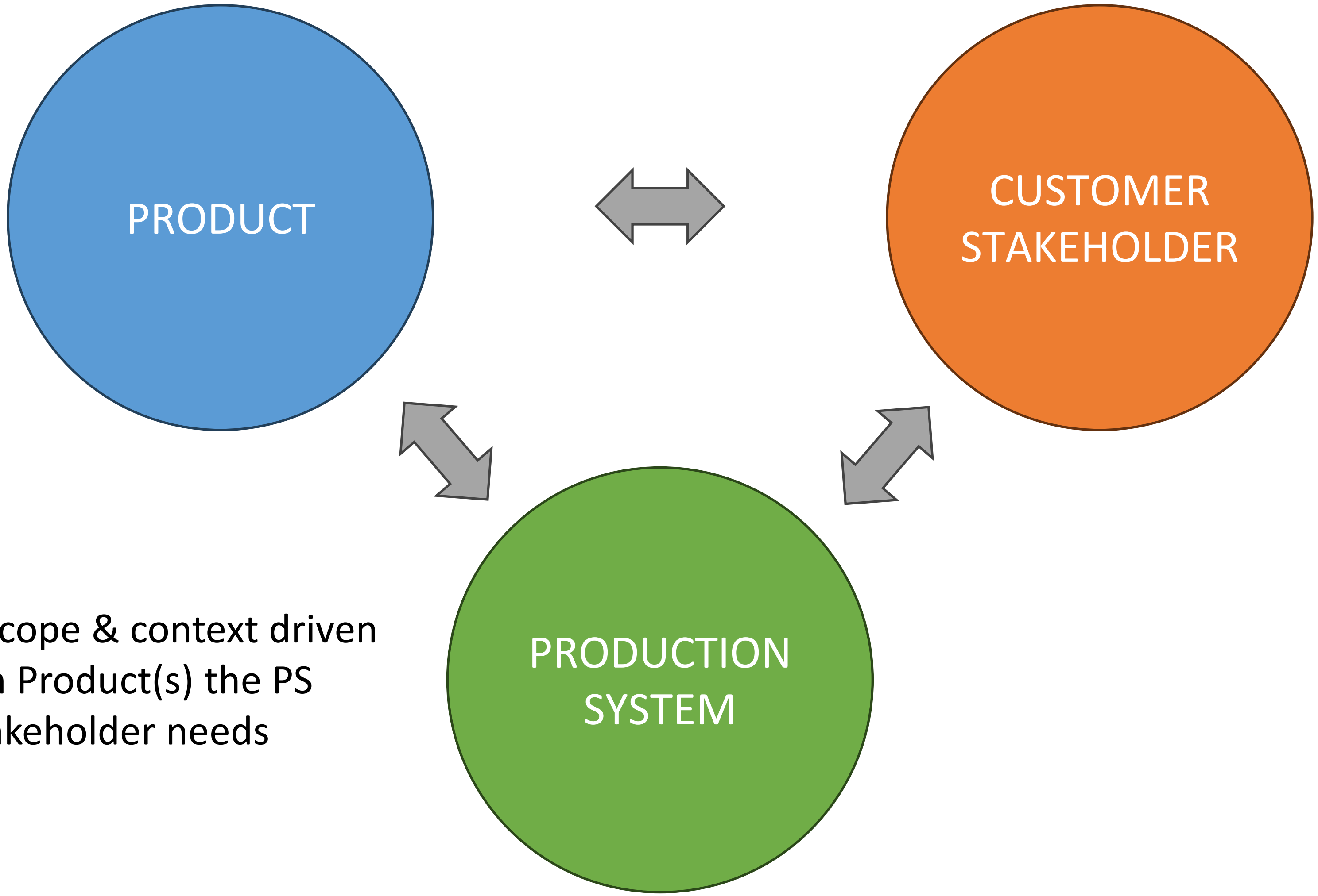
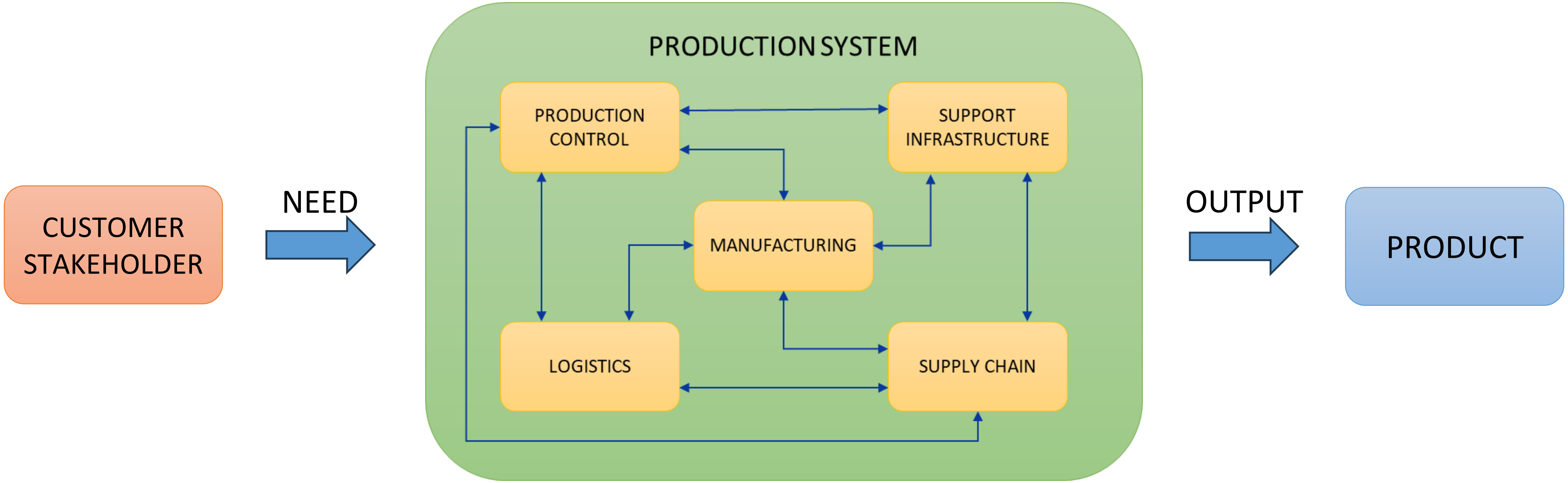


Production System (PS) scope & context driven by relationships between Product(s) the PS makes and Customer/Stakeholder needs

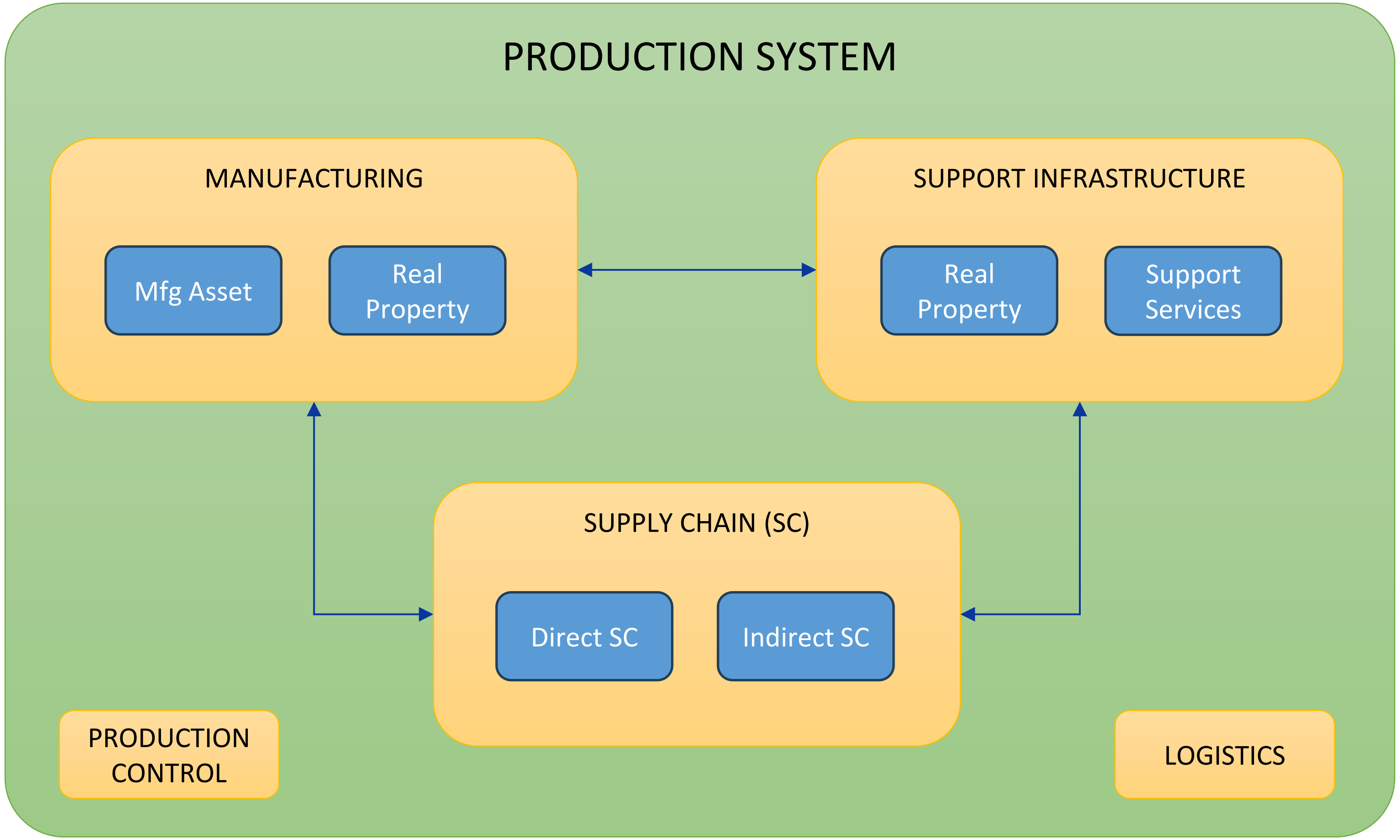
Production System – Complex System of Systems



A Production System is an enterprise system.

An enterprise consists of a purposeful combination (e.g., a network) of interdependent resources (e.g., people, processes, organizations, supporting technologies, and funding) that interact with each other to coordinate functions, share information, allocate funding, create workflows, and make decisions, etc.; and their environment(s) to achieve business and operational goals through a complex web of interactions distributed across geography and time (Rebovich and White 2011, 4-35). --- Reference: SEBOK Enterprise Systems Engineering: Enterprise Systems Engineering (https://sebokwiki.org/wiki/Enterprise_Systems_Engineering)

Production System – Sub-system Composition

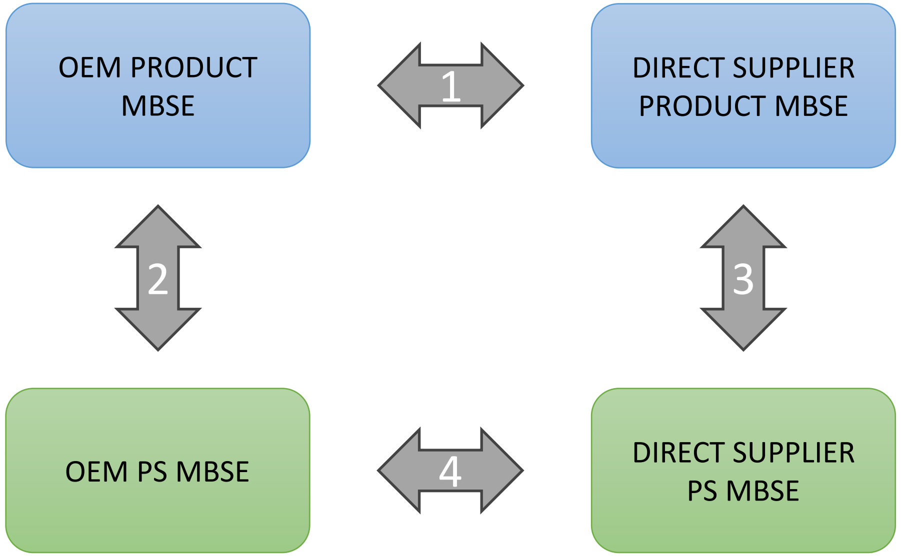


Production System Sub-System Examples

- Mfg Asset – Production Tooling/Equipment
- Mfg Real Property – Mfg Cell Provisions
- Support Real Property – Facility & Site Infrastructure
- Support Services – Non-Mfg Resources & Shared Services
- Direct Supply Chain – Suppliers of product components and/or raw materials
- In-Direct Supply Chain – Suppliers of Mfg Assets & Support Infrastructure Resources

Note: Examples are for reference purposes only and are not meant to be all inclusive or definitive of an actual PS composition.

Production System – Digital Data Exchange & Linkage: OEM and Direct Supplier

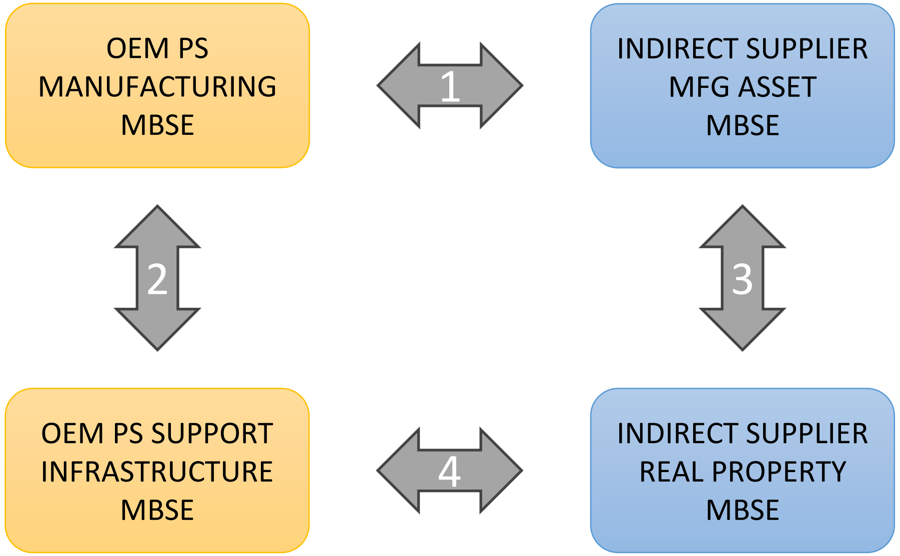


MBSE = MBSE model containing RFL architecture definition
RFL = Requirements, Functional, & Logical architecture
Direct Supplier = Supplies components of OEM Product

<u>MBSE Digital Data Exchange & Linkage – OEM & Direct Supplier</u>

1. OEM Product to/from Supplier Product
   - Enables Product Architecture & Design co-development
   - Enables Supplier Product Specification definition
2. OEM Product to/from OEM Production System
   - Enables Product and PS concurrent development
   - Enables PS manufacturing capability needs
   - Enables Product producibility needs
3. Supplier Product to/from Supplier Production System
   - Equivalent to #2 but for internal supplier context
4. OEM PS to/from Supplier PS
   - Enables manufactured product condition of supply definition
   - Enables OEM & Supplier production interface management

Production System – Digital Data Exchange & Linkage: OEM and Indirect Supplier

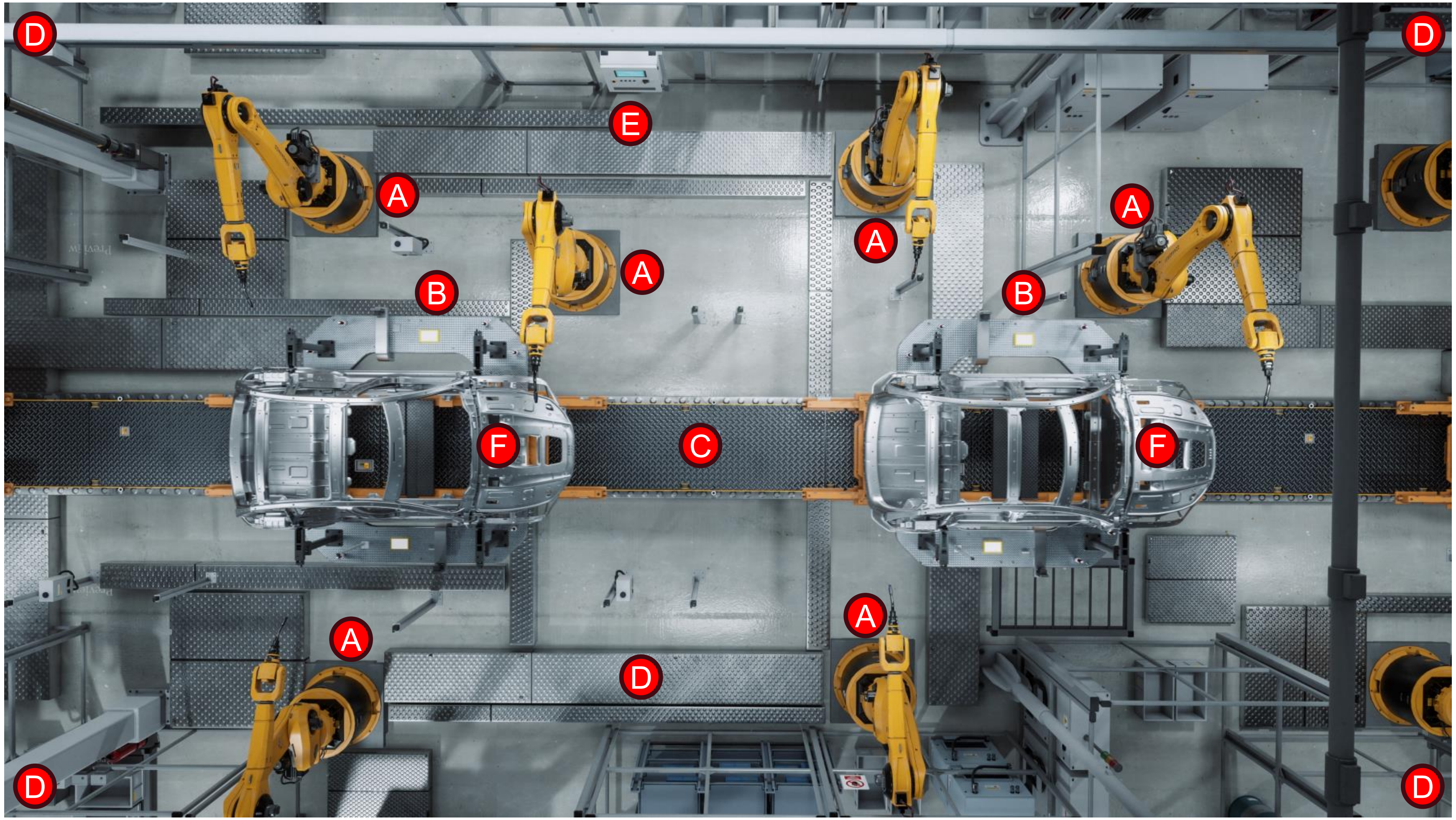


MBSE = MBSE model containing RFL architecture definition
RFL = Requirements, Functional, & Logical architecture
Indirect Supplier = Supplies assets, real property & services included in PS

MBSE Digital Data Exchange & Linkage – OEM & Indirect Supplier

1. PS Manufacturing MBSE to/from Supplier Mfg Asset
   - Enables Mfg Asset Architecture & Design co-development
   - Enables Mfg Asset Specification definition
2. PS Manufacturing to/from PS Support Infrastructure
   - Enables Mfg and Support Infrastructure concurrent development
   - Enables Facility/Real Property capability needs
   - Enables Mfg & Support Infrastructure Interface Mgmt
3. Supplier Mfg Asset to/from Supplier Real Property
   - Enables Mfg Asset and Real Property concurrent development
   - Enables Mfg Asset and Real Property Interface Mgmt
4. PS Support Infrastructure to/from Supplier Real Property
   - Enables Real Property Architecture & Design co-development
   - Enables Real Property Specification definition

Production System – Interface Management



Microsoft 365 Stock Image

Identify Interfaces for:

- A Robots – Mfg Asset
- B Fixtures – Mfg Asset
- C Conveyor – Mfg Asset
- D Factory Structure – Real Property
- E Control Panel – Production Control
- F Car Bodies – Product

Define PS Interfaces via MBSE before physical design

Production System – Digital Thread: Architecture to Physical Design

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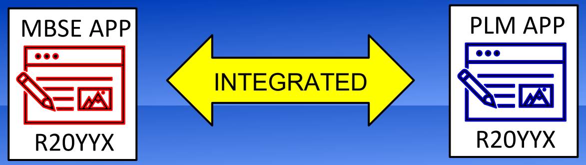

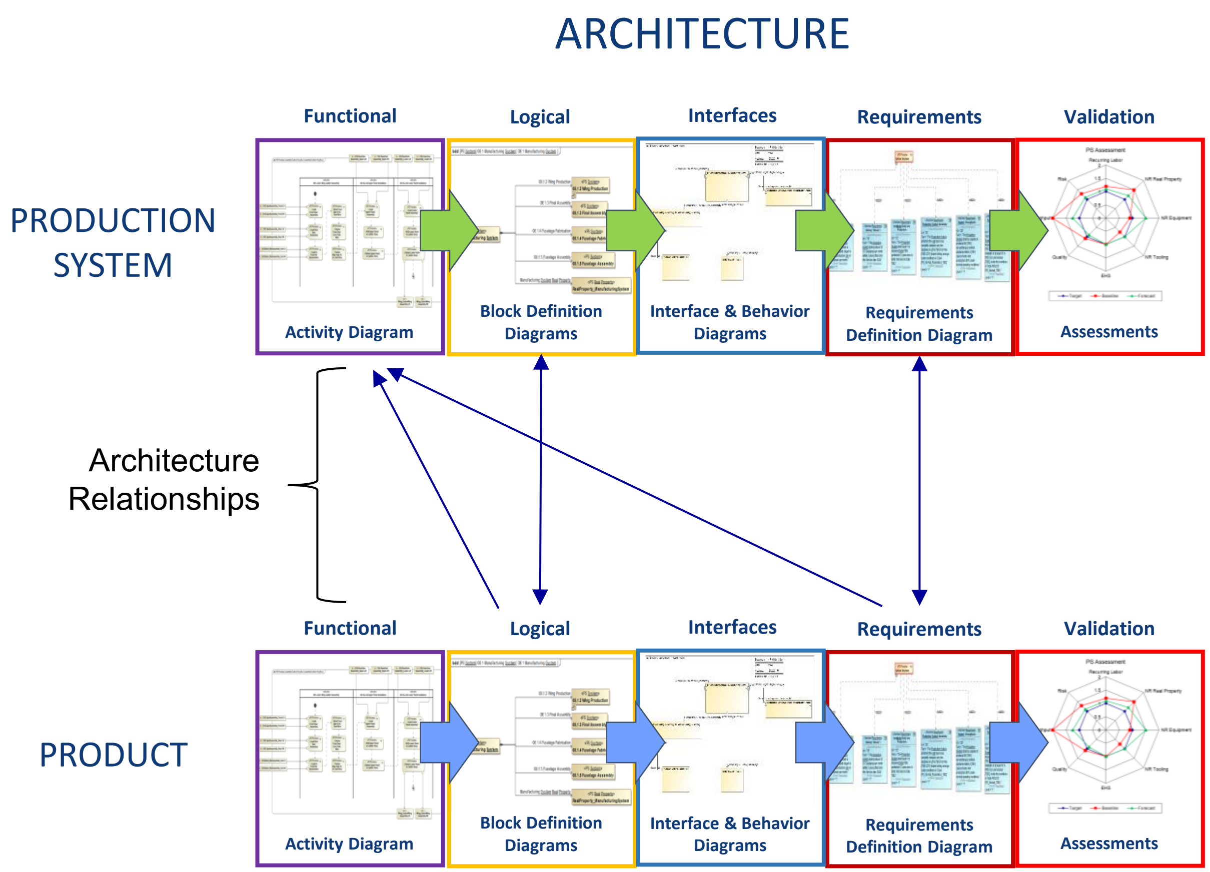

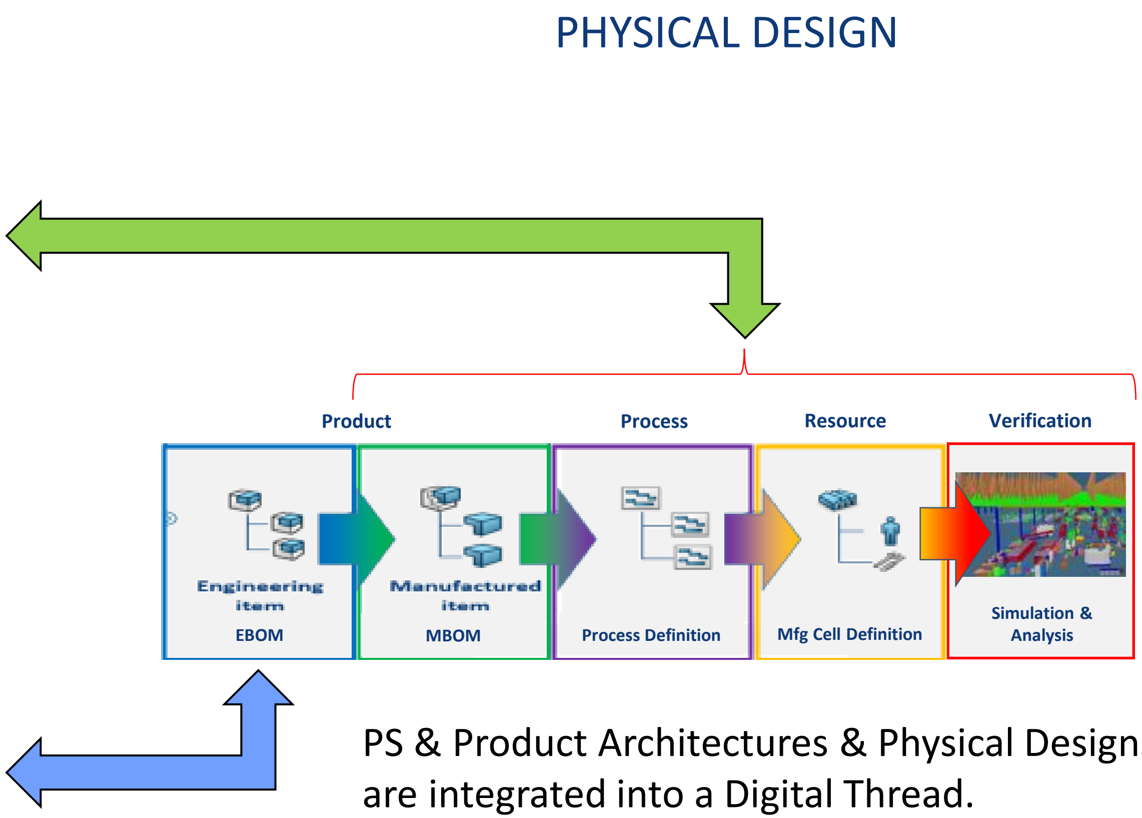

PS & Product Architectures & Physical Designs are integrated into a Digital Thread.

Both Architectures and Physical Designs are concurrently iterated, matured & maintained.

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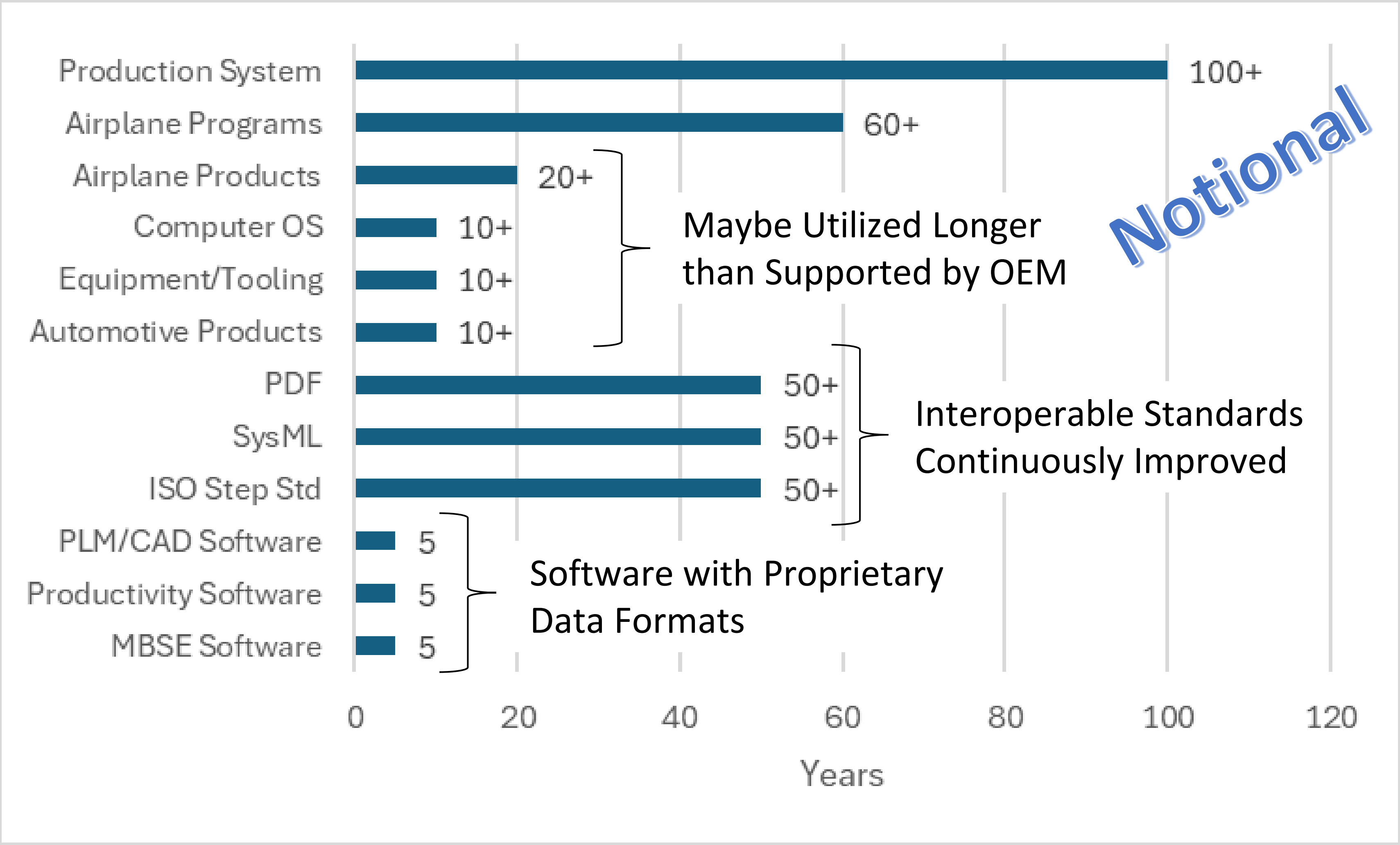
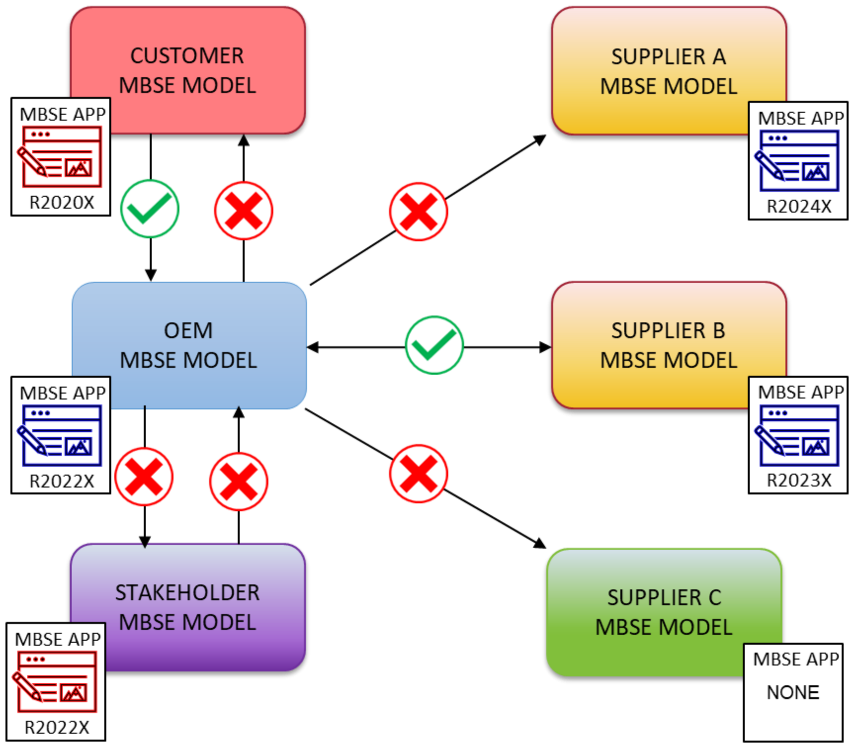
Production System Lifespan Comparison

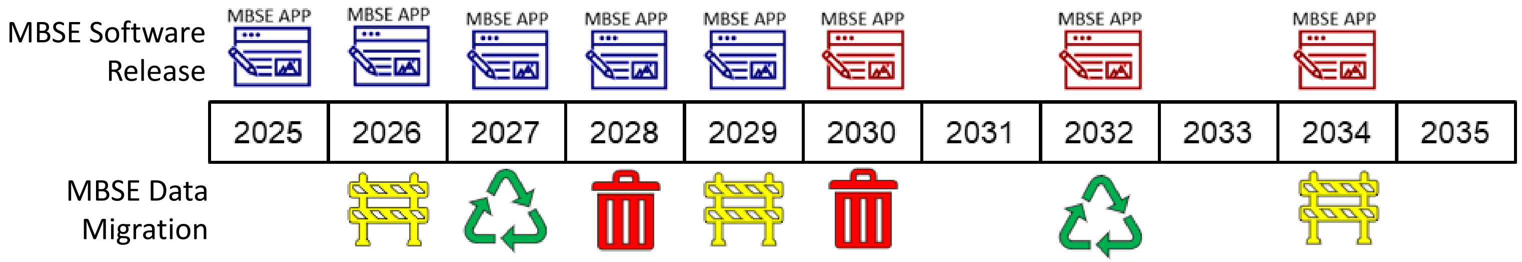


MBSE Data Interoperability

DATA EXCHANGE SCENARIOS



DATA DEFINITION OVER PS LIFESPAN



MBSE Software Vendor #1

MBSE Software Vendor #2

MBSE Data Migration – Easy/Conversion Not Required

MBSE Data Migration – Conversion Required

MBSE Data Migration – Must Start Over (Remaster Data)

Interoperable Data Definition requires authoring applications with backward & forward compatibility to read/write data created using past/future data formats and standards during the lifespan of the Production System and support companies having different vendor applications and application versions.

Conclusion

- Production Systems (PS) are complex system of systems defined, implemented and operated based on the product(s) the PS manufactures to satisfy the needs of customers and/or stakeholders.
- MBSE for Production System development is an emergent design method without widespread usage.
- PS Architecture interdependencies with unique use cases require novel approaches and/or new MBSE standard methods; in comparison to MBSE methods employed for product architectures.
- PS MBSE architecture integrated across interconnected companies, customers, and/or stakeholders. No single MBSE model to define a complete Production System.
- MBSE data interoperability required to enable PS digital data exchanges, interface management, and digital threads across federated sets of MBSE models defined by OEMs, suppliers, stakeholders, and/or customers.
- MBSE data interoperability is a critical enabler for future production systems to be integrated across collaborating companies, to be implemented & sustained cost effectively, and ensure manufacturing high quality products.