The Promise of the Digital Thread

2023 Market & Industry Forum—30 March 2023

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Presenter's Profile

CIMdata

James Roche
Aerospace & Defense
Practice Director

- 35+ years of experience in transformation and IT enablement of product development and manufacturing processes.
- Strategic advisor and program manager for PLM programs across the Americas, Europe, and Asia.
- PLM Practice Manager at CSC Consulting and at A.T. Kearney.
- Previously with EDS, served as chief architect for General Motors' worldwide engineering systems.
- Areas of Focus
  - Facilitating cooperation within the aerospace and defense industry
  - Strategically expanding PLM within aerospace and defense companies
  - Extending PLM from airframe and propulsion OEMs to their external value chains

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Key Takeaways

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What you should understand at the end of this session

- The concept of a digital thread as the progression of product representations, or structures, that are created and consumed along the product lifecycle
- How lifecycle product structures are interrelated in a weblike configuration
- Guidelines for designing and incrementally implementing a digital thread vision

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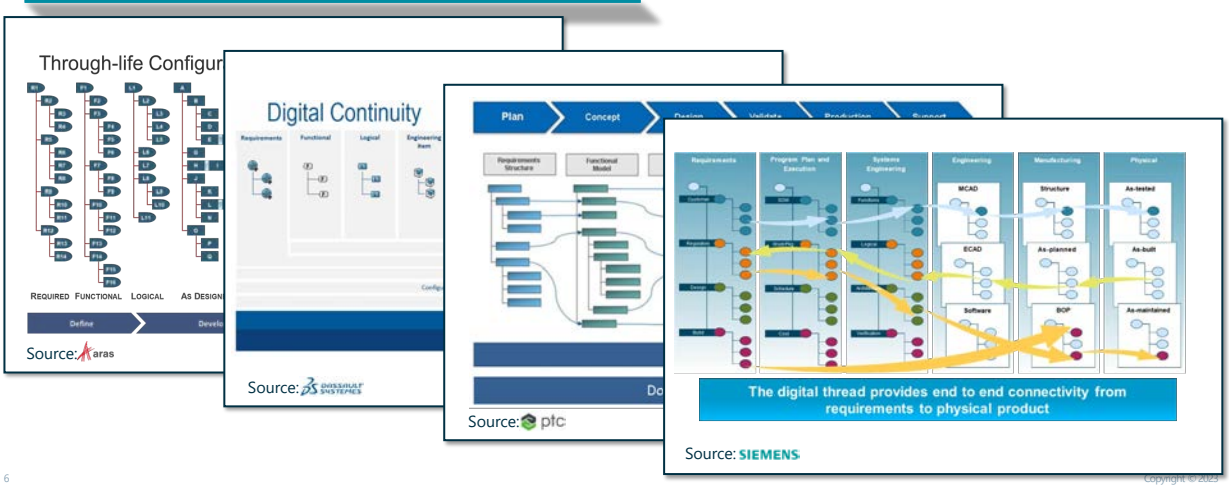
Agenda

- Introduction
- Digital Thread Concepts
- Digital Thread Case Studies
- Concluding Remarks

Digital Thread Comes of Age

Recent advances in PLM solutions have made the Digital Thread technically possible



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Lifecycle Product Structures

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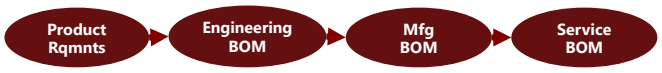
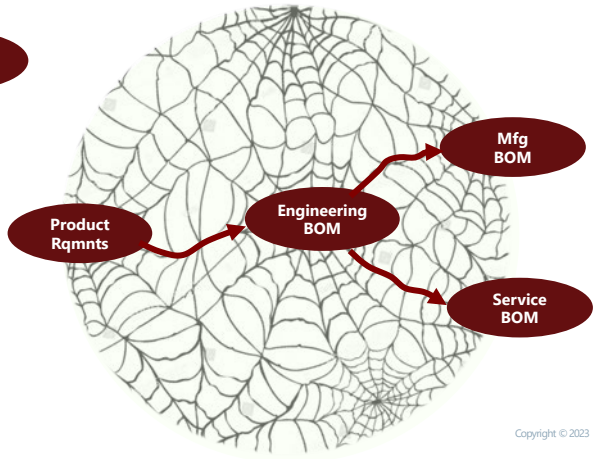
Connections between the four principal product structure configurations – Thread vs web

Product Lifecycle Timeline Sequence (Thread)



Derivative Dependencies (Web)



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Lifecycle Product Structures

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Framework for the Bill of Information (BOI)

- **Product structure** is the organizing construct for all information that defines and is associated with the product definition throughout its lifecycle. There are many views by which this structure can be configured:
  - Requirements view
  - Functional and logical views
  - Engineering view (i.e., eBOM)
  - Purchasing view
  - Manufacturing view (i.e., mBOM)
  - Service view (i.e., sBOM)
  - Sales view
  - and many others, including simulation and test views, as built and inspected views
- On each of these configurations is hung the information needed by the owning business area to perform its role within the overall product program lifecycle

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Agenda

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- Introduction
- Digital Thread Concepts
  - Driving Influences for Digital Thread Design
    - Systems Engineering
    - Program Planning & Control
    - Bill of Information
  - Laying Out a Digital Web
- Digital Thread Case Studies
- Concluding Remarks

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Systems Engineering

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A driving influence for the digital thread

Systems Engineer

The systems engineer should develop the skill for identifying and focusing efforts on assessments to **optimize** the overall design and not favor one system/subsystem at the expense of another while constantly **validating** that the goals of the operational system will be met.

Source: NASA Systems Engineering Handbook

Optimization

Finding an alternative with the most cost effective or highest achievable performance under the given constraints, by maximizing desired factors and minimizing undesired ones.

Source: BusinessDictionary.com

Validation

Showing that the product accomplishes the intended purpose in the intended environment—that it meets the expectations of the customer and other stakeholders as shown through performance of a test, analysis, inspection, or demonstration.

Source: NASA Systems Engineering Handbook

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Systems Engineering

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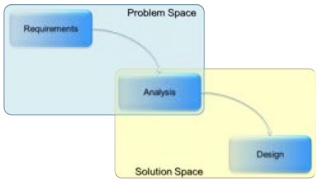
Methods Maturity

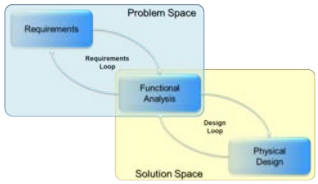
Level 1 – Requirements analysis and design

"Optimization" in the judgement of a good designer



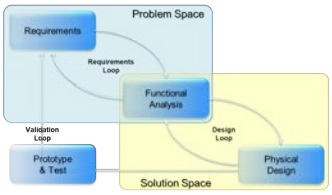
Level 2 – Modeling and simulation

Simulation and trade studies to support requirements analysis and design alternatives evaluation



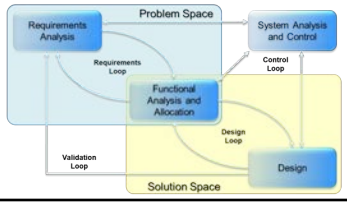
Level 3 – Modeling and simulation with physical validation

Simulation and trade studies to support requirements analysis and design alternatives evaluation, and testing for validation and certification



Level 4 – Modeling and simulation with virtual validation

Application of modeling to support system requirements, design, analysis, verification and validation



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Systems Engineering

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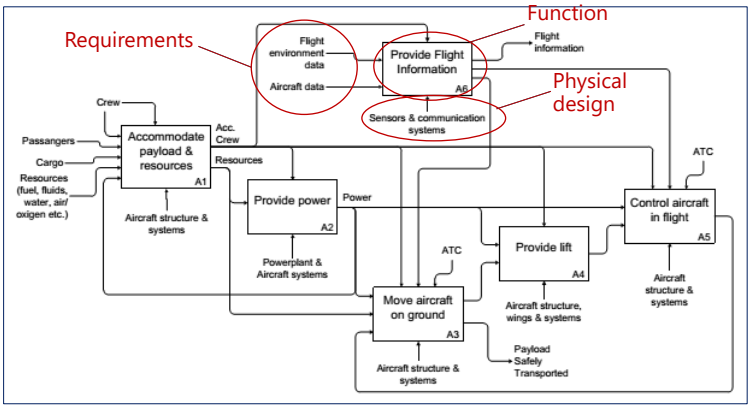
Why "Functional" analysis?

The functional model is the link between requirements and physical design



12 Source: G. Esdras and S. Liscouët-Hanke, Bombardier Product Development Engineering, Aerospace, Montréal QC,~2014

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Systems Engineering

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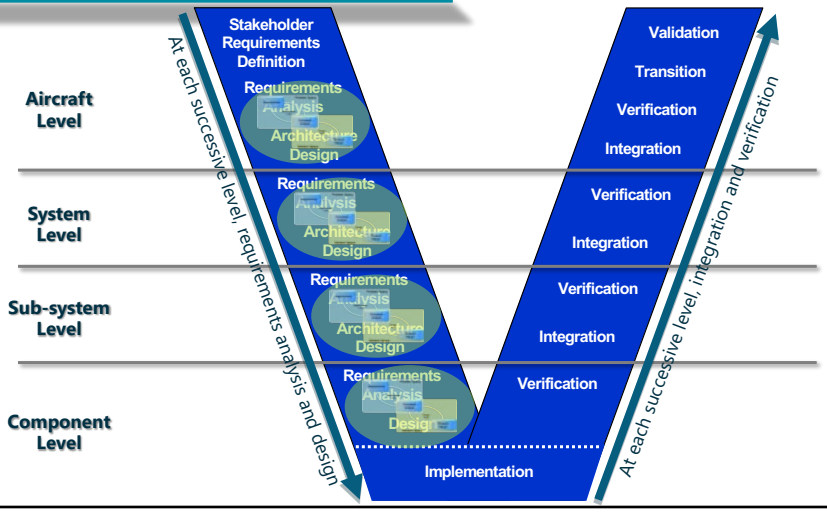
Design processes repeat at each level of the system hierarchy



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Systems Engineering

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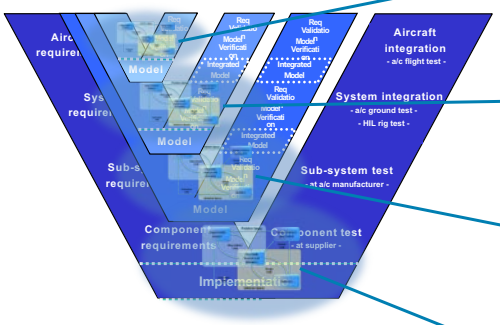
Methods maturity

Level 5 – Automated modeling, simulation, validation

Continuous analysis, allocation, design, verification, integration and validation



MIL

MIL+SIL

Virtual Iron Bird
MIL+SIL+PIL

Physical Iron Bird
MIL+SIL+PIL+HIL

MIL: Model-In-the-Loop simulation
SIL: Software-In-the-Loop simulation
PIL: Processor-In-the-Loop simulation
HIL: Hardware-In-the-Loop simulation

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Program Planning & Control

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Process – Program management and program systems engineering

Reporting
Automated real time program control based on work element deliverables status
(Multiple dashboards, customized by role)

Conceptual Studies → Preliminary Studies → Initial Definition → Joint Definition → Detailed Design → Tests → Maturity → Series → Stream Out

Program Value Statement
- Mission Requirements
- Program Objectives
- Program KPIs

Requirements Allocation
Mission Requirements and KPIs allocated and traceable throughout product structure

Product Structure

Work Structure

Program Org

Program Schedule

Product-to-Work Linkage
Work element deliverables linked to product element artifacts

Organization-to-Work Linkage
Work element linked to organization delivery resources

Work-to-Schedule Linkage
Schedule tasks linked to work element deliverables

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Bill of Information

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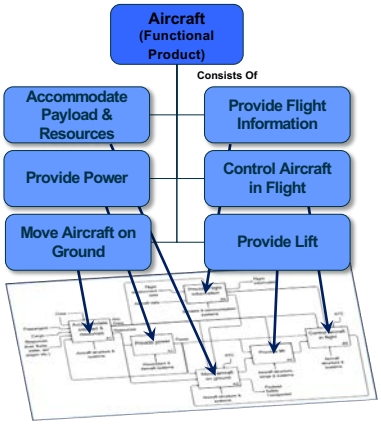
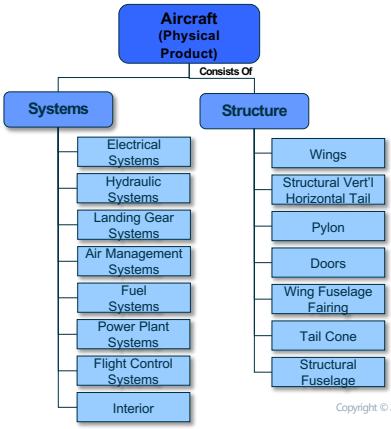
Data scope (1 of 3)

Protocol for the representation of systems engineering data that defines the context, scope and information requirements for various development stages during the design of an aircraft (ISO 10303-233:2012)

Functional Structure



Physical Structure



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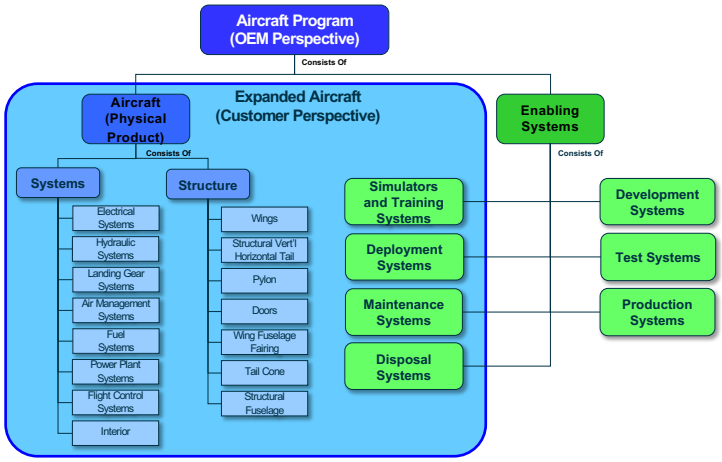
Bill of Information

Data scope (2 of 3)

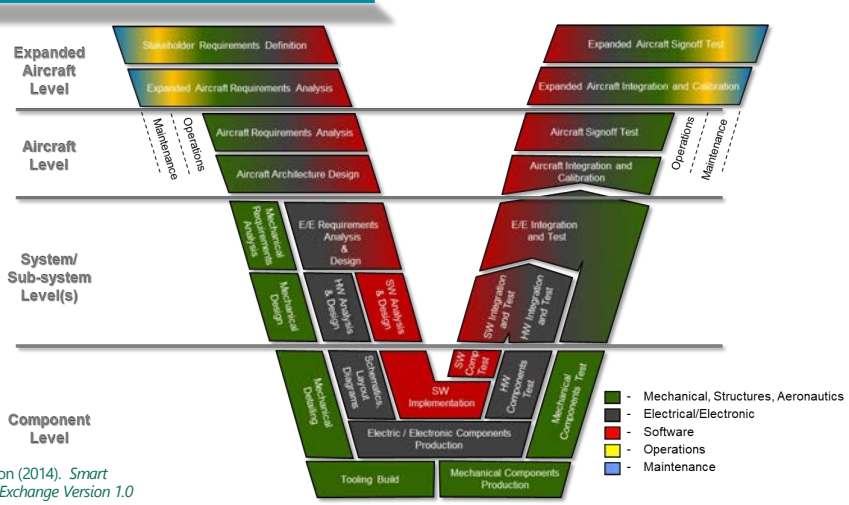
Information for defining an aircraft and its support solution; information required to maintain an aircraft; and information required for through life configuration change management of an aircraft and its support solution (ISO 10303-239:2012)



Bill of Information

Data scope (3 of 3)

V-Model for the Expanded Aircraft includes 3 technical domains plus operations, and maintenance



Adapted from ProSTEP iViP Association (2014). *Smart Systems Engineering, Behavior Model Exchange Version 1.0*

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Digital Web

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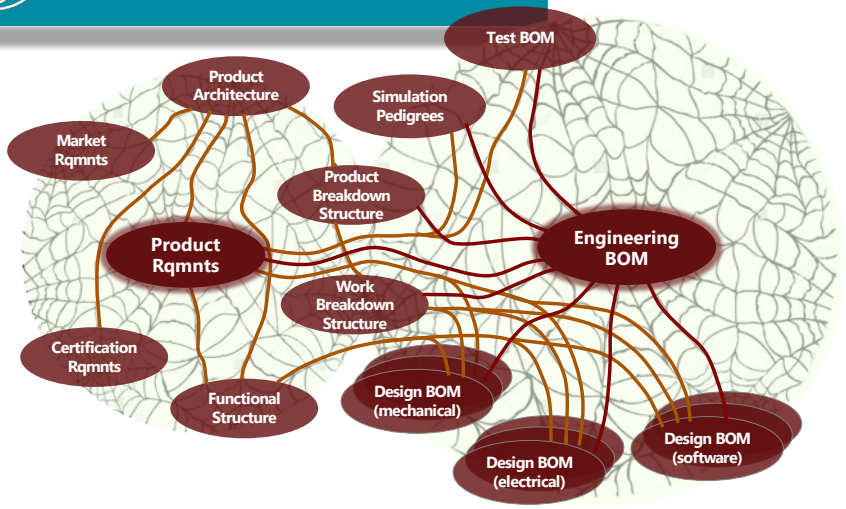
Systems engineering and program planning & control connections



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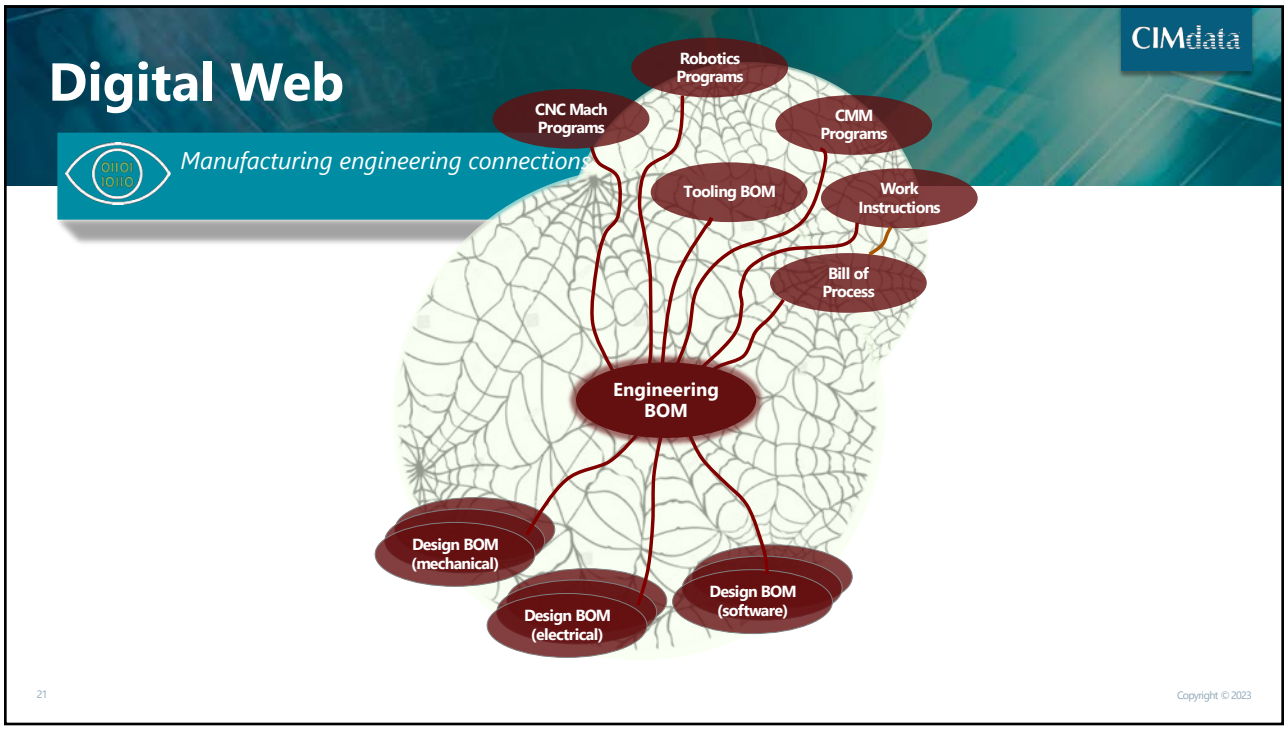

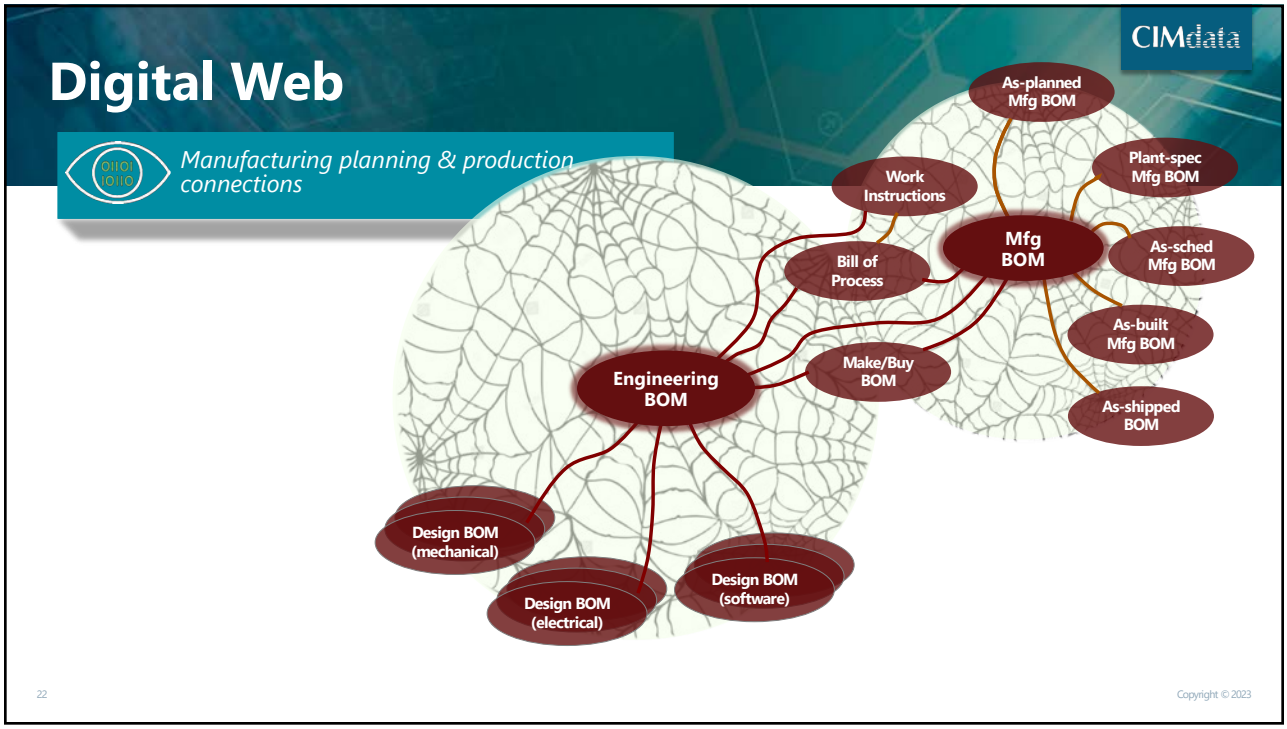

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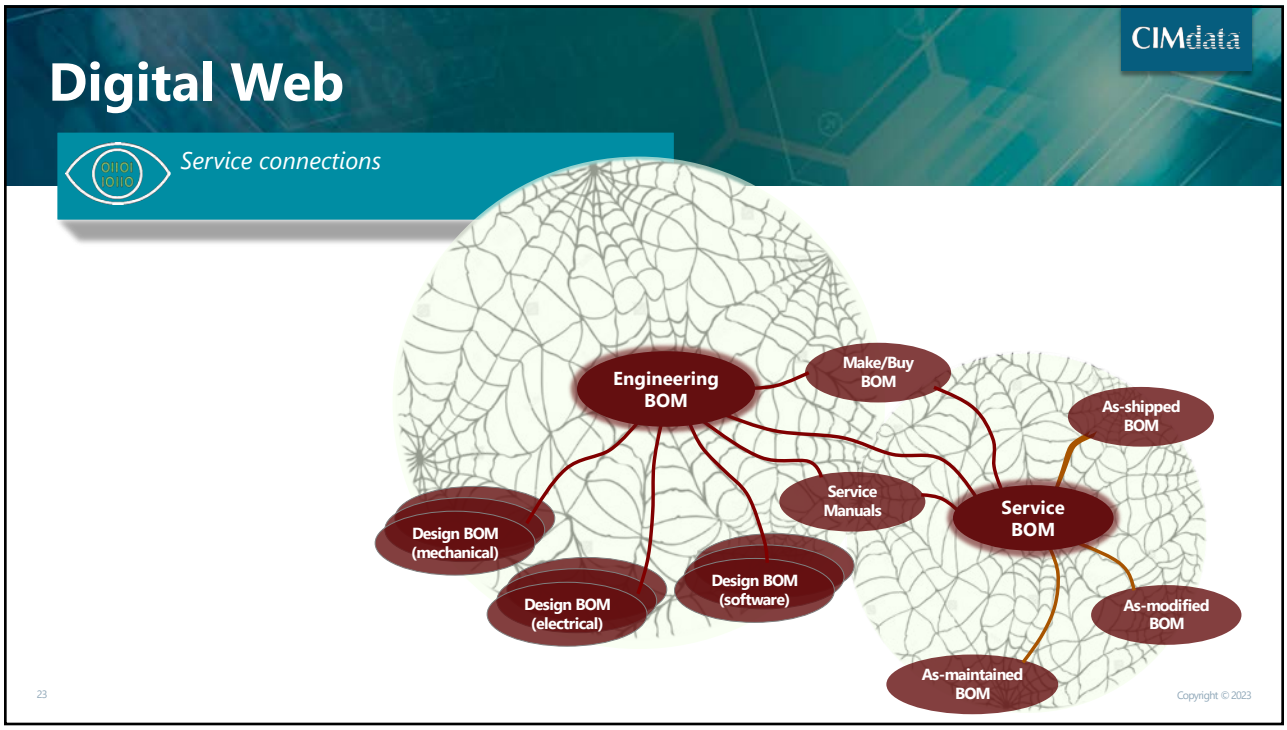

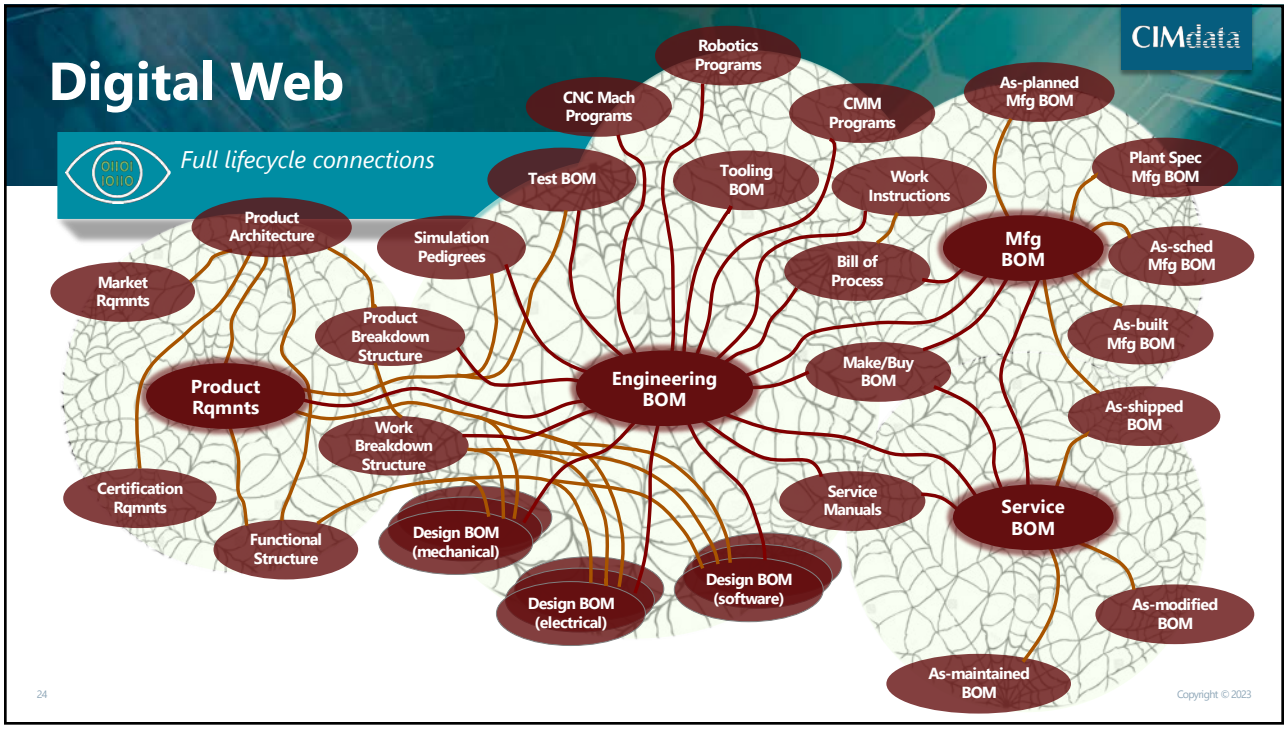

Digital Web & Digital Threads

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Definitions and why it is helpful to work with both

- The Digital Web is a representation of the relationships between product structures that are created and consumed by various communities across the product lifecycle
- Digital Threads are the actual interconnections that occur between elements within and across these structures
- Having the Digital Web representation allows the analyst to define and establish the higher-level patterns between product structures and then provide the user community with a framework for assigning the dependencies between data elements, i.e., the Digital Threads

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Heavy Equipment & Support Packages

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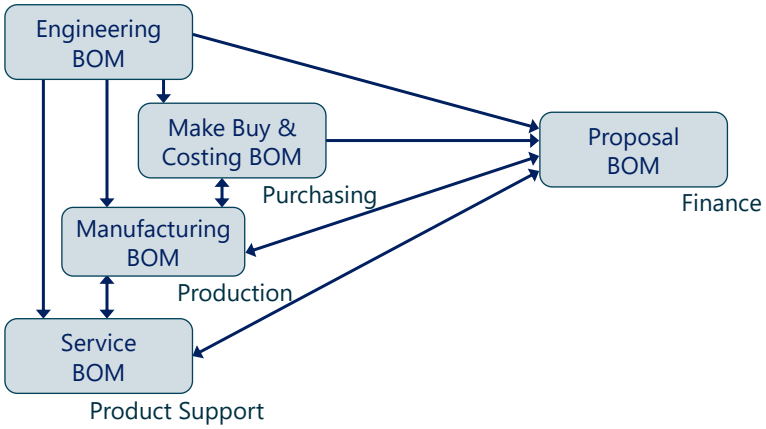
Goal: Improve speed, efficiency and accuracy of proposal preparation



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Specialty High-Tech Equipment

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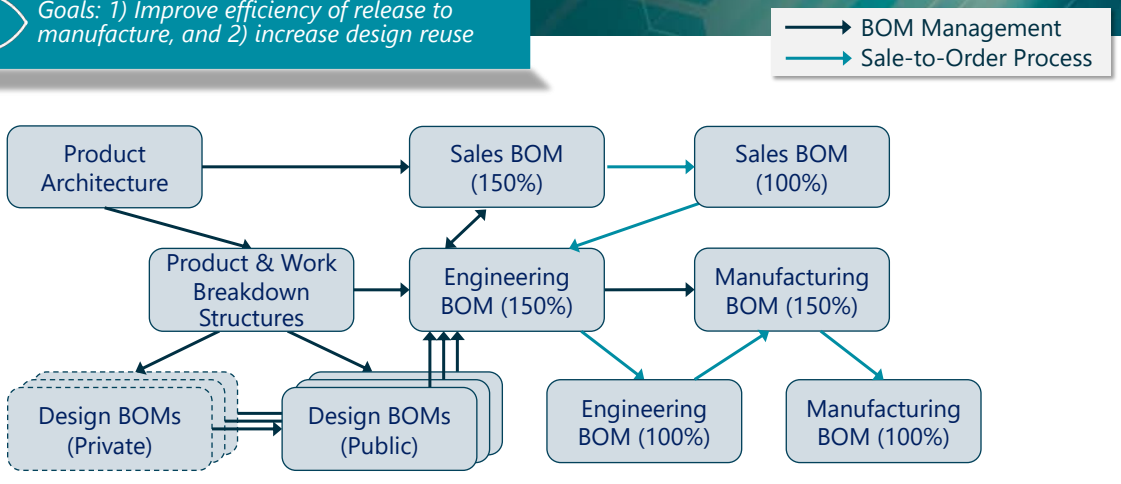
Goals: 1) Improve efficiency of release to manufacture, and 2) increase design reuse



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Concluding Remarks

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The digital thread is really a web and use cases define the threads in the web (1 of 2)

- Digital Thread is a straightforward and powerful metaphor for the concept of linking multiple representations of a product, each tuned to the needs of various creators and consumers, along the lifecycle
- Depicting the relationships between product representations as a web is more useful as a paradigm for defining scope and planning the design for a digital thread implementation
- Systems engineering, program management and bill of information are principal design influences that drive the information configurations and connections within the web

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Concluding Remarks

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The digital thread is really a web and use cases define the threads in the web (2 of 2)

- As with any major endeavor, the best approach to digital thread realization is to plan big – lay out the landscape so that as you build the pieces they fit together – and then build out piece by piece
- Use cases are the pieces – they define scope of the threads in the web and the business value associated with their realization

To Learn More…

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- Access A&D PLM Action Group resources at www.ad-pag.com
  - Digital Twin/Digital Thread Solution Definition for Aerospace and Defense: Phase 3, position paper, Feb 2023
  - Digital Twin/Digital Thread Solution Definition for Aerospace and Defense: Phase 2, position paper, Jul 2022
  - Multiple View Bill of Materials (BOM) Solution Evaluation Benchmarks, report, Jul 2020
  - Multiple View Bill of Materials, position paper, Feb 2019
- Access CIMdata resources at www.CIMdata.com
  - Multi-view BOM Value Potential, webinar, Apr 2022
  - The Digital Thread is Really a Web, with the Engineering Bill of Materials at Its Center, webinar, Sep 2021
  - Making Multi-view BOM a Reality, webinar, Mar 2020
- Contact for further discussion

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Questions & Answers

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What's on your mind?

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CIMdata Defining What Comes Next in Digital Transformation

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