Model Base Engineering Diamond Adoption (2022)

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PLM Road Map™ @ GPDIS 2022

Digital Transformation and PLM – a call for PLM professionals to re-define and re-position the benefits and value of PLM

September 27

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GPDIS 2022 FORUM

Presentation Title: ***Model Base Engineering Diamond Adoption (2022)***

ABSTRACT

Boeing introduced the MBE Diamond concept (symbol) at this forum back in 2018 and have made major strides in our internal implementation across the Boeing Enterprise and adoption across the lifecycle of programs. The MBE Diamond concept depicts how things have evolved from the iconic System Engineering "V" to an integrated Model Based environment enabled by the digital thread and the authoritative source of data/information. One of the key enablers to Digital Transformation is the adoption and integration of industry standards throughout the digital thread.

This presentation will provide an updated version of Boeing's MBE Diamond and how we are applying to concept across our company and will touch on many of the different disciplines and phases of our programs. The upper half of the MBE Diamond represents the Virtual (or Model Based) aspects of Digital Engineering. This presentation will expand on Boeing's use of virtual component in the generation of Digital Twins. In addition, a short discussion on how Boeing leverage the MBE Diamond in our internal communication and training on the company's Digital Transformation.

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Digital Transformation and PLM – a call for PLM professionals to re-define and re-position the benefits and value of PLM

CIMdata®

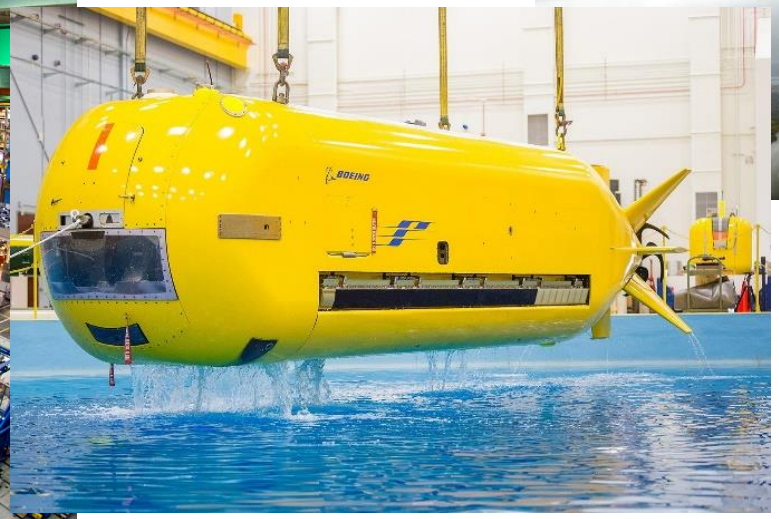
September 27

Don Farr - Biography

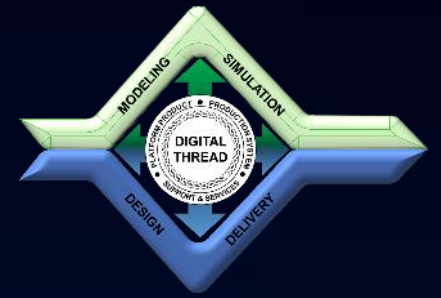
Don Farr

- 31 years at Boeing, 5 years at General Dynamics
- Senior Technical Fellow in Model Based Engineering at Boeing Research & Technology in Huntsville, Al
- System Engineer for over 36 years on dozens of programs:
  - F-22, F-16, F-111, and A-12
  - RAH-66 Comanche Helicopter
  - F-15 Eagle, F/A-18 Super Hornet
  - 777x, 737, 787 Dream Liner
  - Ground Based Missile Defense
  - Systems of System Programs
  - Research and Development Programs
- BSEE from Lamar University, Texas
- MSEE from University of Delaware

Some of Boeing's Products



Why Digital Transformation?



Drives Standard Work – Reduces learning curve; facilitates continuous improvement; integrates safety and quality holistically

Enables Global Optimization – enables design tradeoffs that span the value chain of our products, production, and aftermarket

Promotes Single Source of Data – improves data quality and access (productivity)

Facilitates Model Reuse – enables reuse of proven designs that are enhanced over time

Promotes Disciplined Systems Engineering – getting the requirements right up front reduces rework

Enables the Digital Thread – reduces manual handoffs of data that drive escapes

Improves Change Management – exposes change impact up/down the value stream improving productivity, quality, and safety

Enables Enhanced Modeling – allows embedding of in-process analysis, quality, and safety checks

MBE drives improved Quality, Productivity, and Safety across the value chain

DATA-DRIVEN DECISION MAKING

DATA ANALYTICS (INSIGHT)

DIGITAL TWINS (INTELLIGENCE)

DIGITAL THREAD (CONNECTIVITY)

The Digital Value Chain

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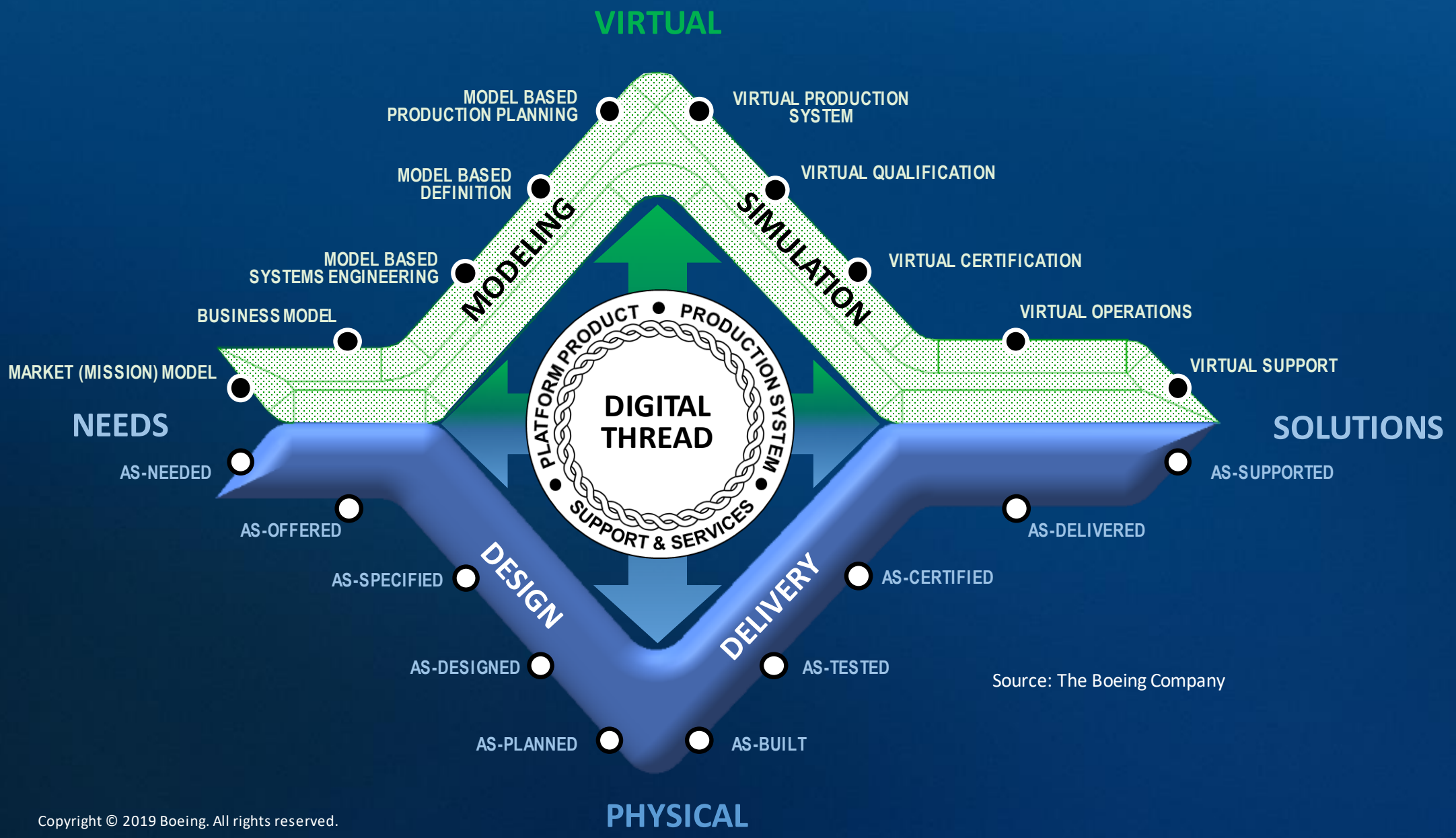
MBE Diamond



Source: The Boeing Company

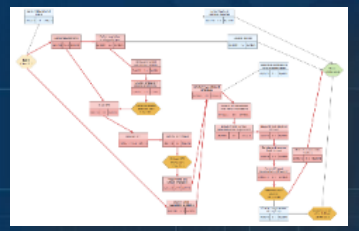
Our Journey…

CAD/CAM

1980s

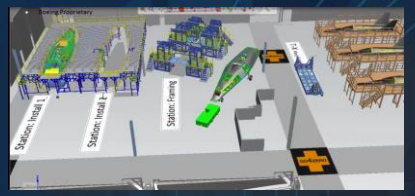
Model Based Definition

2000s



Model Based Systems Engineering

2010s



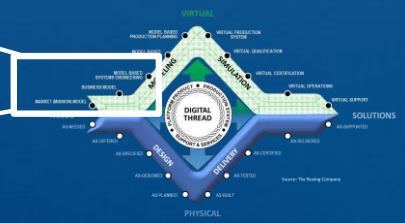
Model Based Enterprise

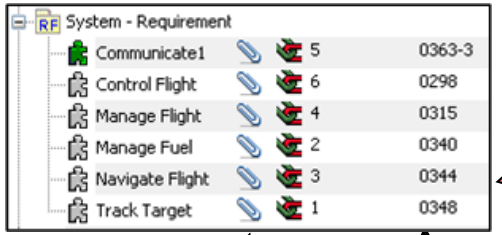
2025

Industry 4.0

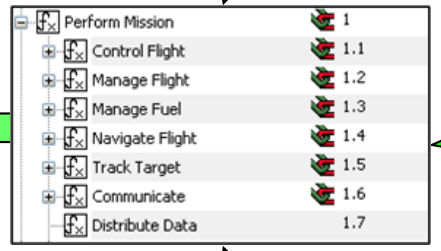
We are Here

Model Based System Engineering





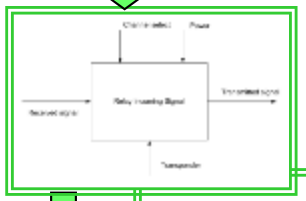
Requirements

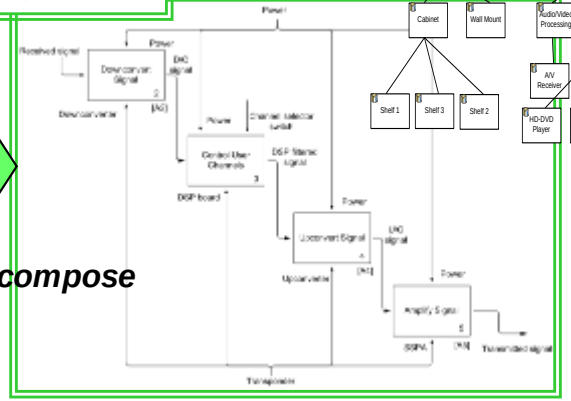


Functional Architecture
(What Has to Be Done)

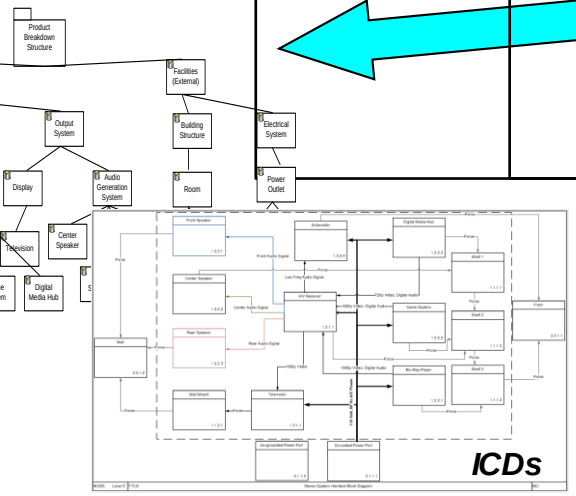
Logical Architecture
(How It Is Done)

Physical Architecture
(How It Is Implemented)





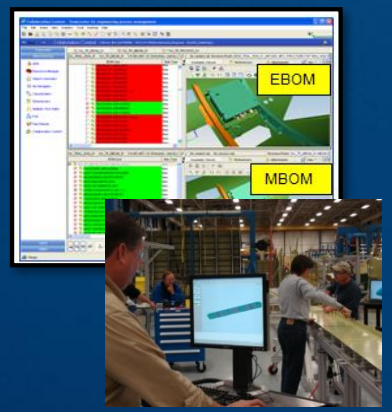
Decompose



ICDs

Production Systems

1st MBI
(F/A-18)



CH-47 MBI

J-UCAS MBI

A-10 TCMfg Integrated
EBOM/MBOM

Product and Process
Analysis

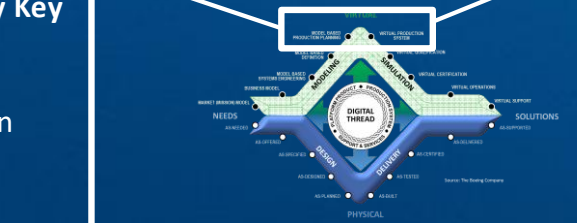
Augmented Reality

MBI in HoloLens

Big Data
Data Analytics

Program MBE Maturity Key
0-3 Digitized
4-5 Model Based
5-6 Industrial Champion

6	6	6
PDM	MBD	MBI



Immersive Work Instructions

PROP 5 5 5
F/A-18 5 5 5
CH-47 6 6 6
V-22 6 6 6
A-10 5 5 5
APACHE 5 1 2
P-8A 4 4 4
GMD 3 1 2
Harpoon 3 1 2
KC-46A 4 1 2
F-15 3 4 5
CST-100 3 5 5
777X 5 4 4
VC-25B 5 2 1
SLS 3 4 5
ORCA 4 4 4
T-7A 6 6 6
PROP 6 6 6
SLAM-ER 5 5 5
Defiant-X 6 6 6

2000 2001 2005 2007 2009 2010 2011 2012 2014 2016 2017 2018 2019 2020

Gathered
Operator WI
requirements

IPDM

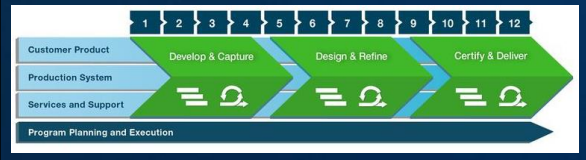
F-15 Mfg Analysis
"Safety Now!"

L+DBR

Start
Right

Gated Process

OBCM

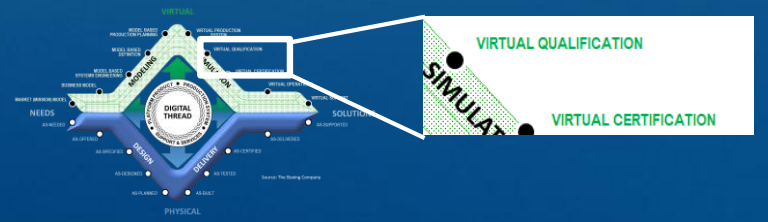


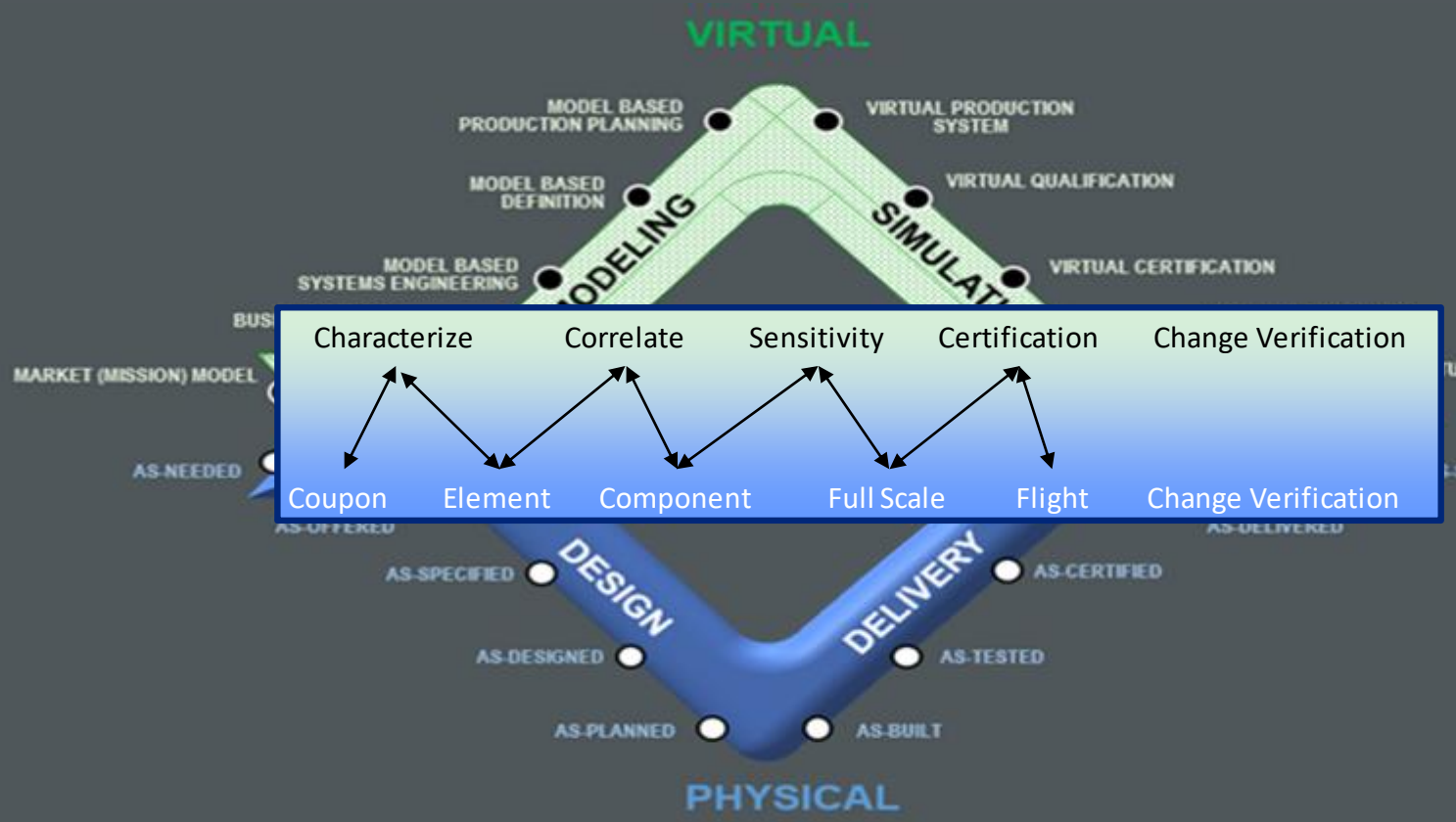
MBE – MBPP Taxonomy

Digital Twin / Digital Thread

Best Practices

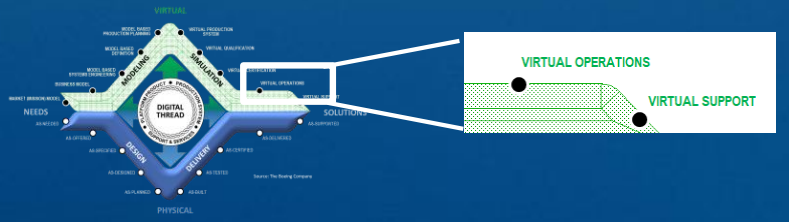
Analysis & Certification





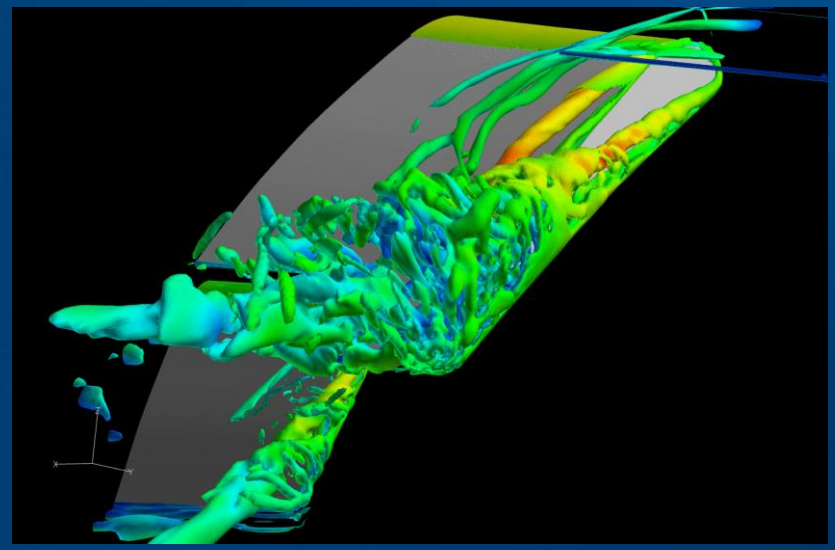
Full Scale	Sensitivities and Extremes
Component	Sensitivities and Extremes
Subcomponent	Sensitivities and Correlation
Element	Correlation
Coupon	Characterization

Operations & Support



Creating Digital Twins during operation

- Twins can only be created and maintained by weaving together the relevant threads
- The Operational Digital Twin needs to me maintained alongside its physical twin
- The amount and quality of the threads will determine the resolution of your twin
- The frequency or the data will determine how stale your twin is, but higher resolution means higher costs

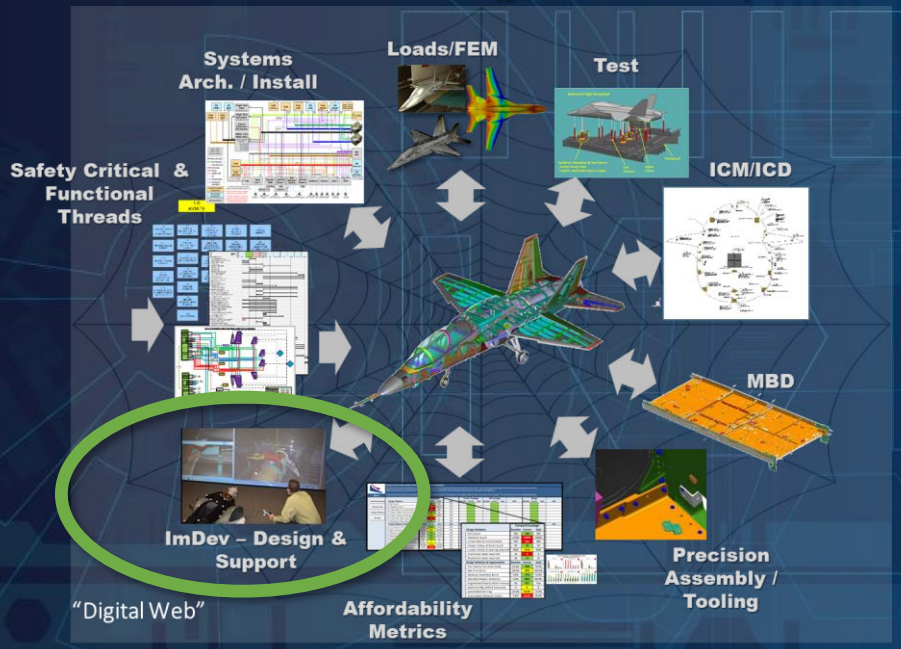


Value Of Using Operational Digital Twins

- Provide the current configuration of the monitored fleet
- An accurate starting point for simulation
- Understanding of the operational fleet at the individual aircraft or component level
- More accurate health management and RUL predictions
- Real world operational data can be used to validate and/or improve products.

The Boeing Immersive Development Environment (ImDev)

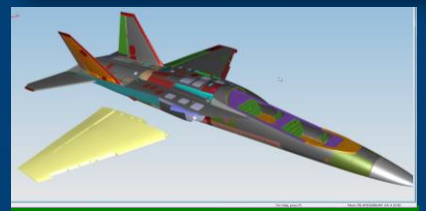
MBE 'Virtual' Digital Ecosystem



Digital and Connected

Immersive Collaboration

- Multidiscipline collaboration and visualization to identify / mitigate risks



Virtual Product Def'n

- Chartless design reviews
- Virtual product validation – 10X reduction in redesign/rework

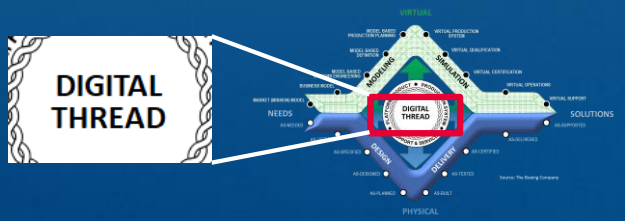
Virtual Manufacturing

- Virtual simulations identify design and manufacturing cost drivers, choke points and hazards to optimize technician productivity and safety

Digital Human

- Real-time ergo, producibility and supportability analysis to optimize productivity & safety

Digital Thread



Systems of Record

- Mission Model
- Virtual Production System
- Business Model
- Virtual Qualification
- MB System Engineering
- Virtual Certification
- MB Definition
- Virtual Operations
- MB Production Planning
- Virtual Support

Advanced Analytics

Global Data Access

Digital Thread Framework

Digital Thread Common Services

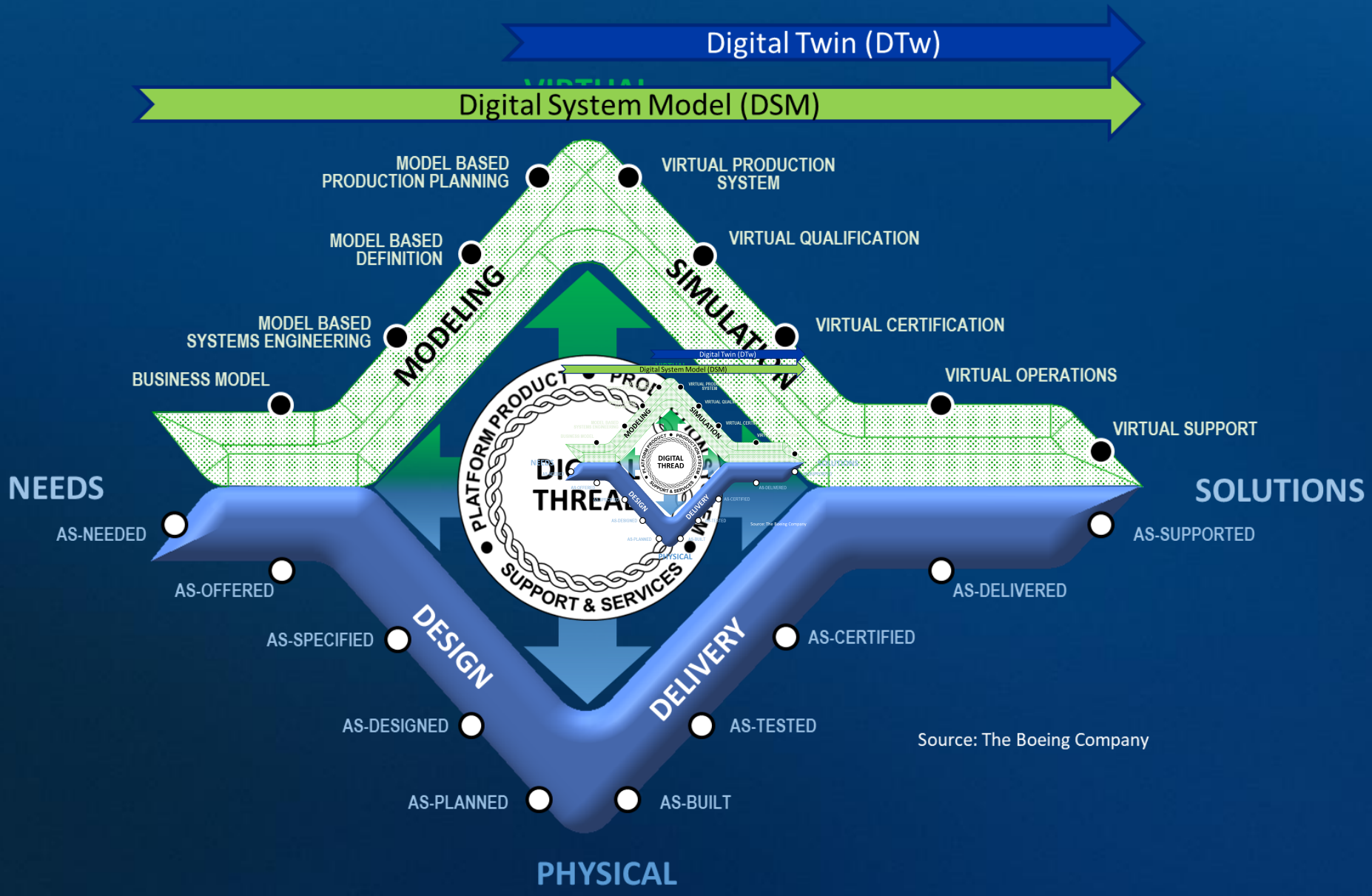
Digital Thread Infrastructure

Global Data Access

Digital Thread Applications

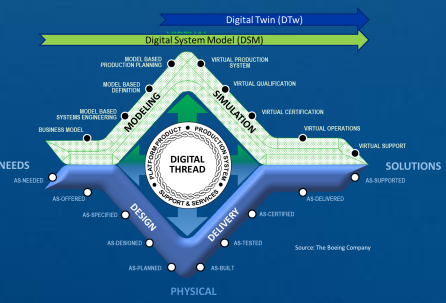
- Safety Analysis
- Production Analysis
- Operational Analysis
- Certification, Verification, Validation
- Many, Many More

Digital System Model / Digital Twin



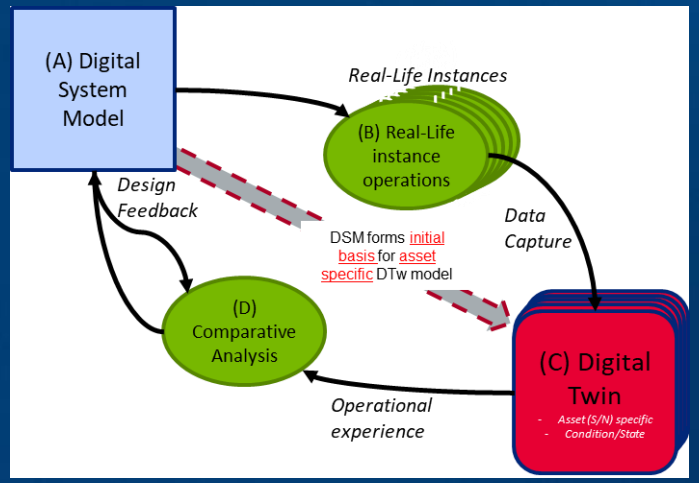
Source: The Boeing Company

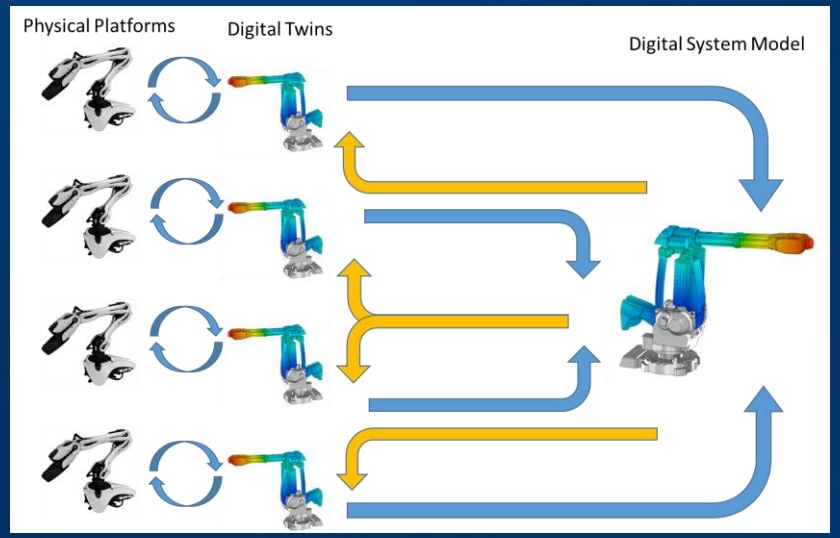
Digital System Model / Digital Twin



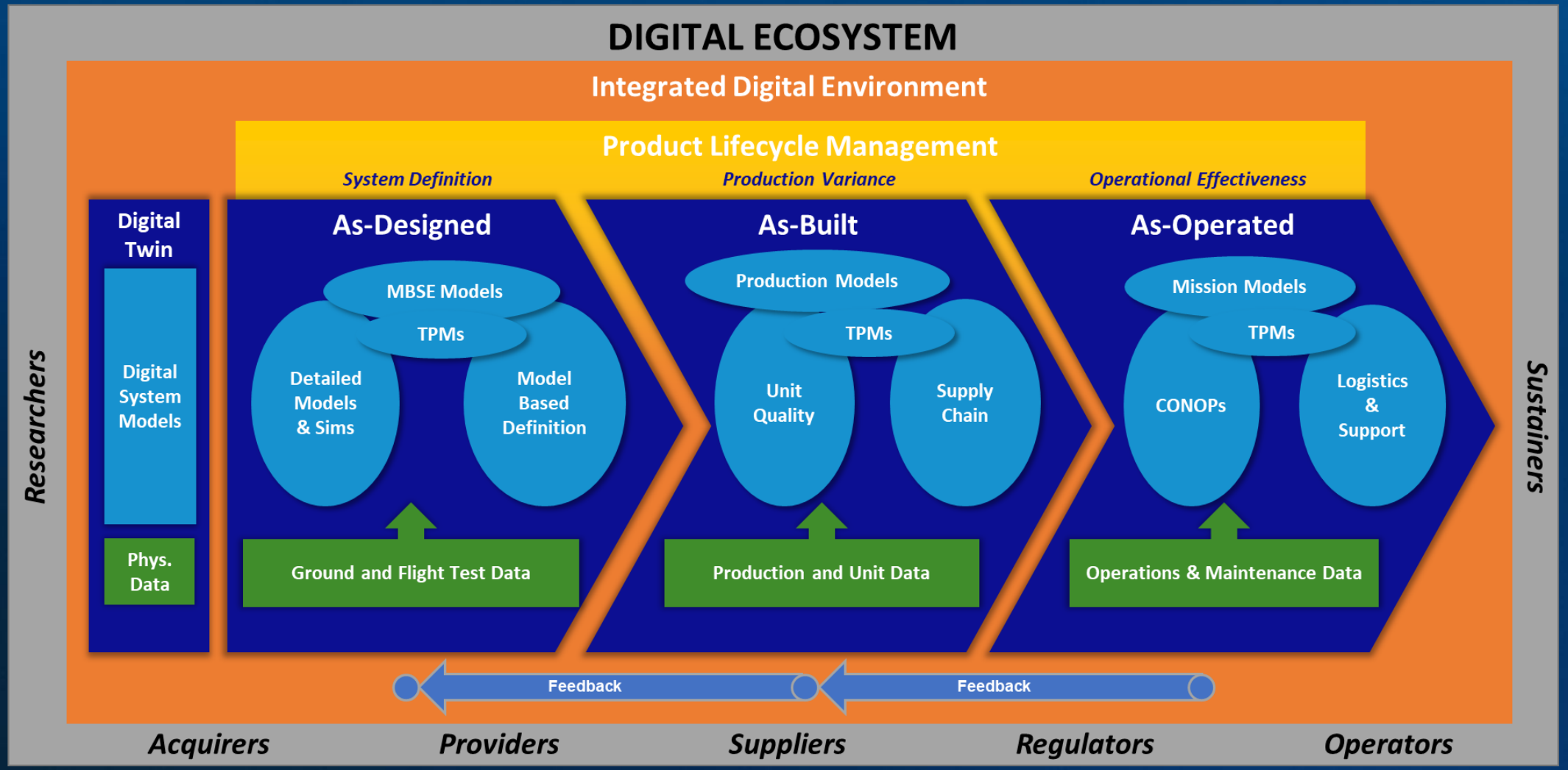
The **Digital System Model** (DSM) is a calibrated digital surrogate of a product, at the level of fidelity currently available that is intended to be the enduring, authoritative source of truth for data-driven decisions.

A **Digital Twin** (DTw) is a virtual representation of the properties and behaviors of a specific instance of a physical system or process that enables prediction and optimization of performance and maintains synchronization with that physical system or process through its operational life.





Digital Engineering Ecosystem



Data Standards

MBE Domain	Relevant Standards
Product Lifecycle Management	ISO 10303-239, ISO 10303-242
Model-Based System Engineering (MBSE)	ISO 10303-233, ISO 10303-239, FMI, HLA, OSLC, ReqIF, SysML, MARTE, Modelica, OWL, MoSSEC, Product Knowledge Framework, XMI
Model Based Definition	ISO 10303-242, ISO 14739 (PRC), ISO 10303-235
Model Based Production Planning	ISO 10303-238, ISO 10303-242
Product Analysis & Simulation	ISO 10303-209, HDF5, U3D
Production / Supply Chain Operations	X12, MTConnect, QIF, DMIS, 3MF, DITA, DocBook, PDF, ISO / IEC 8632 (CGM), ISO 14739 (PRC), ISO 10303-242, SVG, TIFF, ASTM F42, ISO 13399
Support and Services	ISO 10303-239, ISO 10303-242, iSpec 2200, Spec 2000 Chapter 2 - 5, Spec 2000 Chapter 9, Spec 2000 Chapter 11, Spec 2400, Spec 2500, S1000D, SX000i, EN/NAS_9300 (LOTAR), DITA, DocBook, PDF, ISO / IEC 8632 (CGM), ISO 14739 (PRC), SVG, TIFF
Financial Model	XCBL 3.5, X12 EDI
Test and Certification	ISO 10303-242, ISO 10303-239
Product Security, Software and Network	AADL
Product Support and Services Analysis & Simulation	ISO 10303-209, ISO 10303-242, ISO 10303-239
Electrical and Electronics	ISO 10303-210, ISO 10303-242

Questions