



Defining a Model-Based Definition (MBD) Maturity Model

MBE & QIF Summit 2026



Presenter:

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Model-Based Engineering

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Model-Based Definition lead developing the model-based standards strategy for NNS's digital evolution

- 12+ years in shipbuilding
 - Manufacturing
 - Instructor (GD&T Evangelist & MBD practices)
 - Design Engineering
 - Manufacturing Engineering
 - Model-Based Engineering
- DMSC Member
- ASME MBE, Y14 Member
- GDPT-2009 Senior Level



HII SHIPBUILDING DIVISIONS & PRODUCTS

NEWPORT NEWS SHIPBUILDING



Ford-Class
Aircraft Carrier
Programs



Submarine Programs
New Construction



Aircraft Carrier Refuelings
(RCOH) & Inactivation



**Submarine Onsite and
CVN Offsite Fleet
Support Programs**



**Engineering and
Planning Yard
Programs**



**Kenneth A. Kesselring
Site Operations**

INGALLS SHIPBUILDING



America-class
Large Deck
Amphibious Assault
Ships



San Antonio-class
Amphibious Transport
Dock Ships



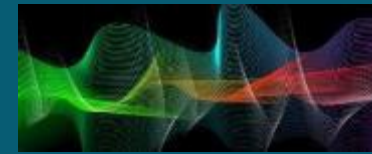
Arleigh Burke-class
Aegis Guided Missile
Destroyers



Legend-class
National Security
Cutters



MISSION TECHNOLOGIES



**Cyber & Electronic
Warfare**



**Live, Virtual,
Constructive Solutions**



Fleet Sustainment



**Nuclear &
Environmental Services**



**Intelligence,
Surveillance &
Reconnaissance**



Unmanned Systems





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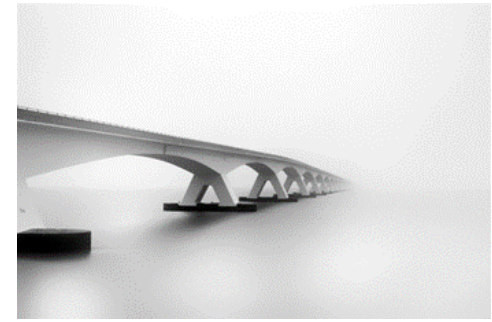
Defining a Model-Based Definition (MBD) Maturity Model



- Background & MBD Definition
- MBD Maturity Model Framework
 - Program Maturity Levels
 - Product Definition Dataset
 - Dataset Completeness Requirements
- Application of Digital Standards
- Summary / Next Steps
- Discussion



MBD Implementation Approach



The MBD Architect's Implementation Goal is:

To establish a governance framework that enables New programs to successfully author, exchange, and consume digital data by creating, exploiting, and managing a comprehensive test environment.

The MBD Architect's Objectives are to:

- Provide a common interpretation of product definition data across multiple organizations.
- Promote the use of models & authoritative sources to make better decisions across the lifecycle.
- Identify, organize, and implement a model-based standards framework for product definition.
- Provide a traceable data linkage between all the primary performers in the product definition standards identification, development, and testing efforts.
- Determine applicability and effectiveness of current industry standards and best practices to be considered for the a New Program.
- Define a process which supports Design for Distributed Manufacturing datasets.



MBD delivers Consistent Actionable Digital Data

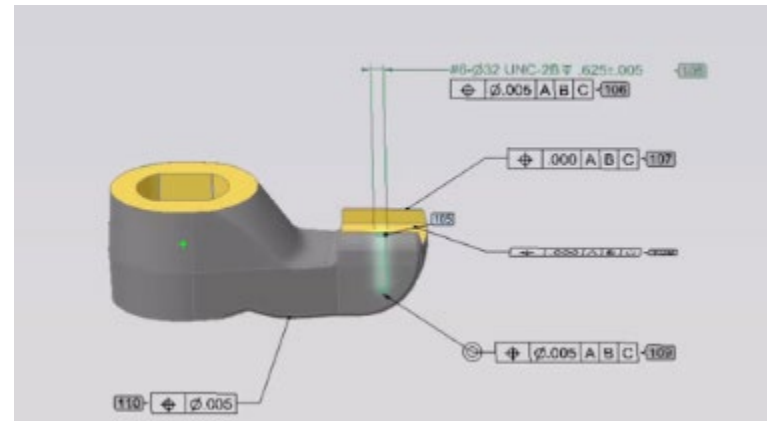
Model-Based Definition (MBD) is a key component of a Model-Based Enterprise (MBE) in which 3D models contain all the information necessary to replace drawing-based products.

The MBD information includes:

- ✓ Model behavior
- ✓ Shape definition
- ✓ Dimensions
- ✓ Tolerances & Materials
- ✓ Manufacturing definitions:
 - Weld call-outs
 - Assembly fit-up information

MBD Provides:

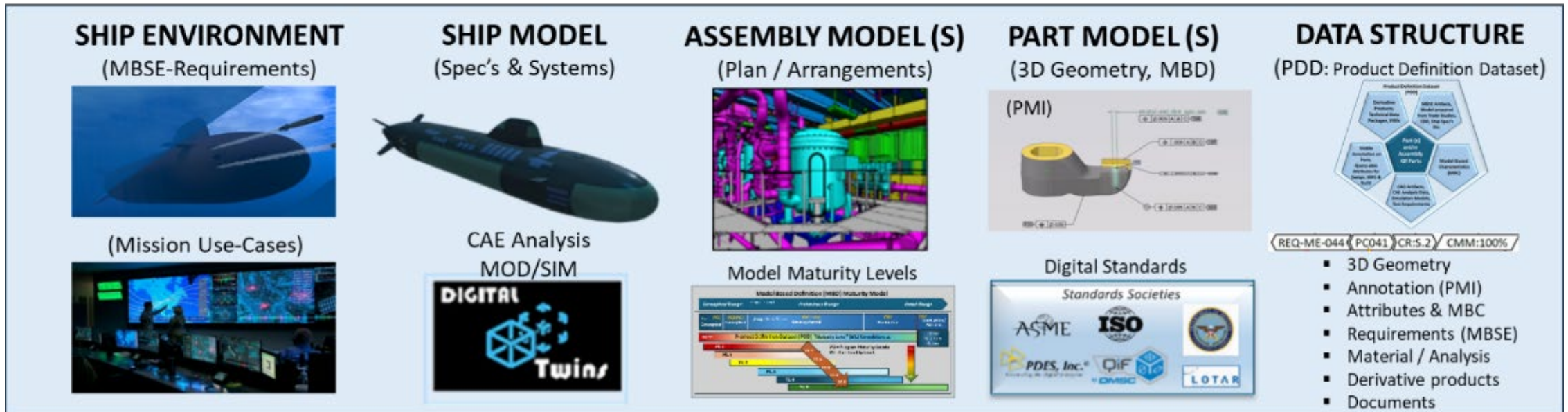
- ✓ Authoritative Source Data Traceability
- ✓ Neutral Interoperable Formats
- ✓ Preserved Feature ID's & Intent



Model-Based Definition (MBD) “ATOMIC LEVEL” Product Definition Dataset (PDD)

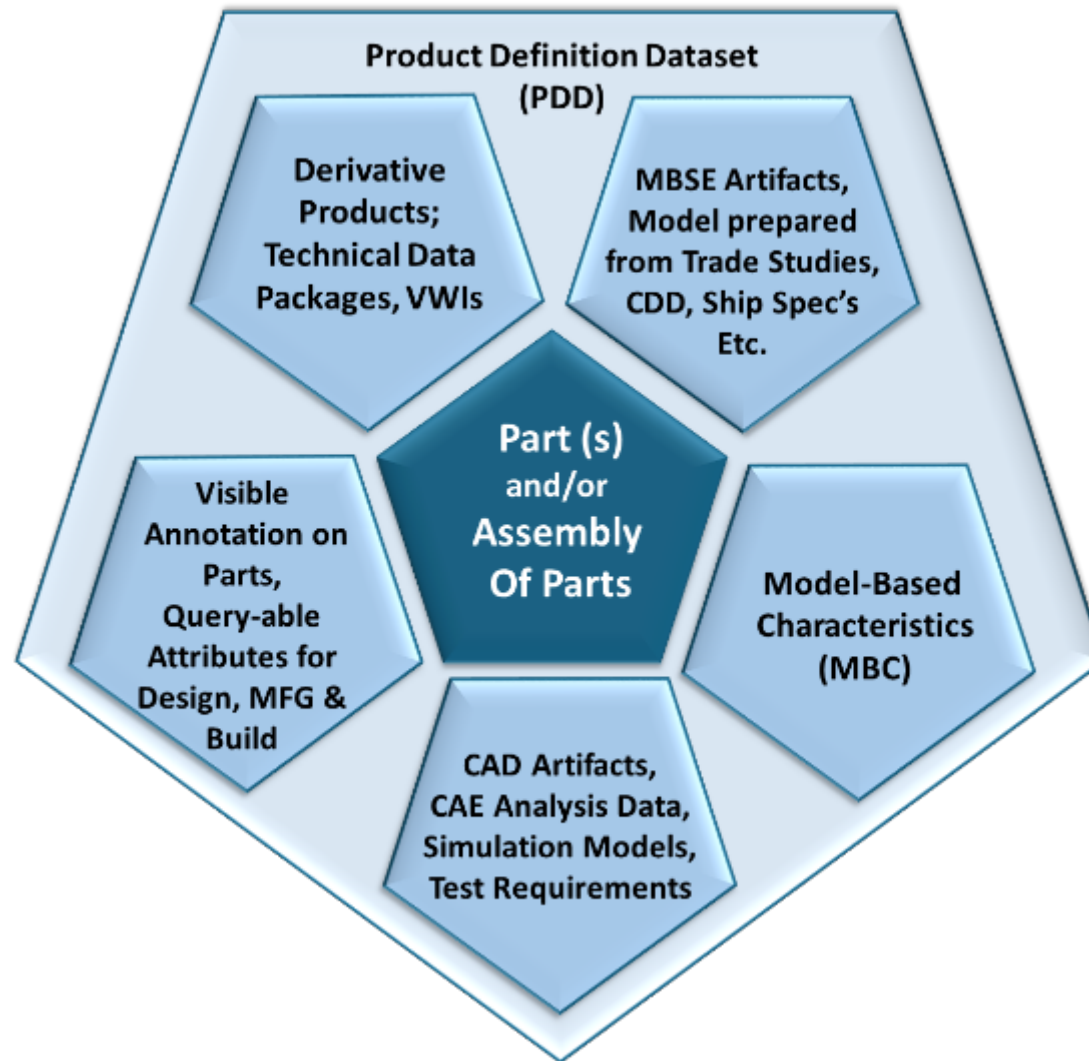


NNS will provide requirements traceability to the level Model-Based Characteristics allows.



MBD has Product Definition Datasets (PDD) at it's Core Structure

MBD Maturity Model Core - Product Definition Dataset (PDD)



The Product Definition Dataset (PDD) is a collection of one or more data file(s) that discloses, directly or by reference, by means of presentation (graphic or textual), representation (semantic or machine readable), or combination of both, the physical or functional requirements of an item.

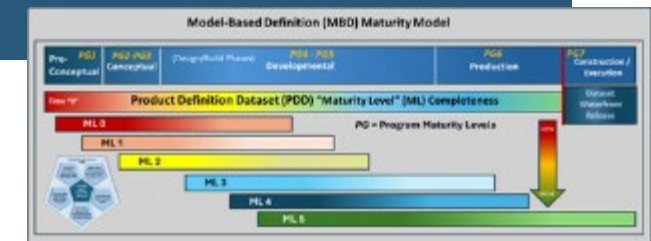


Product Definition Dataset (PDD) Objectives



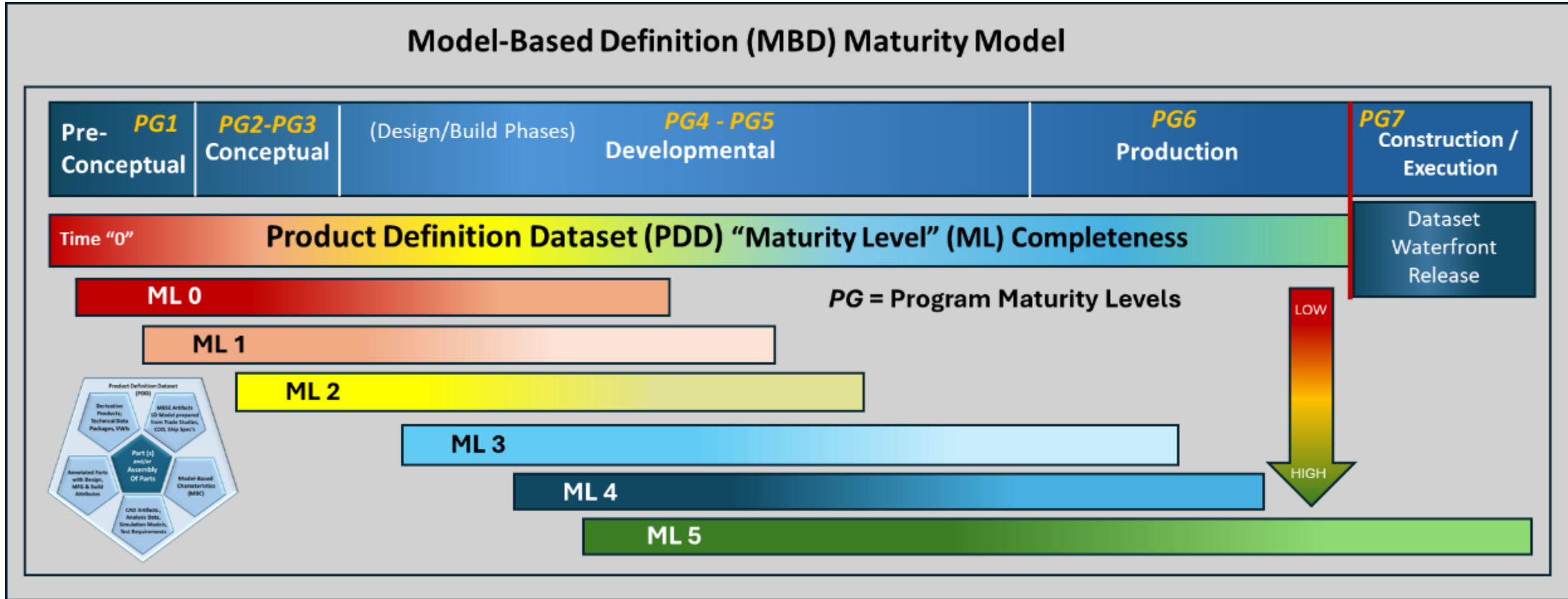
Objectives for defining Product Definition Dataset (PDD's) Maturity Levels:

- Replace drawing based status; number completed, with model-based maturity levels
- Align discrete part / assembly model PDD's with program milestones and decision points
- Generate status reports as needed from database object valuations
- More accurately status the design completion levels by zones & functional disciplines
- Provide early notification of design problems based on quantifiable parameters



MBD Maturity Model Framework

The MBD Maturity Model configuration manages dataset files that consist of individual components or an assembly of parts for the purpose of design through the product life cycle.



MBD Program Maturity Level Definitions



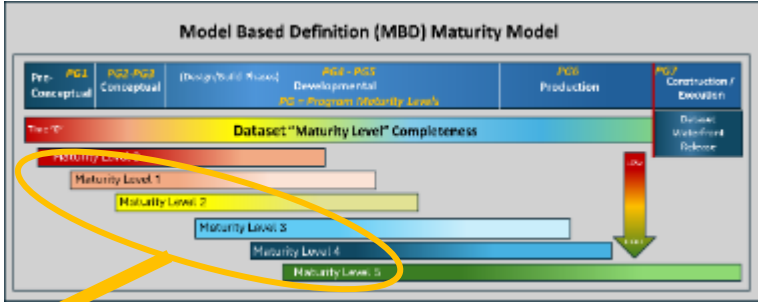
Maturity Level	MBD Program Maturity Level Definitions	Phase
PG 1	Is used for trade space analysis, studies and recommendations.	Pre-Conceptual
PG 2	Is used to verify preliminary design and engineering and to confirm that the technology is feasible and that the design concept has the potential to be useful in meeting a specific requirement.	Conceptual
PG 3	Is used for testing or experimentation and for the analytical evaluation of helping to create the baseline to attain the required mission performance .	Conceptual
PG 4	Is used for testing or experimentation and for the analytical evaluation of the inherent ability of the design approach to attain the required capability performance .	Developmental
PG 5	Supports the purpose of design, analysis, & procurement.	Developmental
PG 6	Is authorized to support the purpose of build (manufacture & install), test, inspection (Quality) processes.	Production
PG 7	Is used for the maintenance and sustainment lifecycles to develop as-produced, as-maintained, and archived models.	Construction/Execution

The MBD Dataset Completeness Requirements table below specifies the dataset maturity in relationship to the program phases.

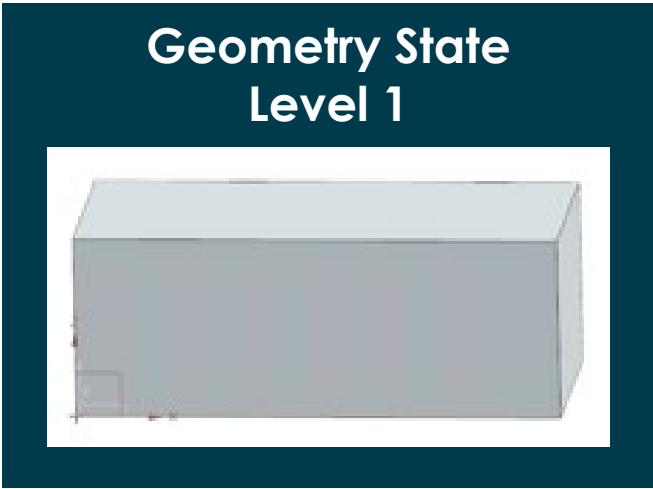


The Dataset Maturity levels (ML0-ML5) are comprehensive of the level below and sum to a fully completed state of ML5.

Product Definition Dataset Completeness Requirements
(levels 0-1)



ML0	Customer questions have been evaluated and assumptions documented in the dataset.
ML0	Dataset Concept designs via Use Cases have been developed.
ML0	Dataset Entrance/Exit criteria applied.
ML0	Dataset has been checked, reviewed, released (for archival purpose).
ML1	Dataset Concept designs from Trade Studies and Research & Development have been evaluated.
ML1	Dataset Concept designs incorporate Lessons Learned from other ship classes.
ML1	Dataset Entrance/exit criteria applied.
ML1	Dataset has been checked, reviewed, released (for archival purpose).

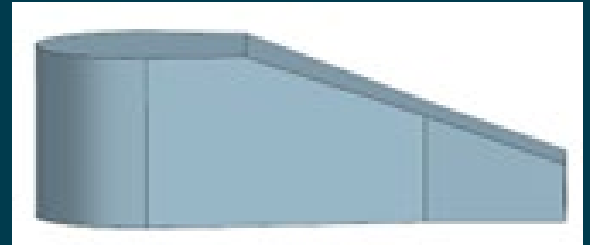


Product Definition Dataset Completeness Requirements

(level 2)

ML 2	Dataset contains preliminary concept design from Trade Studies and is arranged such that it can be used for analytical evaluation of the inherent ability of the design to attain the required performance.
ML 2	Dataset reviews/feedback from NAVSEA, MATL, DBST and Engineering with Comment adjudication completed and documented. Risk/Issues/Opportunities (RIO) be addressed during next subsequent level.
ML 2	Reliability and Maintainability Engineering: from program inception, the SSN(X) MBSE Method ensures Reliability and Maintainability (R&M) engineering is embedded in the system dataset.
ML 2	Dataset parts reflect preliminary (CFE) Make/Buy & GFE decision.
ML 2	Dataset Entrance/Exit criteria applied .
ML 2	Dataset has been checked, reviewed, released (for archival purpose) .

Geometry State Level 2

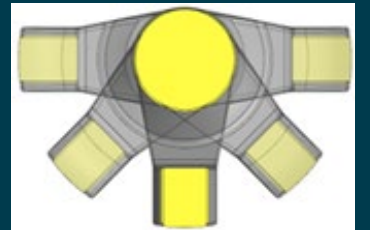
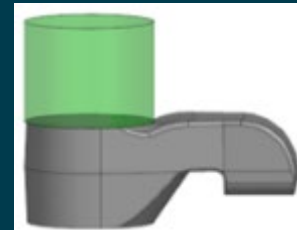
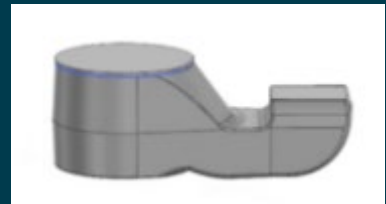


Product Definition Dataset Completeness Requirements

(level 3)

ML 3	Dataset reflects the down select of Trade Studies
ML 3	Dataset contains parts where the arrangement and location orientation <u>meets the intent of approved</u> ship specification .
ML 3	Dataset applies Industry Manufacturing Standards for producibility concepts and maximizes Design for Distributive Manufacturing -(DDM)-to support multiple Suppliers.
ML 3	Dataset utilizes human engineering concepts <u>ASTM F-1166</u> in modeling and arranging.
ML 3	Dataset reviews/feedback from <u>NAVSEA, SUPSHIP, MATL, DBST, Engineering, Planning</u> with Comment adjudication completed and documented. Risk/Issues/Opportunities (RIO) <u>to</u> be addressed during next subsequent level
ML 3	Dataset meets damage control, emergency, mission critical, fleet habitability, and safety requirements To include identification and development of Special Emphasis Program (SEP) <u>systems</u> .
ML 3	Dataset is related to the MBSE reqts, the decomposition of ship specification for traceability.
ML 3	Dataset validation of virtual prototypes to enable for testing, simulation and design <u>analysis</u>
ML 3	Dataset validation of high precision standard modeling practices are adhered to within the <u>tool</u>
ML 3	Dataset ensures design tolerances are adhered to which support design and construction <u>tolerance</u> .
ML 3	Dataset Arrangement is <u>finalized</u> .
ML 3	Dataset Entrance/Exit criteria applied.
ML 3	Dataset has been checked, reviewed, released (for archival purpose).

Geometry State Level 3

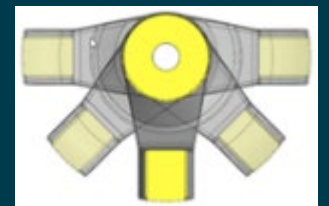
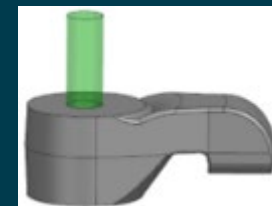
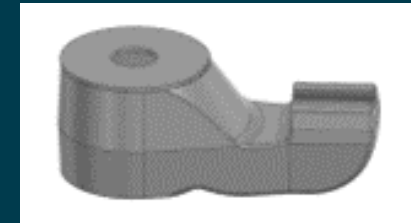


Product Definition Dataset Completeness Requirements

(level 4)

ML 4	Dataset equipment and distributive systems located per ship specifications & diagrams and will include but not be limited to: • System operability • Human interface • Survivability which also includes Special Emphasis Program (SEP) requirements • Build and test plan • Maintenance and access of equipment and system features • Planned removal of all equipment and system features for off-hull maintenance • Equipment interfaces (piping, electrical, HVAC, structure, etc.) • Shock/acoustic requirements • Walkways, ladders/grabs
ML 4	Dataset RIOs from the reviews/feedback have been addressed <u>with solutions</u> .
ML 4	Dataset incorporates all necessary analysis methodologies.
ML 4	Dataset required design, build & manufacturing attributes are <u>assigned</u> .
ML 4	Dataset has utilized Collision /Clearance software to ensure design tolerances are adhered to support construction tolerance.
ML 4	Dataset Entrance/Exit criteria applied
ML 4	Dataset has been checked, reviewed, released (for archival purpose)

Geometry State Level 4

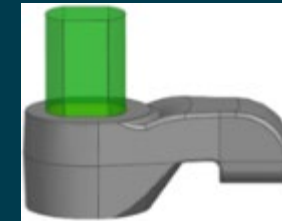
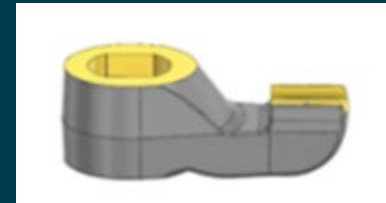


Product Definition Dataset Completeness Requirements

(levels 5-6)

ML 5	Dataset Approvals obtained via Tool Workflows.
ML 5	Dataset required design, build and manufacturing attributes are <u>finalized</u> .
ML 5	Dataset has been validated against MBSE technical requirements to validate against ship specifications.
ML 5	Dataset has all views developed with annotations, model-based characteristics (MBC) for certification to meet technical requirements, manufacture and build.
ML 5	Link Manufacturing dataset to the technical warranted dataset.
ML 5	Dataset has the TDP/VWI linked.
ML 5	Dataset has all artifacts linked.
ML 5	Dataset has all parts meet part maturity PF 5 .
ML 5	Dataset Entrance/Exit criteria applied.
ML 5	Dataset has been checked, reviewed, released (for approved baseline of ship)
ML 6	Dataset is being configuration managed for ship sustainment maintenance and upgrades.

Geometry State Level 5



Product Definition Datasets (PDD) Maturity Levels (Assemblies, Attributes & Annotation)

Below are example of Geometry and Annotation & Attribute State for Pump Assembly. This exemplifies a range from an assembly to the lowest level part for each PDD Maturity Level as required.

Note: The following State definitions were referenced from ASME Y14.47.

Geometry State:

G1=(none): the model that is created with no distinctions made for individual feature

G2=(partial): the model that has a portion of the features represented.

G3=(full): the model that has all features represented or simplified, which may require human interpretation of annotation or attributes for complete geometric definition

G4=(absolute): the model has all the features represented.

Annotation & Attribute State:

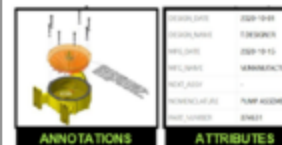
A1=(none): the dataset contains no annotation that defines the product requirements.

A2=(partial): the dataset contains a subset of all the annotation and attributes that define the product requirements

A3=(full): the dataset contains the annotation and attributes that define all product requirements.

A4=(presented): the dataset contains and displays the annotation (including items such as general notes and other product and manufacturing information) that communicates all product requirements without querying the model geometry, regardless of attributes.

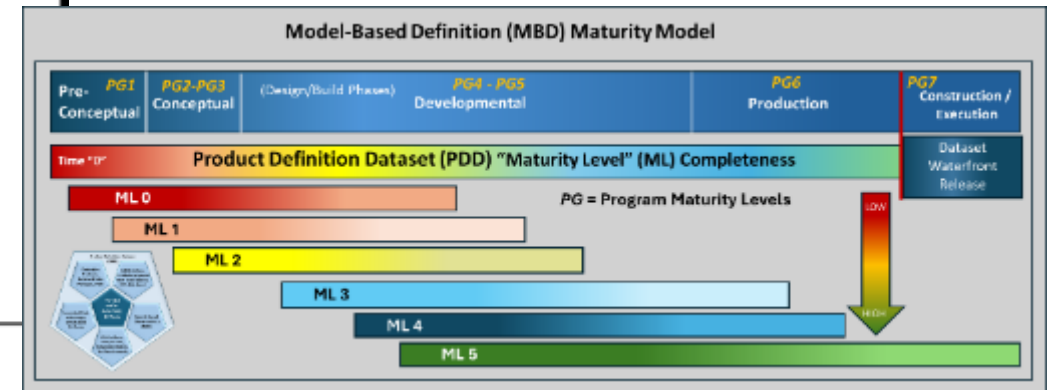
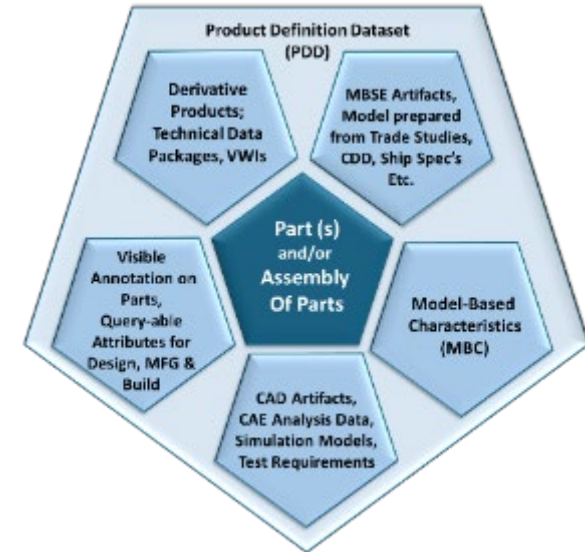
Level	Example	Geometry State	Annotation & Attribute State
ML 0	PDD ML0 Pump Assy. Primitive Spatial Reservation.	G1 	A1-none
ML 1	PDD ML1 Pump Assy. Few Features Added	G2 	A1-none
ML 2	PDD ML2 Pump Assy. Product recognizable with more detailed features.	G3 	A1-none
ML 3	PDD ML3 Pump Assy	G3 	A2-Provides sufficient presentation states to meet Arrangement Approval. Note: Could include welds, general connections & location etc. 

Level	Example	Geometry State	Annotation & Attribute State
ML 4	PDD ML4 Pump Assy	G4 	A3-Provides complete product definition, however requires the user to query the annotated model for features that do not have displayed annotation such as embedded attributes. 
			A4- Provides complete product definition. All annotations are displayed through the use of various presentation states without the need for user to query the model. 

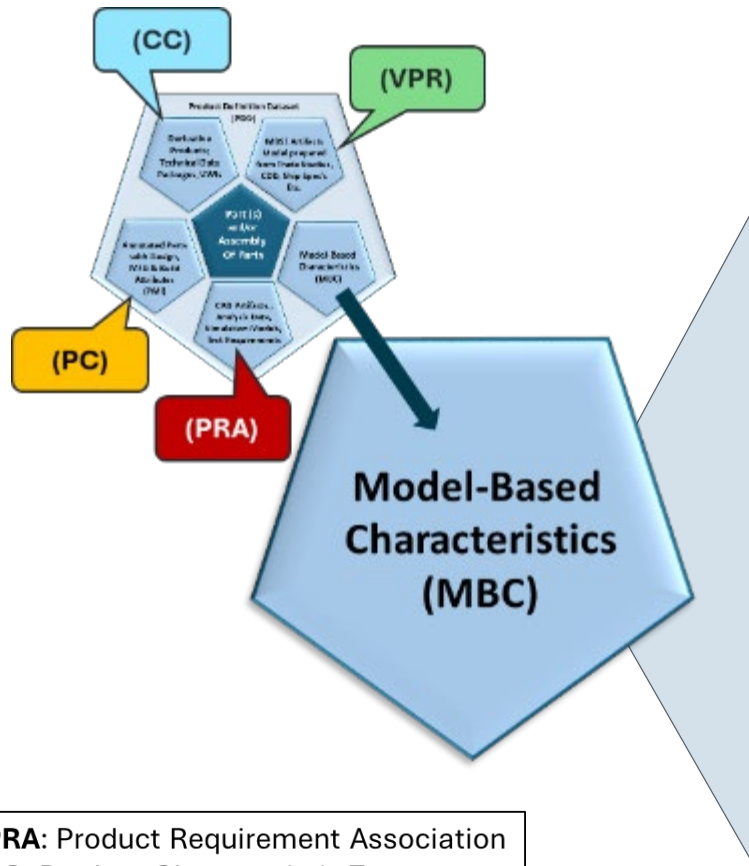
Level	Example	Geometry State	Annotation & Attribute State
ML 5	PDD ML5 Pump Assy	G4 	A3-Provides complete product definition, however requires the user to query the annotated model for features that do not have displayed annotation such as embedded attributes. 
			A4- Provides complete product definition. All annotations are displayed through the use of various presentation states without the need for user to query the model. 

PDD Composition Spreadsheet							
[wrt PDD Completeness Requirements and Part Fidelity Requirements]							
PDD Maturity Completeness Requirements		ML0	ML 1	ML 2	ML 3	ML 4	ML 5
PDD Composition Description							
MBSE Artifacts	Trades Study 1D Models	X	X	X			
	Use Case Study	X	X				
	Capability Development Doc (CDD)		X	X			
	Ship Specifications			X	X		
Part, Parts, Assy of Parts	Legacy Components	PF1	PF1				
	Developmental Model	PF1	PF1				
	Arrangement Model (DDM)		PF2	PF3	PF3	PF4	PF4
	Build-to-Print Component		PF2	PF2	PF3	PF4	PF5
	Engineering Component (DDM)		PF2	PF2	PF3	PF4	PF5
	Geometric weld part ¹				PF4	PF5	PF5
	Non-geometric part (NGP)			PF3	PF4	PF5	PF5
Model-Based Characteristics (MBC)	Product Requirement Association (PRA) ²				X		
	Product Characteristic Tag (PCT) ³				X		
	Criticality Classification (CC) ⁴					X	
	Verification Plan Requirement (VPR) ⁴					X	
CAD Artifacts	CAD Artifacts			X	X		
	Analytical Data			X	X		
	Simulation Model			X	X		
CAE Artifacts	Test Requirements				X	X	
	Annotations				X	X	X
Annotations & Attributes	Design Attributes				X	X	X
	Manuf Attributes				X	X	X
	Build Attributes				X	X	X
Derivative Products	Technical Data Package (TDP)						X
	Visual Work Instruction (VWI)						X
 Note ¹ Initial weld evaluation may begin in ML2. Note ² Reqs Management (MBSE) must be in place [Ref DMSC MBC Standardization 1.0]. Note ³ PMI is required to populate PCT. Note ⁴ Applies to manufacturing operations.							

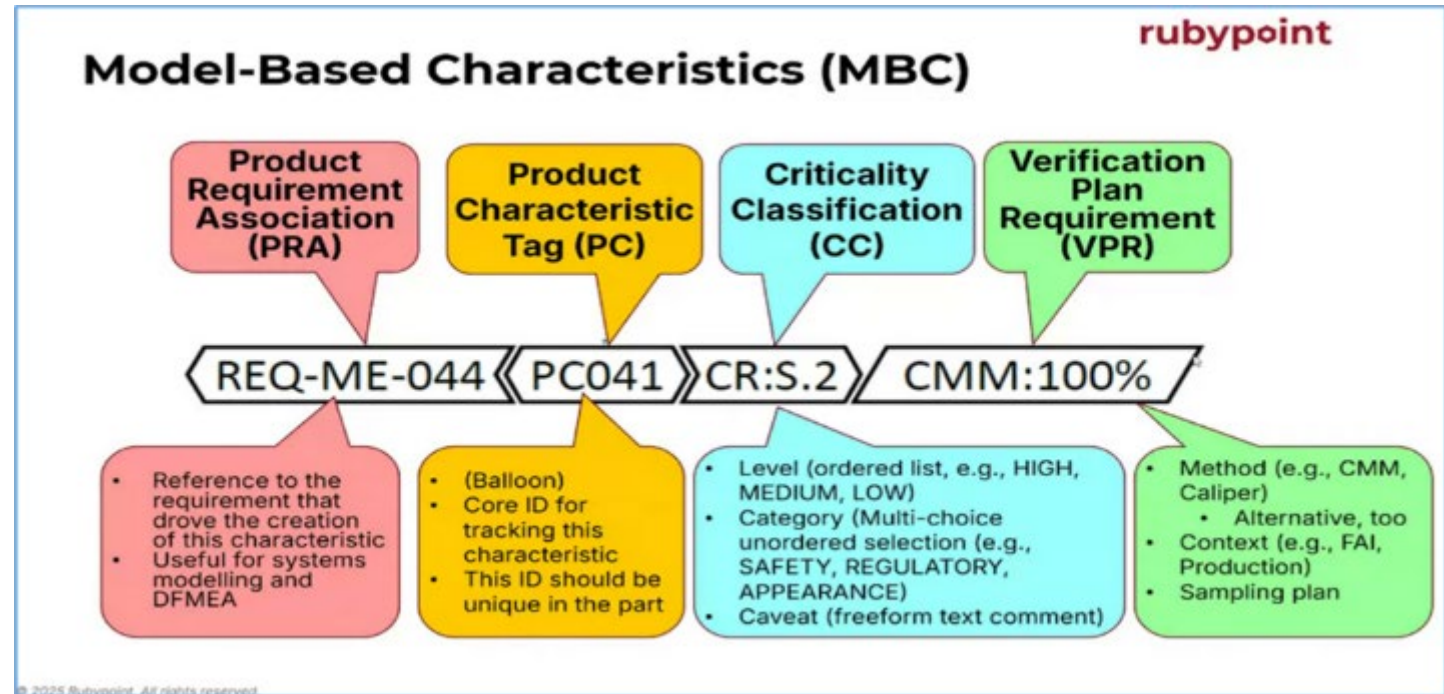
Sustainment



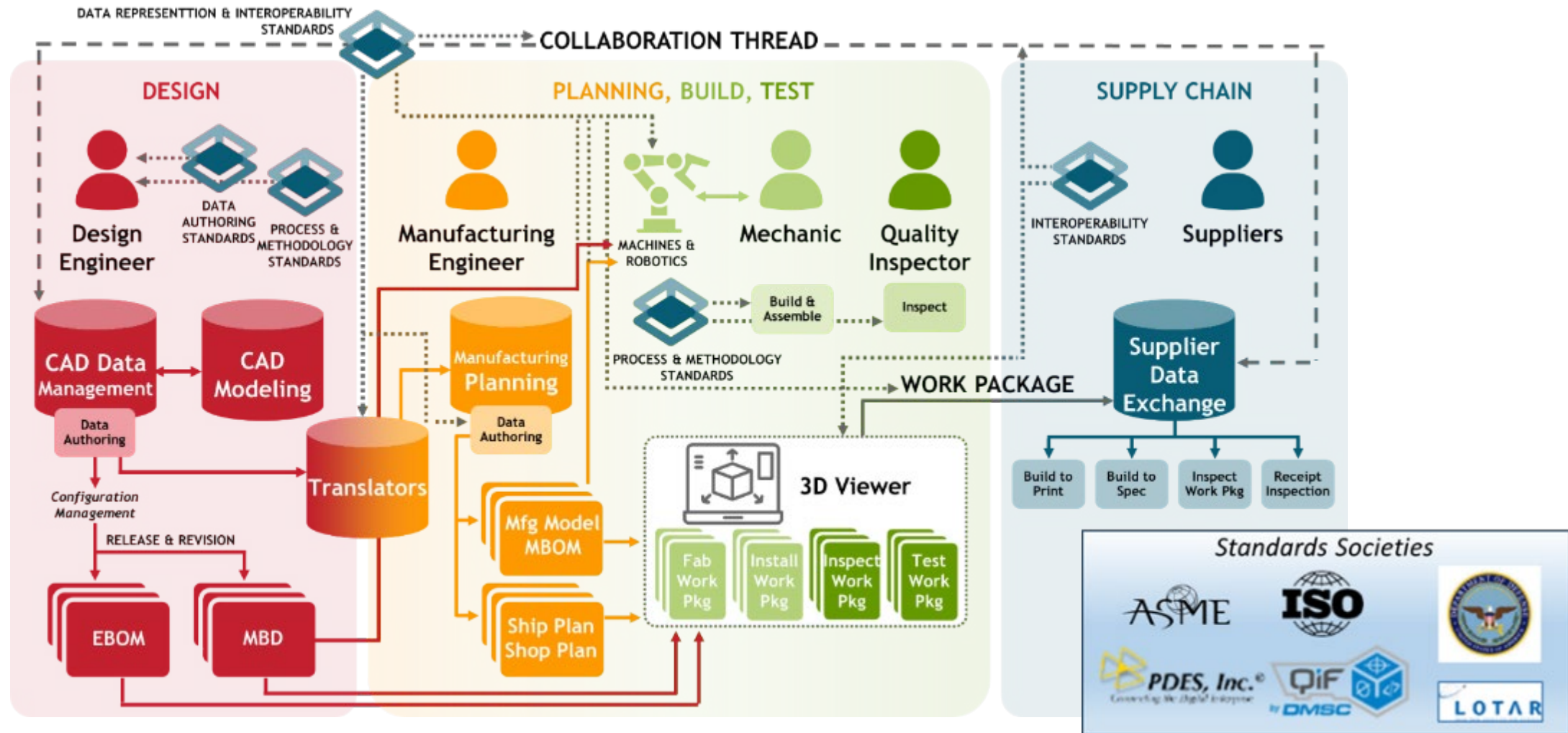
Model-Based Characteristics (MBC) alignment with the PDD



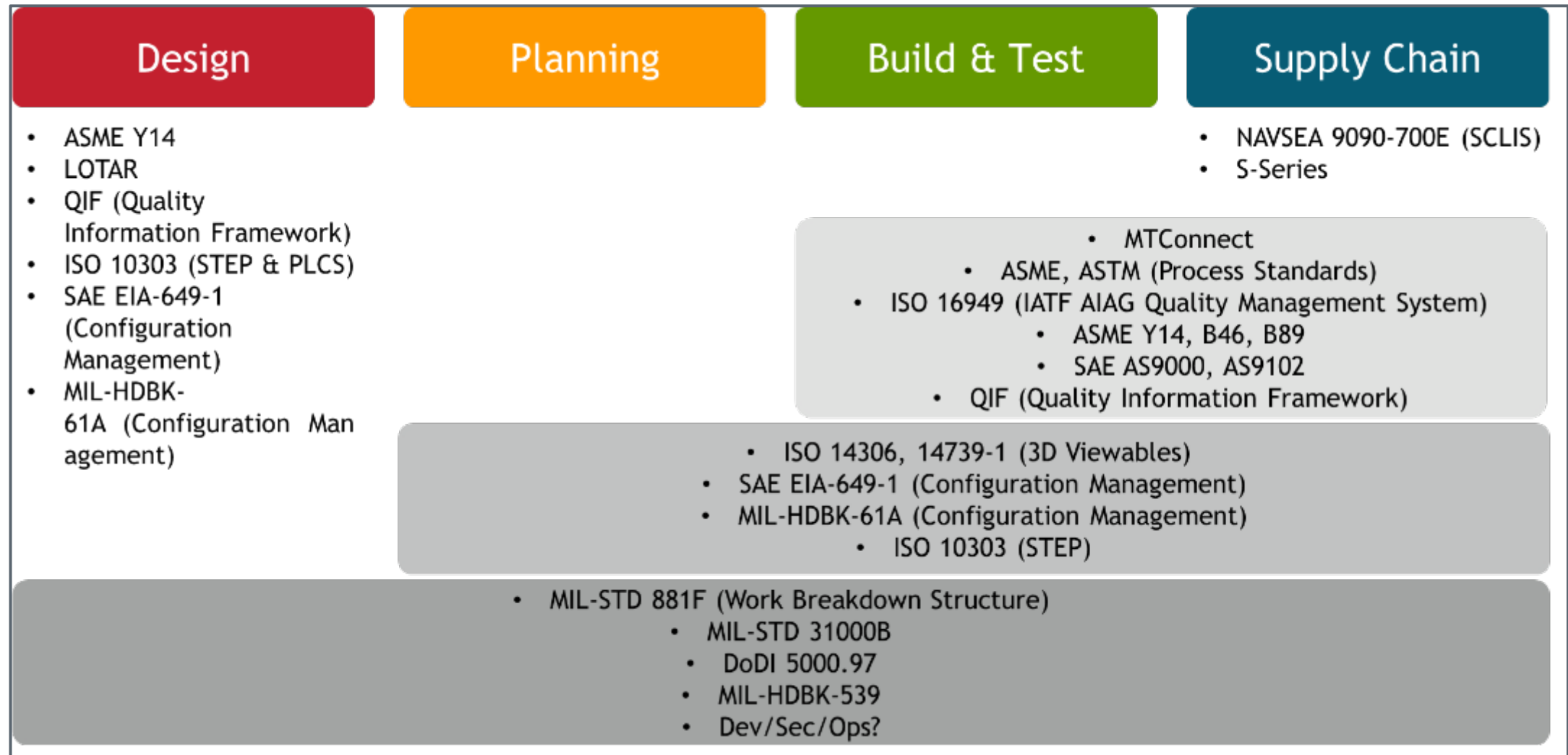
PRA: Product Requirement Association
PC: Product Characteristic Tag
CC: Criticality Classification
VPR: Verification Plan Requirement



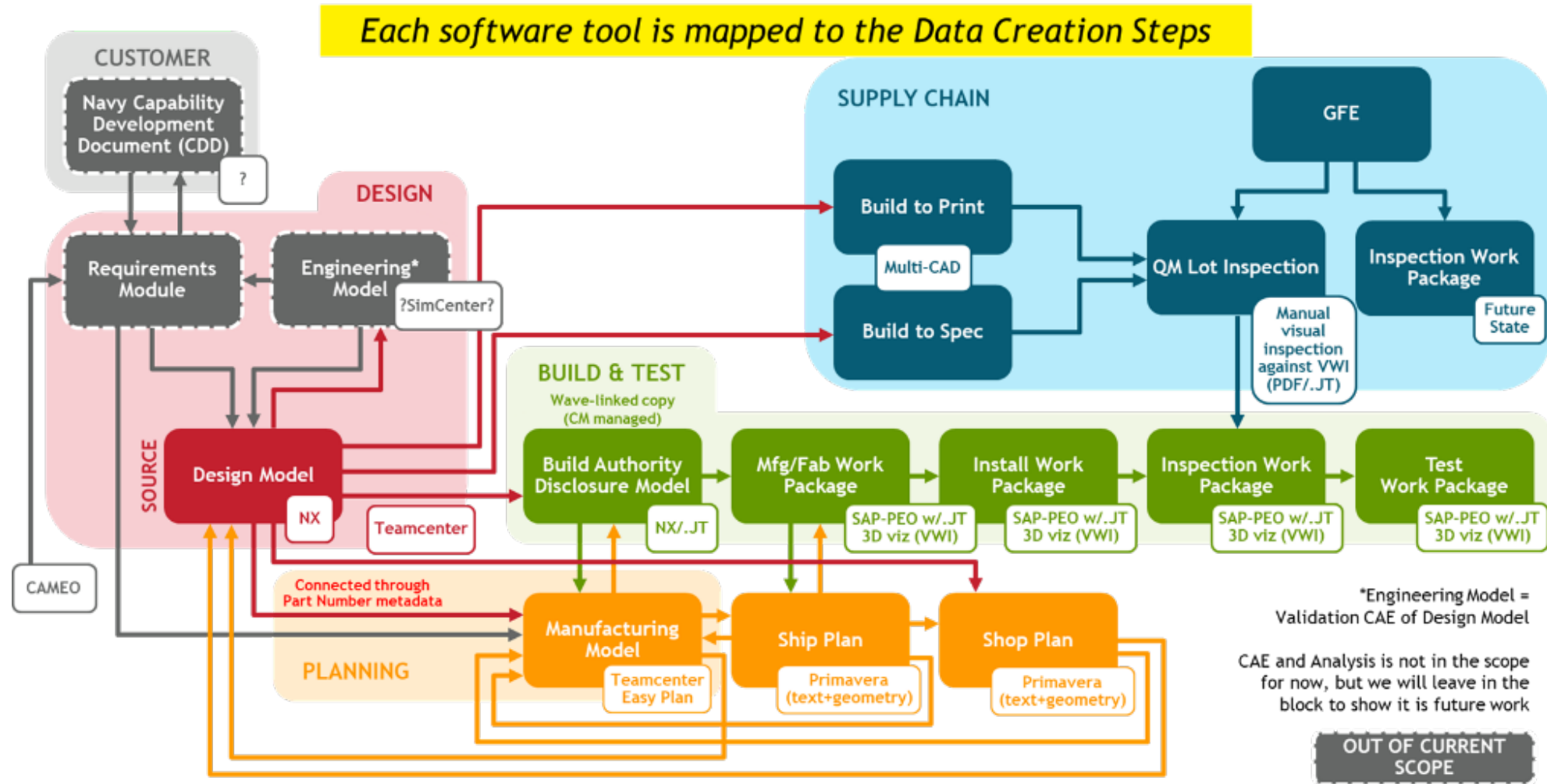
Digital Standards are Integrated over the Lifecycle “Processes”



MBD Standards assigned to the Lifecycle Phases



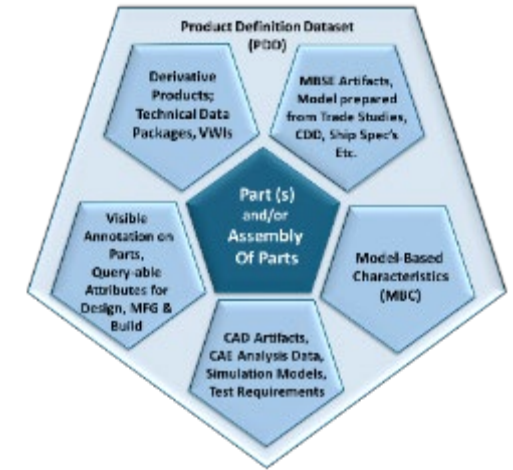
Digital Standards are Mapped across the Value Stream “Tools”



Summary: We strive for Dataset Interoperability

The MBD Maturity Model configuration manages data set files that consist of individual components or an assembly of parts for the purpose of design through the product life cycle.

Establishing Phases for the MBD process enables setting realistic achievements, measuring progress, and collecting feedback over a manageable window for each phase.



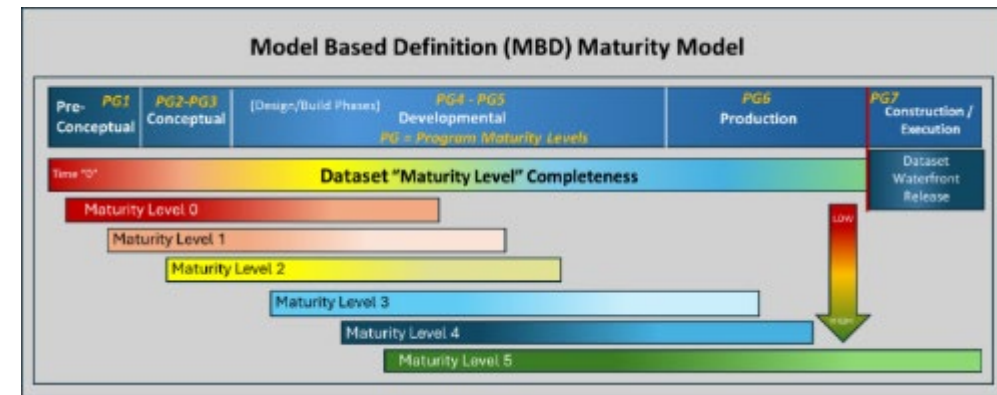
Next Steps:

Execute Complex Pilots

Define PDD Lower Level Requirements

Integrate Model-Based Characteristics (MBC)

Plan Implementation & Automation



Defining a Model-Based Definition (MBD) Maturity Model



Thank You for your attention. Discussion...

