Integrated Digital Shipbuilding

## "Concept of Operations" for a "Model Based Enterprise"

NIST MBE Conference
April, 2017 Gaithersburg, MD

Prepared by:
Mark Debbink
Newport News Shipbuilding

Digital Thread
"Information Connected Digital Enterprise"

Newport News Shipbuilding

Scoping & Estimating

Concept Design

Arrangement Design

Detail Design

Production Planning

Manufacturing Engineering

Supplier Integration

Requirements

TECHNICAL AUTHORITY

PMI

EBOM

PBOM

BUILD AUTHORITY

3D Model

CAE Analysis

Visual Work Instructions

Work Packages

Information Architecture Backbone

Fabrication, Assembly

Requirements Validation

Connecting People, Processes, & Information

"NNS's Shipbuilding Digital Thread"

Disposal Work Package

Execution Work Documents

Availability Planning

Technical Manuals/Documents

Close-Out Work Certification

Test & Inspection

Decommission

IN-SERVICE (LIFECYCLE) AUTHORITY

Ship Delivery

Maintenance, Modernization & Repair

In-service Operations

(Ship Force)

Model Base Enterprise (MBE)
"Maturity Capability Levels" NIST.org

Level 6
- Model Based Enterprise
- Integrated Manufacturing – Integrated Extended Enterprise
- Primary Deliverables Digital Product Definition Package and TDP via the web

Level 5
- Model Based Enterprise
- Integrated Manufacturing – Integrated Internal Enterprise
- Primary Deliverables Digital Product Definition Package and Technical Data Product (TDP)

Level 4
- Model Based Definition
- Integrated Manufacturing – Disconnected Enterprise
- Primary Deliverables 3D Annotated Model and Light Weight viewable via PLM

Level 3
- Model Based Definition
- Native Model CAM – Disconnected Enterprise
- Primary Deliverables 3D Annotated Model and Light Weight viewable

Level 2
- Model Centric
- Native Model CAM – Disconnected Enterprise
- Primary Deliverables 2D Drawing and Native CAD Model

Level 1
- Model Centric
- Neutral Model CAM – Disconnected Enterprise
- Primary Deliverables 2D Drawing and Neutral CAD Model

Level 0
- Drawing Centric
- Disconnected Manufacturing – Disconnected Enterprise
- Primary Deliverables 2D Drawing
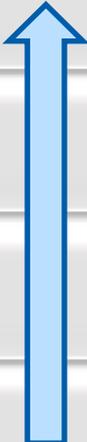
Business Process Productivity and Efficiency Improve when Moving Up the Capability Levels

TA - Engineering & Design Processes

(Technical Authority - TA)

"*Integrated Digital Shipbuilding*"

Decision Authority:
Technical Authority – **(TA)**
Build Authority – **(BA)**
In-Service Authority – **(LA)**

➢ **Denotes Model Based Enterprise (MBE) capabilities**

---

1 Initialize Ship Environment

➢ **Establish IDE; Customer, Vendor Interface**
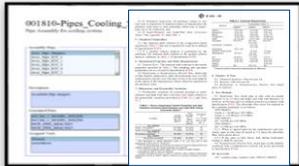
- Set-Up Project environment (IT; HW/SW database, etc)
- Set-up data and Security Models
- Set-up parts Catalogs
- Define configuration (effectivity)
- Track/link ORD requirements
- Define contract type; TA, BA or sequential
- Identify tool interfaces
- **Establish collaboration IDE**

2 Develop Concept Design

➢ **Enable data workflow, standardized reporting**
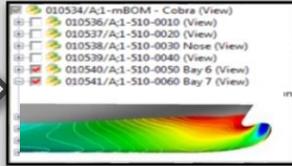
- Set-up parts Catalogs
- Define configuration (effectivity)
- Establish Hull form
- Conduct analysis (systems)
- Develop modeling schedule
- Set-up ship reference grid, decks & bulkheads, molded conventions, etc.
- Place structure, major eqpt, GFI distributed systems, passage volumes
- **External customer view access**

3 Develop Arrangement Design

➢ **3D Model product definition & quality validated during creation using PLM based tools.**

- Finalize hull form
- Conduct 3D Arr. level part modeling, access and removal paths, space reservations, tanks, etc.
- Conduct initial base level planning (BA)
- Define view partitions/groups
- Create workflow for process review
- Conduct analysis, FEA, Wt & CG…
- Extract material forecast (BA)

4 Develop Detail Design
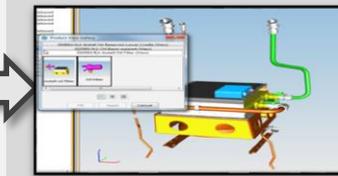
- Finalize design 3D piece parts
- Apply welding joints
- Finalize base level planning (BA)
- Extract list-of-material (long-lead) (BA)
- Conduct design reviews
- Gain Customer approval
- Lock design models
- Create standard product reports

5 Load (TA) PMI for Detail Design

➢ **Model Based: All Configuration Mgt. processes from PLM.**

- Configure TA PMI Libraries & Catalogs
- Create Weld symbols catalog, inspection requirements
- Create dimensions format
- Define notes catalog

---

6 Develop ShipBOM / Material List
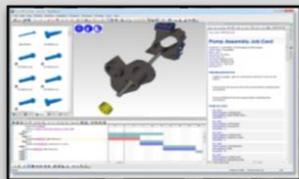
- Auto report SBOM / Material List
- Planning create Base group structure assign events & milestones (BA)

7 Develop (TA) Part and Assembly PMI Views

➢ **Start Compartment Level Management**
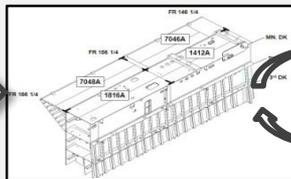
- Author PMI GD&T objects base on (TA) rules
- Author text instructions
- Reuse standard text fragments from library
- Coatings & coverings
- Add symbols, collection data fields
- Define part view groupings/partitions

8 Add Reference Documents to Data Base

Iterative Processes

- Add specification documents & procedures as attachments to the Technical Authority
- Add reference documents – Mil-Specs, inspection criteria, etc.
- Add deviation and waver documents

9 Validate (TA) PMI

➢ **Model contains complete product definition in PMI.**
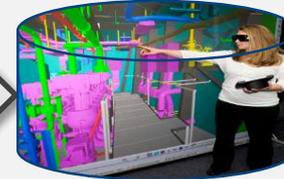
- Perform Validation Activates for TA data.
- Perform PMI variation analysis
- Save PMI and lite weight Context
- Object removal paths, pull space, human ergonomics
- External customer share/access

10 Release (TA) Models to (BA) for Mfg & Assy

- Complete Check lists and Run reports; Wt & CG, holdups, etc.
- Configure(BA)partition/views build planning
- SBOM released
- Lock TA files and prepare for (BA) use
- Technical data is exported and delivered to (BA) customer
- Release TA products & deliverables

BA - Engineering & Design Processes

(Build Authority - BA)

"Integrated Digital Shipbuilding"

11 — Configure (BA) for Mfg & Assy

- BA System set-up, user roles-access
- Receipt and validation of customer & TA outputs
- BA objects are defined, Data & Security model updated

## 12 — Develop (BA) Plan 3D Geometry & PMI
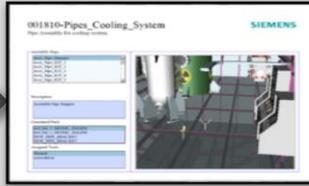
- BA plan & schedule development; (high, intermediate, and detail levels
- 3D Geometry Mfg/Assy; CAM model development, files linked/associated to TA for change notification workflow
- Develop temporary support, jigs & fixtures, lifting pads, etc.
- Generate appropriate (BA) PMI

13 — BOM Management

➢ **Model Base Work Instructions Automation based on model features and PMI.**

- Build BOMs according to functions
- Modify product structure according to manufacturing needs (shop movement)
- Add manufacturing specific parts (consumables, interim parts, ect.)
- Define configuration (effectivity)
- Enable Form, fit, function change notification

14 — Define/Create Work Packages

➢ **CNC data based on and checked to 3D model, update notification enabled.**
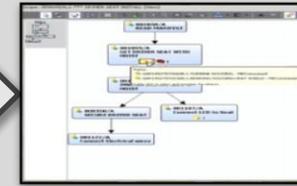
- Perform business management activities; Charging, work centers, network association.
- Author processes and sub-processes
- Author operation steps
- Assign consumed parts to operations
- Add resources (tools & fixtures)
- Define sequence of events
- Test & Inspection requirements
- Define CAM requirements; NC data, pipe bending, etc.

15 — Create Visual (2D & 3D) Work Instructions (VWI)
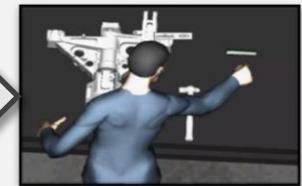
- Attach 2D images, insert text instructions, add symbols
- Create (optional) animations & simulation for documentation when of complicated assemblies
- Create Product Views (3D snap shots, add mark-up, show PMI, set view points, color)
- Embedded 3D Visualization

16 — Assembly/Release Work Packages

➢ **Smart model recognition routines provide automation of work instructions.**
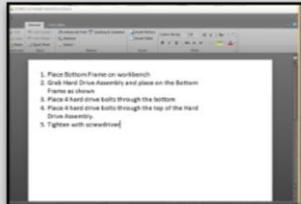
- Associate BOM and Visual work instructions to work packages
- Publish BA Work Instructions
- Develop planning & execution products & deliverables (LA)

17 — Manufacture Products
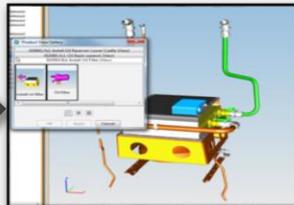
- Perform manufacturing operations, Trades execute work
- Add documents / attachments to operations, such as operation sheets
- Add reference documents – safety plans

18 — Assemble Products

- Perform assembly operations, Trades execute work
- Add documents / attachments to operations, such as operation sheets
- Add reference documents – safety plans

19 — Perform Test Activities

➢ **3D Models, products and process definition accessed from workstation computer.**

- Visual Test Instructions, Model based Test & Inspection
- Trades execute work

20 — Close-Out / Work Certification

➢ **3D Models, products definition available**

Ship Commissioned

- Close-out transactional work activities
- E-signatures added to documents
- (TA) develops and delivers technical manuals for ship In-Service Maintenance

LA - Engineering & Design Processes

(In-Service Authority - LA)

"Integrated Digital Shipbuilding"

---

21 — Utilize 3D models (TA+TVD's)

➤ **3D Models, products definition available to Navy Stakeholders.**

- Define configuration (effectivity)
- Integrate TVD changes with TA as-designed model
- Receipt of Customer & BA outputs
- Executing (Build) organization identified

Concept Studies

2 → Execute Activities as applicable → 10 **Provide Models for LA review**

22 — Perform In-Service Modernization/Maintenance "Logistics"

➤ **Laser scanning and Augmented Reality practices support shipboard configuration to product model configuration verification.**

Ship Maintenance Availability

- Execute planning yard, fleet activity work and Operational support

23 — Perform 3D Virtual Ship Checks

- Finalize 3D model geometry to reflect Ship at-sea configuration
- Laser scanning, digital photogrammetry / Ship check data incorporated into 3D model
- Reconcile 3D model complete (Proofing)

24 — Receive Availability Work Package (AWP)

- Finalize decisions on work content applicability and perform planning activities
- Define required materials, resources and work content time estimates
- Extract Technical Data to create Work Package

25 — Update Environment for (LA) Development

- Verify data and security models to support LA view of the data
- Show PMI, set view points, color, etc.
- Parts catalog updated
- External Customer exchange access
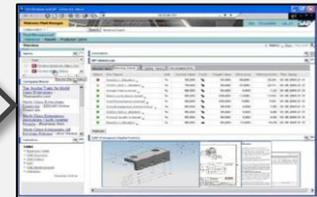
---

26 — Perform (BA) Mfg & Assy Activities

- Perform/Execute Authorized Work

12 → Execute Activities as applicable → 20

Develop (BA) Plan 3D Geometry & PMI — **Close-Out / Work Certification**

Ship to Sea

27 — Perform Availbility Planning (LA)

➤ **Automation used for Tech. Manual creation using data and image mining.**
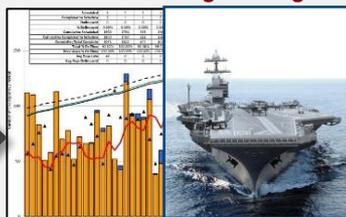
- Update Models

21 → Execute Activities as applicable → 25

Develop As-Built 3D model (TA+TVD's) — **Work Disclosure to (BA) - Navy**

Ship to Sea

28 — Perform Refuel Complex OverHaul (RCOH)

or other availability(BA)

- Perform/Execute Authorized Work

12 → Execute Activities as applicable → 20

Develop (BA) Plan 3D Geometry & PMI — **Close-Out / Work Certification**

29 — Perform Availbility Planning (LA)

➤ **3D Models, products definition available on-board In-Service ship.**

- Update Models

21 → Execute Activities as applicable → 25

Develop As-Built 3D model (TA+TVD's) — **Work Disclosure to (BA) - Navy**

30 — Decommission Ship Activities (BA)

- Perform/Execute Authorized Work

13 → Execute Activities as applicable → 15 20

Develop (BA) Plan 3D Geometry & PMI — **Close-Out / Work Certification**
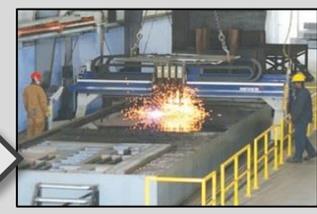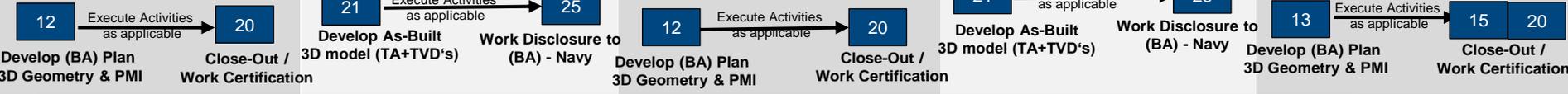
Integrated Digital Shipbuilding – Key Tenets

- "Learn by doing" iterative process development
- Innovation and discovery are necessary for defining uncertain processes
- Create an agile development environment for process evaluation
- Grassroots idea collection
- End-to-End data Configuration Management
- COT's software to greatest extent possible
- Need to support a Collaborative environment
- Agility to upgrade technology faster
- All product data managed by TeamCenter
- Drawingless Model Based Environment
- Convergence on common business processes
- Additive data content through product phases
    - Create once use many times
- Change of data ownership across phases
- Communication and feedback of product information
- Data synchronization and flexibility to handle different use cases
- Continuous material management
- Model Based (PLM) Piece part management, not drawing base hierarchy
- Planning flexibility for continuous improvement
- Integration between IT Systems, no data copy

Business Process changes must be evaluated for end-to-end value stream impact

MBE is a journey – build as you go