Integrated Digital Shipbuilding

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

NIST MBE Conference
April, 2017 Gaithersburg, MD

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Digital Thread
“Information Connected Digital Enterprise”

Scoping & Estimating
Concept Design
Arrangement Design
Detail Design
Production Planning
Manufacturing Engineering
Fabrication, Assembly
Supplier Integration
Test & Inspection

Requirements
CAE Analysis
3D Model
PMI
EBOM
PBOM
Visual Work Instructions
Work Packages
Requirements Validation
Close-Out Work Certification
Technical Manuals/Documents

Disposal Work Package
Execution Work Documents
Availability Planning
Technical Manuals/Documents

In-service Operations (Ship Force)
Ship Delivery

Maintenance, Modernization & Repair

“NNS’s Shipbuilding Digital Thread”

IN-SERVICE (LIFECYCLE) AUTHORITY

Connecting People, Processes, & Information
## Model Base Enterprise (MBE)

"Maturity Capability Levels" NIST.org

<table>
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<tr>
<th>Level 6</th>
<th>Level 5</th>
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<th>Level 3</th>
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| • Model Based Enterprise  
  • Integrated Manufacturing – Integrated Extended Enterprise  
  • Primary Deliverables Digital Product Definition Package and TDP via the web | • Model Based Enterprise  
  • Integrated Manufacturing – Integrated Internal Enterprise  
  • Primary Deliverables Digital Product Definition Package and Technical Data Product (TDP) | • Model Based Definition  
  • Integrated Manufacturing – Disconnected Enterprise  
  • Primary Deliverables 3D Annotated Model and Light Weight viewable via PLM | • Model Based Definition  
  • Native Model CAM – Disconnected Enterprise  
  • Primary Deliverables 3D Annotated Model and Light Weight viewable | • Model Centric  
  • Native Model CAM – Disconnected Enterprise  
  • Primary Deliverables 2D Drawing and Native CAD Model | • Model Centric  
  • Neutral Model CAM – Disconnected Enterprise  
  • Primary Deliverables 2D Drawing and Neutral CAD Model | • 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”

- Denotes Model Based Enterprise (MBE) capabilities

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

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**
   - 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**
   - 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”

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

Denotes Model Based Enterprise (MBE) capabilities

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, etc.)
- Define configuration (effectivity)
- Enable Form, fit, function change notification

14 Define/Create Work Packages
- 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.
- CNC data based on and checked to 3D model, update notification enabled.

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 snapshots, 3D views, etc.)
- 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
- Visual Test Instructions, Model based Test & Inspection
- Trades execute work
- 3D Models, products and process definition accessed from workstation computer.

20 Close-Out / Work Certification
- Close-out transactional work activities
- E-signatures added to documents
- (TA) develops and delivers technical manuals for ship In-Service Maintenance
Notes: Type Commander (TYCOM): NAVY Ship Owner Issues AWP. Planned Incremental Availability (PIA) 20 → 25

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

22 Perform In-Service Modernization/Maintenance “Logistics”
   - Laser scanning and Augmented Reality practices support shipboard configuration to product model configuration verification.
   - 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

27 Perform Availability Planning (LA)
   - Update Models

28 Perform Refuel Complex OverHaul (RCOH) or other availability (BA)
   - Perform/Execute Authorized Work

29 Perform Availability Planning (LA)
   - 3D Models, products definition available onboard In-Service ship.
   - Update Models

30 Decommission Ship Activities (BA)
   - Perform/Execute Authorized Work

Concept Studies

2 Execute Activities as applicable

10 Provide Models for LA review

12 Execute Activities as applicable

25 Execute Activities as applicable

21 Develop As-Built 3D model (TA+TVD’s)

20 Develop (BA) Plan 3D Geometry & PMI

25 Work Disclosure to (BA) - Navy

20 Close-Out / Work Certification

12 Develop (BA) Plan 3D Geometry & PMI

25 Work Disclosure to (BA) - Navy

15 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