

# **GENERAL DYNAMICS**

Bath Iron Works

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## **Design For Manufacturing Initiatives**

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# Background

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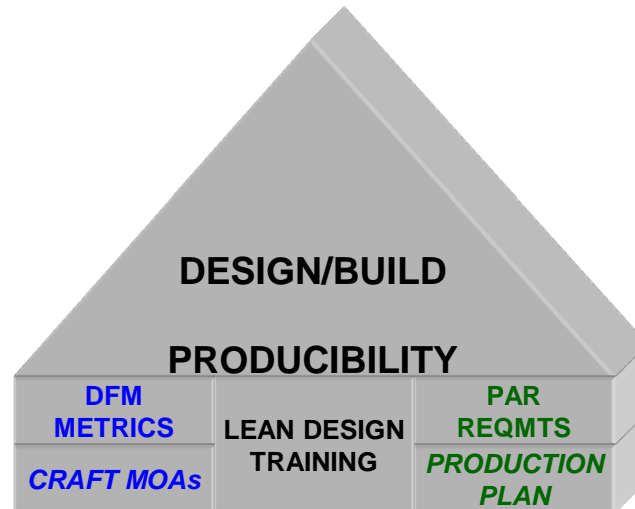
- Significant energy and effort to implement lean processes and lean culture on current construction contracts
- Key component of the ConOps for a recent new construction contract is a rigorous Design Build process to ensure the design is highly producible
  - Integrated Manufacturing and Planning experts into Design Teams
  - Created Design for Manufacturing Handbook
  - Executed DFM and Lean Design training
  - Communicated Production & Test Plan
- Key objectives:
  - Minimize work content
  - Maximize value for the customer
  - Meet performance requirements

# Design for Manufacturing (DFM) Metrics

- How do we utilize DFM Metrics during the design process to assess the level of producibility and provide feedback to the design teams?
- The foundation for the DFM Metrics are the manufacturing preferences defined by Craft Foreman and resident in the DFM Handbook

**DFM Metrics** - evaluate the producibility rules applicable to every design zone

**Example** - minimize direction changes for distributive systems



**PAR Requirements** - define and evaluate zone-specific design needs in support of the Production Plan & Test Plan

**Example** - "The design shall provide for a skid-type outfit package for the firemain subsystem in zone XYZ."

- Initially, the DFM Metrics were evaluated only qualitatively

# BIW Design/Build Review

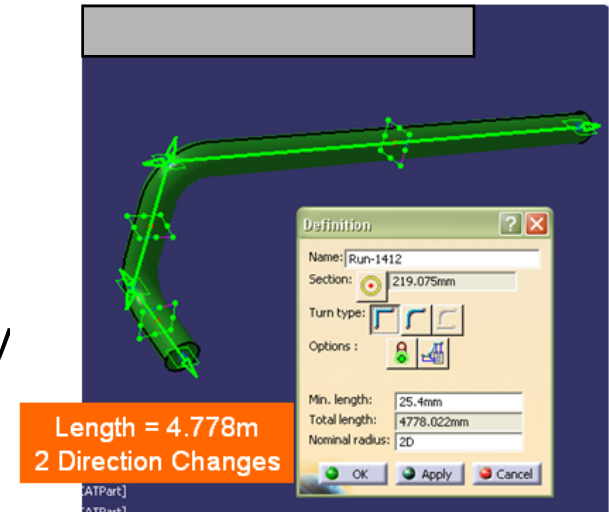
## DFM Metrics – Design Zone XXXX, 50% Review

Qualitative Assessment  
(Green / Yellow / Red)

DFM METRIC	ASSESSMENT		
	DISCIPLINE	STATUS	NOTES, ACTIONS
Minimize directional changes	PIPE	Yellow	Reduce direction changes in system xxx
	VENT	Green	
	ELEC	Yellow	Validate bend radius of port cable way
Minimize pens. thru webs, girders, longls.	PIPE	Red	Lower routing of system yyy, see Issue Log
	VENT	Green	
	ELEC	Green	
Standardize bends for req'd direction changes	PIPE	Green	
Minimize items in Design/Build caution zones	PIPE	Yellow	Adjust system zzz routing, see recommendation in Issues Log
	VENT	Green	
	ELEC	Yellow	Equipment in port caution zone
	MECH	N/A	
	HULL O/F	Green	
Appropriate use of round duct and textile vent	VENT	Green	
Minimize layering of distributive systems	ALL	Red	Validate access to system aaa cableways

# DFM Metrics

- Leverage the CAD Toolset to develop and implement quantitative, programmed DFM Metrics
- The DFM Metrics programs evaluate the geometry and attributes in the Catia CAD model to provide actionable feedback on key producibility indicators
- DFM Metrics Project - requirements were defined, code was developed, tested, and implemented over a two year period
  - Implementation team consisted of GD-Electric Boat IT, CSC, and BIW personnel

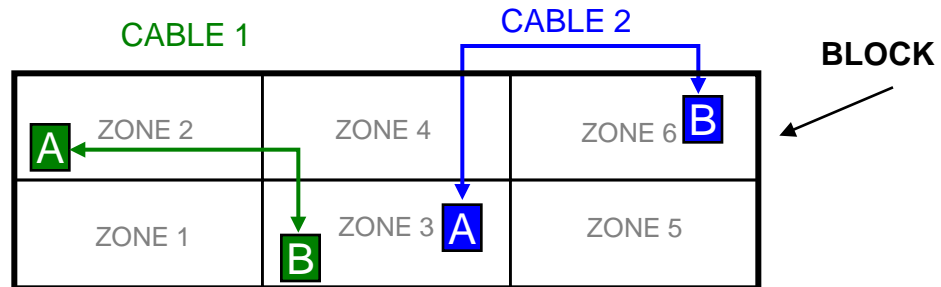


# DFM Metrics – Cable Routing

- Examples of the programmed DFM Metrics in daily usage include:
  - **RD1** - number of pipe direction changes per meter of length
  - **RD2** - number of vent direction changes per meter of length
  - **RD9** - analyzes the required pipe direction changes for the use of standard vs. non-standard bend angles, and bends vs. fittings
  - **RD13** – analyzes percentage of Cables Routed Within Same Major Block

## RD13 REPORTING:

- **CABLE 1 – ROUTING OK**
- **CABLE 2 – EXCEPTION**



*Evaluates complexity while the design is in-process*

# DFM Metrics

- The DFM Metrics were baselined against current construction class to provide a basis for comparison and to establish goals for a new contract
- Summary DFM metric data at 50,70,90, & 100% complete reviews

SHIP	PIPE LENGTH & DIRECTION CHANGES-RD1			PIPE BENDS-RD9					VENT LENGTH & DIRECTION CHANGES - RD2		
	TOTAL LENGTH (METERS)	TOTAL DIRECTION CHANGES	TOTAL DIRECTION CHANGES PER METER	TOTAL DIRECTION CHANGES	STANDARD BENDS	NON-STANDARD BENDS	ELBOWS	PERCENT OF STANDARD BENDS	TOTAL LENGTH (METERS)	TOTAL DIRECTION CHANGES	TOTAL DIRECTION CHANGES PER METER

Goal: 66% improvement

Goal: 50% improvement

Goal: 44% improvement

# Design to Scope

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- Data from the programmed DFM Metrics is also used in support of the BIW “Design to Scope” initiative
  - **Design to Scope (DTS)** – process for ensuring that the production workscope remains aligned with the construction bid estimate
  - **Objective** - mitigate scope growth and cost risk
- Proactively engage Design Teams to reduce work scope
  - **Vent & Pipe** – as-bid length allocated by zone, actuals reported via programmed DFM Metrics
  - **Structure** – as-bid weight allocated by unit, updated by Engineering Weight Control
  - **Cable** – shipwide as-bid length by system, actuals to be reported via programmed DFM Metrics as cable routing proceeds (underway)

# BIW Design/Build Review

## DFM Metrics Reporting – Zone XXX0, 70% Review

DESIGN ZONE	WORK PACKAGE	TOTAL LENGTH (meters)	TOTAL DIRECTION CHANGES	TOTAL DIRECTION CHANGES PER METER
XXX0	BDXXX343UIXXXP00000---	7.0	4	0.57
XXX0	BDXXX521FMXXXP00000---	76.6	59	0.77
XXX0	BDXXX523DSWXXXP00000---	14.0	9	0.64
XXX0	BDXXX528WDXXXP00000---	34.2	53	1.55
XXX0	BDXXX529BALTVXP00000---	37.5	22	0.59
XXX0	BDXXX532CWXXXP00000---	136.0	144	1.06
XXX0	BDXXX532PFWXXXP00000---	45.9	37	0.81
XXX0	BDXXX533PWXXXP00000---	17.8	25	1.40
XXX0	BDXXX541FTVXXXP00000---	31.7	32	1.01
XXX0	BDXXX551ALPXXXP00000---	23.5	22	0.94
XXX0	BDXXX555AFFXXXP00000---	7.1	4	0.56
XXX0	BDXXX555PDAXXXP00000---	1.7	0	0.00
XXX0	BDXXX555WMXXXP00000---	39.1	48	1.23
XXX0	<b>ZONE SUM</b>	<b>472.0</b>	<b>459</b>	<b>0.97</b>

Quantitative DFM metrics data for the pipe work packages

DFM data

DTS data

**Design to Scope, Pipe** – BIW Construction Bid Estimate workscope allocation to zone is 691 meters. Design-length with zone at 70% review is 472 meters, or approx 68% of the as-bid length.

# Design To Scope

			VENT LENGTH			PIPE LENGTH			CABLE LENGTH		
ZONE	DESIGN LEAD	LATEST REVIEW	BIW BID SCOPE	SCOPE IN MODEL	% OF BIW BID	BIW BID SCOPE	SCOPE IN MODEL	% OF BIW BID	BIW BID SCOPE	SCOPE IN MODEL	% OF BIW BID

- BIW's Navy customer has been highly supportive of the application of DFM Metrics and Design to Scope process
- DFM/DTS & Design/Build Process received the 2008 DoD Value Engineering Award

# DFM Metrics & DTS – Next Steps

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- Training
- Opportunities to further exploit DFM Metrics/DTS
  - ↗ Develop baseline for future programs
    - Penetrations per meter of pipe, vent, cableway
    - Parts per ton (unit structure), foundation
  - ↗ Development of additional programmed metrics
    - Complete development of cable routing metrics
    - Weld footage, number of weld passes
- Design for Planning
- Continue to share Best Practices across General Dynamics

# DFM Metrics - Summary

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- DFM Metrics and Design to Scope process have been successfully integrated to promote a more producible, more affordable design
- Provide “leading indicators” regarding the producibility of the new design
- Evaluated at 50/70/90% Design/Build reviews
- The DFM Metrics and Design to Scope processes contribute to Design/Build objectives of minimizing construction workscope and simplifying the design to reduce construction cost
- Good start, how do we take it to the next level