Develop and Implement 'World Class' U.S. Material Standards and Parametric Design Rules to Support Commercial and Naval Auxiliary Ship Construction

Project Final Status Report

by

National Steel & Shipbuilding Co.

on

June 16th 2004

Maritech ASE Project #99-21
Technology Investment Agreement (TIA) 20000215

Material Standards & Parametric Design Rules

- **Team Members**

  NASSCO (lead), Halter, Electric Boat, Bath Iron Works, Ingalls, Newport News Shipyard, M. Rosenblatt & Son, Designers and Planners, Proteus, Vibtech, Munro & Associates., First Marine International, SPAR, Integration Partners, ABS, Hopeman Bros., Simsmart, University of Washington, University of Michigan, Webb Institute.

Major Accomplishments

Material Standards & Parametric Design Rules

- **Developed Functional Volume Design Approach and Training Software**
- **Enhanced Proteus IDNA Software**
- **Developed CID Architecture**
- **Developed Standards Library**
- **Developed Design Rules and Templates**
- **Applied Lean Design to Shipbuilding**
- **Training Materials Published**
- **Workshops conducted**

Strategic Vision

Material Standards & Parametric Design Rules

An integrated pre-production process based on comprehensive standardization across the principal functional areas of Engineering, Estimating, Materials, and Planning.

This process applies standardization to material, equipment, design, material selection, cost estimating, interim products, arrangements, zone designs and whole-ship designs

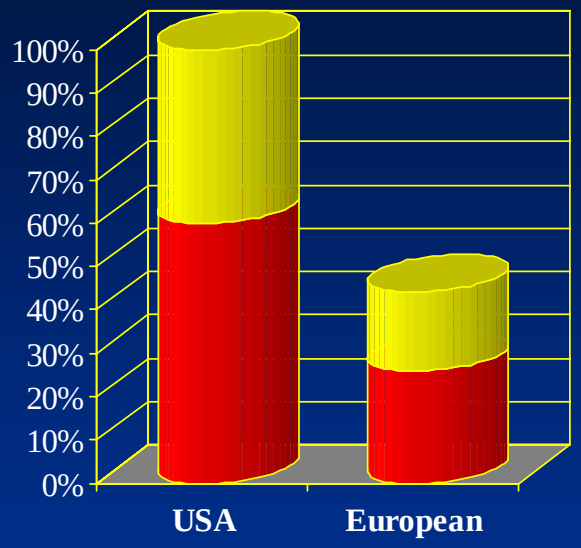
Expected Benefits

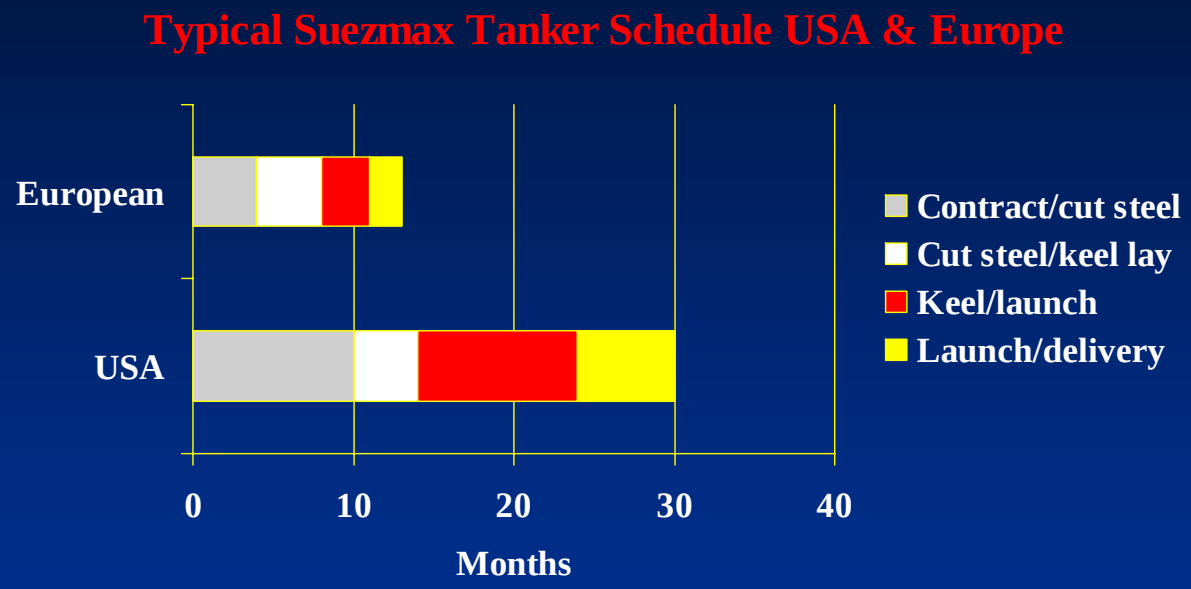
Material Standards & Parametric Design Rules

- ***Five-fold*** **increase in the throughput of preliminary designs and cost estimates that a shipyard can produce in response to market inquiries**
- ***33% reduction*** **in cost and cycle time for pre-production processes during the contract, transition, and detail design phases.**

Expected Benefits

Material Standards & Parametric Design Rules





Reduce Material Cost and Cycle Time

Typical Design and Engineering Cycle Time in the USA

Contract Award

Steel Scope Defined

Functional Definition

(6 Months)

Total System Development
Structural Steel
Piping Systems
Electrical Sys.
HVAC

Outfit Scope Defined

Transition Definition

(6 Months)

Structural Steel and Outfitting Interface
Systems Engineering and Detail Engineering Interface

Detail Definition/Planning and Budgeting

(1-1.5 Years)

Production Information
Outfit Product Breakdown
Budgeting

Engineering

Contract Definition

(6-8 Months)

Guidance Documents
Ship Specification
General Arrangement
Machinery Arrangement
Midship Section/Scantlings
Key System Diagrams
Equipment List

Estimating

Words Into Scope

Contract Estimate

(2-3 Months)

Scope * Rate = $

Scope:
Spec Matl. Inquiries
Tons of Steel/Weld Ft
Feet of Pipe
Feet of Cable
Ft^2 Vent Duct
Ft^2 Paint Surface
Metal Outfit Parts

Material & Labor Budgets by Group

8 - 12 Months

18 - 24 Months

Proposed Process

Material Standards & Parametric Design Rules

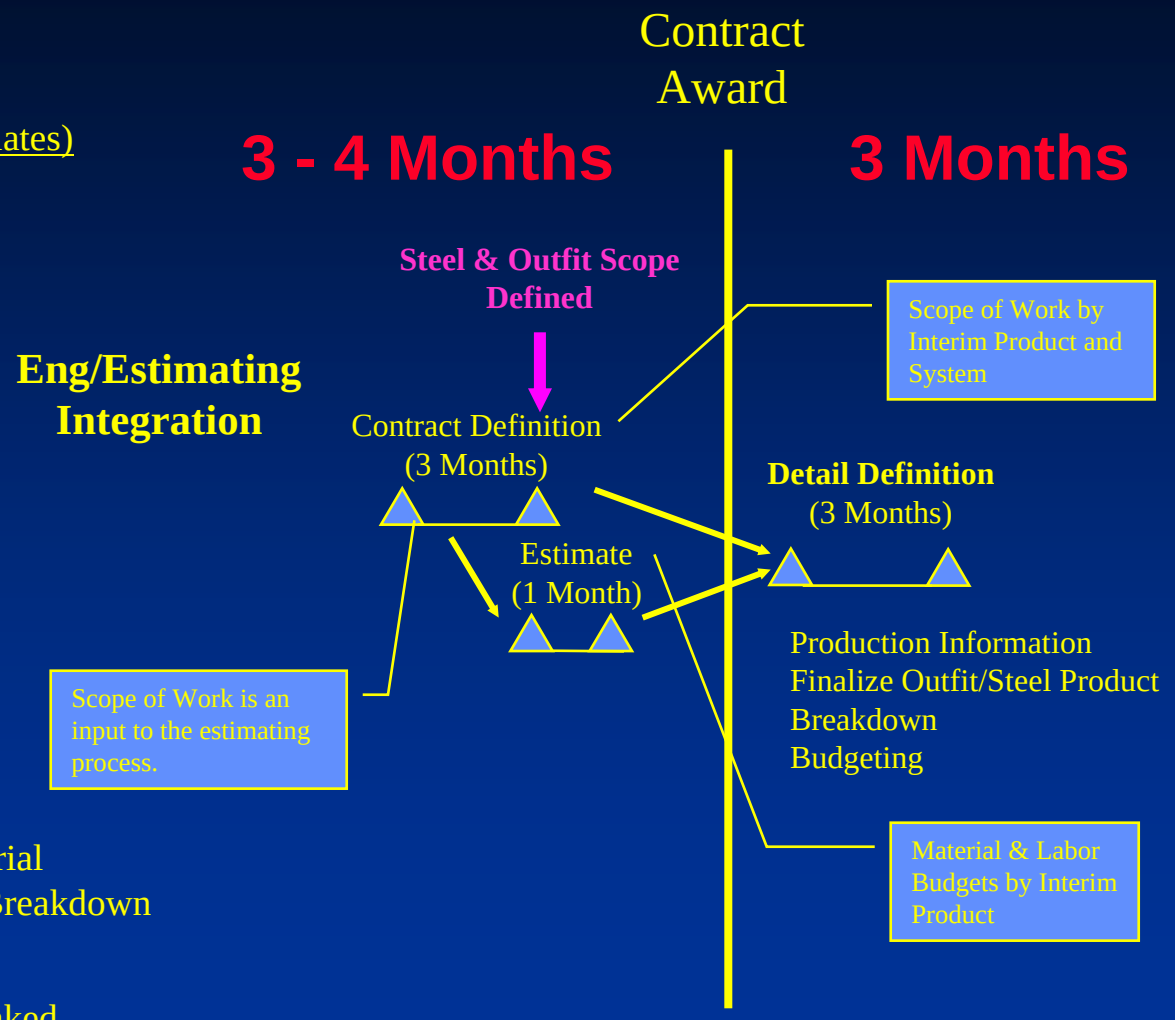
Contract Definition
(Built from Project Specific Templates)

Guidance Documents
Ship Specification
General Arrangement
Machinery Arrangement
Midship Section/Scantlings
Key System Diagrams
Equipment List

System Development
Structural Steel
Piping Systems
Electrical Sys.
HVAC

Producability Issues:
Defining and Locating Outfit Material
Defining Structural Steel Product Breakdown

Estimating
Apply Material and Labor Rates linked
to projects specific templates.



Functional Volume Design

Material Standards & Parametric Design Rules

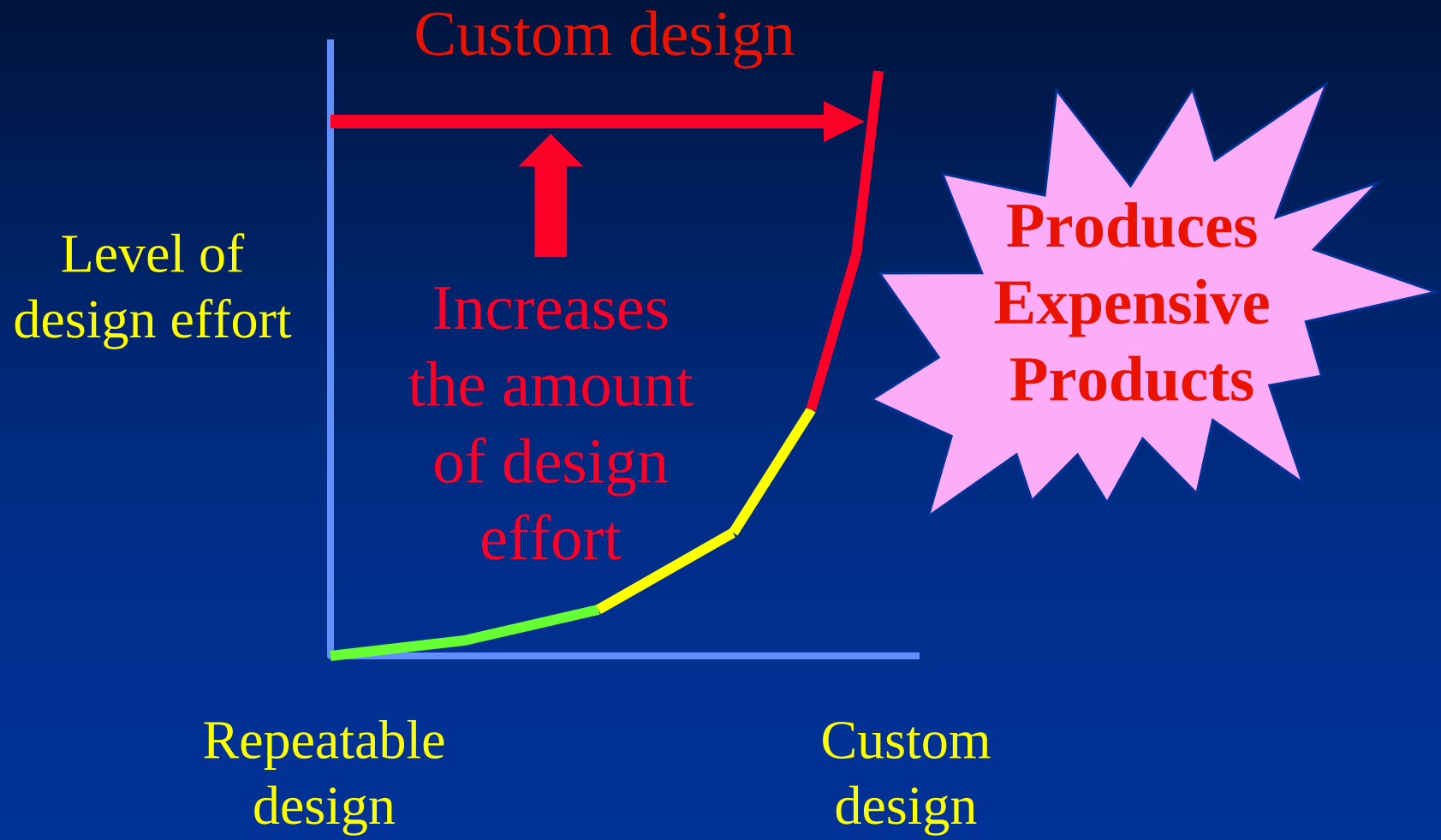
Problems with the Existing Design Process

Creates "custom" design solutions that are:

- **Intrinsically of "lower technical confidence" and "higher commercial risk".**
- **At a price that is well above the expectations of the international market.**
- **At a cost that makes the shipyard uncompetitive.**
- **With excessive design cost and lead time.**

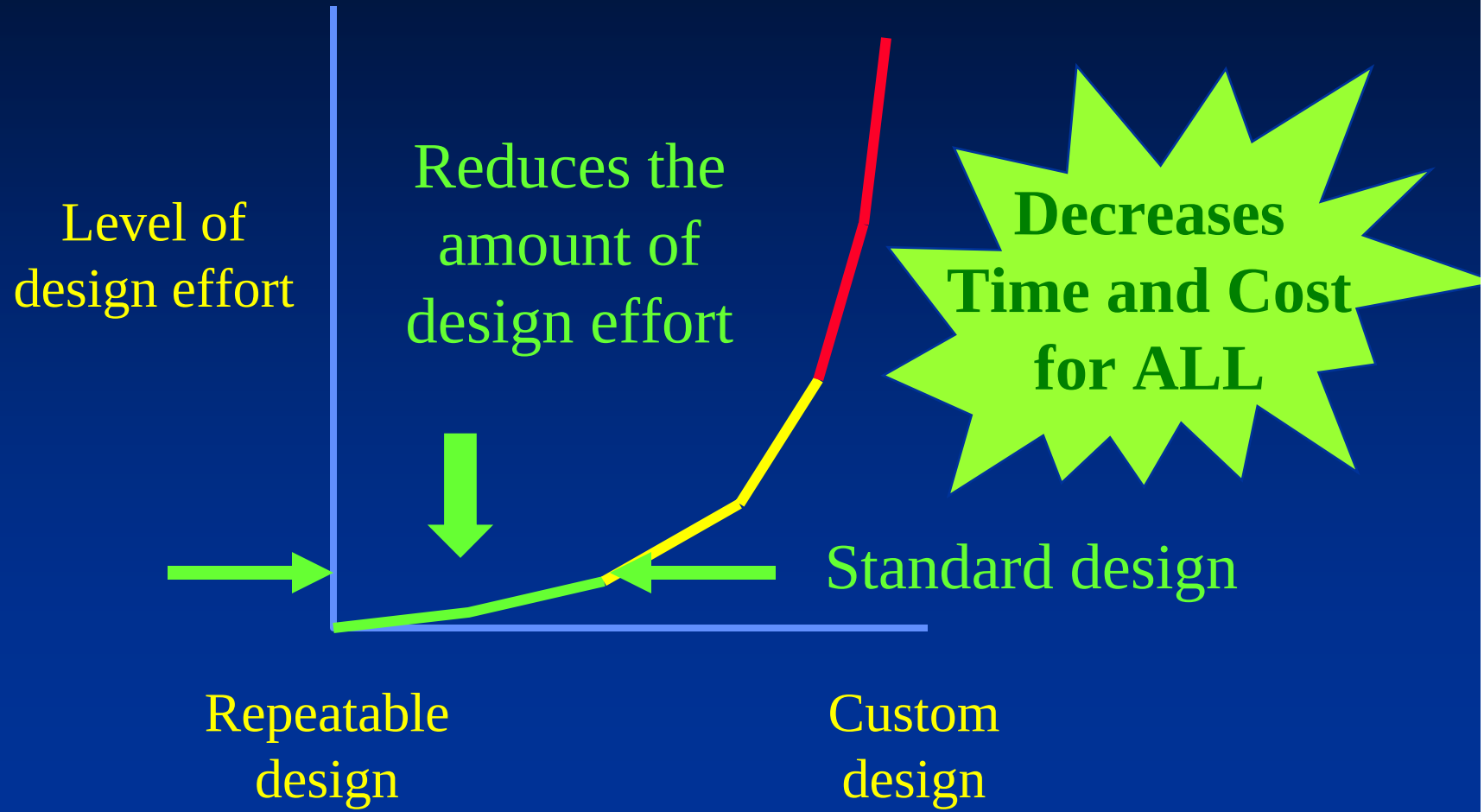
Standard v Custom Design

Material Standards & Parametric Design Rules



Standard v Custom Design

Material Standards & Parametric Design Rules



Project Accomplishments

Material Standards & Parametric Design Rules

- **Task 1 - Methodology Templates & Guides**
  - Project Methodology template, revised
    - » Provided a detailed project plan
  - Lean Methodology Guide
    - » Conducted two industry workshops
    - » Provided hands-on experience in applying DFMA principles
  - Software Methodology Guide
    - » Provided guidance for software development (any project)
  - Education and Tech Transfer Guide
    - » Provided guidance and sets expectations

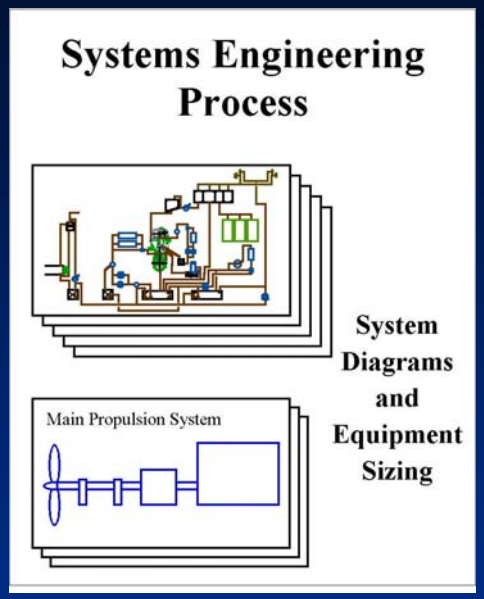
Project Accomplishments

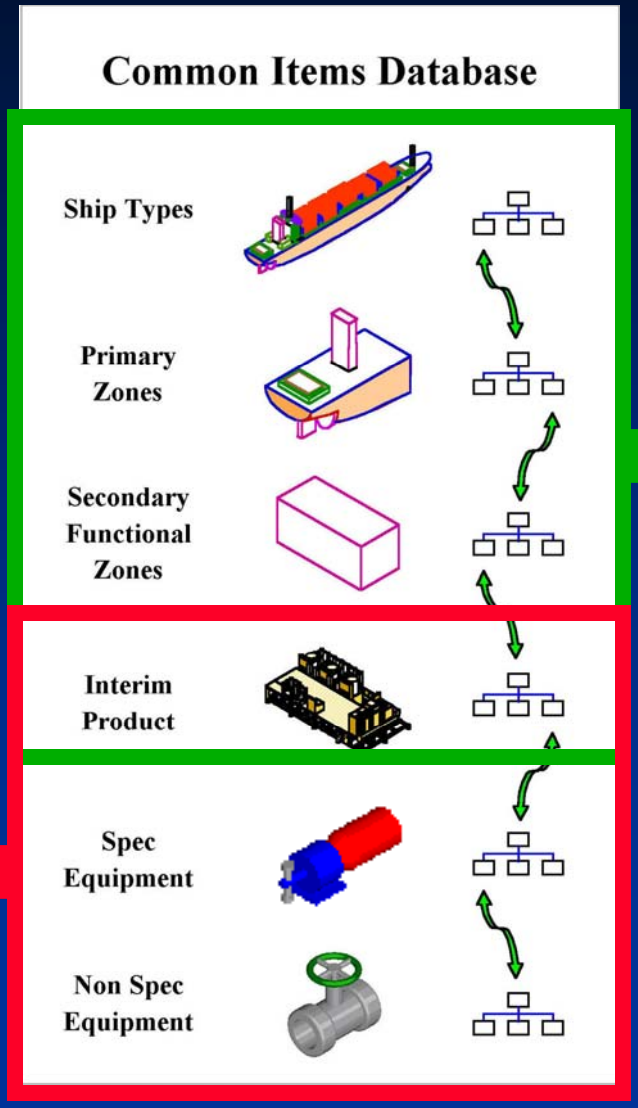
Material Standards & Parametric Design Rules

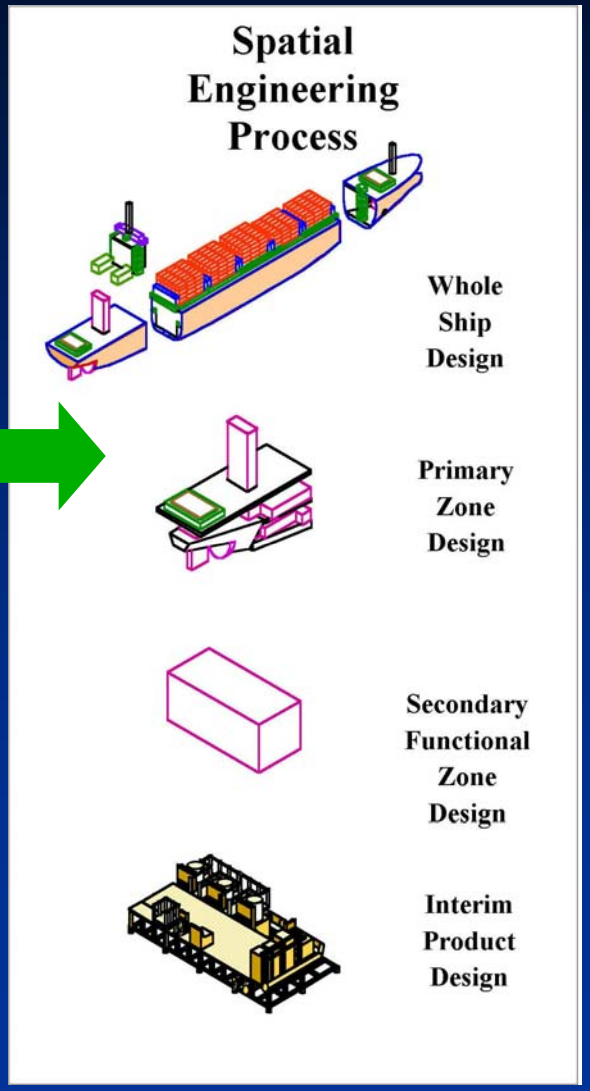
- **Task 2 - Common Item Database (CID)**
  - Develop and Populate CID with Spec & Non-Spec Material/Equipment
    - » Defined commercial shipyard data requirements
    - » Defined business process & procedures
    - » Defined organizational requirements
    - » Defined part equivalency process & procedures
    - » Defined CID architecture
    - » Populated CID with over 650 products from more than 730 suppliers (over 740 product types in 45 product categories)
    - » Product catalog development - Identified over 200 Data templates at the functional volume level with over 400 associated product templates

CID and the Design Process

Material Standards & Parametric Design Rules

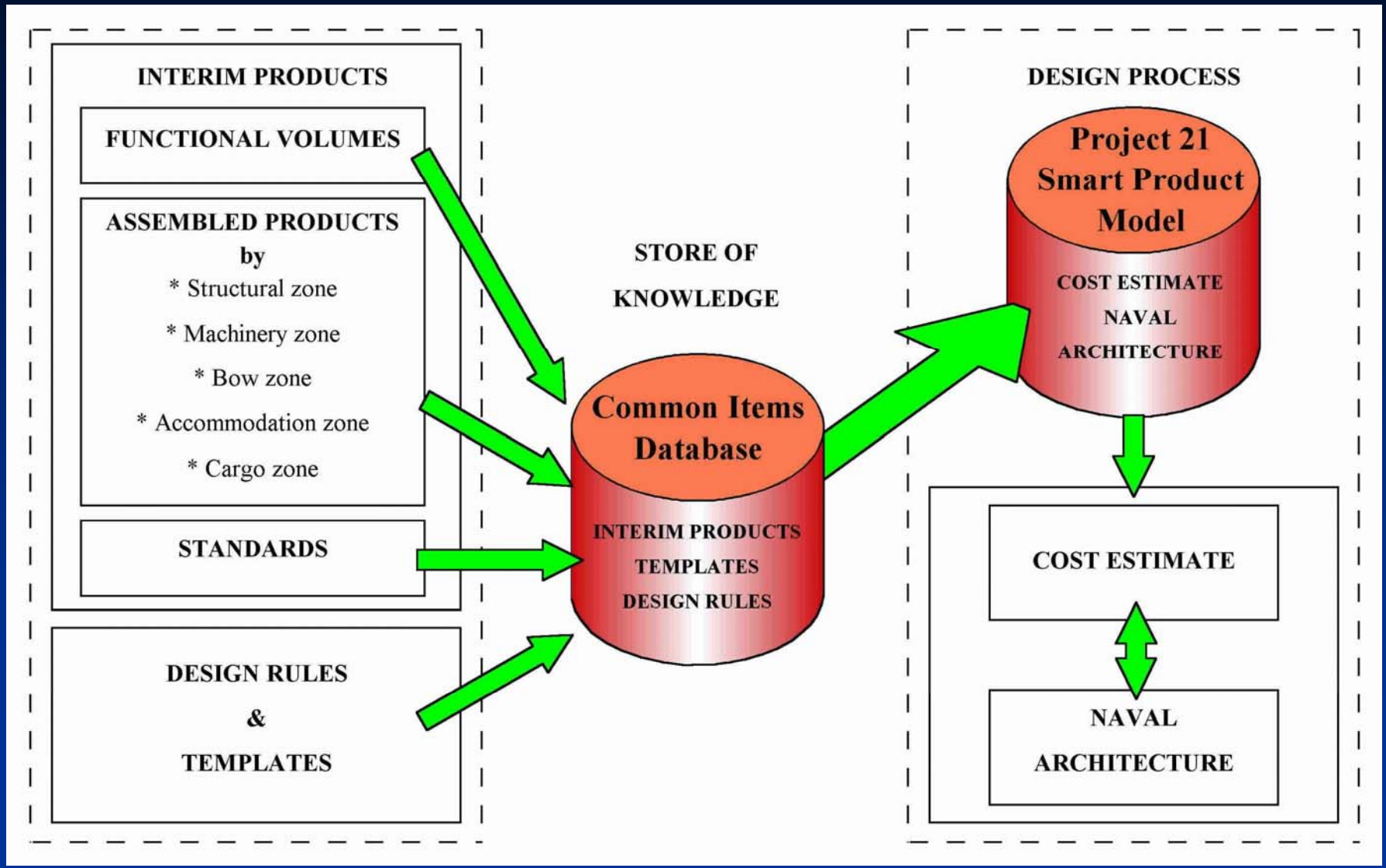






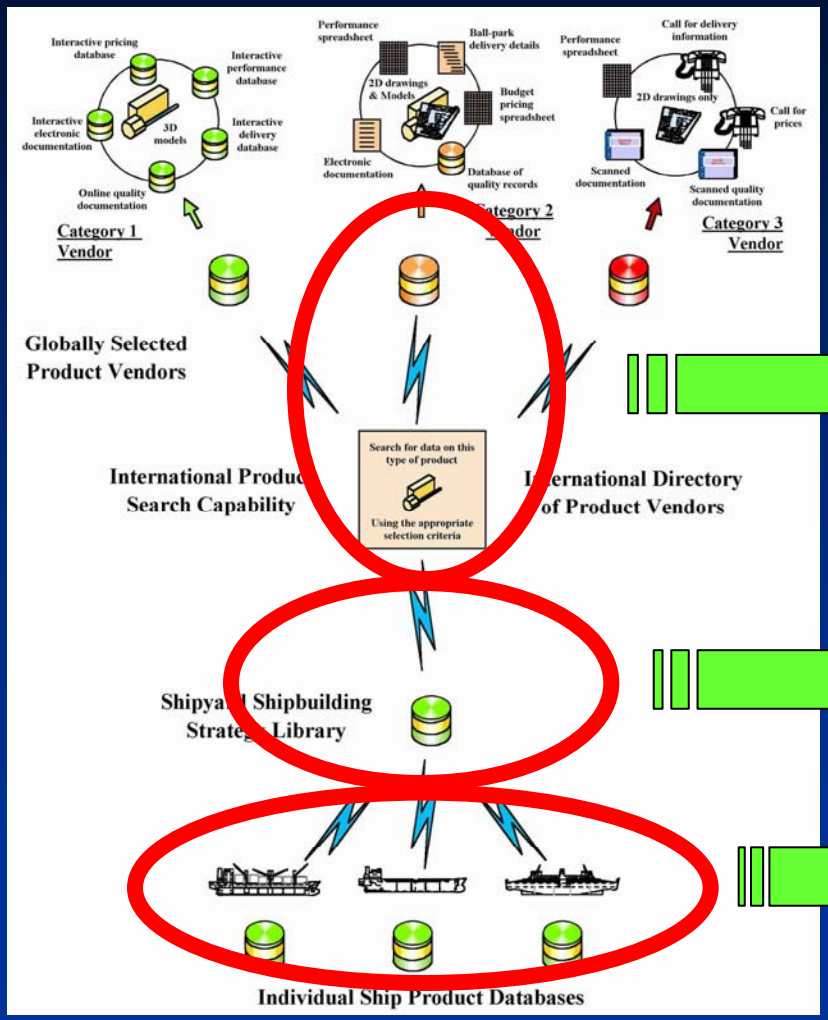
CID and the Design Process

Material Standards & Parametric Design Rules



CID Architecture

Material Standards & Parametric Design Rules



- **Gatekeeper**
- **Product Catalog**
- **Project Database**

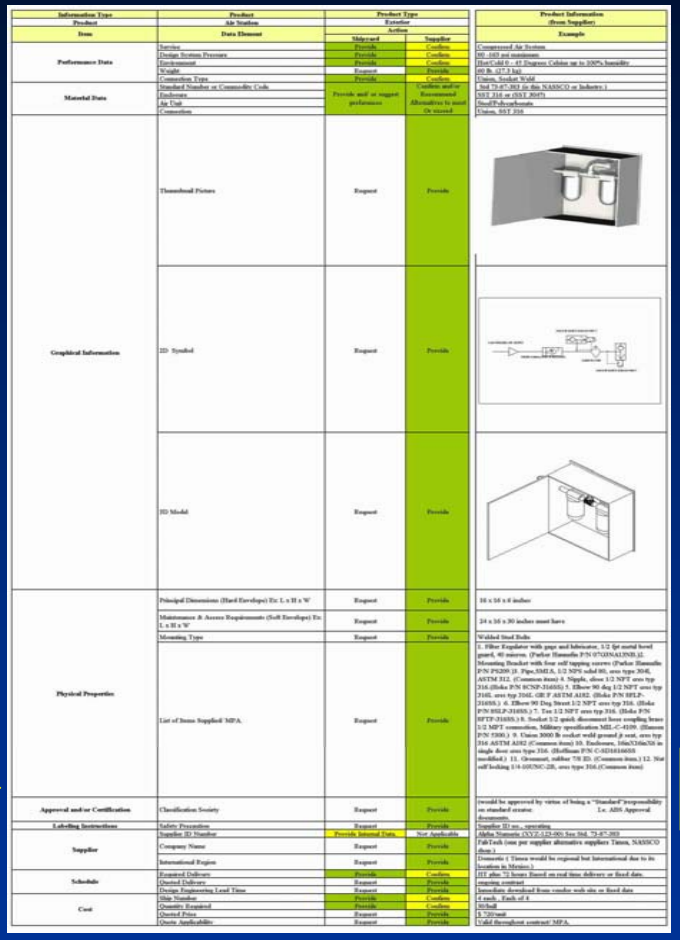
Product Data Templates

Material Standards & Parametric Design Rules

Standards

Spec Equip

Non - Spec Equip



Data Sheets

Performance Data
Material Data
Graphic 2D, 3D
Physical Properties
Approvals
Labeling
Supplier Data
Schedule
Cost

Common Item Database

Project Accomplishments

Material Standards & Parametric Design Rules

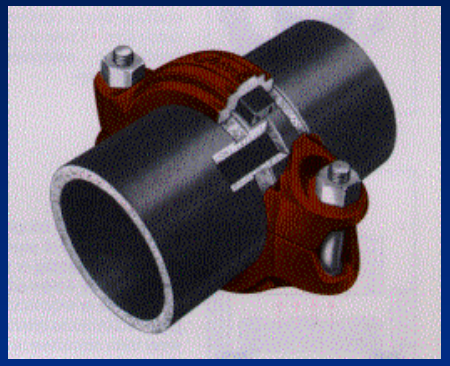
- **Task 3 - Develop a Set of Nationally Acceptable Material & Design Standards (outfit & structure)**
  - 960 steel and outfit standards delivered
  - Over 1200 standards submitted to project team for review

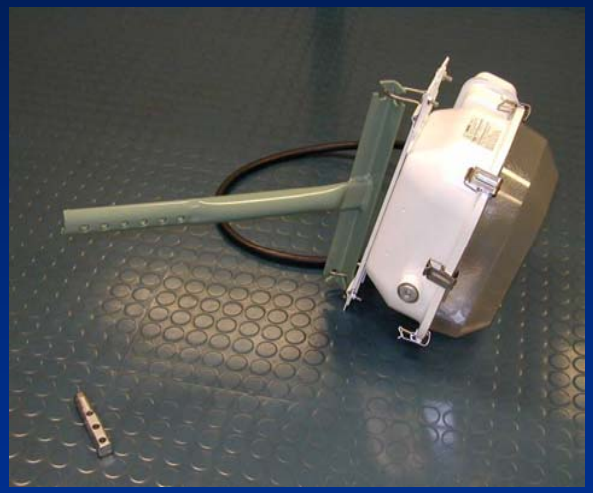
- **Delivered Standards**
  - 252 Structural Standards
  - 708 Outfitting Standards
    - » 95 Electrical Standards
    - » 134 Metal Outfit Standards
    - » 391 Piping Standards
    - » 88 HVAC Standards

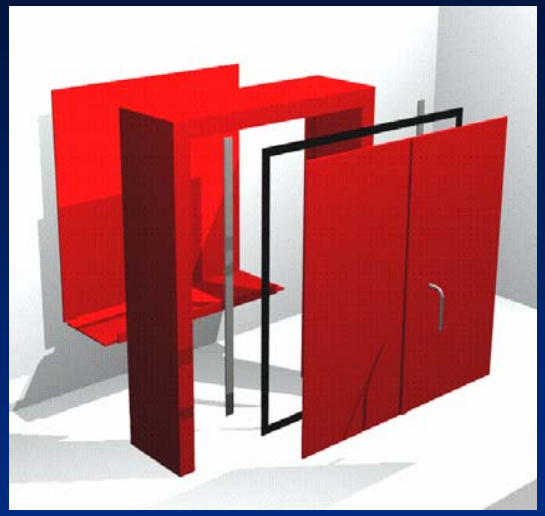
Types of Standards

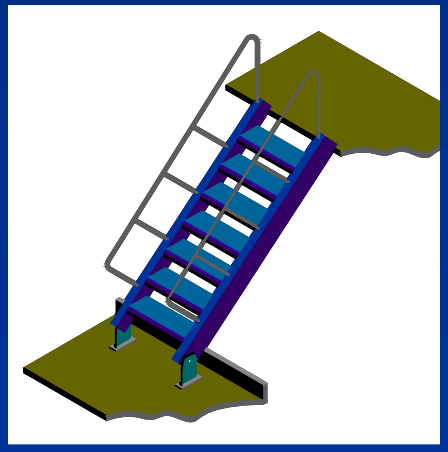
Material Standards & Parametric Design Rules

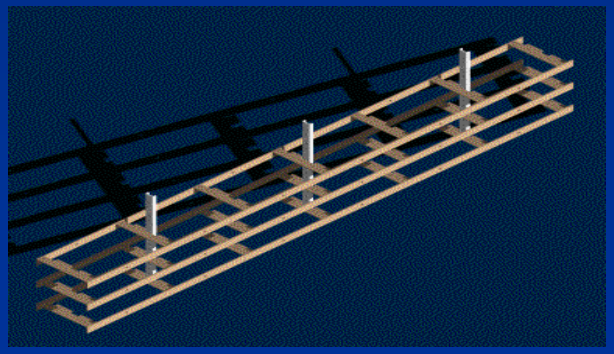
- **Parts Standards**
- **Interim Product Standards**
  - Groups of parts or assemblies

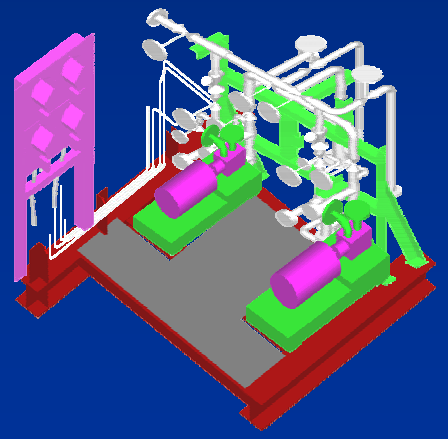






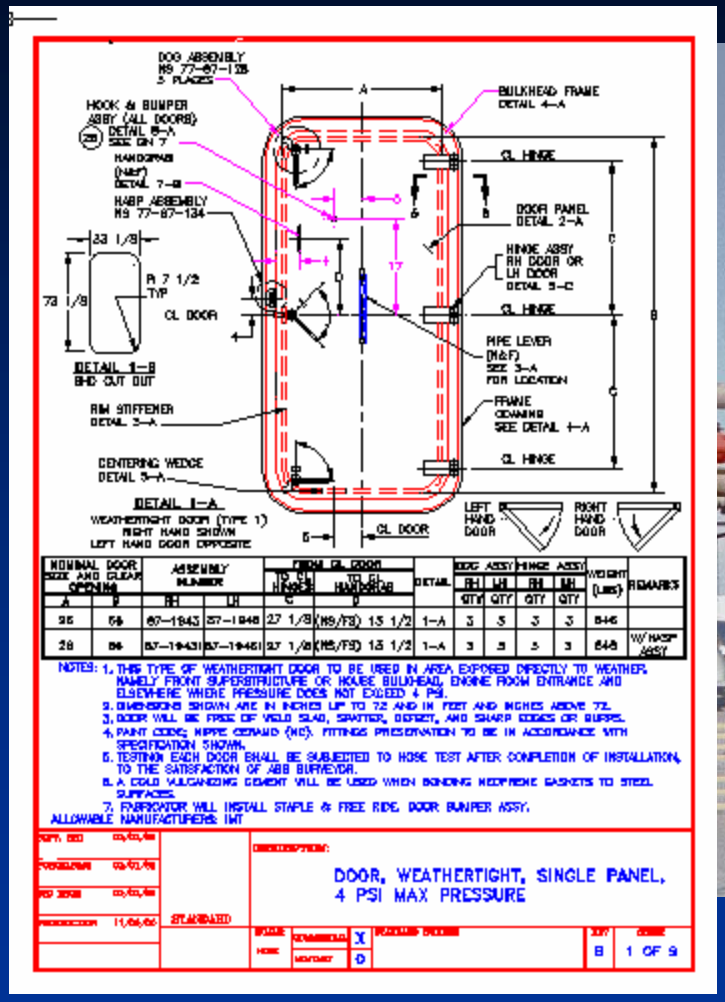






Material & Design Standards

Material Standards & Parametric Design Rules

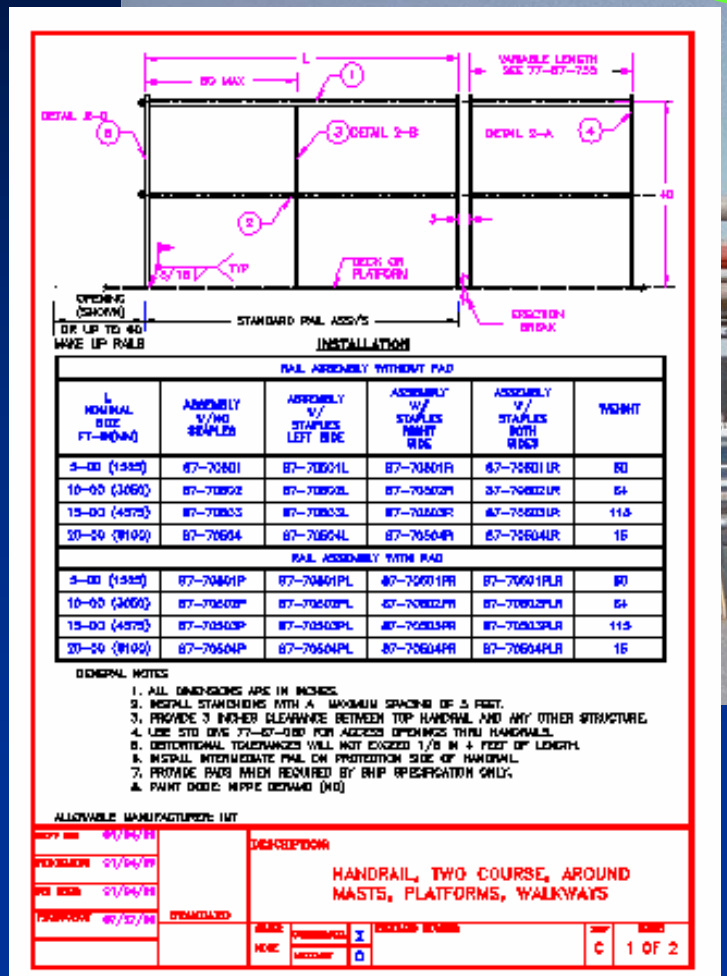


W/T DOOR

Material & Design Standards

Material Standards & Parametric Design Rules

Life Rails



L

VARIABLE LENGTH SEE 77-87-755

80 MAX

DETAIL B-B

DETAIL 2-B

DETAIL 2-A

40

TYP

DECK OR PLATFORM

OPENING (SHOWN)

STANDARD RAIL ASSYS

DIRECTION BREAK

OR UP TO 40' MAKE UP RAILS

INSTALLATION

L NOMINAL SIZE FT-IN(MM)	ASSEMBLY W/NO STAPLES	ASSEMBLY W/ STAPLES LEFT SIDE	ASSEMBLY W/ STAPLES RIGHT SIDE	ASSEMBLY W/ STAPLES BOTH SIDES	WEIGHT
RAIL ASSEMBLY WITHOUT PAD					
5-00 (1525)	67-70601	67-70601L	67-70601R	67-70601LR	80
10-00 (3050)	67-70602	67-70602L	67-70602R	67-70602LR	84
15-00 (4575)	67-70603	67-70603L	67-70603R	67-70603LR	115
20-00 (6100)	67-70604	67-70604L	67-70604R	67-70604LR	15
RAIL ASSEMBLY WITH PAD					
5-00 (1525)	67-70601P	67-70601PL	67-70601PR	67-70601PLR	80
10-00 (3050)	67-70602P	67-70602PL	67-70602PR	67-70602PLR	84
15-00 (4575)	67-70603P	67-70603PL	67-70603PR	67-70603PLR	115
20-00 (6100)	67-70604P	67-70604PL	67-70604PR	67-70604PLR	15

DESIGN NOTES

1. ALL DIMENSIONS ARE IN INCHES.
2. INSTALL STANCHIONS WITH A MAXIMUM SPACING OF 5 FEET.
3. PROVIDE 3 INCHES CLEARANCE BETWEEN TOP HANDRAIL AND ANY OTHER STRUCTURE.
4. USE STD DWG 77-87-080 FOR ACCESS OPENINGS THRU HANDRAILS.
5. DIRECTIONAL TOLERANCES WILL NOT EXCEED 1/8 IN 4 FEET OF LENGTH.
6. INSTALL INTERMEDIATE RAIL ON PROTECTION SIDE OF HANDRAIL.
7. PROVIDE PADS WHEN REQUIRED BY SHIP SPECIFICATION ONLY.
8. PAINT CODE: NIPPE DEMAND (ND)

ALLOWABLE MANUFACTURER LIST

DESCRIPTION

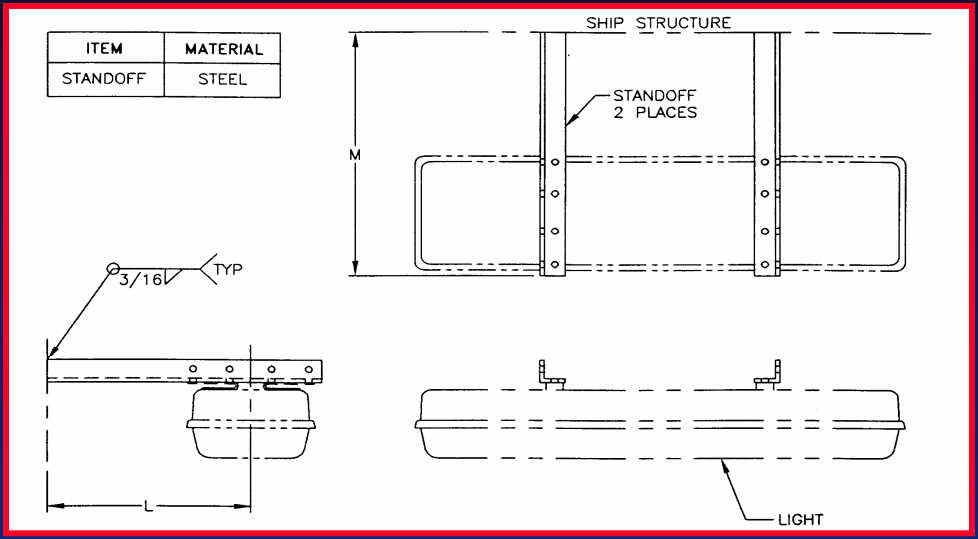
HANDRAIL, TWO COURSE, AROUND MASTS, PLATFORMS, WALKWAYS

C

1 OF 2

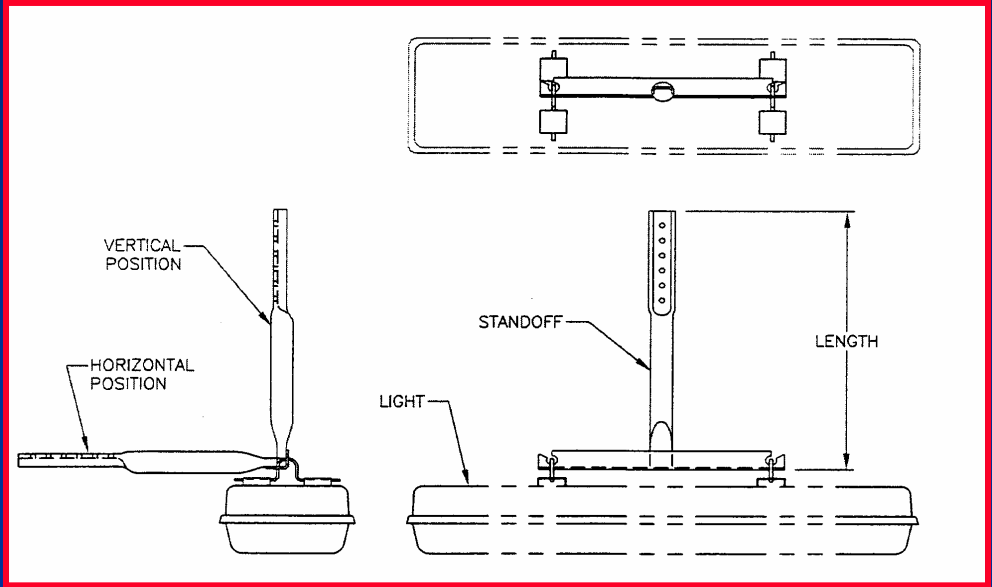
Material & Design Standards

Material Standards & Parametric Design Rules



Before

After



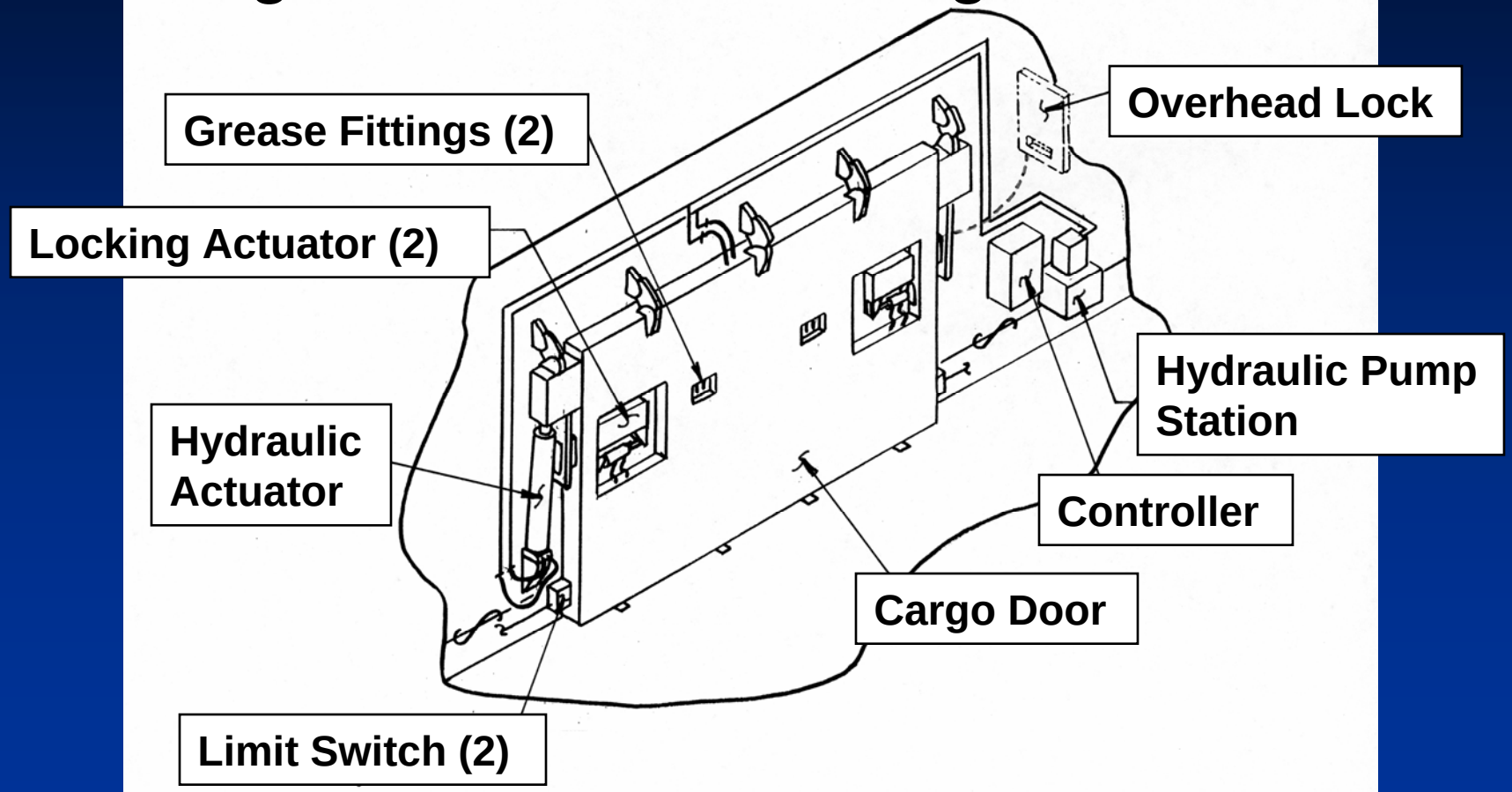
Light Standoff

Reduction of Parts/Work Content & Increased Functionality

Material & Design Standards

Material Standards & Parametric Design Rules

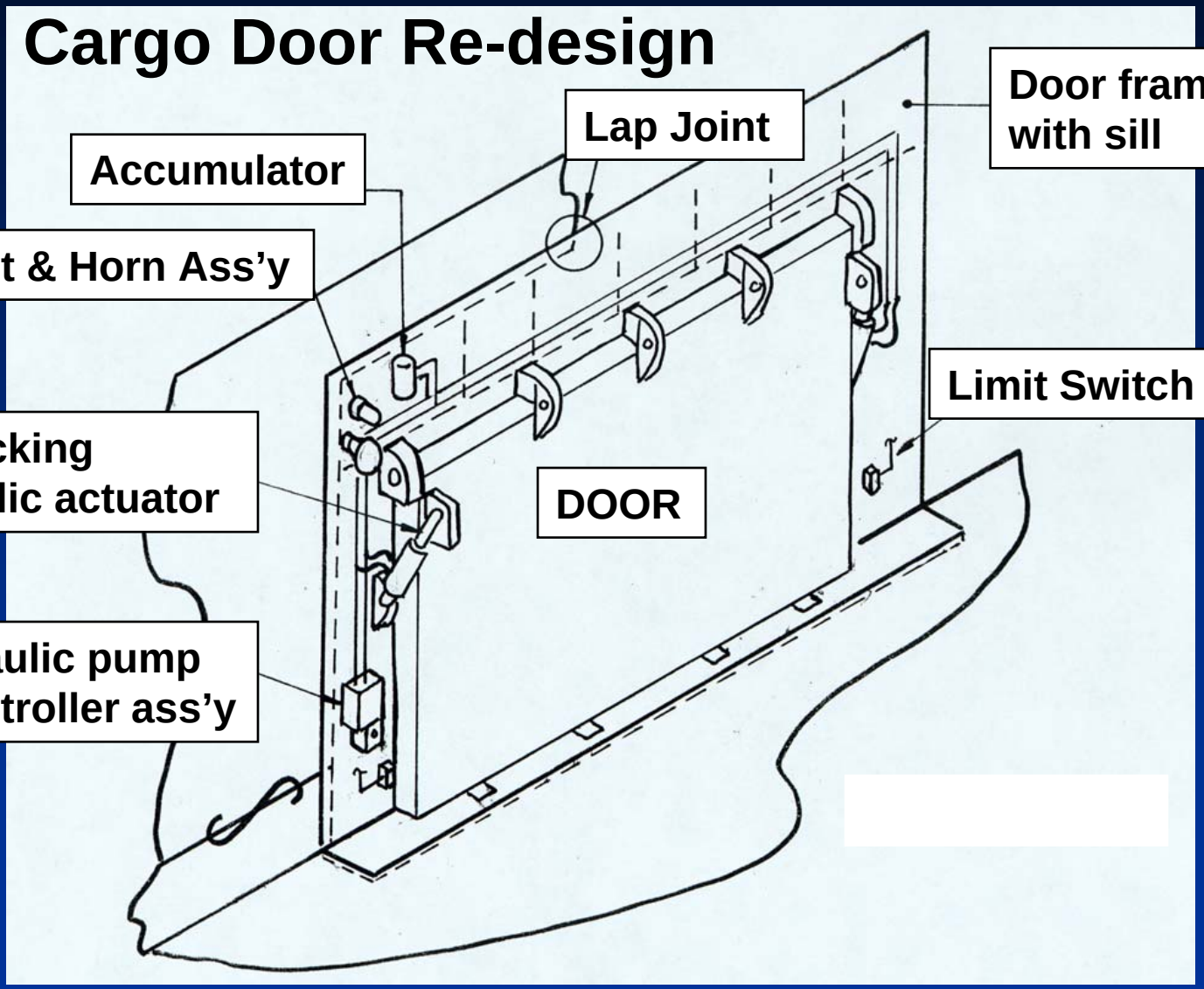
Cargo Door Baseline Design



Material & Design Standards

Material Standards & Parametric Design Rules

Cargo Door Re-design



Material & Design Standards

Material Standards & Parametric Design Rules

Cargo Door Improvements

- Modular door & frame fully assembled and tested
- Lap joint to bulkhead
- Single lip seal
- Integrated control box
- Latching hydraulic cylinders
- Accumulator instead of hand pump

Parts Reduction **> 40%**

Operations Reduction **> 40%**

Project Accomplishments

Material Standards & Parametric Design Rules

- **Task 4 - Develop Technical Approach for Early-Stage and Parametric Ship Design Tools**
  - Identified and evaluated existing tools
  - Developed Proteus/Spar Flagship software suite
    - » Released Smart Product Model (SPM) Advanced Parametric Ship Design, Cost Estimating, and Production Planning software
    - » Integrated the Herbert stability & hydrostatics toolset
    - » Industry workshops conducted to demonstrate the parametric "Smart Product Model" (SPM)
    - » Paper and demonstration presented at SPS Ypsilanti (2001)

Initial Design Tools

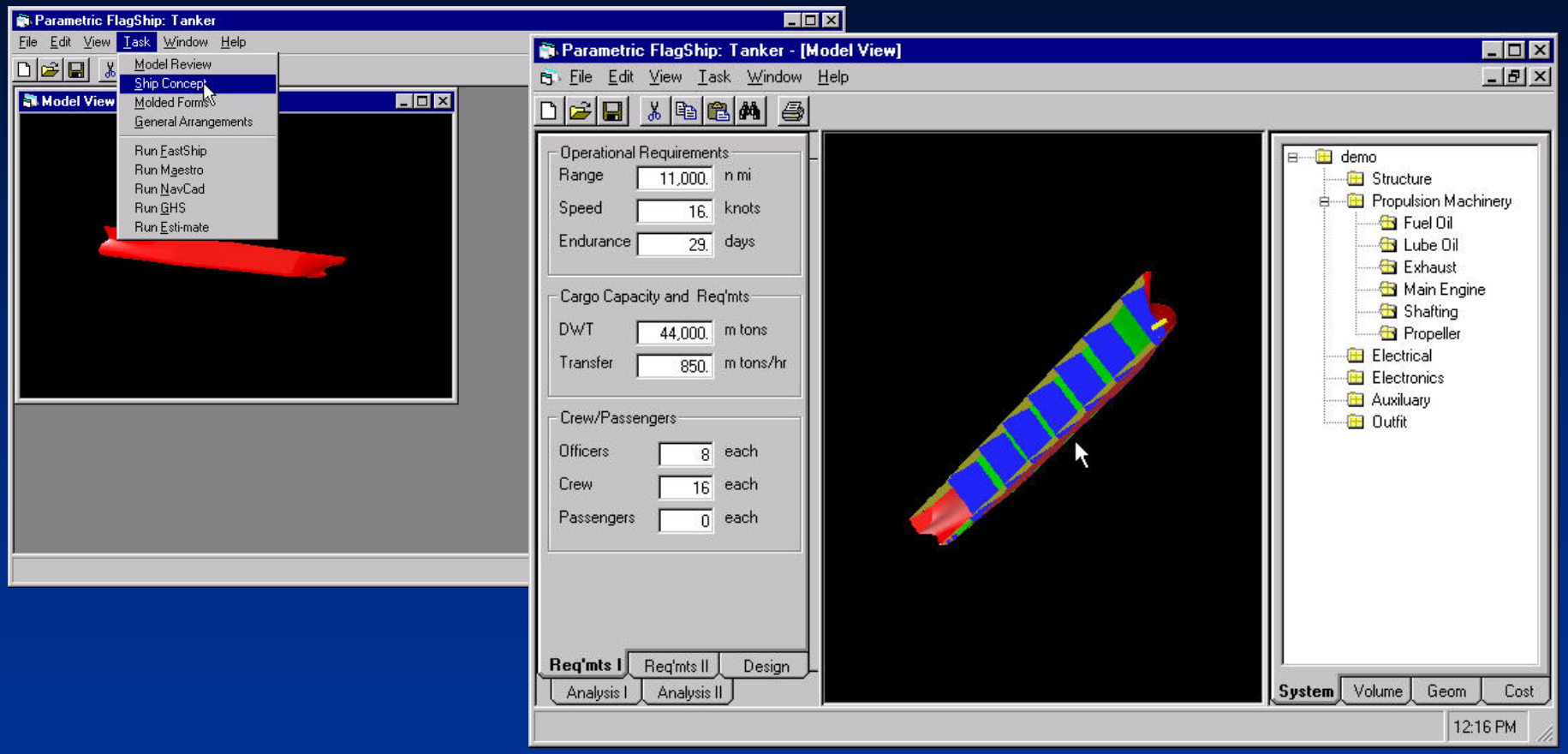
Material Standards & Parametric Design Rules

- **GCRMTC / MR&S Design Synthesis Model**
  - Defines principle characteristics based on owner requirements
- **Proteus / Spar Flagship suite**
  - Smart Product Model (SPM) Advanced Parametric Ship Design, Cost Estimating, and Production Planning
- **SPM infrastructure**

Software Product	Functional Area
FastShip	Hullform Design
GHS/SDS	Hydrostatics and Stability
NavCad	Resistance and Powering
MAESTRO	Structural Modeling / Design
ESTI-MATE	Cost Estimating
PERCEPTION	Production Planning

Smart Product Model (SPM)

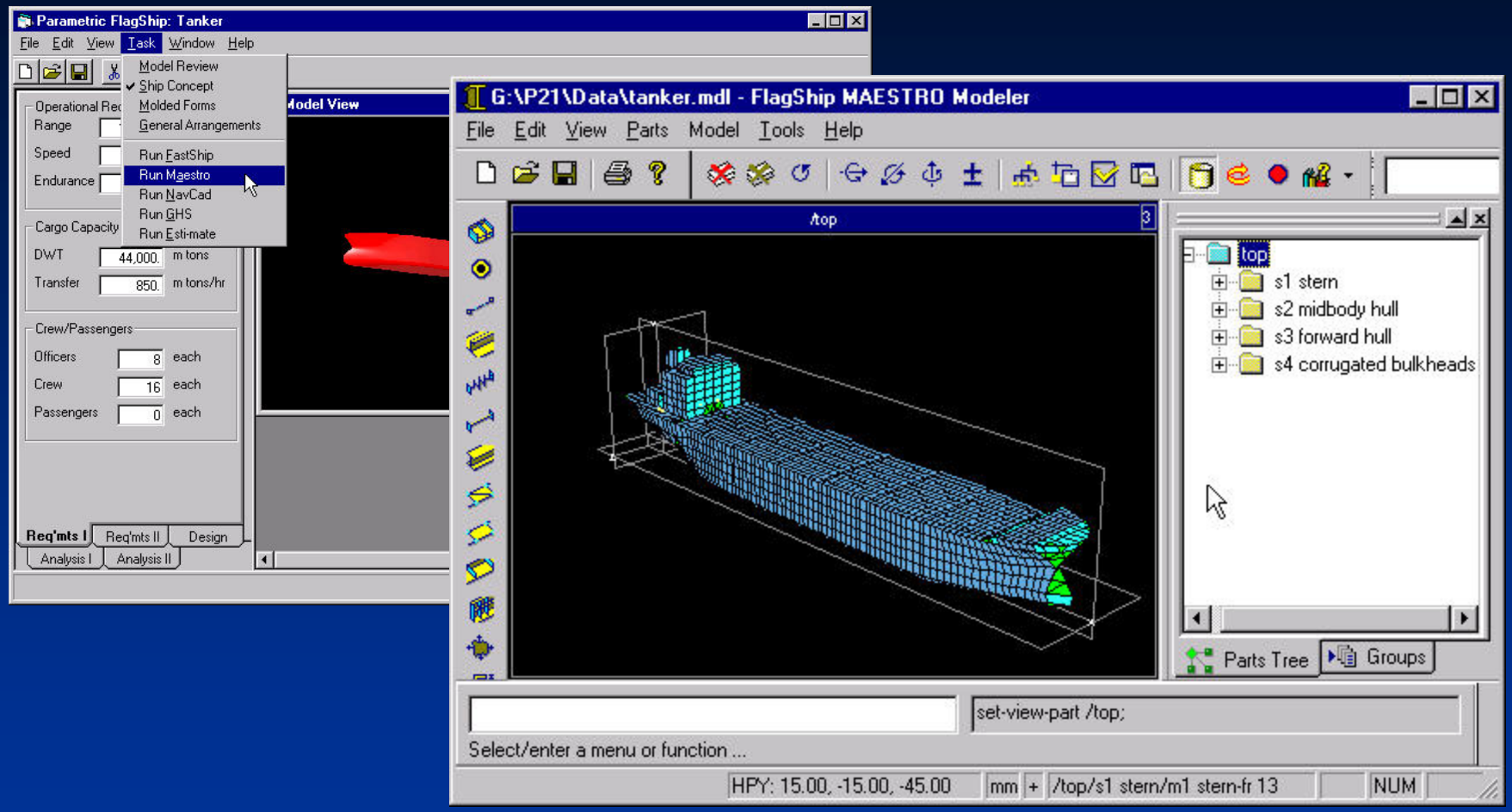
Material Standards & Parametric Design Rules



Parameters include top level owner's requirements, classification and limiting dimensions, naval architecture design parameters , ship characteristics, cost and labor analyses.

Smart Product Model (SPM)

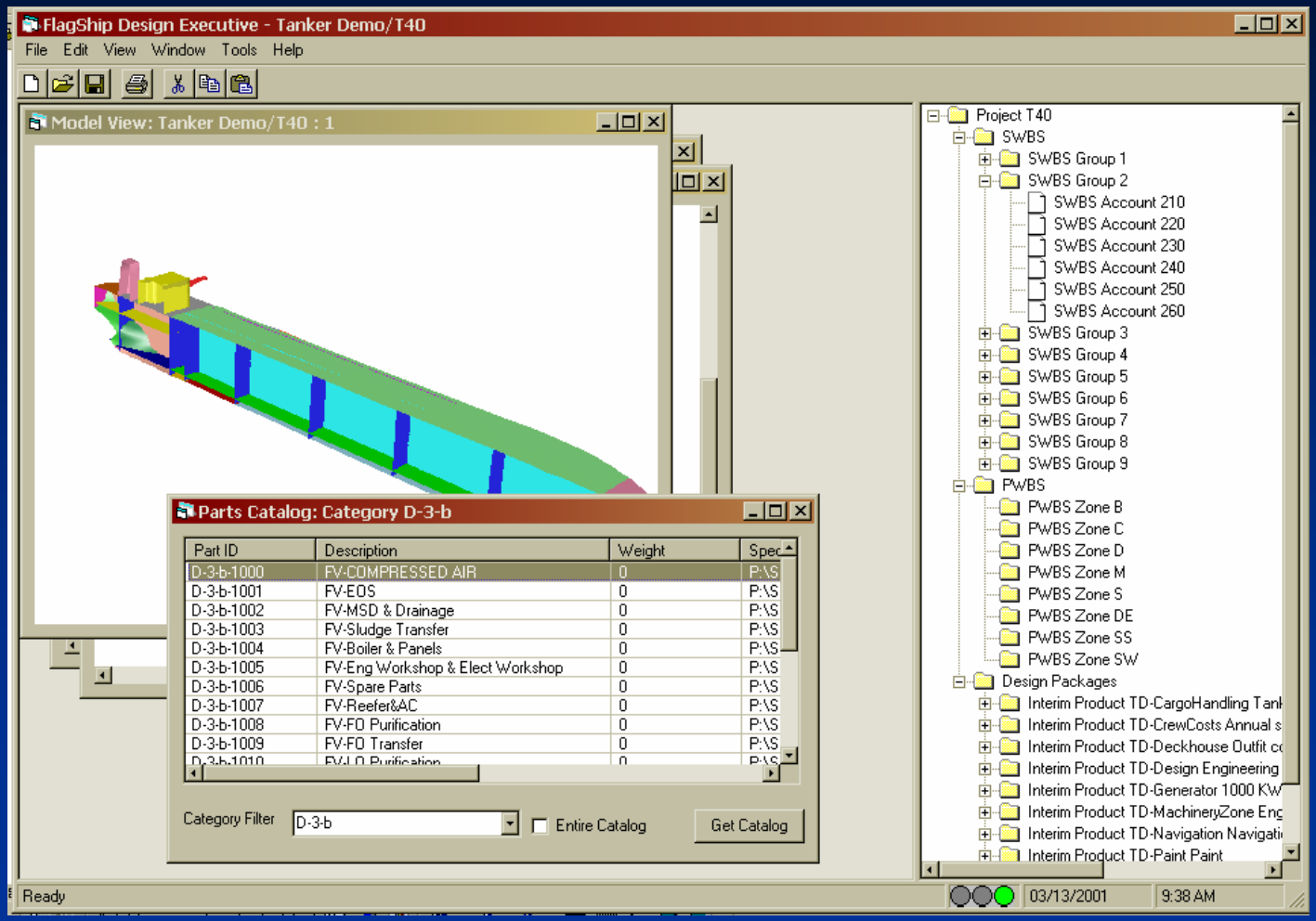
Material Standards & Parametric Design Rules



The SPM is linked to stand-alone tools for detailed design and analysis

Cost ESTI-MATE Model

Material Standards & Parametric Design Rules



Design Process Development

Material Standards & Parametric Design Rules

CID

-Standard Interim Products
-Material Standards
-Ship Data
-Catalog of Design Rules

Standard Type Data

Design Tools

Accom Design
Estimate
SPM

"Producible" Design Package

"Confident" Cost Estimate

Project Accomplishments

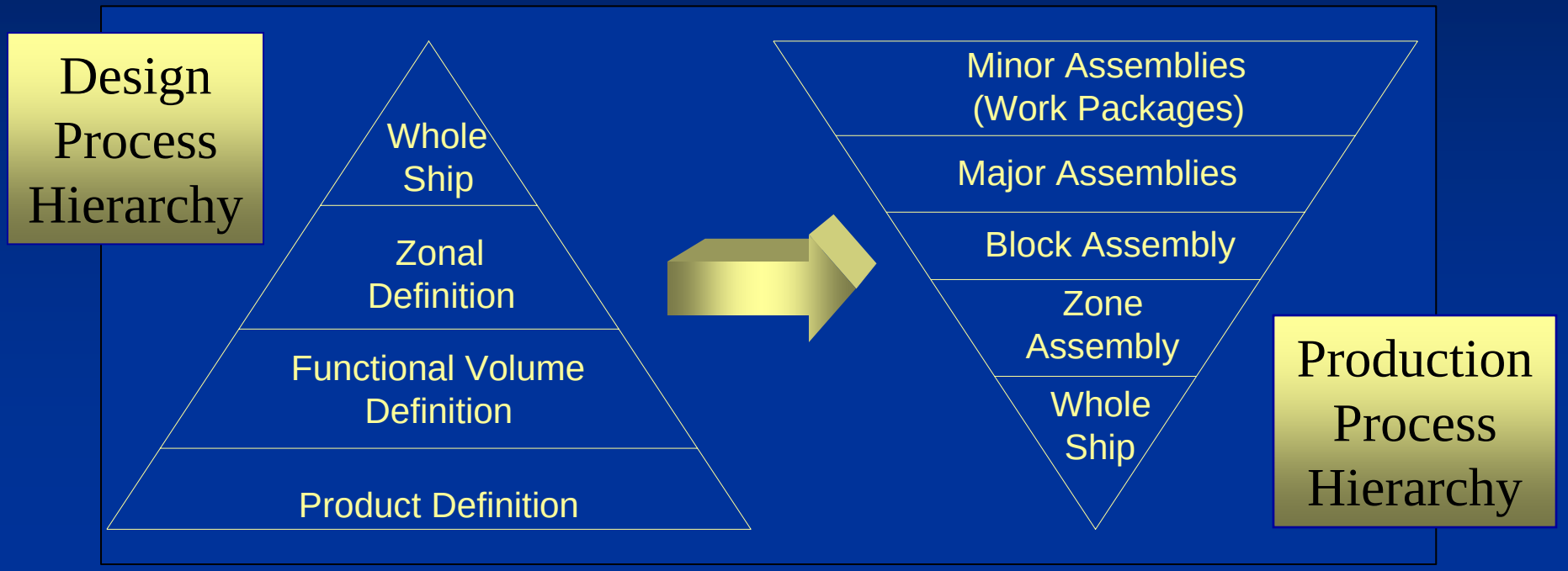
Material Standards & Parametric Design Rules

- **Task 5 - Develop Metrics and Rules for 'Whole-Ship' Design**
  - Developed metrics that characterize design and cost estimating processes for three generic ship types that are representative of the product mix for a medium-size US shipyard
    - » Container ship
    - » Product/Crude Tanker
    - » RO/RO Trailer Ship
  - Rules catalog development, over 500 rules captured

Design Rule Hierarchy

Material Standards & Parametric Design Rules

Design Rules Functional Volume Design



Project Accomplishments

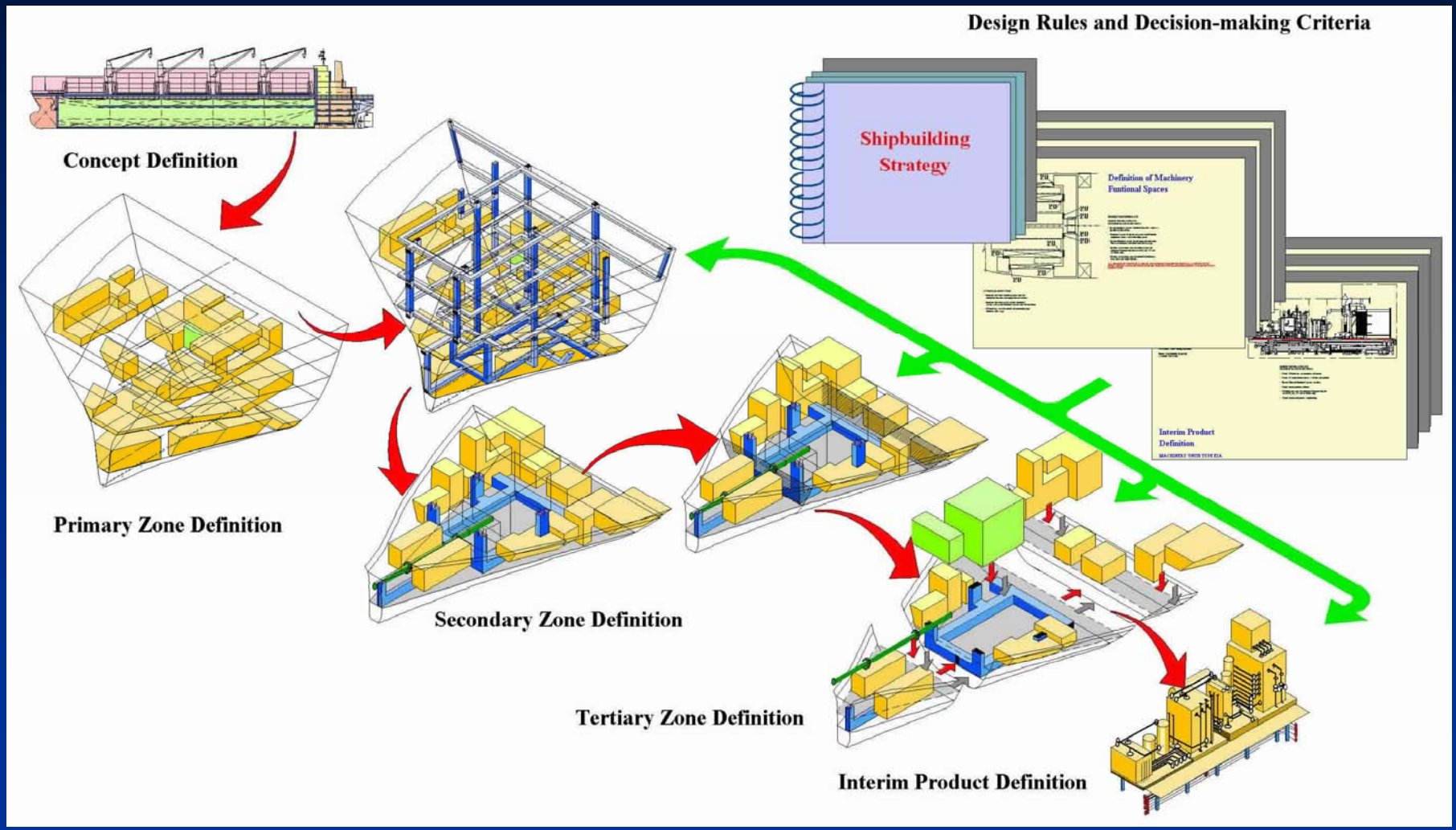
Material Standards & Parametric Design Rules

- **Task 6 - Develop Zone Design Rules & Material Templates**
  - Generic Interim Products Defined
  - Developed Design & Material Templates and Rules for each Ship Zone (Structure, Cargo, Machinery, Accommodations.)
  - Defined Functional Volume Design method and processes
    - » Integrated design and cost estimating process
    - » Conducted training on methodology at Industry workshops
    - » Two technical papers presented at SNAME Ship Production Symposium

Functional Volume Design

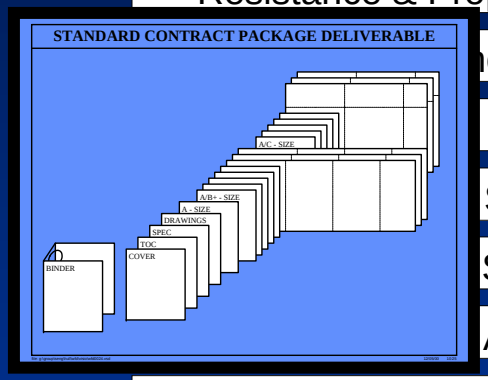
Material Standards & Parametric Design Rules

Design Process Application



Existing Design and Estimating Process

Material Standards & Parametric Design Rules



Lines Plan

Resistance & Propulsion (Model)

neuvering (Model)

Stability

Section

Analyses

Construction Profile & Deck Plans

Capacity Plan & Stowage Arrgt.

Machinery Arrangement

Key System Diagrams

List of Equipment

tric Load Analy

Key Purchase Spe

Vendors List

Contract Spec

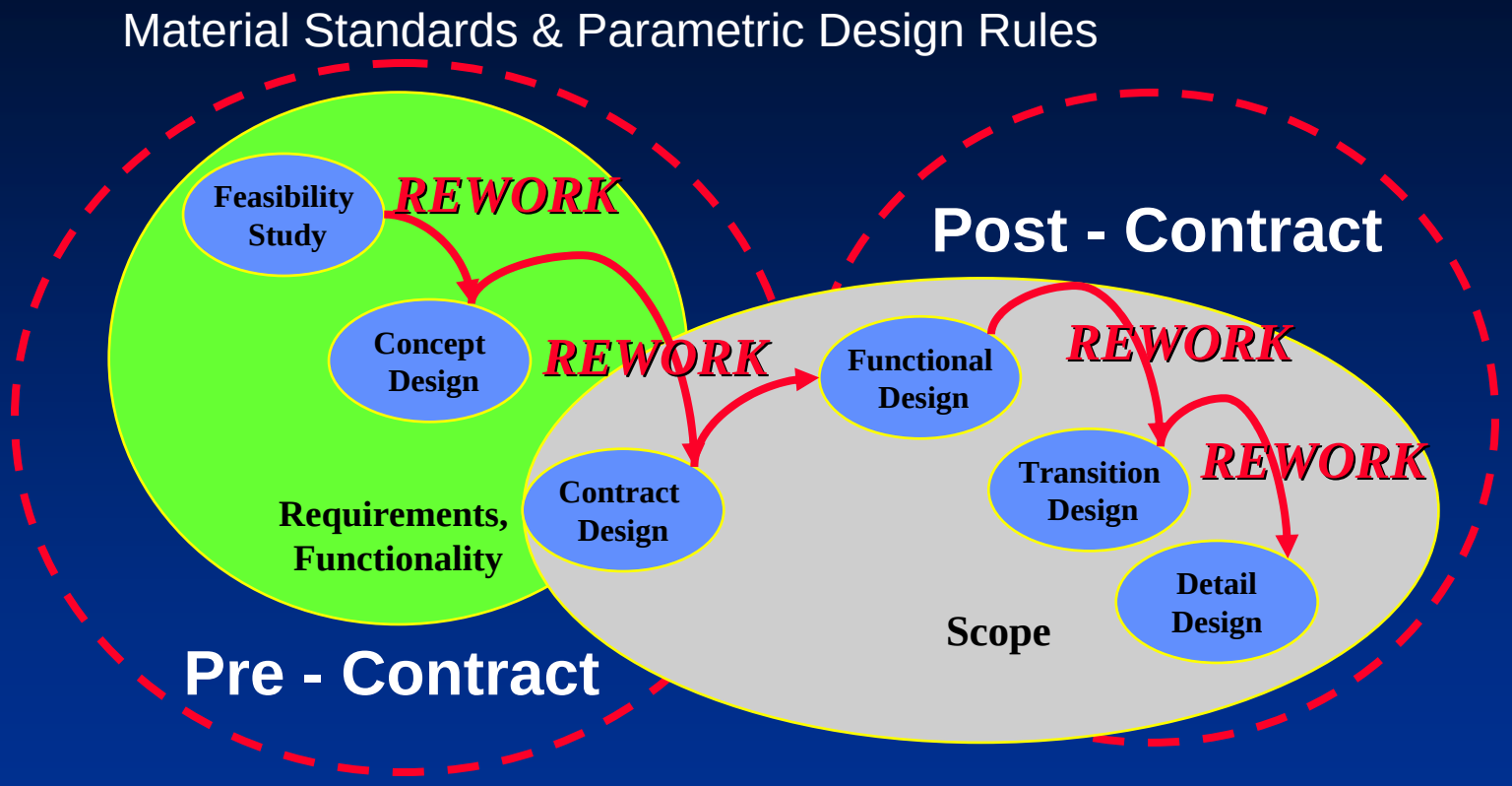
Bid Level Estimate

SCOPE

$$$

Words and Pictures are converted to SCOPE and Dollars

Existing Design and Estimating Process



- Scope defined late
  - Therefore Estimating defines notional scope
- Many aspects of “design definition” are really “rework”
  - Rework is associated with information quality
  - Improving information quality reduces rework and shortens design cycle

Functional Volume Design

Material Standards & Parametric Design Rules

Integrates pre-contract activity to communicate SCOPE by using templates

- ***Design*** **- visibility and responsibility for SCOPE**
- ***Estimating*** **- responsibility for rates and CER's**

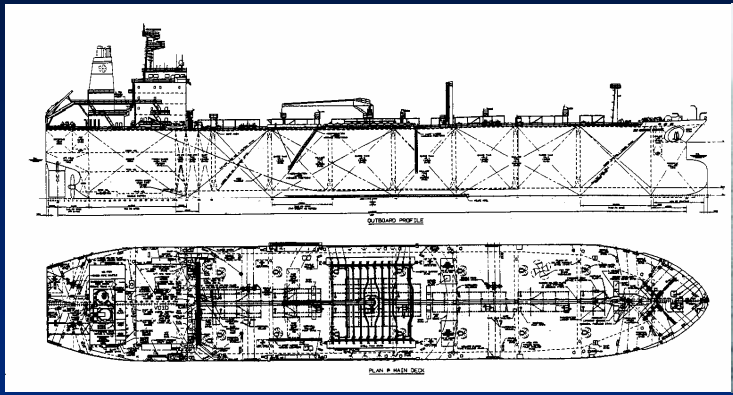
Together they drive out cost and eliminate re-work

- **Risk is minimized - technical, cost, & schedule**
- **Schedule is reduced**

Ship Type Selection

Material Standards & Parametric Design Rules

- **Task 7 - Validation Effort**



Baseline Design selected as NNS Double Eagle Class Tanker

- Contract design package submitted
- Produced a video and a electronic photo file of the vessel

A COMPLETE SHIP DESIGN WAS NOT VALIDATED

Project Accomplishments

Material Standards & Parametric Design Rules

- **Task 8 - Technology Transfer & Education**
  - **Module 1 Background/Need for Project**
    - Module 1.1 Current State of Art/Lean Principles
    - Module 1.2.1 Ship Design Toolset
    - Module 1.2.2 Information Systems
  - **Module 2 Material & Equipment Standards**
    - Module 2.1.1 Use of Standards
    - Module 2.1.2 Data Base Mgt – CID Part Equivalency
    - Module 2.1.3 Data Base Mgt – CID Audit Process
    - Module 2.1.4 Data Base Mgt – Data Element Dictionary
    - Module 2.1.5 ABS/USCG Approvals
    - Module 2.2.1 Specification Equipment Standards
    - Module 2.2.2 CID Spec. Equipment Standards
    - Module 2.2.3 CID Non-Spec. Equipment Standards

Project Accomplishments

Material Standards & Parametric Design Rules

- **Task 8 - Technology Transfer & Education**
  - **Module 3 Parametric Design Rules & System Tools**

Module 3.0	Improved Pre-Production Processes
Module 3.1	Introduction to Design Process
Module 3.2	Parametric Ship Design Tool
Module 3.6	Design & Material Templates
Module 3.7	Interim Products
Module 3.11	Accommodations & Deckhouse

  - **AccomDesign Software**

Module A1	Software Operating Instructions
Module A2	Software Use Example

Project Accomplishments

Material Standards & Parametric Design Rules

- **Task 9 - Prepare Project Reports & Deliverables**
  - 37 workshops and presentations conducted at Ship Production Symposia, NSRP Panel meetings, Project participant status reports and SNAME meetings at the national level.
  - 8 Journal papers written
  - Posted over 50 project deliverables on project web sites
    - » nsrp.org
    - » usashipbuilding.com
  - University classes and independent study work has been presented at U of Michigan & U of Washington
  - One Master's Thesis at the University of Washington
  - Developed ACCOM Design training software
  - Completed 12 Education and Training Modules

Potential Further Developments

- **Verify Functional Volume Design Approach Through Full Implementation**
  - A Methodology template has already been delivered
- **Continue Rules and Templates Development**
  - Further Develop Macro Standards for Integrated Products Across the Whole Ship
- **Demonstrate Applicability to Naval Ship Design**
- **Leverage On-going Developments with E Commerce and Common Parts Catalog Use**
- **Application of Expert Systems to Design Process**