THE NATIONAL SHIPBUILDING RESEARCH PROGRAM

Proceedings of the REAPS Technical Symposium

Paper No. 25: Producibility from Conceptual Design to Ship Construction

U.S. DEPARTMENT OF THE NAVY CARDEROCK DIVISION, NAVAL SURFACE WARFARE CENTER
DISCLAIMER

These reports were prepared as an account of government-sponsored work. Neither the United States, nor the United States Navy, nor any person acting on behalf of the United States Navy (A) makes any warranty or representation, expressed or implied, with respect to the accuracy, completeness or usefulness of the information contained in this report/manual, or that the use of any information, apparatus, method, or process disclosed in this report may not infringe privately owned rights; or (B) assumes any liabilities with respect to the use of or for damages resulting from the use of any information, apparatus, method, or process disclosed in the report. As used in the above, “Persons acting on behalf of the United States Navy” includes any employee, contractor, or subcontractor to the contractor of the United States Navy to the extent that such employee, contractor, or subcontractor to the contractor prepares, handles, or distributes, or provides access to any information pursuant to his employment or contract or subcontract to the contractor with the United States Navy. ANY POSSIBLE IMPLIED WARRANTIES OF MERCHANTABILITY AND/OR FITNESS FOR PURPOSE ARE SPECIFICALLY DISCLAIMED.
ABSTRACT

Producibility concepts may be applied in a variety of ways. Three main classifications are identified:

1. At the conceptual design stage
2. At the design development stage
3. As a method of reducing operational costs by removing work content, shortening the construction time and rationalizing material requirements of existing designs.

This paper reviews the effectiveness and likely benefits to be gained from these three approaches and examines design engineering, production engineering, facilities engineering and personnel engineering as applied at these three levels.
Figure 1

COST CONTROL POTENTIAL

START STUDIES

AGREE CONTRACT

CONTROL BUDGET ESTIMATE

START CONSTRUCTION

MAX

INFINITE INFLUENCE

OPTIMUM INFLUENCE

RAPIDLY DECREASING INFLUENCE

MINIMUM INFLUENCE

MIN

DESIGN ESTIMATING

DESIGN PRODUCIBILITY

PROJECT ENG PROCUREMENT

CONSTRUCTION COST ANALYSIS

PRINCIPAL ACTIVITIES

TIME

COST CONTROL INFLUENCE

REPORTING

COST

524
Length-Dead weight Options

1. 159.84 m LBP
   22.95 m B. / 25,500 dwt

2. 166.32 m LBP
   22.95 m B. / 26,800 dwt
   28.05 m B. / 33,800 dwt

3. 172.80 m LBP
   22.95 m B. / 27,900 dwt
   28.05 m B. / 35,200 dwt

4. 185.76 m LBP
   22.95 m B. / 30,250 dwt
   28.05 m B. / 38,200 dwt

5. 192.24 m LBP
   22.95 m B. / 31,400 dwt
   28.05 m B. / 39,750 dwt
Beam & Type Options

CONVENTIONAL

WIDE HATCH

FOREST PRODUCTS

28.05 m B.Mld.

22.95 m B.Mld.

Figure 4
Multiples of longitudinal modular dimensions in:

HOLD LENGTH

HATCH LENGTH

OVERALL LENGTH

172.80m LBP VESSEL - CARGO HOLD SECTION PROFILE
Multiples of VERTICAL Modular Dimensions

Multiples of TRANSVERSE Modular Dimensions

WIDE HATCH

CONVENTIONAL

28.05m Beam

22.95m Beam

ALTERNATIVE MIDSHIP SECTIONS
Hatch covers and coamings are assembled and tested 'off site' and delivered to the ship under construction.

Final welding of the coamings is completed and module welded in position.
Figure 11

Operational Characteristics of Shipbuilding

Owner

To State
- Mission requirements
- Vessel performance
- Outline specification
To Agree
- Delivery date
- Quality requirements
- Price

Engineering

To Specify
- Material requirements
- Quality standards
- Equipment performance criteria
To Provide
- Technical data matched to production capability
- Material requisitions

Commissioning

To Conduct
- Inspections
- Tests
- Trials
Within
- Contractual agreement
- Company quality standards
- Programmes & schedules

Control

To Specify
- Delivery dates
- Resource requirements
- Allocation of budget
To Provide
- Work definition
- Schedules
- Budgets
- Forecasts

Production

To Produce
- Components
- Assemblies
- Vessels
Within
- Budget
- Schedule
- Quality specification

Purchasing

To Procure
- Materials
- Equipment
- Services
To Satisfy
- Requisitions
- Quality standards
- Schedules
- Budgets
Figure 12

PRINCIPAL PROCESS RELATIONSHIPS
**Figure 13**

### Table of Parts

<table>
<thead>
<tr>
<th>Part No</th>
<th>Qty</th>
<th>Material</th>
<th>Dimensions</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>4</td>
<td>m.s. pipe</td>
<td>600 dia x 6000 long</td>
</tr>
<tr>
<td>2</td>
<td>4</td>
<td>Coupling</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>3</td>
<td>100x100x2 toe</td>
<td>3200 long</td>
</tr>
<tr>
<td>4</td>
<td>9</td>
<td>#</td>
<td>750 long</td>
</tr>
<tr>
<td>5</td>
<td>12</td>
<td>m.s. bar</td>
<td>25 dia x 1550 long</td>
</tr>
<tr>
<td>6</td>
<td>12</td>
<td>m.s. washer</td>
<td>25 mm dia</td>
</tr>
<tr>
<td>7</td>
<td>12</td>
<td>m.s. nut</td>
<td>M24 thread</td>
</tr>
<tr>
<td>8</td>
<td>12</td>
<td>m.s. lock</td>
<td>M24 thread</td>
</tr>
</tbody>
</table>

**Note:**

6000 length (item 1) can be altered to suit the customer's specific requirements.
### TABLE 1

**DESIGN CONSIDERATIONS**

<table>
<thead>
<tr>
<th></th>
<th>Operational requirements study.</th>
</tr>
</thead>
<tbody>
<tr>
<td>b</td>
<td>Principal dimensions selection.</td>
</tr>
<tr>
<td>c</td>
<td>Body plan.</td>
</tr>
<tr>
<td>d</td>
<td>Form variation.</td>
</tr>
<tr>
<td>e</td>
<td>Hydrostatic calculations.</td>
</tr>
<tr>
<td>f</td>
<td>Main dimensional analysis.</td>
</tr>
<tr>
<td>s</td>
<td>Freeboard.</td>
</tr>
<tr>
<td>h</td>
<td>Subdivision.</td>
</tr>
<tr>
<td>i</td>
<td>Propulsion system</td>
</tr>
<tr>
<td>j</td>
<td>Capacity calculations.</td>
</tr>
<tr>
<td>k</td>
<td>Preliminary selection of equipment.</td>
</tr>
<tr>
<td>l</td>
<td>Machinery component selection.</td>
</tr>
<tr>
<td>m</td>
<td>Electrical component selection.</td>
</tr>
<tr>
<td>n</td>
<td>Weight and C.G. calculation.</td>
</tr>
<tr>
<td>o</td>
<td>Trim and stability calculation.</td>
</tr>
<tr>
<td>p</td>
<td>Damaged stability calculation.</td>
</tr>
<tr>
<td>q</td>
<td>Strength calculations.</td>
</tr>
<tr>
<td>r</td>
<td>Speed prediction.</td>
</tr>
<tr>
<td>s</td>
<td>General arrangements.</td>
</tr>
<tr>
<td>t</td>
<td>Machinery systems balance calculations.</td>
</tr>
<tr>
<td>u</td>
<td>General arrangement of engine room</td>
</tr>
<tr>
<td>v</td>
<td>Pipe systems.</td>
</tr>
<tr>
<td>w</td>
<td>Electrical systems.</td>
</tr>
<tr>
<td>x</td>
<td>Technical specification.</td>
</tr>
</tbody>
</table>
TABLE 2
PRODUCIBILITY CONSIDERATIONS

a) Principal Dimensional Check
- Launch/float out.
- Navigation.
- Crane cover and clearance.
- Ground/dock loading.

b) Vessel Characteristics
- General arrangements.
- New/unknown type.
- Construction philosophy.
- Zone configuration.
- Special technological requirements.
- Structural configuration.
- Hull form
- Supplier/subcontract content,
- Technical interdependence.
- Modularity and standards.
- Balance of work content.

c) Facility Characteristics
- Berth/dock dimensions.
- Tidal influence.
- Accessibility.
- Levels of technology employed.
- Human skills.
- Working practices.
- Resource balance.
- Manufactured products.
Table 2 cont’d

- Material storage.
- Crane capacities.
- Internal transport.
- Material dimensions.
- Standards.
- Production capacity.

**d) Assembly Philosophy**

- Steel.
- Outfit.
- Pipework.
- Engineering.
- Electrical.
- Subcontract content.
- Painting.
- Zone outfitting.
- Block breakdown.

**e) Manufacturing Philosophy**

- Standards.
- Range of products.
- Modularity.
- Material definition.
- Jigs and tooling.
- Technical information.
- Balance of manufacturing resources.
- Subcontract content.

**f) Planning and Control**

- Programme and cost.
- Sequence of work.
- Work content analysis.
- Productivity.
- Sensitivity.
Figure 15
Additional copies of this report can be obtained from the National Shipbuilding Research and Documentation Center:

http://www.nsnet.com/docctr/

Documentation Center  
The University of Michigan  
Transportation Research Institute  
Marine Systems Division  
2901 Baxter Road  
Ann Arbor, MI  48109-2150

Phone: 734-763-2465  
Fax: 734-763-4862  
E-mail: Doc.Center@umich.edu