The following is an extract from a speech by K. Matsushita about Japanese and American business competition.

• We will win and you will lose. You cannot do anything about it because your failure is an internal disease. Your companies are based on Taylor’s principles, Worse, your heads are Taylorized too. You firmly believe that sound management means executives on one side and workers on the other, on one side men who think and on the other side men who can only work. For you management is the art of smoothly transferring the executives’ ideas to the workers’ hands.
DESIGN FOR PRODUCTION

SHIPBUILDING PRODUCTIVITY AND COMPETITIVENESS

• We have passed the Taylor stage. We are aware that business has become terribly complex. Survival is very uncertain in an environment filled with risk, the unexpected, and competition.

• We have measured, better than you, the new technological and economic challenges. We know that the intelligence of a few technocrats, even very bright ones, has become totally inadequate to face these challenges. Only the intellects of all employees can permit a company to live with the ups and downs and the requirements of its new environment. Yes we will win and you will lose. For you are not able to rid your minds of the obsolete Taylorism that we never had.
DESIGN FOR PRODUCTION

SHIPBUILDING PRODUCTIVITY AND COMPETITIVENESS

• Is Matsushita right?

• Are we doomed to fail with the approach that brought us the post war industrial boom and our current advanced standard of living?

• Taylorism (specialization) brought us mass production and all its productivity benefits. [Shipbuilding is not a mass production industry and heavily depends on craft skills]

• Can we rise to the challenge and prove him wrong?

• To help us answer these questions we must examine our productivity and competitiveness.
DESIGN FOR PRODUCTION

SHIPBUILDING PRODUCTIVITY AND COMPETITIVENESS

• What is PRODUCTIVITY?

• How is it measured?

• How can it be compared across industries and countries?

• If we do not have the answer to any of these questions we cannot measure or compare our performance
DESIGN FOR PRODUCTION

SHIPBUILDING PRODUCTIVITY AND COMPETITIVENESS

• Productivity can be used to measure performance of countries, industries, companies and individuals.
• Early concepts and measures were mainly for the macroeconomic level of analysis.
• Productivity is an important concept in that it is used for many important purposes.
• Since the late 1940’s, it has been increasingly used to measure performances in individual companies.
• The underlying concepts and measurement techniques are the same, regardless of the level of application.
• By comparing productivity over successive time periods, any improvement (growth) in productivity can be measured.
DESIGN FOR PRODUCTION

SHIPBUILDING PRODUCTIVITY AND COMPETITIVENESS

- Productivity is the amount of output achieved for a given amount of input.

- Input could be materials, manpower and energy.

- Problem is that it is desirable to have a dimensionless measure.

- This can be achieved by converting all output and input to dollars.

- However, there are useful Productivity Metrics that are not dimensionless
DESIGN FOR PRODUCTION

SHIPBUILDING PRODUCTIVITY AND COMPETITIVENESS

• The major challenge that US shipbuilders face for the foreseeable future is improving productivity.

• It is a broad strategic issue. As such it must be of concern to government, management, and workers.

• However, it is management’s responsibility to set and take the necessary action to accomplish productivity goals.

• In the 1940s and 1950s, the measurement of productivity focused on output, or the production of as much as possible.

• In the 1960s and 1970s, quantity was no longer as important as efficiency, or production at lowest cost.

• Today, productivity is effectiveness, which is a combination of right product, right time, quality, and efficiency.
DESIGN FOR PRODUCTION

SHIPBUILDING PRODUCTIVITY AND COMPETITIVENESS

• It is clear that productivity is a complex issue. There are no simple and easy solutions. It is and always will be a long term threat and challenge to business.

• To improve productivity we need to consider four basic areas:
  Management development
  Strategic development and integration of technology
  Recognition/reward systems
  Adversarial philosophy

• In the shipbuilding industry they all need to be improved
SHIPBUILDING PRODUCTIVITY AND COMPETITIVENESS

Productivity is influenced by:

- Technology
- Facilities
- Management Competence
- Work Organization
- Work Practice
- Worker Skill Level
- Worker Motivation
SHIPBUILDING PRODUCTIVITY AND COMPETITIVENESS

Productivity Measurements

General

• Sales ($) per employee

• Profit ($) per employee

• Profit percentage per employee
SHIPBUILDING PRODUCTIVITY AND COMPETITIVENESS

Productivity Measurements (Continued)

Shipbuilding

• Man Hours/ Tonne (Steel Weight or Lightship Weight)
• Steel Tonne Throughput/Man Hours X Shipyard Steel Shop area
• Man Hours/Joint Weld Length (JWL)
• Total Cost per DWT Tonne
• Total Cost per Lightship Tonne
• Steel Cost per Steel Weight Tonne
• Outfit Cost per Outfit Weight Tonne

Some shipyards define productivity as BUDGET man hours divided by ACTUAL man hours.
DESIGN FOR PRODUCTION

SHIPBUILDING PRODUCTIVITY AND COMPETITIVENESS

Know where the Work Content is:

<table>
<thead>
<tr>
<th></th>
<th>Naval Ship</th>
<th>Commercial Ship</th>
</tr>
</thead>
<tbody>
<tr>
<td>% ManHrs</td>
<td>30</td>
<td>55</td>
</tr>
<tr>
<td>% Manhrs</td>
<td>300,000</td>
<td>110,000</td>
</tr>
<tr>
<td>% Manhrs</td>
<td>70</td>
<td>45</td>
</tr>
<tr>
<td>% Manhrs</td>
<td>700,000</td>
<td>90,000</td>
</tr>
</tbody>
</table>

- Structure
  - 30% ManHrs/300,000 Manhrs
  - 55% ManHrs/110,000 Manhrs

- Machinery and Outfit
  - 70% ManHrs/700,000 Manhrs
  - 45% ManHrs/90,000 Manhrs

- Berth Steel Manhours are 55% of Total Steel Manhours

- This is mainly due to Welding:
  - In Shops: 1 MH for 1.3 feet JWL
  - On Plattens: 1 MH for 0.8 feet JWL
  - On Berth: 1 MH for 0.2 feet JWL

- Advanced Outfitting:
  - On Unit: 1 MH per Weight Tonne
  - On Block: 4 MH per Weight Tonne
  - On Board: 8 MH per Weight Tonne
DESIGN FOR PRODUCTION

SHIPBUILDING PRODUCTIVITY AND COMPETITIVENESS

• Steel Labor Rate depends on two main factors:
  Ship Type - Defines complexity
  Ship Size - Defines influence of size

• Other factors are:
  Production Technology
  Erection Block Lift Weight
  Consistency of throughput

• For example, the LSD 41 has 6,500 LT Steel Weight and a Labor Rate of about 154MH/LT. Based on Dry Cargo ships designed to ABS of similar Steel Weight, the Labor Rate for a single vessel contract would be 54MH/LT.

• How can the LSD 41 warrant such a high rate?
SHIPBUILDING PRODUCTIVITY AND COMPETITIVENESS

• The difference is because of differing complexities of ship and can be explained by a number of approaches.
• For example, consider only the average structural plate area per pound and JWL. For the LSD41 the first parameter would be twice the cargo ship value and the second would be 5 to 8 times (need to consider both values as different shipyards measure JWL differently)
• Therefore the labor Rate Ratio for LSD41 compared to Dry Cargo Ship would be:

\[
\frac{2 \times 0.4^* + 5 \times 0.35}{138\text{MH/LT}} = 2.55 \text{ OR } \frac{2 \times 0.4 + 8 \times 0.35}{194\text{MH/LT}} = 3.6
\]

*0.4 and 0.35 are the proportion of Structural MH affected by density and weld length respectively.
SHIPBUILDING PRODUCTIVITY AND COMPETITIVENESS

• Productivity in US shipyards must be improved.
• Productivity focus is usually on direct labor, but management, engineering and indirect labor productivity has biggest leverage for improvement.
• Must develop ways of measuring management, engineering and indirect productivity.
• Labor productivity is a combination of labor performance, labor utilization, process efficiency, and planning effectiveness.
• Of the four, only the first one is directly controlled by the worker.
• The other three offer the greatest potential for productivity improvement and are solely dependent on management.
DESIGN FOR PRODUCTION

SHIPBUILDING PRODUCTIVITY AND COMPETITIVENESS

- **Labor performance** is influenced mainly by environment and motivation.

- **Labor utilization** is that portion of the work time for which the worker is actually working.

- **Process efficiency** relates to machine utilization, materials handling and work methods.

- **Planning effectiveness** is the means to ensure that skilled and motivated workers have the necessary information, tools, materials, and support at the correct time and place to perform the assign task.
DESIGN FOR PRODUCTION

SHIPBUILDING PRODUCTIVITY AND COMPETITIVENESS

• Productivity is not a linear (or summation) combination of these factors but a compound (multiplication) combination.

• This accounts for the “factors of magnitude” differences in productivity between similar shipyards.

• How this occurs can be demonstrated by considering only three of the factors (We are unable to visualize four dimensions). They will be Workers Performance, Workforce Utilization, and Method Level.
DESIGN FOR PRODUCTION

SHIPBUILDING PRODUCTIVITY AND COMPETITIVENESS

• **Workers Performance** is the ratio of the Target or Measured Work Content Standard Manhours to the Actual Manhours taken.
  
  \[
  \frac{80 \text{ Standard Manhours}}{100 \text{ Actual Manhours}} = 0.8
  \]

• **Workforce Utilization** is the ratio of the Possible worked manhours and the Actual worked manhours.
  
  \[
  \frac{[200 \text{ Attendance MH-40 Stoppage MH}]}{200} = 0.8
  \]

• **Method Level** is the ratio of manhours required by the best available method o the standard manhours for the existing method.
  
  \[
  \frac{80 \text{ Standard manhours for best available method}}{100 \text{ manhours for actual method used}} = 0.8
  \]
DESIGN FOR PRODUCTION

SHIPBUILDING PRODUCTIVITY AND COMPETITIVENESS

FIGURE 1.6 Productivity space.
SHIPBUILDING PRODUCTIVITY AND COMPETITIVENESS

• Thus it can be seen how there can be significant productivity differences between shipyards.
• When the fourth factor (additional dimension) is also considered the differences will be even greater.
• It also explains how an advanced shipyard can have low productivity.
• It is therefore clear that if a shipyard desires to improve productivity, it must first determine the existing values of the productivity factors. Then it can work on the low value factor(s) before contemplating change to the best. It is illogical to undertake large investments in facilities if existing performance, utilization, and planning effectiveness are low.
SHIPBUILDING PRODUCTIVITY AND COMPETITIVENESS

- Sverdrup identified the following factors by which productivity can be influenced:
  - Planning and Control
  - Design Simplification
  - Incentive Wage Systems (Motivator)
  - Investments in facilities, equipment and training
  - Subcontracting

- Sverdrup also quotes “It is our experience (B&W) that the greatest possibilities for productivity improvement are to be found at the design stage, not only at the time of making the working drawings, but also at the earliest stage of specifying the product.”
SHIPBUILDING PRODUCTIVITY AND COMPETITIVENESS

- Productivity improvement through design can be achieved, without detriment to function, quality and reliability, by:
  Reducing number of connections
  Standardizing details
  Reducing number of moves and rotations
  Consideration of shipyard cost rather than supplier cost
  Providing engineering information, CAM information and material lists in a form directly usable by the users.

- Standards make it possible to:
  Reduce design work content and time
  Attain group manufacturing benefits in ship production
  Facilitate effective material control by number and variety reduction
SHIPBUILDING PRODUCTIVITY AND COMPETITIVENESS

- Productivity improvement depends on a rational use of all resources.

  Work instructions available in time and in such a form that each work station knows exactly what to do and when to do it.

  Materials and tools available at the right time.

  Processing, assembly, erection and installation carried out under the best possible working conditions.
DESIGN FOR PRODUCTION

SHIPBUILDING PRODUCTIVITY AND COMPETITIVENESS

• Detailed design productivity can be improved by having a Shipbuilding Policy and Build Strategy complete and approved prior to commencement of design and construction of a ship.

• Production productivity improvement will depend on ability to reorganize traditionally separate craft work in parallel.

• Productivity improvement is possible through improved material control. If workers must wait or search for material and tools when they need them, their productivity will be significantly less than possible. It is predicted that up to 30% of a workers time is lost this way.
SHIPBUILDING PRODUCTIVITY AND COMPETITIVENESS

• Good modern facilities do not in themselves guarantee high productivity.

• Sophisticated computer systems, automation and robotics will not in themselves guarantee high productivity.

• Unions and work rules are not directly responsible for low productivity. They are constraints but can be accommodated.

• None of the above three alone cause low productivity.

• Real direct productivity problem is management ability.

• High productivity depends mainly on the ability of management to organize work so that facility and worker utilization are optimized.
DESIGN FOR PRODUCTION

SHIPBUILDING PRODUCTIVITY AND COMPETITIVENESS

• Good work organization is characterized by:
  High utilization of area
  Clearly identified workstations
  Clearly identified interim products
  Packaged (Kitted) material
  Relevant and timely technical information
  Simply but effective planning systems
  Visual work station performance metrics at each station
  Worker self-measurement
  Good maintenance
  Good Housekeeping
Ways to improve productivity

- Standardization
- Simplification
- Specialization

- Increased STANDARDIZATION will make it possible to identify and set up work stations with minimum product variety

- SIMPLIFICATION of interim products will lead to reduced work content and easier production

- With simplified production, increased SPECIALIZATION of processes and equipment will lead to greater efficiency
Ways to improve productivity (Continued)

• Do not try to improve overall performance by a percentage, such as 5 or 10%. This will waste time trying to improve strengths as well as weaknesses.

• First determine weaknesses (a performance gap) and improve them.

• It is easier to improve a weakness than to improve a strength.

• Therefore attack the weaknesses (determine gap and improve performance against it - then you can target 100% and 300% improvements) for early and significant gains.
SHIPBUILDING PRODUCTIVITY AND COMPETITIVENESS

Ways to improve productivity (Continued)

- Ensure that top management is involved and committed to productivity improvement. Limiting it to lower level management and workers will fail due to lack of long term support.

- Don’t confuse improving productivity with cutting cost. It will probably reduce cost, but the two are distinct and important.

- It is necessary to train both managers and workers to enable them to learn what productivity really is, why it is necessary, how to measure it, and how to manage it.
SHIPBUILDING PRODUCTIVITY AND COMPETITIVENESS

Highly productive shipyards are characterized by:
- Clearly defined objectives and policy
- Short build cycles
- Overlapping and integration of structure and outfit
- An awareness by management of productivity measures

To achieve high productivity:
- First, develop a Shipbuilding Policy
- Next, develop shipyard Process Flow and establish Work Stations
- Establish integrated Planning and Process Development
- Prepare a Build Strategy for each contract.
- Measure and Control performance
WHAT IS TECHNOLOGY

• Technology is the knowledge and processes used to provide products for human use.
• Technology is thinkware, software and hardware as well as their application processes.
• In shipbuilding it is the practices used to design and build ships and other marine products.
• Advanced technology shipbuilding is associated with production oriented design, block construction, very short berth erection times and ships that are virtually complete at launch.
• Advanced technology alone does not assure the production of internationally competitive ships.
SHIPBUILDING PRODUCTIVITY AND COMPETITIVENESS

NSRP GLOBAL SHIPBUILDING TECHNOLOGY SURVEY

• Studies were performed in 1978 and 1993-4
• Objective was to determine how U.S. shipbuilding technology compared to world class foreign shipbuilding technology
• Depth of Studies - Number of shipyards surveyed

<table>
<thead>
<tr>
<th>COUNTRY</th>
<th>1978</th>
<th>1993/4</th>
</tr>
</thead>
<tbody>
<tr>
<td>USA</td>
<td>13</td>
<td>5</td>
</tr>
<tr>
<td>Japan</td>
<td>12</td>
<td>1</td>
</tr>
<tr>
<td>UK</td>
<td>7</td>
<td>2</td>
</tr>
<tr>
<td>France</td>
<td>2</td>
<td>0</td>
</tr>
<tr>
<td>West Germany</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>Sweden</td>
<td>2</td>
<td>0</td>
</tr>
<tr>
<td>Denmark</td>
<td>1</td>
<td>1</td>
</tr>
</tbody>
</table>

• In 1978 each US shipyard was compared to 4 similar type best foreign shipyards. Used 3 “model” Japanese shipyards (New High Volume, Large and Small modernized)
## DESIGN FOR PRODUCTION

SHIPBUILDING PRODUCTIVITY AND COMPETITIVENESS

**NSRP GLOBAL SHIPBUILDING TECHNOLOGY SURVEY**

- **Depth of Studies - Number of Factors**

<table>
<thead>
<tr>
<th>ITEM</th>
<th>1978</th>
<th>1993/4</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of Categories</td>
<td>8</td>
<td>7</td>
</tr>
<tr>
<td>Number of Elements</td>
<td>70</td>
<td>62</td>
</tr>
<tr>
<td>Number of Technology Levels</td>
<td>4</td>
<td>5</td>
</tr>
</tbody>
</table>

- **Depth of Studies - Shipyard Size**

<table>
<thead>
<tr>
<th>ITEM</th>
<th>1978</th>
<th>1993/4</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>US</td>
<td>Foreign</td>
</tr>
<tr>
<td>Large Shipyards</td>
<td>2</td>
<td>4</td>
</tr>
<tr>
<td>Medium Shipyards</td>
<td>6</td>
<td>7</td>
</tr>
<tr>
<td>Small Shipyards</td>
<td>5</td>
<td>5</td>
</tr>
</tbody>
</table>
## Technology Levels

<table>
<thead>
<tr>
<th>LEVEL</th>
<th>PRACTICE</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>1960 shipbuilding practice - multiple berths, small cranes, on-board outfitting after launch, and manual operating systems</td>
</tr>
<tr>
<td>2</td>
<td>1970 shipbuilding practice – modernized facilities, fewer berths or a building dock used, larger cranes, pre-outfitting, and some computer based operating systems</td>
</tr>
</tbody>
</table>
## Technology Levels (Continued)

<table>
<thead>
<tr>
<th>LEVEL</th>
<th>PRACTICE</th>
</tr>
</thead>
<tbody>
<tr>
<td>3</td>
<td>1980 shipbuilding practice – new or fully re-developed shipyard with large capacity cranes, single dock with some protection from environment, large degree of mechanization and extensive use of computers</td>
</tr>
<tr>
<td>4</td>
<td>1985 shipbuilding practice – continuous improvement, large block construction, advanced &amp; zone outfitting with ship virtually complete at launch</td>
</tr>
<tr>
<td>LEVEL</td>
<td>PRACTICE</td>
</tr>
<tr>
<td>-------</td>
<td>----------</td>
</tr>
<tr>
<td>5</td>
<td>1990 state of the art shipbuilding practice – developed from level 4 through automation, integration of operating systems, effective use of CAD, CAPP and CA material planning, improved quality control through mastering dimensional and/or accuracy control</td>
</tr>
</tbody>
</table>
Technology Audit Elements

A. Steelwork Production
B. Outfit Production
C. Other Pre-erection
D. Ship Construction & Outfit Installation
E. Layout & Environment
F. Amenities
G. Design, Drafting, Production Engineering & Lofting
H. Organization & Operating Systems
## Technology Audit Results

<table>
<thead>
<tr>
<th>Element</th>
<th>U.S. Shipyards</th>
<th>Foreign Shipyards</th>
</tr>
</thead>
<tbody>
<tr>
<td>A. Steelwork Production</td>
<td>2.91</td>
<td>(.6)</td>
</tr>
<tr>
<td>B. Outfit Production</td>
<td>3.30</td>
<td>(.4)</td>
</tr>
<tr>
<td>C. Other Pre-Erection</td>
<td>3.83</td>
<td>(.3)</td>
</tr>
<tr>
<td>D. Ship construction</td>
<td>3.18</td>
<td>(.8)</td>
</tr>
<tr>
<td>E. Layout &amp; environment</td>
<td>2.94</td>
<td>(.4)</td>
</tr>
<tr>
<td>G. Design, Drafting, etc.</td>
<td>3.45</td>
<td>(.9)</td>
</tr>
<tr>
<td>H. Organization/ Operating</td>
<td>4.04</td>
<td>(.7)</td>
</tr>
<tr>
<td>OVERALL LEVEL</td>
<td>3.40</td>
<td>(.6)</td>
</tr>
</tbody>
</table>
Productivity versus Technology

Technology is only one part of the Productivity equation. Productivity is influenced by a combination of the following factors:

- Technology
- Facilities
- Planning
- Management capability
- Work organization
- Work practices
- Worker motivation
- Worker skills
Productivity versus Technology
In the 1978 Study Report it was stated:

“Probably the single most important requisite to making major investments in facilities, is to have orders supporting economies of scale. Level technology calls for purpose designed jigs, fixtures and equipment, heavy lift capability, etc., which are not readily adaptable to small runs of different ship types, at least not efficiently. Thus if the market does not provide a basis for long range programming, individual shipyards must determine whether the highest level of technology is economical for them.”

THIS IS EQUALLY TRUE TODAY
Productivity versus Technology

• There is a lot of room for improvement without investment in “Advanced Technology.”

• In fact, experience has clearly shown that the introduction of advanced technology into a facility that is not operating at its best with what it has, will not reap the full benefit of the new technology.

• So first, it is necessary to make all the improvements you can with what you have and then decide what advanced technology you need to put you ahead of the competition and to maintain a competitive advantage.
Productivity versus Technology
Justification of Position

• General Motors chose technology route and spent billions on fully automated factory. Results were disappointing. Factory closed down.

• Ford chose to improve the design and build process. This resulted in the Taurus team and a very successful car.
DESIGN FOR PRODUCTION

Productivity versus Technology

![Diagram showing the development of technology over time with productivity requirements for different regions like Japan, North Europe, US & Rest of Europe. The graph highlights the gap between technology and productivity, indicating required improvements.](image-url)
Productivity versus Technology

Global Technology Study Conclusion

• Instead of narrowing the technology gap between US and foreign shipyards it has opened slightly.
• The best US shipyard technology level is a full level below the best foreign shipyard.
• This is probably because US shipyards try to maintain flexibility to respond to bid requests for any ship type, whereas foreign shipyards are more focused on a few ship types.
• While US shipyards have reduced the gap by half for one category in Element C, namely Other Pre-erection Activities, which was the largest difference in 1978, the gap for other three categories has significantly increased.
Productivity versus Technology

Productivity Metrics

• Before proceeding into Competitiveness it is necessary to develop an acceptable Productivity Metric.

• There is no universally accepted productivity metric.

• A metric should be based on a readily available parameter.

• Potential candidates for shipbuilding are Steel Weight, Lightship Weight, Displacement, and Gross Tonnage.

• The first four are all weights and would give similar results. The final candidate is a volume.

• Experience has shown that weights are not a good parameter and volume fairs little better.
Productivity versus Technology

Productivity Metrics (Continued)

- To overcome this problem the concept of Compensated Gross Tonnage was developed. The compensation is to take into account ship type (complexity) and size.

- The concept has been developed by the Association of West European Shipbuilders and the Shipbuilders Association of Japan since 1967 and was adopted by OECD in 1974 as a parameter on which to base national shipbuilding output comparisons.

- Compensation coefficients have been developed over many years through negotiation between major shipbuilding countries. They have been developed for all types of commercial ships BUT NOT FOR NAVAL SHIPS
Productivity versus Technology

Productivity Metrics (Continued)

• The CGT has been used as the parameter for a productivity metric in the form of:
  Manhours/CGT
  CGT/Man Year

• It was originally used for aggregate measures such as countries, but it has been refined to apply to individual shipbuilders.

• It was used by EEC to measure shipyard competitiveness and as a decision tool to decide which shipyards could stay in business and which must close.

• So it is recognized and accepted by many as a very important metric. However, its acceptance and use in US is very limited.
Productivity versus Technology

Productivity Metrics (Continued)

• How effective is the CGT approach as a productivity metric?

• If it was precise, for different ship types and sizes constructed in the same shipyard, the man hours per CGT would be the same.

• It can be seen from the next table that it is not precise, but it is a significant improvement over Steel Weight.

• It is acknowledged that compensation coefficients could be developed for steel weight, but this has not been done and any independently developed values would not have the international acceptance of the international shipbuilders such as is the case for CGT.
### Comparison of Productivity Measures

<table>
<thead>
<tr>
<th>SHIP TYPE</th>
<th>MH/ST. WT.</th>
<th>MH/CGT</th>
</tr>
</thead>
<tbody>
<tr>
<td>VLCC</td>
<td>16</td>
<td>32</td>
</tr>
<tr>
<td>SuezMax Tanker</td>
<td>19</td>
<td>22</td>
</tr>
<tr>
<td>Product Tanker</td>
<td>27</td>
<td>20</td>
</tr>
<tr>
<td>Chemical Tanker</td>
<td>46</td>
<td>36</td>
</tr>
<tr>
<td>Bulk Carrier</td>
<td>19</td>
<td>20</td>
</tr>
<tr>
<td>Container ship 4400TFEU</td>
<td>19</td>
<td>22</td>
</tr>
<tr>
<td>Container ship 1800TFEU</td>
<td>28</td>
<td>22</td>
</tr>
<tr>
<td>Reefer</td>
<td>43</td>
<td>34</td>
</tr>
<tr>
<td>General Cargo</td>
<td>56</td>
<td>29</td>
</tr>
<tr>
<td>Ferry</td>
<td>51</td>
<td>39</td>
</tr>
<tr>
<td>Ocean Tug</td>
<td>105</td>
<td>31</td>
</tr>
</tbody>
</table>
Compensated Gross Tonnage

- The Compensated Gross Tonnage is given by multiplying the Gross Tonnage by a Compensation Coefficient.
- The Compensation Coefficient normalizes the Gross Tonnage to that of a 10,000 ton Deadweight General Cargo Ship.
- Compensation Coefficients have been agreed by OECD and are presented in a table for different ship types and sizes.
Compensated Gross Tonnage (Continued)

• The Gross Tonnage of a ship is a measure of its volume.

• Another name for the process is Admeasurement, which originated in England in the 16th century as a way to measure the earning capability of a ship, so to assign dock fees and taxes.

• It developed over the years into a very complex set of rules with exemptions and deductions, but not the same in every country.

• So the old measurement processes were replaced by an international measure in 1970 by IMO.
Gross Tonnage
The International Gross Tonnage is given by:

$$GT = K1 \times V$$

Where $K1$ is a coefficient and $V$ is the molded volume of all enclosed spaces in the Hull and Superstructure.
### Appendix 2

Coefficients $K_1$ and $K_2$ referred to in Regulations 3 and 4(1)

<table>
<thead>
<tr>
<th>$V$ or $V_c$</th>
<th>$K_1$ or $K_2$</th>
<th>$V$ or $V_c$</th>
<th>$K_1$ or $K_2$</th>
<th>$V$ or $V_c$</th>
<th>$K_1$ or $K_2$</th>
<th>$V$ or $V_c$</th>
<th>$K_1$ or $K_2$</th>
</tr>
</thead>
<tbody>
<tr>
<td>10</td>
<td>0.2200</td>
<td>45,000</td>
<td>0.2931</td>
<td>330,000</td>
<td>0.3104</td>
<td>670,000</td>
<td>0.3165</td>
</tr>
<tr>
<td>20</td>
<td>0.2260</td>
<td>50,000</td>
<td>0.2940</td>
<td>340,000</td>
<td>0.3106</td>
<td>680,000</td>
<td>0.3166</td>
</tr>
<tr>
<td>30</td>
<td>0.2295</td>
<td>55,000</td>
<td>0.2948</td>
<td>350,000</td>
<td>0.3109</td>
<td>690,000</td>
<td>0.3168</td>
</tr>
<tr>
<td>50</td>
<td>0.2340</td>
<td>60,000</td>
<td>0.2956</td>
<td>360,000</td>
<td>0.3111</td>
<td>700,000</td>
<td>0.3169</td>
</tr>
<tr>
<td>70</td>
<td>0.2385</td>
<td>65,000</td>
<td>0.2964</td>
<td>370,000</td>
<td>0.3114</td>
<td>710,000</td>
<td>0.3170</td>
</tr>
<tr>
<td>100</td>
<td>0.2430</td>
<td>70,000</td>
<td>0.2972</td>
<td>380,000</td>
<td>0.3116</td>
<td>720,000</td>
<td>0.3171</td>
</tr>
<tr>
<td>200</td>
<td>0.2485</td>
<td>75,000</td>
<td>0.2980</td>
<td>390,000</td>
<td>0.3118</td>
<td>730,000</td>
<td>0.3173</td>
</tr>
<tr>
<td>300</td>
<td>0.2540</td>
<td>80,000</td>
<td>0.2988</td>
<td>400,000</td>
<td>0.3120</td>
<td>740,000</td>
<td>0.3174</td>
</tr>
<tr>
<td>500</td>
<td>0.2695</td>
<td>90,000</td>
<td>0.3006</td>
<td>410,000</td>
<td>0.3123</td>
<td>750,000</td>
<td>0.3175</td>
</tr>
<tr>
<td>700</td>
<td>0.2750</td>
<td>100,000</td>
<td>0.3024</td>
<td>420,000</td>
<td>0.3125</td>
<td>760,000</td>
<td>0.3177</td>
</tr>
<tr>
<td>1000</td>
<td>0.2805</td>
<td>110,000</td>
<td>0.3042</td>
<td>430,000</td>
<td>0.3127</td>
<td>770,000</td>
<td>0.3179</td>
</tr>
<tr>
<td>2000</td>
<td>0.2860</td>
<td>120,000</td>
<td>0.3060</td>
<td>440,000</td>
<td>0.3129</td>
<td>780,000</td>
<td>0.3181</td>
</tr>
<tr>
<td>3000</td>
<td>0.2915</td>
<td>130,000</td>
<td>0.3078</td>
<td>450,000</td>
<td>0.3131</td>
<td>790,000</td>
<td>0.3183</td>
</tr>
<tr>
<td>5000</td>
<td>0.2970</td>
<td>150,000</td>
<td>0.3096</td>
<td>460,000</td>
<td>0.3133</td>
<td>800,000</td>
<td>0.3185</td>
</tr>
<tr>
<td>7000</td>
<td>0.3025</td>
<td>170,000</td>
<td>0.3114</td>
<td>470,000</td>
<td>0.3134</td>
<td>810,000</td>
<td>0.3187</td>
</tr>
<tr>
<td>10000</td>
<td>0.3080</td>
<td>200,000</td>
<td>0.3132</td>
<td>480,000</td>
<td>0.3136</td>
<td>820,000</td>
<td>0.3189</td>
</tr>
<tr>
<td>20000</td>
<td>0.3135</td>
<td>250,000</td>
<td>0.3150</td>
<td>490,000</td>
<td>0.3138</td>
<td>830,000</td>
<td>0.3191</td>
</tr>
<tr>
<td>30000</td>
<td>0.3190</td>
<td>300,000</td>
<td>0.3168</td>
<td>500,000</td>
<td>0.3140</td>
<td>840,000</td>
<td>0.3193</td>
</tr>
<tr>
<td>50000</td>
<td>0.3245</td>
<td>500,000</td>
<td>0.3186</td>
<td>510,000</td>
<td>0.3142</td>
<td>850,000</td>
<td>0.3195</td>
</tr>
</tbody>
</table>

Coefficients $K_1$ or $K_2$ at intermediate values of $V$ or $V_c$ shall be obtained by linear interpolation.
Productivity versus Technology

CONSTANT COST CURVES

COST PER CGT = COST/EMPLOYEE YEAR x EMPLOYEE YEARS/CGT

<table>
<thead>
<tr>
<th>COST/CGT</th>
</tr>
</thead>
<tbody>
<tr>
<td>$3000/CGT</td>
</tr>
<tr>
<td>$2000/CGT</td>
</tr>
<tr>
<td>$1000/CGT</td>
</tr>
</tbody>
</table>

EMPLOYEE YEARS/CGT

COST/EMPLOYEE YEAR, U.S. DOLLARS (1,000)
Productivity versus Technology
Productivity Metrics (Continued)

• The CGT based productivity metric can be extended into a competitiveness tool by developing Constant Cost Curves, such as shown in the next Figure.

• It can be used to plot competitive positions of countries or individual shipbuilders, as also shown in the Figure.

• Finally it can be used to differentiate between large and small shipyards to see if there is any significant difference because of technology levels and size, as shown in the following figure.
Productivity versus Technology
Productivity versus Technology
Productivity Metrics (Continued)

• As previously mentioned the OECD did not develop Compensation Coefficients for naval ships.

• In the 1993/4 Global Technology Study an attempt was made to develop some preliminary values for naval ships. The next figure and TABLE are a result of that attempt.

• They are very preliminary and should be used with great care.

• Work on developing naval ship compensation coefficients is continuing in UK an US.
DESIGN FOR PRODUCTION

Productivity versus Technology

![Graph showing CGT coefficients for naval ships]

- Navy Constant: (Frigates, Destroyers, Amphibious Assault Carriers)
- Naval Auxiliaries
### Productivity versus Technology

#### Estimated Preliminary CGT for Naval Ships

<table>
<thead>
<tr>
<th>Ship Type</th>
<th>Compensation Coefficient</th>
</tr>
</thead>
<tbody>
<tr>
<td>Frigate</td>
<td>10 to 18</td>
</tr>
<tr>
<td>Destroyer</td>
<td>8 to 14</td>
</tr>
<tr>
<td>Cruiser</td>
<td>7 to 12</td>
</tr>
<tr>
<td>Aircraft Carrier</td>
<td>2 to 4</td>
</tr>
<tr>
<td>LSD</td>
<td>3 to 5</td>
</tr>
<tr>
<td>LHD</td>
<td>2 to 4</td>
</tr>
<tr>
<td>Fleet Oiler</td>
<td>1.5 to 2</td>
</tr>
<tr>
<td>LSD</td>
<td>3 to 5</td>
</tr>
<tr>
<td>LHD</td>
<td>2 to 4</td>
</tr>
<tr>
<td>Fleet Oiler</td>
<td>1.5 to 2</td>
</tr>
</tbody>
</table>
Productivity versus Technology
Productivity Metrics (Continued)

• Tom Lamb has been working on developing relationships between productivity, and shipyard size and applied technology.

• Work is still ongoing but results so far are encouraging

• The next slide shows a dilemma that can only be explained by such relationships.
### Use of DWT and GT as Metrics

<table>
<thead>
<tr>
<th>Country</th>
<th>No. of Man Hours</th>
<th>DWT Delivered</th>
<th>GT Delivered</th>
<th>MH/DWT</th>
<th>MH/GT</th>
</tr>
</thead>
<tbody>
<tr>
<td>Japan</td>
<td>114,000,000</td>
<td>19,000,000</td>
<td>14,000,000</td>
<td>6.02</td>
<td>8.17</td>
</tr>
<tr>
<td>Korea</td>
<td>91,000,000</td>
<td>21,000,000</td>
<td>14,000,000</td>
<td>4.33</td>
<td>6.50</td>
</tr>
</tbody>
</table>
Productivity Prediction Equation

• MH/CGT = A x SS^C1 x TL^C2

• MH/CGT = 28.75 x SS^0.577 x TL^-3.607

SS is the Shipyards Size defined by number of Production Employees

TL is the Technology Level from Survey
<table>
<thead>
<tr>
<th>Country</th>
<th>SS</th>
<th>TL</th>
<th>MH/CGT</th>
</tr>
</thead>
<tbody>
<tr>
<td>Japan</td>
<td>1,200</td>
<td>4.5</td>
<td>6.5</td>
</tr>
<tr>
<td>Korea</td>
<td>16,000</td>
<td>4.0</td>
<td>42.5</td>
</tr>
<tr>
<td>Korea</td>
<td>6,000</td>
<td>4.0</td>
<td>24.6</td>
</tr>
<tr>
<td>USA</td>
<td>6,000</td>
<td>3.7</td>
<td>32.6</td>
</tr>
<tr>
<td>USA</td>
<td>800</td>
<td>3.3</td>
<td>16.0</td>
</tr>
</tbody>
</table>
DESIGN FOR PRODUCTION

• The use of CGT as the basis of a Productivity metric is significantly superior to any other readily available measure.

• There is potential for developing a prediction equation for Productivity metric based on technology and other shipbuilding factors.

• The prediction model represents the known productivity reasonably well. Shows Korean dilemma of high technology but low productivity and shows adverse impact of increasing size.
DESIGN FOR PRODUCTION

WORLD CLASS

• High standards of business performance
• Profitably meeting customers needs
• Continuously improving
• Design and build in quality from start
• Seamless organization with flat structure
• Employee involvement and commitment key to success
WORLD SHIPBUILDING SITUATION

- World market prices 75% of average European cost today
- In most cases price is 70% of shipowners competitiveness consideration. Delivery time is only 20%
- Of course, delivery time cannot be significantly longer than international offering.
- Shipowners are looking for lowest price to offset dismally low freight rates.
- World class shipyard employment averages 1,200 and deliver to 8 ships per year, but the two large Korean shipyards employ 7,000 and 12,000 respectively. However, they deliver 40 and 70 ships per year.
US SHIPBUILDING SITUATION

- US is not competitive with the world class shipyards
- Most US shipbuilders acknowledge that there is a productivity gap between US and best in the world to a factor ranging from 1.5 to 3
- US delivery times are more than double best in the world shipbuilders
- Some US shipbuilders deny this and state it is all “smoke and mirrors” involving hidden subsidies
- US shipbuilding industry solution is politically oriented looking for support from the government through protected domestic trade, subsidies and build programs. Sealift ships is an example.
US SHIPBUILDING SITUATION (Continued)

- US is not recognized by world shipowners as a place to come for commercial ships. In fact there is a definite disadvantage in most shipowners minds, especially after the Newport News and Atlantic Marine financial disasters.
- Average employment in US large shipyards ranges from 3,500 to 18,000.
- US high cost is due to both low productivity (1/2) and high material cost (+30 to 50%).
- US shipyards want to remain dual purpose shipyards. Unfortunately, there is no successful dual purpose shipyard in the world. Even the Japanese defense shipyards are not as productive as their other commercial only shipyards.
# DESIGN FOR PRODUCTION

## Productivity Comparison between US and Japanese Shipyard

<table>
<thead>
<tr>
<th></th>
<th>First Ship</th>
<th>5 Ship Average</th>
<th>Fifth Ship</th>
</tr>
</thead>
<tbody>
<tr>
<td>ASI</td>
<td>KHI</td>
<td>Ratio</td>
<td>ASI</td>
</tr>
<tr>
<td>TOTAL PRODUCTION ACTIVITIES, ONLY</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Design, Planning, and Mold Loft</td>
<td>1233</td>
<td>588</td>
<td>0.48</td>
</tr>
<tr>
<td>Hull Production Activities, ONLY</td>
<td>601</td>
<td>122</td>
<td>0.20</td>
</tr>
<tr>
<td>Hull Design, Planning, and Mold Loft</td>
<td>561</td>
<td>243</td>
<td>0.43</td>
</tr>
<tr>
<td>Outfitting Production Activities ONLY</td>
<td>250</td>
<td>68</td>
<td>0.27</td>
</tr>
<tr>
<td>Outfit Design, Planning, and Mold Loft</td>
<td>672</td>
<td>345</td>
<td>0.51</td>
</tr>
</tbody>
</table>

**KHI/ASI Production Comparison for the First, Fifth, and Average of Five Ships (in Thousands Manhours)**
### Productivity Comparison between US and Japanese Shipyard

<table>
<thead>
<tr>
<th>Hull Activities</th>
<th>ASI</th>
<th>KHI</th>
<th>Ratio</th>
<th>ASI</th>
<th>KHI</th>
<th>Ratio</th>
<th>ASI</th>
<th>KHI</th>
<th>Ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cut and Fabrication</td>
<td>107</td>
<td>34</td>
<td>0.32</td>
<td>102</td>
<td>32</td>
<td>0.31</td>
<td>99</td>
<td>31</td>
<td>0.31</td>
</tr>
<tr>
<td>Sub Assy and Ass'y</td>
<td>135</td>
<td>95</td>
<td>0.70</td>
<td>129</td>
<td>90</td>
<td>0.70</td>
<td>126</td>
<td>86</td>
<td>0.66</td>
</tr>
<tr>
<td>Erection</td>
<td>219</td>
<td>96</td>
<td>0.44</td>
<td>209</td>
<td>91</td>
<td>0.44</td>
<td>204</td>
<td>87</td>
<td>0.43</td>
</tr>
<tr>
<td>Production Engineering</td>
<td>48</td>
<td>13</td>
<td>0.27</td>
<td>13</td>
<td>5</td>
<td>0.30</td>
<td>4</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Hold Off</td>
<td>54</td>
<td>32</td>
<td>0.69</td>
<td>52</td>
<td>11</td>
<td>0.21</td>
<td>50</td>
<td>1</td>
<td>0.02</td>
</tr>
<tr>
<td>Cranes</td>
<td>56</td>
<td>16</td>
<td>0.29</td>
<td>54</td>
<td>15</td>
<td>0.28</td>
<td>63</td>
<td>15</td>
<td>0.28</td>
</tr>
<tr>
<td>Miscellaneous</td>
<td>44</td>
<td>2</td>
<td>0.05</td>
<td>42</td>
<td>2</td>
<td>0.05</td>
<td>41</td>
<td>2</td>
<td>0.05</td>
</tr>
<tr>
<td>Subtotal</td>
<td>663</td>
<td>268</td>
<td>0.43</td>
<td>601</td>
<td>246</td>
<td>0.41</td>
<td>577</td>
<td>222</td>
<td>0.38</td>
</tr>
<tr>
<td>Design Engineering</td>
<td>148</td>
<td>23</td>
<td>0.16</td>
<td>41</td>
<td>6</td>
<td>0.15</td>
<td>13</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Total Hull Activities</td>
<td>811</td>
<td>311</td>
<td>0.38</td>
<td>642</td>
<td>251</td>
<td>0.39</td>
<td>690</td>
<td>223</td>
<td>0.38</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Outfitting Activities</th>
<th>ASI</th>
<th>KHI</th>
<th>Ratio</th>
<th>ASI</th>
<th>KHI</th>
<th>Ratio</th>
<th>ASI</th>
<th>KHI</th>
<th>Ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td>Piping, Fabrication, and Assembly</td>
<td>125</td>
<td>116</td>
<td>0.93</td>
<td>113</td>
<td>110</td>
<td>0.97</td>
<td>106</td>
<td>106</td>
<td>1.00</td>
</tr>
<tr>
<td>Machinary Fab and Assy</td>
<td>49</td>
<td>38</td>
<td>0.71</td>
<td>48</td>
<td>33</td>
<td>0.69</td>
<td>47</td>
<td>32</td>
<td>0.68</td>
</tr>
<tr>
<td>Electrical Fab and Assy</td>
<td>60</td>
<td>31</td>
<td>0.62</td>
<td>56</td>
<td>29</td>
<td>0.53</td>
<td>52</td>
<td>21</td>
<td>0.51</td>
</tr>
<tr>
<td>Sheet Metal Fab and Assy</td>
<td>64</td>
<td>24</td>
<td>0.39</td>
<td>62</td>
<td>23</td>
<td>0.38</td>
<td>60</td>
<td>21</td>
<td>0.35</td>
</tr>
<tr>
<td>Insulation</td>
<td>29</td>
<td>24</td>
<td>0.83</td>
<td>28</td>
<td>23</td>
<td>0.82</td>
<td>27</td>
<td>22</td>
<td>0.81</td>
</tr>
<tr>
<td>Painting</td>
<td>107</td>
<td>41</td>
<td>0.41</td>
<td>102</td>
<td>42</td>
<td>0.41</td>
<td>100</td>
<td>40</td>
<td>0.40</td>
</tr>
<tr>
<td>Fitting and Outfitting</td>
<td>143</td>
<td>56</td>
<td>0.39</td>
<td>137</td>
<td>63</td>
<td>0.39</td>
<td>134</td>
<td>51</td>
<td>0.38</td>
</tr>
<tr>
<td>Testing</td>
<td>32</td>
<td>4</td>
<td>0.12</td>
<td>30</td>
<td>2</td>
<td>0.07</td>
<td>26</td>
<td>2</td>
<td>0.07</td>
</tr>
<tr>
<td>Cranes for Outfitting</td>
<td>14</td>
<td>1</td>
<td>0.07</td>
<td>13</td>
<td>1</td>
<td>0.08</td>
<td>13</td>
<td>1</td>
<td>0.08</td>
</tr>
<tr>
<td>Services and Unlocated</td>
<td>50</td>
<td>13</td>
<td>0.26</td>
<td>48</td>
<td>12</td>
<td>0.25</td>
<td>47</td>
<td>12</td>
<td>0.26</td>
</tr>
<tr>
<td>Outfitting Production Engineering</td>
<td>86</td>
<td>26</td>
<td>0.30</td>
<td>24</td>
<td>9</td>
<td>0.38</td>
<td>8</td>
<td>1</td>
<td>0.13</td>
</tr>
<tr>
<td>Subtotal</td>
<td>758</td>
<td>371</td>
<td>0.49</td>
<td>660</td>
<td>336</td>
<td>0.51</td>
<td>622</td>
<td>318</td>
<td>0.51</td>
</tr>
<tr>
<td>Design Engineering</td>
<td>265</td>
<td>26</td>
<td>0.11</td>
<td>72</td>
<td>7</td>
<td>0.10</td>
<td>23</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Total Outfitting Activities</td>
<td>1023</td>
<td>399</td>
<td>0.39</td>
<td>732</td>
<td>343</td>
<td>0.47</td>
<td>646</td>
<td>315</td>
<td>0.49</td>
</tr>
<tr>
<td>Total Manhours</td>
<td>1834</td>
<td>710</td>
<td>0.39</td>
<td>1374</td>
<td>694</td>
<td>0.45</td>
<td>1238</td>
<td>637</td>
<td>0.45</td>
</tr>
</tbody>
</table>

*KHI/ASI production comparison for the first, fifth, and average of five ships (in thousands manhours)*
### Productivity Benchmarks

**Typical Production Manhours**

<table>
<thead>
<tr>
<th>SHIP TYPE</th>
<th>CGT</th>
<th>EUROPE</th>
<th>JAPAN</th>
</tr>
</thead>
<tbody>
<tr>
<td>VLCC</td>
<td>37,500</td>
<td>1,200,000</td>
<td>1,000,000</td>
</tr>
<tr>
<td>Product Tanker</td>
<td>21,000</td>
<td>475,000</td>
<td>400,000</td>
</tr>
<tr>
<td>Bulk Carrier</td>
<td>31,200</td>
<td>643,000</td>
<td>465,000</td>
</tr>
<tr>
<td>Container Ship</td>
<td>35,000</td>
<td>765,000</td>
<td></td>
</tr>
<tr>
<td>Container Ship</td>
<td>19,500</td>
<td>434,000</td>
<td></td>
</tr>
<tr>
<td>Ferry</td>
<td>29,000</td>
<td>1,200,000</td>
<td></td>
</tr>
</tbody>
</table>

**Typical Design Manhours**

- Product Tanker: 75,000 Single Hull, 102,000 Double Hull
- Bulk Carrier: 36,000
- Container Ship: 72,500
- Ferry: 230,000
Constant Cost Curve & Competitiveness

- U.S.*
  - Recent Commercial ship overall ratio of 125 to 185 is off the scale
- Korea
- Germany
- Denmark

Cost per Man Hour (U.S. dollars)

Man Hours per CGT

- $2000 / CGT
- $1000 / CGT

12/15/98
DESIGN FOR PRODUCTION

Design and Build Cycle Time

• Short design and building cycle times are directly related to high annual output, such as:
  4 to 6 VLCCs
  6 to 8 140,000TDWT Tankers and/or Bulk Carriers
  4 to 6 container ships
  Or
  8 Product Tankers

• I honestly believe that a shipyard bidding on a new contract at a given time has an ideal design and build cycle that would give the lowest cost, taking into account current work and order book.
Design and Build Cycle Time (Continued)

• Short design and build cycles are only possible with sufficient and continuous demand for ships. 4 month berth times require 3 or more ship completions per year.

• Typical Japanese shipyard delivering 8 ships per year has a 16 ship (or 2 year) backlog of orders.

• If the ship market is such that a shipyard has only one ship delivery per year or even every 2 or 3 years, it does not make sense to shorten the cycle time. This would only result in worker build up and layoff until the next order come along.

• It is better to stretch out the schedule to allow level manning and work throughput to match demand.
Design and Build Cycle Time (Continued)

The dilemma is that to get into the international commercial shipbuilding game US shipyards have to offer design and build cycles that are the same as those available from world class shipbuilders.

Examples of (Construction - keel laying to delivery) and Total Contract award to delivery cycle times are:

<table>
<thead>
<tr>
<th>SHIP TYPE</th>
<th>EUROPE (AVER)</th>
<th>DENMARK</th>
<th>JAPAN</th>
<th>USA</th>
</tr>
</thead>
<tbody>
<tr>
<td>VLCC</td>
<td>(17)24</td>
<td>(5)16</td>
<td>(9)18</td>
<td></td>
</tr>
<tr>
<td>Product Tanker</td>
<td>(13)20</td>
<td></td>
<td>(8)15</td>
<td></td>
</tr>
<tr>
<td>Container Ship 4400TEU</td>
<td>(17)28</td>
<td>(5)12</td>
<td>(9)</td>
<td></td>
</tr>
<tr>
<td>Container Ship 1880TEU</td>
<td>(12)20</td>
<td>7</td>
<td></td>
<td>(24)32</td>
</tr>
<tr>
<td>Ferry</td>
<td>(13)24</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
DESIGN FOR PRODUCTION

FIGURE 7.11 - TYPICAL JAPANESE DESIGN AND BUILD SCHEDULES
How does Technology Influence Competitiveness?

- Competitiveness depends on a number of factors, including Productivity which is only partly influenced by technology.

- The factors are:
  - Productivity
  - Material Cost
  - Delivery Schedule
  - Labor Rates
  - National Shipbuilding Policy
  - Marine Industry Infrastructure
  - Financing
  - Subsidies
There is no universally accepted definition of competitiveness.

KPMG Peat Marwick, in their study of the competitiveness of EEC shipyards, defined it as “the ability to win and execute shipbuilding orders in open competition and stay in business.” I would add

PROFITABLY

As already discussed measure that has been accepted by most shipbuilding countries to compare shipbuilding productivity is Manhours/CGT.

This can be made into a quasi-competitiveness metric by multiplying the manhours by the shipyard labor rate in US dollars or plotting the Productivity metric on a base of US dollars per manhour.
Competitiveness Equation

In Germany, V. Bertram has developed a Competitiveness Equation, namely:

\[ P \times F \times A \times (1+S) \times \frac{X}{K} > 1 \]

Where:
- \( P \) = Productivity (CGT/Man Year)
- \( F \) = Production Range (Personnel Cost/Total Cost)
- \( A \) = Attractiveness of Product (Market price/CGT)
- \( S \) = Subsidy ratio
- \( X \) = Exchange Rate
- \( K \) = Cost position (Labor cost/Man Year)
Competitiveness Summary

• Technology is only one of many factors influencing productivity, which in turn, is only one of many factors influencing competitiveness.

• Short design and build cycle time can only be achieved with a corresponding high and continuous throughput.

• There may be a shipyard throughput below which it is impossible to be internationally competitive.

• Experience in other successful shipbuilding countries suggest that it may not be possible to achieve international commercial shipbuilding competitiveness in a dual purpose shipyard.