Introduction

The world in which the maritime industry operates is undergoing a technological change that is more pronounced now than in the past because of the degree of advancement, the frequency of introduction, the size of the resources needed to bring them about, the rate of diffusion, and the interaction between political, economic, and national security events. Technological change is the most powerful factor in the business environment today and its power is growing. Technological change is impressive, not only because of its variety, but also because of its chain reaction effects on the industry and society. Unquestionably, our era of dynamic business change is based on technological progress and competition. In this rapidly changing environment, products, materials, skills, and production facilities are made obsolete in a very short period of time. At the same time, new findings in science and advancements in technology offer opportunities equally far reaching making it a first requirement of the leaders in business and government to be sensitive, aware and more receptive to technological change as a major force to be employed in creating that all important competitive edge.

Maritime transportation must consider, adopt, and use these new technologies. Materials, computers, robotics, communications and energy technology change, to name but a few, must be more strongly harnessed by the maritime industry.

This paper addresses some of the major challenges that are facing the maritime industry and discusses possible courses of action to deal with these challenges.

High Technology Development in the Maritime Industry — Robot in Shipyard Production Welding Ship Plate

What is the future of the U.S. maritime industry is the most important question facing the maritime field today. If this question can be answered in a clear and positive manner, the solutions will become evident. This future growth for the maritime industry must be examined from a commercial and a national security view.

Significance of Maritime Future

The U.S. depends on its domestic and international trade as a vital element of its economic infrastructure. Our nation's well-being is intertwined with that of the rest of the world resulting in substantial commodity trade which depends upon responsible international transportation services. As shown on Figure 1, U.S. trade has had a long term increase. Forecasts indicate the growth will continue. By the year 2000, 1.48 billion tons of U.S. trade is forecasted to be available for merchant shipping -- an increase of 700 million tons from 1980. The U.S. trade is growing. The market for growth of the U.S. maritime industry is clearly present.

Total Tonnage of U.S. Sea Trade and Tonnage Carried of U.S. Flag Ships

The magnitude of the trading opportunity required of the merchant marine serving the U.S. is shown in Figure 2. The U.S. is the leader in world trade. Of the seven industrial nations, 26% of the total trade is to or from the U.S. Figure 3 shows ship construction opportunities for 1980 to the year 2000. This figure considers U.S. foreign trade as the market and examines the deadweight and number of vessels required to carry this trade. The scale on the left denotes number of vessels. It indicates that nearly 1400 new vessels will be required by the year 2000, or a deadweight of 56 million of new construction -- a significant opportunity for U.S. shipbuilding industries.
World Trade for Seven Industrialized Nations
(In Billions for U.S. Dollars)

<table>
<thead>
<tr>
<th>Country</th>
<th>1980 Estimated World Trade</th>
<th>Percent of Seven Nations</th>
</tr>
</thead>
<tbody>
<tr>
<td>United States</td>
<td>$477</td>
<td>26</td>
</tr>
<tr>
<td>West Germany</td>
<td>366</td>
<td>21</td>
</tr>
<tr>
<td>Japan</td>
<td>224</td>
<td>13</td>
</tr>
<tr>
<td>France</td>
<td>221</td>
<td>13</td>
</tr>
<tr>
<td>United Kingdom</td>
<td>200</td>
<td>11</td>
</tr>
<tr>
<td>Italy</td>
<td>167</td>
<td>10</td>
</tr>
<tr>
<td>Canada</td>
<td>119</td>
<td>6</td>
</tr>
<tr>
<td>Total of Seven Nations</td>
<td>$1,744</td>
<td>100</td>
</tr>
</tbody>
</table>

Source: OECD Economic Outlook

Given that the U.S. maritime industry is vital to the nation's national security interests, it must not only survive, but it must keep pace with projected growth and trade. The merchant marine is a service industry. Its criticality to the nation can be measured by its ability to establish and maintain the U.S. as a world trade leader assisting our foreign trade and providing efficient transportation control of our commerce.

The importance of trade to our national economy has been rapidly increasing. This trade/national economy relationship has been flat up to the late 1960's. In the late 1960's, the percentage of U.S. trade as a part of the national economy began to dramatically increase (Figure 4). By 1980, the percentage of U.S. trade to the total gross national product reached 18.5%. Estimates are that by the year 2000 this could reach 30%. The message is that we must maintain efficient control over this rapidly growing, important sector of the U.S. economy.

In summary, the potential U.S. maritime growth is based on:

- the U.S. being the world's trade leader;
- the maritime shipping requirements in the U.S. being large and growing;
- the U.S. economy being increasingly dependent on foreign trade.

With this trade opportunity, growth potential, and national importance, our maritime future ought to be an optimistic one.

Problems Facing the Maritime Industry

The following are a few first order problems facing our industry:

- Studies indicate U.S. construction costs are more than 100% higher than foreign construction. This makes the introduction of new, competitive equipment difficult.
- Shipbuilding prices in the world are related to various foreign government support programs.
- U.S. operating costs in some shipping sectors have been over 100% higher.
- Shipping to the U.S. is open. Foreign ships that can meet our trade requirements can enter and leave our markets at will.
- And finally, the U.S. maritime investment in change and its ability to adapt has been low. Our research and technology development investments have been meager.

Challenges

To develop a national strategy which will create an environment conducive to a healthy maritime industry, we must first understand the nature of the competitive forces that have driven us to our present status. These competitive forces are described in terms of challenge which, if successfully addressed in a coordinated manner, will provide, a priori, the solutions to a healthy maritime future.

The challenges—so powerful that management in the next decade will be the management of continuous change—include:

- the targeted industry strategy;
- developing countries' nationally focused application of its resources;
- the technology explosion.
It is the "targeted industry strategy" that the Japanese have used so effectively in steel, shipbuilding, and automobile construction, and is now being copied worldwide. The U.S. must meet this challenge.

Another challenge is the emergence of the developing countries that have natural resources and low cost labor that can be nationally harnessed and focused towards shipping and shipbuilding. A third major challenge is the technology explosion which has generated something like 90% of all our knowledge in the sciences within the last 30 years. It will double our knowledge again in the next 10-15 years and will tend to make major investments obsolete long before their useful life can be realized. A fourth challenge that has been defined is overcoming the special problems in the U.S. of limited return on equity of major industries related to the adverse effect of our past business practices, tax laws and inflation.

**Industry Cycle**

Most U.S. industries have suffered under these four challenges--the maritime industry possibly more so because of its international nature. One concept used to explain the general industrial conditions in the U.S. is the Kandratief long wave. This concept pictures an industrial trend as a cycle with a 54-year period (Figure 5). Recently, the Massachusetts Institute of Technology (MIT) rationalized the long wave concept into four phases. The last general industry long wave is pictured as starting in 1929. The first phase is a 15-year collapse in which obsolete facilities in overcapacity are written down. Then at the end of that period, a tremendous excess demand over supply developed which resulted in a massive 20-year capital reinvestment program for the U.S. industry. For a normal U.S. industrial base, prices were going up faster than cost, and profit margins were large. MIT further points out that this process of high cash flow-large profit margins tends to reject new technology on the basis that this is something too risky to try when things are going so well with the present system. The third phase occurs with the balance of supply and demand and with a facility overcapacity of about 25% worldwide. During this period, competition holds down price as costs continue to rise, and business begins to erode its assets in real terms. At the end of this third phase, the enormous national and worldwide overcapacity must be shut down. The fourth phase of this long wave cycle is a period of economic turbulence in which the recession cycles deepen and the next collapse occurs. If we use 1929 as the beginning of this long wave cycle, the nation is now in the 53rd year of this 54-year cycle. This is the time of challenge, i.e., follow the cycle down or aggressively employ technology, and rationalize overcapacity and obsolete facilities in order to improve the competitive position and rapidly advance our productivity.

For the maritime industry, this long wave cycle has not been the clear situation. The impact of technology, entrance of developing countries, and target industry strategy occurred simultaneously to an overcapacitated U.S. industry in the 1940's with limited U.S. reaction. As a result of World War II, worldwide shipbuilding capabilities were rebuilt. After World War II, devastated countries rebuilt their shipbuilding and ship operating bases leaving the U.S. with a smaller market and overcapacity. Figure 6 indicates both the shipbuilding and ship operating cycles for the U.S. The data for the construction cycle is derived from a ratio of U.S. shipbuilding to world shipbuilding tonnage launched. For the ship operation cycle, the data is developed from a ratio of U.S. fleet to world fleet tonnage. A logarithm scale is used in the plot to more readily visualize the overall trends. Thus, for shipbuilding the decline started about 40 years ago. As a result, the basic technology improvements in the U.S. shipbuilding scene did not occur, while in other countries these new shipbuilding facilities and processes were put into place. Overcapacity and market decline, caused by the targeted industry strategy and technologies, have caused the decline rather than a business cycle as with most smokestack American 50-year cycles. The net result is a highly dampened U.S. maritime industry.

What can the U.S. reaction to this condition be? To answer this, the three challenges must be examined: targeted industry strategy, technology, and entrance of developing nations. We cannot, nor should we halt the effective and natural entrance of developing nations into the maritime industry. Yet, we can use the two remaining challenges to our advantage -- targeted industry strategy and technology.
National industry targeting has not been a traditional U.S. strategy because it limits competitive practices. We need to explore a new approach.

Concerning technology, the 54-year cycle that normally rejects new technology has recently seen a spectacular explosion of new products and systems in the U.S. This rapid acceptance of technology, which is focused on improving production and our competitive position, could also be applied to the maritime industry. We should not reject new high technologies.

**Targeted Maritime Industry Strategy**

A great force that is restructuring the U.S. economy is Japan’s targeted industry strategy. Japan adopted this concept as a basic strategy and targeted steel, automotive, shipbuilding, consumer electronics, and microchips as priority areas. The concept is simple. If, as in Figure 7, a log of the cost of a product over its lifetime is plotted against a log of its cumulative volume, a straight line results. Every time the volume doubles, the cost goes down by about 20%. It is simply a conservative learning curve process. The traditional price history is illustrated by the top line where a new product is marketed in small volumes, but as volume increases, economies of scale result in cost decreases. Typically, a U.S. manager will leave the price at this level independent of the market reaping short term profits. As the market grows, the manager is then required to drastically reduce prices in order to remain in the market. However, if prices had been decreased early (as shown by the dotted line) to a point below everyone’s entry point, the resulting profits might be 10 times as much. Targeted industry strategy is being used by many foreign nations.

**LEARNING CURVE STRATEGY**

![Learning Curve Diagram]

The procedure followed by those nations that have successfully used targeted industry strategy is to first target an industry for growth, then bring together all the players in that industry. Next, the business is concentrated. Imports are controlled to enhance base load economies of scale in the home market. Then R&D objectives, based on manufacturing engineering improvements, are parcelled out to avoid redundant efforts, and new systems are supported with low-cost capital. Market share is gained very rapidly until economies of scale catch up with the prices.

The U.S. maritime industry has suffered from the overseas application of the targeted industry strategy. In addition, other U.S. industries, such as steel, automobiles, machine tools, and consumer electronics, have also suffered. Leadership in other areas, such as plastics, aircraft, petrochemicals, computers, and flexible manufactured machinery, are being similarly threatened. The application of this strategy as used by other countries is unencumbered by restrictive anti-trust laws and often is supported by a host of other nationally supported measures. The United States, however, still has the world’s most advanced research capability, an incomparable industrial infrastructure, and the largest maritime market. It can regain or retain its competitiveness by taking more advantage of these inherent opportunities.

The U.S. maritime industry should respond to the international industry targeted strategy. It is important to remember that the U.S. has by far the world’s most advanced technology in almost every area of interest. It has the industrial infrastructure with which to translate new developments into products and processes. It has a unique entrepreneurial culture and the largest international maritime market. And finally, it has the world’s most effective capital formation capability. All that is needed are the initiatives required to mobilize these capabilities, remove the barriers that impede collaboration, and further enhance the incentives for doing so. The United States can then be a major beneficiary of this burgeoning period of change.

**Expanding Technology**

The magnitude of the world technology explosion can best be seen in the fact that in this last 30-year period, something like 90% of all scientific knowledge has been generated. This pool will double again in the next 10 or 15 years. Figure 8 shows the explosion of technology being plotted from the beginning of civilization up to the year 2000. There is a tremendous build-up of underutilized technology fueling the next cycle in electronics, communications, engineering, plastics, biogenetics, specialty chemicals, pharmaceuticals, and so forth. This build-up has not found its way into the maritime industry as rapidly as in other industries. These new technologies must be rapidly applied to our maritime industries in order to reach the growth potential this country demands. Shipbuilding and ship operating, being such highly competitive industries, must take particular note of these vast technology changes and apply them in their businesses.

New systems will take on increased significance in the next few years, and we are looking ahead to one of the most interesting periods the world has ever seen. The industries that are rapidly employing the best of the U.S. technologies, not necessarily producing the “high technologies,” are rapidly expanding. Many new companies with new maritime industry support potential have been formed in the last several years.

How is the rest of the world reacting to these changes? The U.S. a decade ago was generating something like 75% of the world’s technology. Now the U.S. share is about 50%. In another decade it may be 30%, not because we are generating less, but because the other 95% of the world will also be contributing. All countries in the world now see technology as being essential to the quality of life and are getting into this business. For example, China intends to be at the leading edge of every technology by the end of this century.
The Recent Explosion of Technology

This explosion of technology, therefore, is much more significant than is realized and it will continuously change. Some of the areas in which new developments will occur and which should be rapidly considered by the maritime industry in order to regain its position are materials for ship construction and equipment, agriculture and biochemical areas for transport potential, electronic systems for fleet management, flexible manufacturing for building and repair, etc. Example areas in which these new developments could impact the maritime industry are graphite fiber and reinforced plastics. The materials industry is progressively worked its way into construction, aircraft, automobiles, and appliances. The technology is not only in new materials, but in the capability of engineering the materials and the structure simultaneously for industrial use. Both material and construction costs are reduced.

Looking at the technology development environment in the maritime sector, Figure 9 gives a comparison of the U.S. transportation research investments being made. The last of the previously mentioned problems is readily apparent. i.e., "R&D investment in the maritime field is low." Air transportation research is one of the lowest -- 5% of the total. Air transportation is one of the highest -- 63% of the total. This is in spite of the fact that water transportation moves 36% of domestic freight. The lack of priorities as to R&D efforts in the maritime field is quite evident.

A basic requirement for a healthy, competitive industry is the necessity to keep looking ahead. We must be able to move forward or change directions to insure that requirements are met in the best way possible for our nation and our industry. To accomplish this, two consistent themes emerge:

1. We must strive to be world leaders.
2. We must seek to identify and move aggressively into maritime business areas of highest growth potential.

To capitalize on the world changes, we must strive to be leaders in the elements that are necessary for business success. U.S. strength resides within innovations in productivity and technology. Leadership will involve a coordinated development, implementation and technology diffusion process. It's not enough to search for options, conduct experiments, or just apply developed innovations (Figure 11). To be in a leadership role, all stages of the innovation process must be in place. A second point to note is that innovation requires more than the technology. Market, economic, and national policy development are requirements to be in the leadership role through innovation.

R&D is a major tool and since it receives relatively little maritime industry support, there is a need for research and development in the maritime industry. In the pursuit, several R&D directions became evident.

First, we must pursue research in the new ocean shipping growth markets.
Second, we must develop and build the most productive ships—ships that are of competitive capacity with rationalized crews, yet not complex in terms of operation.

Third, we must improve overall productivity and efficiency within the maritime industry itself.

Fourth, we must reduce ship construction time, reduce maintenance costs through effective standardization and simplification of systems.

Fifth, we must reduce fuel costs through improvements in overall fleet efficiency and utilization of alternate fuels.

Sixth, our future fleet must have a national security potential without sacrificing its competitive position in the commercial market.

And finally, we must have stronger partnerships between government/industry, management/labor, and academia. No innovation or long term development effort can succeed without the continual partnership of each of these important elements. Part of the problem with successful technology applications is related to the "rates of implementation," the long term associated with obtaining institutional changes. A government/industry partnership could be used to speed up this process.

**Summary**

Our nation's well-being is increasingly dependent on international commodity trade, which relies upon efficient and competitive transportation services. By the year 2000, 1.48 billion tons of U.S. trade is forecasted to be available for merchant shipping. This could mean that 1400 new vessels will be required by the year 2000. The maritime shipping requirements in the U.S. are large and growing.

Competition, productivity and technology are the key challenges facing the maritime industry. The targeted industry strategy has been used effectively by other maritime nations to improve their productivity and competitive position over the U.S. industry. The U.S. must meet this challenge. In addition, technology is rapidly growing in the U.S. Unquestionably, dynamic business change is based on technological progress. Skills and facilities are made obsolete in a short period. At the same time, achievements in technology offer major new opportunities.

The marine industry has a tendency to define competitiveness, productivity and technology in terms of the present. This results in the industry playing a continuous game of "catch up" in cost parity with its competitors.

### Maritime Energy Efficiency Measures

<table>
<thead>
<tr>
<th>Technology</th>
<th>Max. Claimed Savings (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Coal Fired</td>
<td>95</td>
</tr>
<tr>
<td>Coal Oil Slurry</td>
<td>40</td>
</tr>
<tr>
<td>Slow Steaming</td>
<td>30</td>
</tr>
<tr>
<td>Adiabatic Engines</td>
<td>25</td>
</tr>
<tr>
<td>Slow Speed and Medium Speed Diesel</td>
<td>25</td>
</tr>
<tr>
<td>Wind Assist Vessel</td>
<td>25</td>
</tr>
<tr>
<td>Optimization of Ship</td>
<td>25</td>
</tr>
<tr>
<td>Contrarotating Propeller</td>
<td>13</td>
</tr>
<tr>
<td>Large Slow Turning Propeller</td>
<td>19</td>
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<tr>
<td>Plant Tuning</td>
<td>10</td>
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<tr>
<td>Redesign Propeller</td>
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<tr>
<td>Controllable Pitch Propeller</td>
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<tr>
<td>Weather Routing</td>
<td>3-10</td>
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<tr>
<td>Ducted Propeller</td>
<td>8</td>
</tr>
<tr>
<td>Self Polishing Anti-Fouling Coating</td>
<td>7</td>
</tr>
<tr>
<td>Waste Heat Recovery—Diesel</td>
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</tr>
<tr>
<td>Cascade Turbine Bleed</td>
<td>5</td>
</tr>
<tr>
<td>Fuel Oil Emulsions</td>
<td>5</td>
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</tbody>
</table>

*Source: Summary of International Maritime Fuel Conservation Measures, Argonne National Laboratory, 1982.*
competition. By the time the necessary technology and the associated social, institutional and regulatory changes have been made to implement the technology, the competition has progressed to another plateau of competitiveness. The cyclical nature of U.S. industries has not been the case for the maritime industries. Since World War II it has been a highly dampened industry. In the 1940's, the impact of technology, entrance of developing countries, and targeted industry strategy occurred simultaneously to an overcapacitated U.S. industry. These actions have continued to the present. This nation and the maritime industry must respond to technology change and the targeted industry strategy.


Figure 13

There must be a strong future orientation to a maritime strategy. New technologies in electronics, communications, materials, chemicals, and robotics, for example, must be rapidly applied. The direction of this technological approach should be toward new ocean shipping growth markets, development and building of the most productive and competitive ships, improvement in the overall productivity and efficiency of the maritime industry, reduced shipbuilding and shipping costs through effective standardization and simplification of systems, reduced fuel costs and use of alternate fuels, and a future maritime fleet with national security potential without sacrificing its competitive position.

To accomplish the necessary technology innovations, we must have stronger partnerships. All components (labor, management, government and academia) must want, and must work together in order to build an innovative and productive industry. The signs that this can happen, and is happening in some instances, are present.

In short, the maritime industry must become competitive by the application of the best technology potential of this nation. It must also use long term national strategy to compete on an international scale. We have the market, the technology, the structure, and the need. We can and must meet the challenges of international competition, productivity and technology.

References


