MARITECH PROGRAM IMPACTS ON GLOBAL COMPETITIVENESS OF THE U.S. SHIPBUILDING INDUSTRY AND NAVY SHIP CONSTRUCTION

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POTOMAC INSTITUTE FOR POLICY STUDIES
1600 WILSON BOULEVARD, SUITE 1200
ARLINGTON, VA 22209

DRAFT

WITH KEY CONTRIBUTIONS FROM

ECONOMIC STRATEGY INSTITUTE
1401 H STREET NW, SUITE 750
WASHINGTON, DC 20005

DRAFT

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Dr. James J. Richardson, Study Director

Researchers

POTOMAC INSTITUTE FOR POLICY STUDIES
Mr. Mike Hammon
Mr. Michael Swetnam
Ms. Stephanie Tennyson
Ms. Laura Worcester
ECONOMIC STRATEGY INSTITUTE
Dr. Lawrence Chimerine
Mr. Andrew Szamosszegi

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Preface

This is the final report of a study conducted by the Potomac Institute for Policy Studies under the sponsorship of the MARITECH Program Office at the Defense Advanced Research Projects Agency (DARPA). The Economic Strategy Institute (ESI) contributed to the study through the development and analysis of overarching economic indicators.

The Potomac Institute for Policy Studies (the Institute) is a not-for-profit organization dedicated to the development and support of non-partisan analysis of technology and technology policy. The Institute has conducted studies that provide insight into the impact of new technologies and processes on our society, the proper relationship between government and industry in meeting future needs, and the state of the U.S. industrial base.

The Institute would like to thank the MARITECH Program Office, led by Mr. Bob Schaffran, for the collective insights and information shared by the staff throughout our investigations. We would also like to thank the many Shipyard personnel and shipbuilding industry experts who contributed so substantially to this study. Views expressed in the following are our own, however, and do not necessarily reflect the opinions of the MARITECH Program Office or other contributors.

This survey study was conducted over three months. It featured on-site interviews with nearly one hundred people (some of whom are identified in Annex A), coupled with considerable analysis. The analytical portion of the study included an examination of the individual shipyards, principally by the Potomac Institute for Policy Studies, and an economic analysis performed by the Economic Strategy Institute (found at Annex B).

The study does not purport to be an in-depth microeconomics analysis, although the ESI contribution provides a significant understanding of the economic backdrop for the U.S. shipbuilding situation. Our primary hope is that we have presented an aggregated view of MARITECH participants, both government and industry (but principally the latter). We did not, as a rule, validate data provided by the shipyards to describe their MARITECH experiences, except to compare it with that provided by government managers and with pertinent published information. We feel, however, that we have captured the essence of MARITECH's impact. Further, we believe the case summaries contain a wealth of information that can be usefully exploited by further analysis.

List of Common Acronyms and Definitions

ASE	MARITECH **A**dvanced **S**hipbuilding **E**nterprise Program
AOE	Fast Combat Navy support Vessels
AOTR	**A**greement **O**fficer's **T**echnical **R**epresentative
Big 6	The "Big 6" shipyards, that construct Navy ships, are: Avondale, Bath Iron Works, Electric Boat Corporation, Ingalls, NASSCO, and Newport News.
Bulk Carrier, Bulker, Dry Bulk*	Vessels that range in size from small coastal craft to ships of over 150,00 deadweight capacity which are designed for the carriage of bulk commodities.
CAD/CAM	**C**omputer **A**ided **D**esign/**C**omputer **A**ided **M**anufacturing
cgt*	**C**ompensated **G**ross **T**ons **--** Unit of measurement developed to measure level of shipbuilding output.
Container Ships *	Vessels designed to carry full loads of containers in fixed cell guides.
COMPASS	**C**ommercial **O**bject **M**odel of **P**roducts/Processes for an **A**dvanced **S**hipbuilding **S**ystem **-** It seeks to develop a comprehensive, affordable, Windows-based ship design and data management system that integrates and manages the data required for ship design, construction and lifecycle support, and will be scalable for use by shipyards of all sizes.
COSCO	**C**hina **O**cean **S**hipbuilding **Co**mpany
DARPA	**D**efense **A**dvanced **R**esearch **P**rojects **A**gency
dwt*	**D**ead**w**eight **T**onnage **-** The number of tons of 2,240 pounds that a vessel can transport of cargo, stores and bunker fuel. It is the difference between the number of tons of water a vessel displaces "light" and the number of tons it displaces when submerged to the "load line."
E-CAT	A high speed, low wake, fuel efficient catamaran ferry.
FIRST	**First** Principles Approach for Ship IPPD **-** This project will develop an integrated product and process environment based on "first principles" (such as manufacturing constraints) to rapidly conceive, analyze, and estimate alternative ship designs with an emphasis on providing production and life-cycle level of detail information during pre-contract design.
FFG	**F**ast **F**rigate, **G**uided Missiles
General Cargo Ships*	The most versatile in the merchant fleet as individual units can also carry bulk cargo.
gt*	**G**ross **T**onnage **--** The total of all the enclosed spaces within a ship, expressed in tons, each basic unit of which equals 100 cubic feet (2.831 cu. m).
IMTA	**I**nternational **M**ultimodal **T**ransport **A**ssociation
INCAT	**In**ternational **Cat**amarans
IPDE	**I**ntegrated **P**roduct **D**ata **E**nvironment
IPPD	**I**ntegrated **P**roduct and **P**rocess **D**evelopment
IS, IT	**I**nformation **S**ystems, **I**nformation **T**echnology
ldt*	**L**ight **D**isplacement **T**onnage **--** The actual weight of an empty ship.
LPD	Amphibious Transport Dock
LSD	Dock Landing Ship
LST	Tank Landing Ship

MARAD	U.S. Department of Transportation's **Mar**itime **Ad**ministration
MariSTEP and STEP	**Mari**time **St**andard for the **E**xchange of **P**roduct is a is a MARITECH sponsored project targeting prototype implementations of the emerging STEP shipbuilding application protocols. This project will develop and test prototype STEP-compliant translators to facilitate the transfer of ship three-dimensional product model data between different companies with different computer-aided design and manufacturing systems via a neutral file format.
MEJ	**M**ARITECH **E**ngineering **J**apan
MMCS	**M**ulti-**M**ission **C**argo **S**hip
NIIIP	**N**ational **I**ndustrial **I**nformation **I**nfrastructure **P**rotocols **-** will allow the sharing of information throughout an enterprise (among separate business areas). This is difficult because of the heterogeneity of computing environments, the pervasiveness of legacy systems, and the rapidly changing information technologies and protocols.
NSnet	**N**ational **S**hipbuilding **Net**work **-** NSnet is an electronic communications network for the maritime community which will bring the technological strengths of DARPA and the Nation (Information Technology) to the maritime industry.
NSRP	**N**ational **S**hipyard **R**esearch **P**rogram is a unique cost shared government and industry program. Its mission is to assist the US shipbuilding and repair industry in achieving and maintaining global competitiveness with respect to quality, time, cost and customer satisfaction.
NSSC	**N**ational **S**hipbuilding and **S**hipyard **C**onversion Act of 1993
OECD	**O**rganization for **E**conomic **C**ooperation and **D**evelopment
OPA-90	**O**il **P**rotection **A**ct of 1990
OSV	**O**ff-shore **S**upply **V**essel
PWBS	**P**roduct-oriented **W**ork **B**reakdown **S**tructure
Reefer	Refrigerated Cargo Ship
RO/RO	**R**oll-**O**n/**R**oll-**O**ff (ship loading)
SBD	**S**imulation **B**ased **D**esign is used as an environment for concept and contract design using IPPD.
SC (as in SC-21)	**S**urface **C**ombatant (Ship)
SHIIP	**Sh**ipbuilding **I**nformation **I**nfrastructure **P**roject **-** This project will develop technologies that allow a shipbuilder to reduce the time and cost of ship construction through a new shipbuilding methodology that leverages off new, innovative information (intra-net) systems, by developing an advanced electronic shipyard information infrastructure.
SPARS	**S**hipbuilding **Par**tners And **S**uppliers **-** is a deployment project to establish Virtual Enterprise (VE) technologies for shipbuilding. The VE will represent customers, partners, subcontractors, and suppliers using NIIIP technologies.
SSN	Attack Submarines
SWATH	**S**mall **W**aterplane **A**rea **T**win **H**ull
Tankers (Chemicals)*	Class of vessel specifically designed to cater to the liquid chemicals market, capable of transporting various grades of chemicals, solvents, and acids.
Tankers (Gas)*	There are two categories: (1) Liquid Natural Gas (LNG) Tankers and (2) Liquid Petroleum Gas (LPG) Tankers
Tankers (Oil and Product)*	Vessels principally involved in carriage of crude oil and its derivatives.

TOTE	**T**otem **O**cean **T**railer **E**xpress
TQM	**T**otal **Q**uality **M**anagement
UCSD	**U**niversity of **C**alifornia, **S**an **D**iego
ULCC*	**U**ltra **L**arge **C**rude **C**arriers **-** Large tankers of no official size but variously described as being one between 350,000 dwt and 550,000 dwt.
VLCC*	**V**ery **L**arge **C**rude **C**arriers **-** Large tankers of no official size but variously described as being one between 100,000 dwt and 350,000 dwt.
VE	**V**irtual **E**nterprise **-** A temporary consortium of independent member companies which come together to exploit fast-changing worldwide product manufacturing opportunities.
ZOLT	**Z**one **O**utfitting **L**ogic **T**echnology

* Data from Hans J. Peters, *The Maritime Transport Crisis*

Executive Summary

The U.S. shipbuilding industry is faced with a difficult task, one of achieving success in a global market that features tough and skilled competitors, who are most often subsidized to an extent that the U.S. industry has not experienced since 1981. Simultaneously, its principal customer, the Navy, has cut back procurements. The industry must become competitive, or face an uncertain future. It must make the gains necessary to compete in the global market, to ensure its share of domestic ship orders, and to be able to deliver affordable and effective Navy vessels. MARITECH has moved the industry toward these goals along a broad front of process improvements, new technologies, facilities modernization, and new markets. The job is far from over. The U.S. shipbuilding industry is not yet able to compete internationally, but MARITECH has been an important start that should be continued.

Background. The MARITECH Program began with the National Defense Authorization Act for FY1993, Public Law 102-484, which required the President to present a plan to Congress for the revitalization of the U.S. shipyards.[1] Its principal goal was to encourage the U.S. shipbuilding industry to expand into the international commercial market. It has been managed by the MARITECH Program Office, operating under the Defense Advanced Research Projects Agency (DARPA). MARITECH will be transferred to Navy management during the coming year. MARITECH's five objectives are to: encourage and support proactive market analysis and product development; develop a portfolio of U.S. designs; develop innovative design and production processes and technology; facilitate government and industry technology transfer activities; and encourage formation of consortia for short- and long-term technology investment strategies.

The purpose of this report is to document the findings and recommendations of the MARITECH Review Project – an independent examination of the MARITECH Program and its accomplishments. The review was conducted by the Potomac Institute for Policy Studies and reinforced by an economic analysis prepared by the Economic Strategy Institute (see Annex B).

[1] The five objectives of the President's Plan developed in response to this act were to: ensure fair international competition through OECD; improve competitiveness, through the MARITECH Program; eliminate unnecessary government regulation; finance ship sales through Title XI loan guarantees; and assist international marketing.

Major Conclusions. It would be wildly optimistic to expect MARITECH to create a globally competitive shipyard industry in five years with $220M. ***But, MARITECH has accomplished much. Its impact on the shipyards visited by the Review Team was surprisingly pervasive. Nearly all facets of U.S. shipyard operation are undergoing change, much of this change is due to MARITECH.*** For example, MARITECH projects contributed significantly to improving business and construction processes. These projects increased productivity, a key to global competitiveness. MARITECH's influence is particularly impressive because the funding of the program was relatively low, considering the problems it tackled.

The Navy is already benefiting from commercial shipbuilding practices and standards. Those benefits will grow with active Navy involvement. However, differences in business and construction philosophies between the Navy and the commercial sector make it difficult for Navy shipyards to enter the commercial market. The Navy will receive full benefit of commercial wisdom only when U.S. shipyard processes and practices are up to international standards. But, these standards are best attained through global competitiveness -- possible for Navy shipbuilders only if the Navy reduces the shipyard's dualism by accepting commercial processes and practices to the degree possible. This "catch 22" must be resolved by the Navy, and the MARITECH follow-on program, the MARITECH Advanced Shipbuilding Enterprise Program (ASE), can be an excellent vehicle for that resolution.

The U.S. shipbuilding industry is beginning to progress. With MARITECH's aid, the industry has built 9 new ships (with 17 under construction), and has produced 31 new ship designs. In June 1997, the U.S. orderbook for ships (100 gross tons or larger) totaled more than 640,000 gross tons, good enough for thirteenth place in the global rankings. That compares to less than 220,000 gross tons for a twenty-third place ranking as recently as December 1995.[2] ***As of April 1997, there were 21 commercial ships on U.S. orderbooks, with a total contract value of approximately $1 billion. The budgetary impact of these sales result in sufficient direct and indirect activity to produce enough tax revenue to nearly pay for the whole five-year program.***[3]

But, there are downsides. Despite signs that foreign subsidies may diminish in the future, they currently pose a decided disadvantage to U.S. shipyards. Even if the field were level, American shipbuilders are behind the rest of the world in productivity. Finally, although many Navy leaders have supported the industry's need to become competitive in the global shipbuilding market, the Navy is not yet a fully active partner in that pursuit.

Some specific examples of industry accomplishments, aided by the MARITECH Program, are listed below.

Alabama: Alabama shipyard built a pipe fabrication facility, adopted a 3D capability to reduce interference. This, and cutting machines driven by CAM data, saved 20% on production labor hours on Dannebrog tankers.

Avondale: A new steel handling and fabrication facility yielded 10-20% productivity improvement (+ 2% annually), and will save LPD-17 production costs.

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[2] Lloyd's Register, June 1997.
[3] See ESI Report, "Overarching Economic Considerations" in Annex B.

Bath Iron Works (BIW): The self-adaptive robotic welding project to automate the welding of 5,000 to 10,000 structural beam erection joints, will save about $500K per ship, and reduce high cost and injury of rework. BIW established relationships with Kværner Masa and Mitsui that remain intact today, and imported technologies and processes that are applied to Navy shipbuilding (claiming annual cost avoidance of $11M to $13M on construction of AEGIS destroyers).

Bender Shipbuilding: Bender will reduce the cost of operations and ship construction time by 50% through their MARITECH project, Organization of Work in a 2nd Tier U.S. Shipyard. New CAD and layout software reduced re-piping and re-running pipe time by 30%, saving 4-5,000 man-hours per ship (uses software with plasma machine to precut pipe holes).

Bollinger: MARITECH put Bollinger "on the map" in the domestic offshore liftboat industry. Liftboat leg construction simulation saves 10% in material and production (cost & time) -- using this software reduces proposal preparation time by a factor of four. AutoCAD shared with all engineers/designers reduced the design process by a factor of five.

Electric Boat: An approximate cost avoidance of $20M per ship was realized through SHIIP, MariSTEP, and SPARS.

Gladding-Hearn (G-H): Partly as a result of the MARITECH program, it has seen a doubling of sales volume, and consequently, increased its workforce by 30%. G-H has a two year backlog of orders (triple its pre-MARITECH backlog). G-H estimates that the current market should drive the fast ferry business for approximately the next ten years.

Halter Marine: Halter is currently building a 42.5M High Speed, Low Wake Pax Ferry that will be debuted at the IMTA in New Orleans in October 1998. It created an electronic infrastructure linking their yards. Halter is using extended aluminum deck and stiffeners (extrusion vice panel with stiffener welded), which results in less distortion, labor savings and lighter weight design.

Ingalls Shipbuilding: Self-adaptive robotic welding could increase its robotic welding from 2-5% to 5-9% per ship.

Marinette Marine: Marinette initiated enterprise IS to link design, production, business, subcontractors and suppliers and built an international vendor database for current price and performance information on customer-preferred vendors. It also adopted just-in-time inventory practices. Its integrated design/production change process reduced re-work rates to 1% from 12%.

NASSCO: This Shipyard improved material and interim product flow which should result in a 25% reduction in steel cost and cycle time. It improved block pre-outfitting procedures which decreased time from launch to delivery from 12 to 8 months on Navy Sealift Ships, and also resulted in the seventh ship having 35% fewer production man-hours than the first.

Newport News (NNS): NNS plans to increase robotic welding from 4% to 15-20% which will yield 25-50% reduction in welding time. It estimated a 50% reduction in schedule and costs when all computers have been networked into a MARITECH overarching computer management decision tool.

Nichols Brothers: Nichols implemented ZOLT (PWBS) in all design/production/ business centers, yielding a 20-30% production time reduction between vessels and the better material flow saved 3 months production time on tugs and aluminum ferries.

Todd Pacific: Worker input changed T-beam slot-cutting operation from 12 hours to 4 minutes. Todd realized a 30% steel shop productivity increase (35% time and effort savings between Ferries 1 & 2 -- an additional 17% between 2 and 3). Through accuracy control improvements, Todd reduced ship-ways work man-hours from 100,000 on Ferry 1 to 50,000 on Ferry 2, to projected 40,000 hours on Ferry 3.

Recommendations.

Initiate a MARITECH follow-on program, ASE, in the Navy. Both the Institute's review of 14 shipyards, and ESI's economic analysis, strongly support continuation of the efforts begun under MARITECH for another five years. The goal of ASE should be to continue to move U.S. shipyards toward world class commercial shipbuilder status, ***and to find ways for the Navy to facilitate and benefit from the pursuit of those commercial goals***. MARITECH should be a major part of the deliberations by the Executive Control Board of the National Shipbuilding Research Program (NSRP) and the Navy, as they define the ASE Program.

An important issue is the focus of the ASE. Its principal focus must remain on global commercial competitiveness, or it will lose considerable impact on the shipyards and Navy shipbuilding alike. But this is not enough, for if the program is successful in improving shipyard performance, but the Navy fails to apply commercial practices to naval shipbuilding, benefits to the Navy will be indirect, at best.[4] For this reason, the Navy should be responsible for the second program goal – the adoption of commercial practices into the Navy.

Some specific suggestions for ASE are presented below.

- **Place less emphasis on marketing and new ship designs.**
- **Place more emphasis on business and construction processes, technology improvements, and training and education (to include sharing lessons learned and resolving terminology differences in business/design/production processes).**
- **Develop and acquire supporting technologies as justified by the processes they enable (e.g., information technologies, automated welding, IT).**
- **Institute an ongoing assessment process at the beginning of the program.** This process should continuously evaluate, collect lessons learned, and make recommendations concerning progress and performance along critical paths.

[4] In fact, the program may end up favoring non-Navy yards. Partly because they cannot rely on Navy business for survival, virtually all of the these yards see their future in the global commercial market (as opposed to three out of the "Big 6" Navy yards). This, and the fact that they do not have to accommodate Navy practices, has allowed them to optimize their operations for commercial success.

Final Report: MARITECH Program Impacts on Global Competitiveness of the U.S. Shipbuilding Industry and Navy Ship Construction

I. Introduction

A. Background[5]

The U.S. shipbuilding industry is an American anomaly. It is a fairly large employer, but its production levels are relatively low.[6] It can produce remarkably sophisticated warships, but cannot compete in the global commercial marketplace.

The industry emerged from World War II as the world's largest in terms of output. U.S. yards made the transition from mass-producing hundreds of commercial and military vessels to building predominantly commercial ships. However, they progressively lost global market share because they could not compete on a cost or productivity basis with their European and Japanese rivals. To compensate for such losses, the U.S. government protected the industry through construction subsidies that improved U.S. ship sales considerably. In the mid-1970's, U.S. shipbuilders built an average of 20 large commercial ships per year. In 1981, however, these subsidies ended and a dramatic decrease in the U.S. share of the commercial market began. In the early to mid-1990's, U.S. shipyards averaged fewer than two ships per year.[7]

B. Navy Business

> ***"The average rate of production in the FYDP is adequate in the near term to support the projected FY03 force of about 300 ships. However, beyond FYDP, this rate of production will not permit us to maintain the required ship and aircraft inventory."***
> ***SECNAV John H. Dalton, 1998 Congressional Posture Hearings***

As shown in Figure 1, there has been a general decline in the Navy's procurement of ships since 1988. Naval procurement is down from an average of 19 vessels annually in the 1980s to a projected 5.7 vessels annually over 1998-2003. These concerns have impacted the shipbuilding industry and its affiliates, and the impact is beginning to be visited upon the Navy through rising shipbuilding costs, even as Navy budgets are reduced. Figure 1

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[5] Much of this Background is taken from the ESI report, included as Annex B, and from shipyard case summaries prepared by the Potomac Institute for Policy Studies (see Annex C).

[6] As shown by Exhibits II-3, 4, and 5 in the ESI report, Overarching Economic Considerations" in Annex B, productivity is the major hurdle in gaining U.S. shipyard international competitiveness.

[7] Data from Shipbuilders' Council of America (SCA) report, "International Shipbuilding Aid-Shipbuilding Aid Practices of the Top Organization of Economic Cooperation and Development (OECD) subsidizing Nations and Their Impacts on U.S. Shipyards." This and other pertinent publications referenced are listed in Annex D.

also indicates that under the most optimistic projection -- the Five

Year Defense Program (FYDP) -- a fairly flat procurement rate can be expected. It takes little experience with DoD budgets to know that the probability of maintaining these levels through future Congressional budget actions is low indeed. The quote of the Secretary of the Navy betrays his doubt that the targeted 300-ship Navy can be maintained even if FYDP levels are approved by Congress. Therefore, it can be assumed that without successful re-entry of commercial markets, U.S. shipyard downsizing will continue.

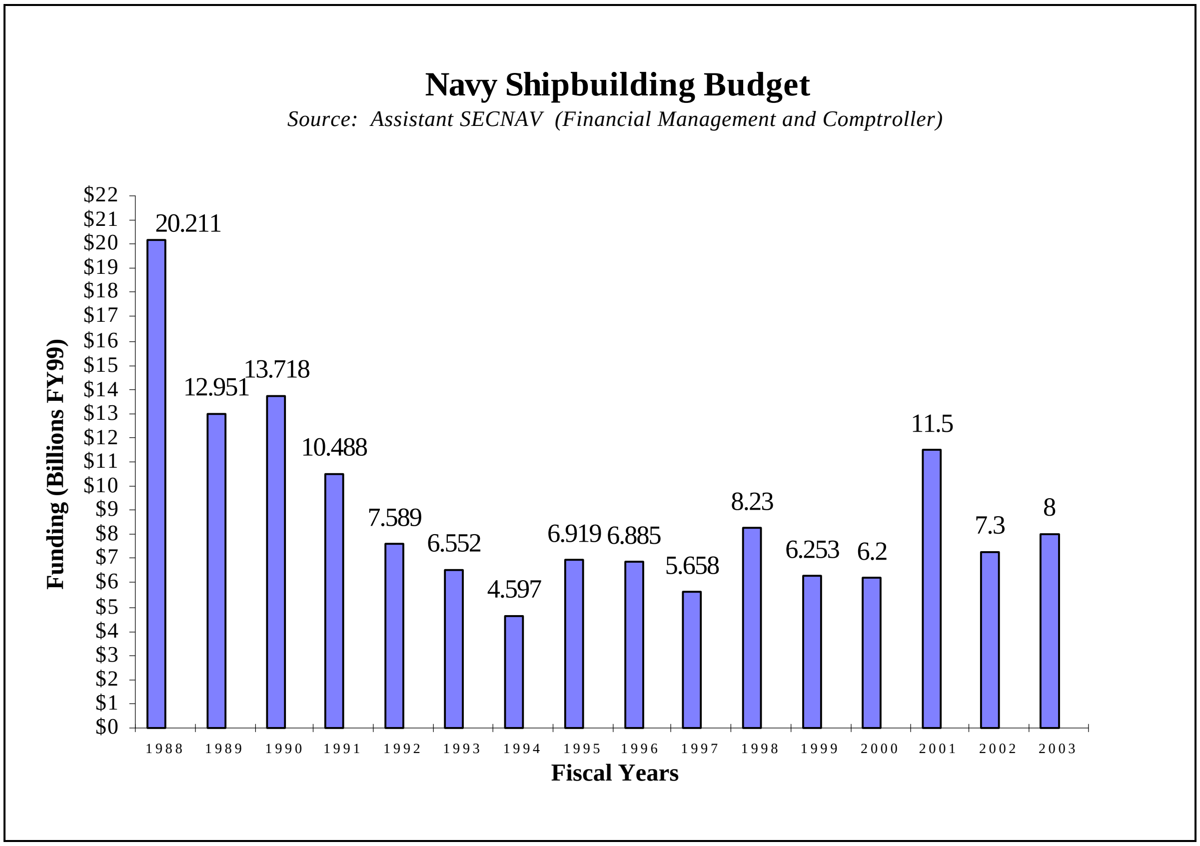

FIGURE 1. NAVY SHIPBUILDING BUDGET

Table 1 presents a quick reference of Navy business performed by the 9 shipyards engaged in that work. The "Big 6" Navy shipyards are indicated by an asterisk.

Shipyard	Navy Business
Avondale*	Current Navy construction includes the Hope Class sealift ships. The LPD-17, which Avondale won last year, is in design. A recent study showed that Nimitz Class aircraft carriers could be built in the existing yard, if Avondale had nuclear facilities.
Bath Iron Works*	At this time, BIW is working with Avondale Shipyard and the Navy on applying the Integrated Product and Process Development (IPPD) to construct LPD-17s. The shipyard does little repair work, preferring ship construction. As of May 1997, BIW had contracts for 11 Navy destroyers and no reported commercial vessels.[8] The Shipyard is looking toward new Navy programs, such as the SC-21 family of ships.[9] They plan to begin building four LPD-17s in 2000. Overall BIW expects about 118 Navy shipbuilding contracts through 2006. To date, 39 have been awarded.
Bollinger	Bollinger has built 62 high performance patrol boats; it has a backlog of 52 Coast Guard Cutters, which keeps it from pursuing additional work at this time.
Electric Boat*	In 1899 EB built the first practical submarine. The first four submarines built at Groton, Connecticut were sold to the Republic of Peru in 1924. During both world wars, EB delivered and repaired U.S. submarines. In 1952, EB constructed the world's first nuclear powered submarine, the Nautilus. This was followed by the construction of numerous nuclear submarines, from Seawolf to Trident. In the early 1970's EB built the SSN668 class. Today, EB is working on the new Seawolf and the Connecticut (SSN22) and has secured a contract for a third boat (SSN23).
Halter	Halter is the leading designer and builder of specialized oceanographic ships for the U. S. Navy, building all but one of them for the Navy since 1988. Halter's experience includes building ocean surveillance ships, SWATH ocean surveillance ships, hydrographic survey ships and oceanographic research ships. In addition, they designed and built the Mark V patrol craft for the U.S. Special Operations Command. Halter has also built other patrol craft for the U.S. Navy.
Ingalls*	Ingalls is centered on Navy business, with a history of building multi-mission destroyers, amphibious assault ships (LHDs), and guided missile cruisers. In 1987, Ingalls was awarded the lead on a contract to build 17 Aegis guided missile destroyers; ten have been delivered. In March 1998, the Navy awarded a contract to Ingalls to build an additional eight Aegis guided missile destroyers. Ingalls is teaming with BIW, Lockheed Martin, and General Electric to compete for the SC-21 program.
NAASCO*	Current Navy construction includes six 36,100 ton RO/RO and one 19,700 ton sealift replenishment ships. NASSCO is proposing to use a version of its vehicle carrier ship design as a replacement for aging Naval MarAd Ready Reserve Fleet RO/RO vessels.
Newport News*	NNS is the only shipyard in the U.S. capable of building and servicing a full range of surface and submersible ships. It is also the only U.S. yard that can build Nimitz-class nuclear-powered aircraft carriers, and one of only two that can build U.S. Navy nuclear-powered submarines.
Todd	Several ships have been constructed for the Navy, including nearly a third of the Fast Frigate Guided Missile Ships (FFG) in service today. The yard does much naval vessel repair [e.g., maintaining Navy Fast Combat Support Navy Vessels (AOE)].

TABLE 1. NAVY BUSINESS BY PARTICIPATING SHIPYARDS

[8] According to *Marine Log*, June 1997.

[9] The SC-21 proposal was submitted by a team (BIW, Ingalls, Lockheed Martin), with the ship construction to be split evenly between BIW and Ingalls.

C. International Commercial Business and Status of U.S. Shipyards

One way to counter the reduction in Navy business is to try to resurrect U.S. participation in the international shipbuilding market. This could be accomplished through adopting the dual-use approach that is being applied throughout the DoD.[10] However, dual-use cannot be a solution where there is no robust commercial industry. That is essentially the case with the U.S. shipbuilding industry today, which for the past decade has neglected the building of commercial vessels for the international market.

Recent attempts to redress this neglect have not been encouraging. In the mid-70's, U.S. shipbuilders built, on average, 20 large commercial ships per year. This production rate has steadily decreased, with fewer than 20 ships being built during the entire eleven-year span from 1982 to 1993 (see Figure 2 and 3).[11] This situation, coupled with the diminishing demand for Navy ships, has resulted in an atrophy throughout much of the American shipbuilding industry, illustrated by recent declines in U.S. shipyard employment (see Figure 4). As a result, the industry's ability to compete in global commercial shipbuilding and to build the most cost effective naval ships is threatened.

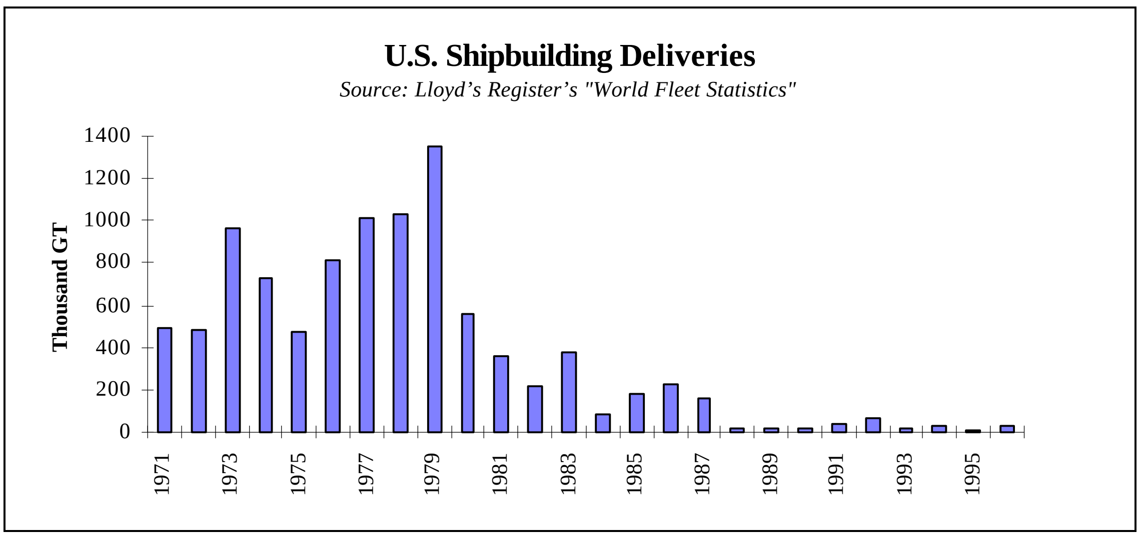

FIGURE 2. NUMBER OF SHIPS IN THE GLOBAL MARKET PRODUCED BY U.S. SHIPYARDS

At this time the world commercial market is dominated by Japan,[12] Korea, Europe, and China, in that order. The international commercial shipbuilding industry is currently in overcapacity, possibly by as much as 30%. It is also distorted by huge national subsidies

[10] In this context, dual-use is defined as products, processes, or acquisition practices that are capable of meeting requirements for military and non-military application.

[11] Shipbuilders' Council of America (SCA), "International Shipbuilding Aid-Shipbuilding Aid Practices of the Top OECD subsidizing Nations and Their Impacts on U.S. Shipyards," Arlington, VA, 1993.

[12] "Sales among Japan's top six shipbuilders reached a record $48 billion in the year ending March 1997," according to *The Wall Street Journal*, 12 February 1998.

at levels not seen in the U.S. for many years.[13] China is viewed as a future major competitor by the industry, with some observers arguing that it already has achieved third-place status.[14]

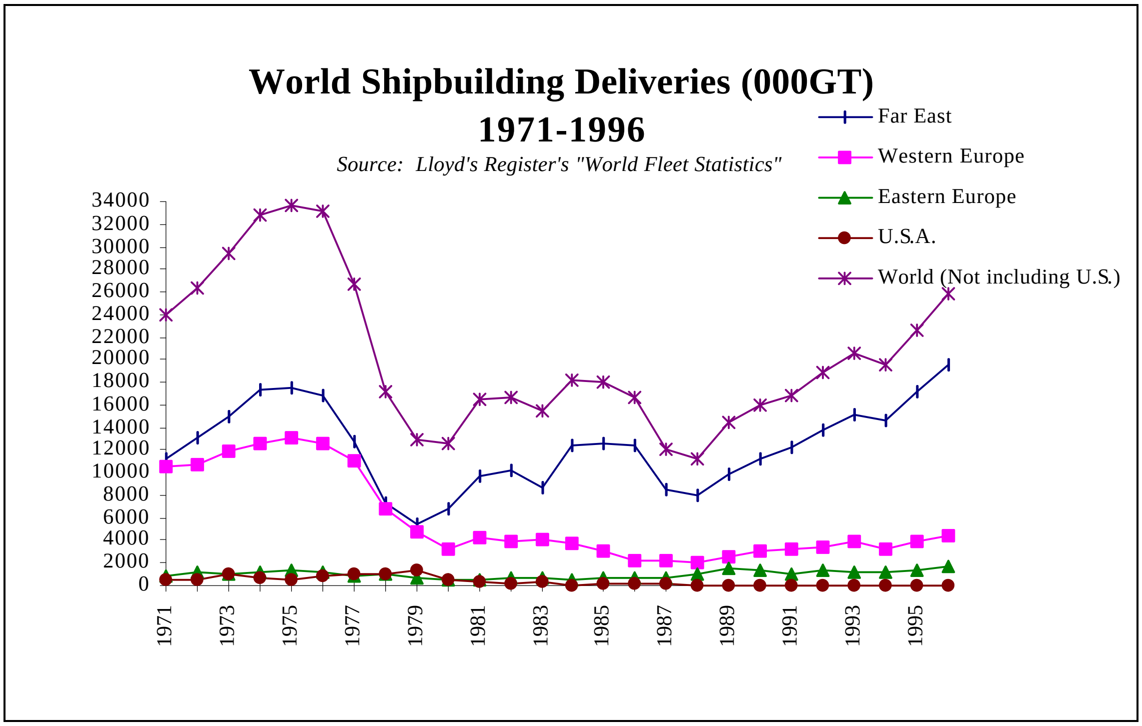

FIGURE 3. WORLD SHIPBUILDING DELIVERIES

[13] Much of the discussion was taken from a more comprehensive treatment of subsidies that appears in ESI's report in Annex B.

[14] Hitachi Director, Hiromitsu Miyasaka, stated that "in the long run, China will be our major rival," *The Wall Street Journal*, 12 February 1998.

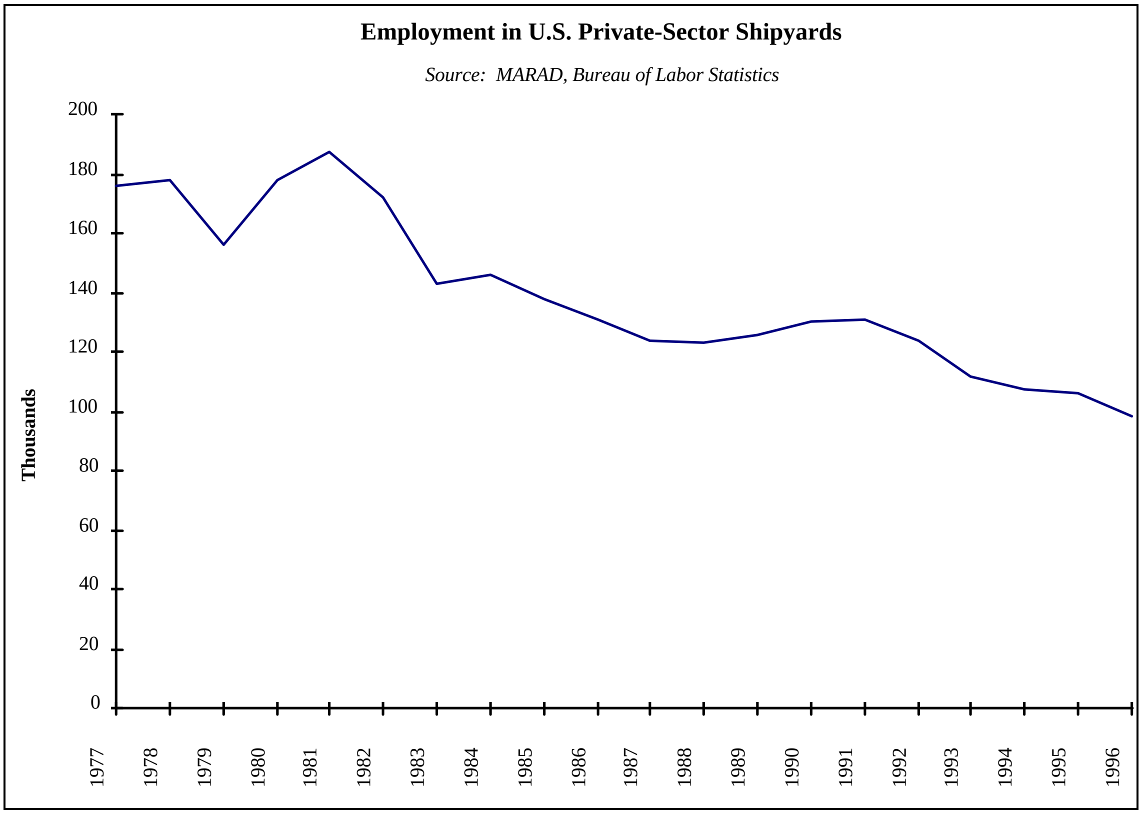

FIGURE 4. SHIPYARD EMPLOYMENT

The extent of Asian subsidies is difficult to determine, since they are often well-hidden. By contrast, the Europeans have an explicit policy of making its subsidies transparent. For instance, the European Union limits construction subsidies to 9% per year. According to a study by the British government, maximum subsidy benefits reached 30% of contract price in Spain, 29% in Denmark, 16% in the UK, and 14% in Germany, exclusive of aid for restructuring, which is substantial.[15] Anti-subsidy measures for shipbuilding taken recently by the Organization of Economic Cooperation and Development (OECD) are seen by many observers as a partial solution to worldwide subsidies; however, we found much skepticism about the effects of this OECD agreement among shipyards visited. (See Annex B for more discussion on this subject.) The bottom line is that it will be extremely difficult for the U.S. shipbuilding industry to compete under this decidedly tilted playing field.

But there may be some good news on the horizon. The Asian economic downturn and its solution, perhaps aided by the OECD, may reduce subsidies and lead China and Korea to adopt caution in worsening the worldwide shipbuilding overcapacity.[16] Further, market trends look good. Figures 5 and 6 provide evidence that the world fleet and international seaborne trade are growing again. Figure 7 reveals that the fleet is also aging. So, newbuilding demand should be robust through 2000, although, as shown in Figure 5, it is expected to tail off in 2003. In addition, freight rates do not appear to be rising as rapidly as expected. This may be due to the Asian economic difficulties. Signs of soft pricing are emerging in the tanker market, mainly in Japan and Korea.[17]

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[15] See ESI Report, "Overarching Economic Considerations" in Annex B with data from Stephan Wagstylk, "Leaky Lifeboat of Subsidies: Help from Governments for Ailing Shipbuilders Has Failed to Create a Competitive Industry in Europe, " *Financial Times*, 22 February 1996, 21.

[16] As part of negotiations to join the OECD, the Korean government assured European members that it would not rescue Korean yards that experienced financial difficulties due to reckless capacity expansion. See Europe Information Service, *Shipbuilding/European Policy-Industry Report*, The Investext Group, 1997: 11. This, combined with the bankruptcy of the Korean companies, Halla shipbuilding and Halla Heavy Industries, send a signal that it may be time to diminish subsidies and rationalize capacity in Asia. For more, see ESI Report, "Overarching Economic Considerations" in Annex B.

[17] See ESI Report, "Overarching Economic Considerations" in Annex B.

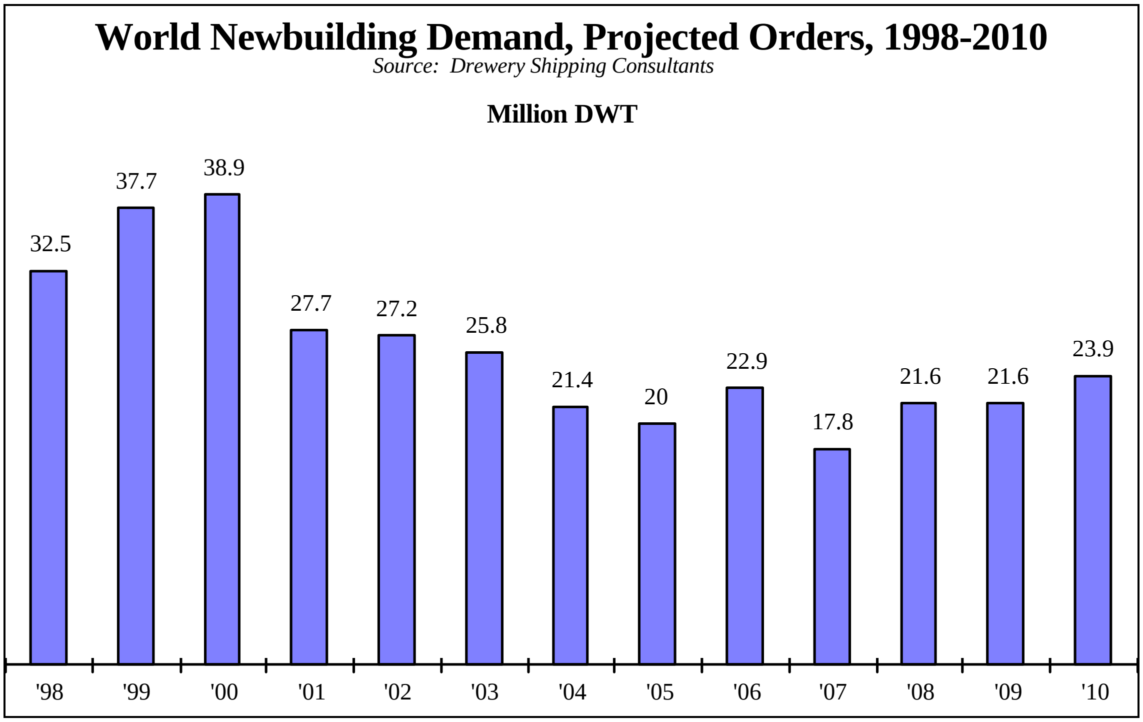

FIGURE 5. WORLD NEWBUILDING DEMAND

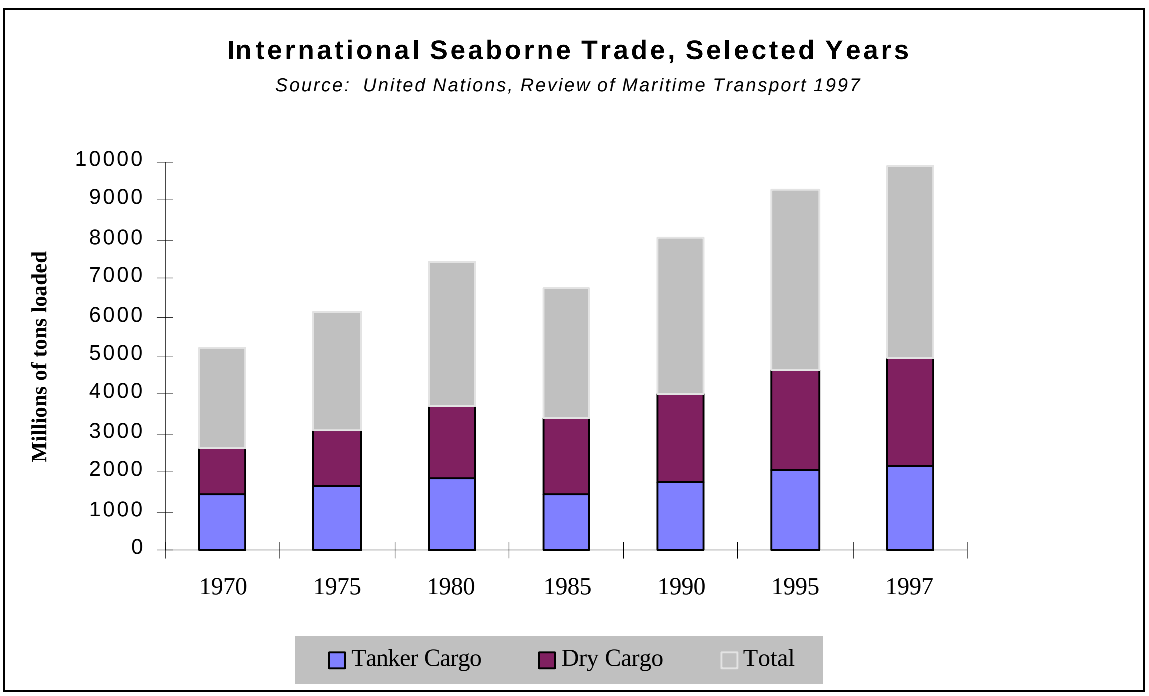

FIGURE 6. INTERNATIONAL SEABORNE TRADE GROWTH

Unfortunately, even in the absence of subsidies provided to foreign shipbuilders, it seems unlikely that U.S. shipyards can compete on a level field for international market share. It is clear from Figure 8 that labor costs are not the problem, since U.S. costs are lower than many of its competitors. But, productivity comparisons between the U.S. and its foreign competitors are far from favorable. Several studies on worldwide productivity of this industry, referenced in Annex B, compare U.S. performance to its competition. As recently as the early 1990's, labor productivity in U.S. yards was found to be one-fourth to one-third that of Japanese counterparts, and two-fifths to one-half that of European shipyards. These figures are sobering. They indicate, for example, that it would take the U.S. nearly four times as many man-hours as a Japanese yard to build the same ship. Since, according to a Merrill Lynch study, Korean shipyards are about two-thirds as productive as those in Japan, the U.S. is also well behind Korea.[18]

There is more optimism in the domestic market. Protection offered by the Jones Act and the Passenger Service Act has meant much to the industry and, although they are in some dispute in Congress, the Acts will probably not be seriously challenged.[19] U.S. ship owners, who have waited for a decision on this matter, speak of a backlog of repairs and orders that will form a "bow wave" of near term domestic business. The offshore oil

[18] Japan's ASISI concluded that U.S. productivity would need to improve by roughly 15 percent per year for seven years just to catch up to international levels. K. Han, Shipbuilding, *Korea: VLCC Impact, New Picks - Industry Report*, Merrill Lynch Capital Markets June 26, 1997, p. 13-14. See also ESI Report, "Overarching Economic Considerations" in Annex B.

[19] The Jones Act, section 27 of the Merchant Marine Act of 1920 (46 U.S.C. app. 883), and several related laws, require that cargo transported by water between points in the United States be carried on U.S.-built, -owned, -crewed, and -registered ships. The Passenger Service Act of 1886 (46 U.S.C. 289) prohibits foreign owned ships from transporting passengers form one U.S. port to another U.S. port.

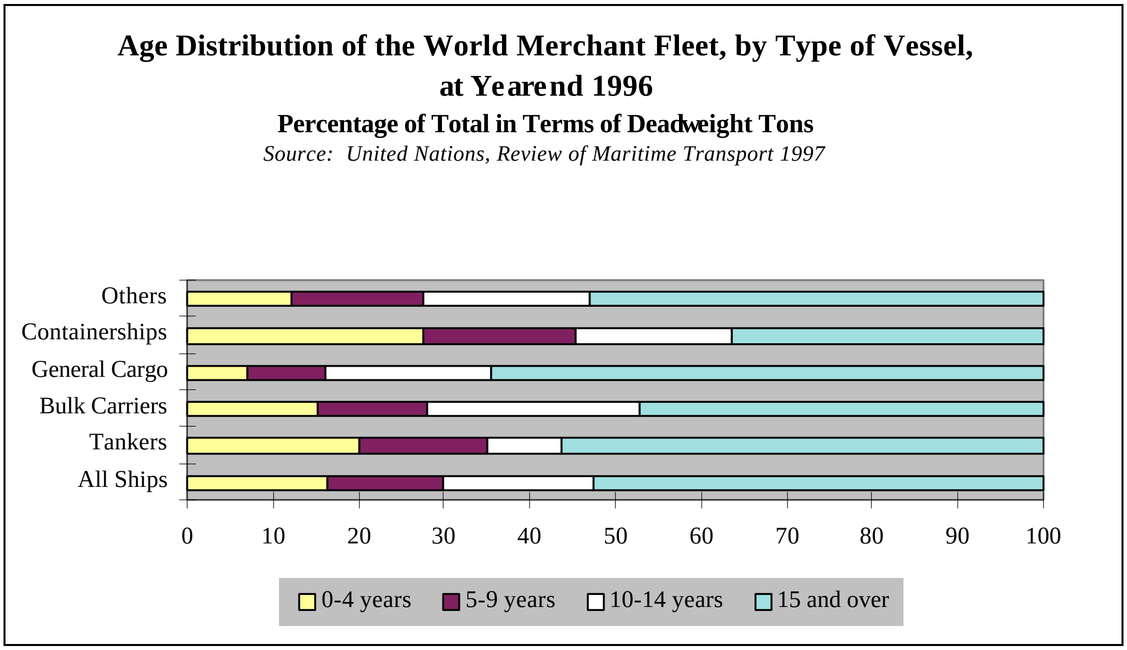

FIGURE 7. THE AGING FLEET

exploration and production market is also improving. As of last year, five "jack-up" oil rigs and 50 Off-shore service vessels of various types, as well as smaller craft, such as tugs and ferries, were under construction at U.S. shipyards.[20] *But problems may threaten even the domestic market, due principally to U.S. process inefficiencies, lack of proprietary designs and standards, and a reported dearth of component suppliers.*

Statistics presented in this report show the impact of this history. U.S. Shipyard employment and deliveries to the international market are down, and productivity is not keeping pace with the competition. Recently, the Philadelphia Shipyard was sold to Kværner Shipbuilding, a European competitor rated as an industry leader, adding another competitive threat. Kværner recently outlined its aggressive commercial goals:

> "Martin Saarikangas, President of Kværner Shipbuilding, emphasized the importance of Kværner's Philadelphia Shipyard to the company's goal of expanding its shipbuilding operations in the U.S. An investment of $45 million will be put into the yard, and Kværner will purchase the first three ships built at a cost of $80 million." [21]

Yet despite its problems, U.S. shipbuilding is a vital national industry.

- Although it employs only 0.5% of the U.S. manufacturing workforce, it is a major employer in certain regions, such as the Gulf Coast.
- Further, every $1.00 spent on shipbuilding leads to $1.74 in additional economic activities.
- According to the ESI economic analysis, as of April 1997, there were 21 commercial ships on U.S. orderbooks, each of which were developed under MARITECH, with a total contract value of approximately $1 billion. **These**

[20] *Marine Log*, June 1997: 31.

[21] See *Marine Log*, "Kværner unveils plans for U.S. marine market." 5 May 1998.

sales result in sufficient direct and indirect activity to produce tax revenue to pay for nearly the entire five-year MARITECH program.

- Ironically, despite its lack of competitiveness, the shipbuilding and repair industry typically runs a trade surplus. In 1997, for instance, the surplus reached $600 million.
- Finally, the industry's role in building American Navy ships alone makes it a national asset we cannot afford to squander.

Perhaps there is not much the Navy (or the shipyards) can do about foreign subsidies, other than hope that they are reduced by economic realities and by OECD's anti-subsidy efforts. However, achieving a level of productivity that is competitive with the rest of the world is a goal which is addressable, and which has ramifications well beyond the capture of the U.S. share of the global market. Clearly, domestic ship buyers would prefer the affordability and excellence that comes from a world class industry. With Navy budgets unlikely to increase, that Service must also seek more affordable naval vessels through the same improvements.

The way to accomplish all of this is to simply regain the excellence needed to compete in the international shipbuilding market. Albeit difficult, this single achievement would move U.S. shipbuilding forward along three fronts:

- the global commercial market,
- the domestic commercial market, and
- naval shipbuilding.

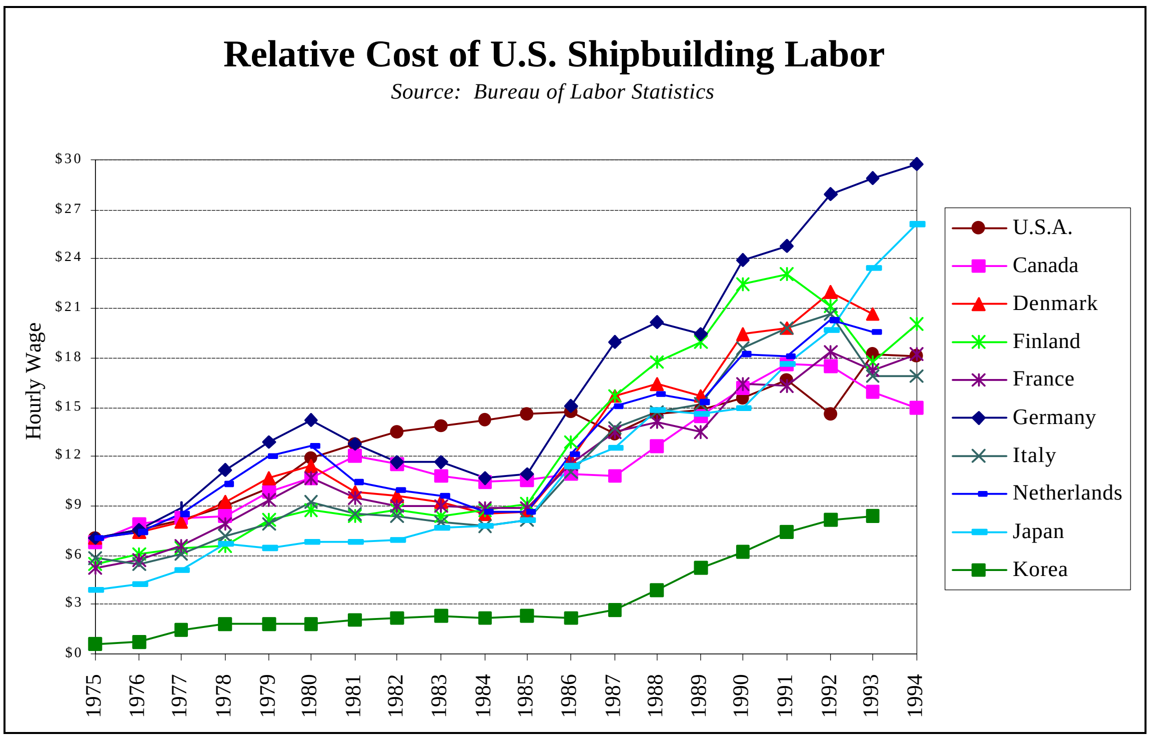

FIGURE 8. U.S. SHIPYARD RELATIVE LABOR COSTS

D. The MARITECH Program

The MARITECH Program.[22] The considerations referred to in Section C convinced the Administration and Congress that the U.S. shipbuilding industry must become commercially competitive in the international market. The MARITECH Program began with the National Defense Authorization Act for FY1993, Public Law 102-484, which required the President to present a plan to Congress for the revitalization of the U.S. shipyards. The President's Plan, developed in response to this act, embraced five objectives:

- ensure fair international competition through OECD,
- improve competitiveness through the MARITECH Program,
- eliminate unnecessary government regulation,
- finance ship sales through Title XI loan guarantees, and
- assist in international marketing.

The MARITECH Program was principally initiated to encourage the U.S. shipbuilding industry to expand into the commercial sector, thereby increasing its potential for staying in business and passing savings gained from commercial efficiencies and economies of scale to the Navy. It is managed by the MARITECH Office, operating under the Defense Advanced Research Projects Agency (DARPA). The management of MARITECH will be transferred to the Navy during Fiscal Year 1997. Five objectives were assigned to the program:

- encourage and support proactive market analysis and product development,
- develop a portfolio of U.S. designs,
- develop innovative design and production processes and technology,
- facilitate government and industry technology transfer activities, and
- encourage formation of consortia for short- and long-term technology investment strategies.

The MARITECH program is industry-driven. It awarded matching federal funds, on a competitive basis, to develop and implement technologies and advanced processes for the competitive design, marketing, production, and support of commercial ships. A series of Broad Agency Announcements (BAAs) released over FY1994-FY1997 addressed the following.

- Near Term:
  - BAA 94-09, 95-02, 96-01: Development of innovative, world class ship designs with a specific market and/or customer in mind, as well as the production processes and technology required to construct the ships competitively.
  - BAA 94-44: Development and demonstration of advanced systems that will improve the manufacture, operation, and/or repair of ships (shipbuilding processes).
- Long Term:
  - BAA 96-05, 96-42: (1) Development and demonstration of innovative application of new technologies and processes that would vastly improve a

[22] Much of this information was taken from, "MARITECH: A Technology Development Program for Competitive Commercial Ships and Affordable Navy Ships," Stuart, Schaffran, Dallas, and Fraser, DARPA, 1993.

shipyard’s capabilities in market analysis, supplier relations, and other advanced business practices (2) Development and demonstration of revolutionary system-wide, integrated design and production technologies that would reduce the total time of the design and construction process.

The MARITECH Program sponsored over 65 projects. Since the review project was a shipyard-centric study, we grouped the projects differently from the MARITECH Program Office, as is shown in the next section of this report.

II. The MARITECH Program Review Project

The MARITECH Program Review Project[23] studied a cross-section of the shipyard-managed MARITECH projects. Fourteen shipyards were examined during the study to accomplish the following goals:

- Provide an independent assessment of ongoing and completed shipyard-managed projects conducted under MARITECH.
- Assess how well these projects are serving the objectives set by the MARITECH Program Office, and how well they are furthering the goals of the individual shipyards.
- Identify potential benefits of MARITECH to Navy shipbuilding.[24]
- Derive lessons learned to help guide future efforts and provide insight into prioritization of goals and approaches. These lessons reflect observations on the effectiveness of the process to pursue the fundamental aims of MARITECH.
- Collect and document examples, which illustrate both benefits and difficulties encountered in conducting a program with an emphasis on creating a commercial market.

Performance metrics were derived to facilitate a measurement of progress toward meeting shipyard and MARITECH goals. Table 2 presents these metrics.

<u>1. Ship Design and Construction Strategies</u>
a. What ships have been sold, built, are under construction, or have been designed?
b. What changes in construction strategies have been developed?
c. What commercial competitive benefits were derived?
<u>2. Technologies Developed or Applied to Improve Design, Production, Operation, and/or Repair of Ships</u>
a. What technologies have been developed or applied?
b. What commercial competitive benefits were derived?
<u>3. Facility Expansion or Modernizations and Process Enhancements</u>
a. What facility modernizations or expansions or process enhancements have taken place?
b. What commercial competitive benefits were derived?
c. Were foreign shipyards visited? Did they influence modernization and process enhancement?
<u>4. Commercial Business Practices</u>
a. What new commercial business practices resulted from MARITECH projects?
b. What new business markets were developed or expanded?
c. Were any international competitive benefits derived from business processes?
<u>5. Impact on Navy Shipbuilding</u>
a. What is the impact of the projects on Navy shipbuilding?
b. What commercial practices are now being using in Navy contracts?
c. What positive impacts could result from Navy adoption of commercial business methods identified?
<u>6. MARITECH Program Process</u>
a. What cultural and process changes have resulted?
(1) Has forming consortia become a normal approach in shipyard commercial and Navy business practices?
(2) Has teaming become a normal approach in shipyard commercial and Navy business practices?
(3) Were associations with foreign partners useful? Are they likely to continue?
b. What MARITECH processes did shipyards like or dislike, and were there suggestions for future programs?
<u>7. Global Shipbuilding Market</u>
a. Where is the global ship market going?

[23] For more details on objectives and methodology employed in this review, see "MARITECH Program Review Project Plan, PIPS 98-1," Potomac Institute for Policy Studies, Dated 4 December 1997.

[24] Original MARITECH objectives failed to mention direct Navy benefits from commercial economies of scale, efficiencies and advanced technologies, as opposed to sustainment of the shipbuilding industrial base. Even so, we feel that these aspects of MARITECH are vitally important.

b.	Will it become more or less viable for U.S. shipbuilders to compete in the global market?
c.	How can the U.S. successfully compete globally and what should be the role of MARITECH?

TABLE 2. PERFORMANCE METRICS

Organization of Project Areas. As indicated earlier, we developed a slightly different taxonomy of the MARITECH program in order to support a shipyard-centric approach. For purposes of the study, we organized the projects under five headings:

1. Ship construction and design, which consisted of designs developed or acquired by the shipyard, using MARITECH funds. The disposition of the design was of significant interest. For example, if a ship was subsequently constructed and sold in the international marketplace, we deemed the MARITECH sponsorship a success. Subsidiary successes were sought as well. Some of these "lower value" successes are sales within the domestic market, application to Navy ships, and derivation of standards or use to test or embed new processes or technologies. Examples of MARITECH-sponsored designs are NNS's Double Eagle tanker, TPSC's Mark III Jumbo Ferry, and Gladding-Hearn's and Nichols Brothers' Fast Ferry.
2. Development or acquisition of new technologies or processes for design, production, operation or repair of ships. Examples of these technologies and processes are the adoption of line heating techniques, automated welding, CAD/CAM proliferation and networking, design production teaming, and IPPD adoption.
3. Facility expansion and modernizations were often planned and initial groundwork was done under MARITECH.
4. Commercial business practices include~~s~~ adapting information technologies, process improvements, marketing, and employing programmatic processes encouraged by MARITECH. We also looked at the benefits of surveys of, and relationships established with, international competitors.
5. Benefits to the Navy, provided by such projects as work flow, information technologies.

Individual Shipyard Case Summaries. Review Teams were formed and responsibility for each shipyard was assigned to a particular team member. Data on individual projects and shipyards were collected through interviews with the MARITECH Program Office, Agreement Officer's Technical Representative (AOTR), shipyards, and contributing experts. At least two team members were present at most shipyard interviews.

In order to maintain consistency, the same core data was gathered and analyzed at each shipyard. Much of this common information was in the form of performance metrics, derived to measure the important impacts of MARITECH across the spectrum of shipyards visited. Examples of success and failure, conclusions, and lessons learned were developed. Case summaries were formatted to document our findings on each shipyard. Each case summary includes background information on the subject shipyard, as well as a discussion of MARITECH projects managed or participated in by that shipyard. The summaries also describe shipyard-level strategies impacted by MARITECH projects, and provide answers to performance metrics questions.

Prior to publication, case summaries were reviewed by the subject shipyards to ensure that no proprietary information or commercially sensitive material is published. Their comments on conclusions drawn were also solicited.

Aggregation of Data and Conclusions to the Program-Level. Performance metrics, conclusions, and lessons gained from the individual shipyards were then aggregated to the MARITECH program level. Performance metrics are quantifiable indicators of how well the shipyards are fulfilling the objectives of the MARITECH program, and their own goals were used to develop final program-level judgments. All questions pertain to MARITECH-sponsored efforts. Table 3 offers aggregated answers to some of these questions. The answers should add up to 14, except in cases where there was no response by one or more shipyards.

Aggregated Shipyard Responses

Shipyard responses to questions based on the performance metrics shown in Table 2 are presented under each case summary in Appendix D. These responses were used in developing conclusions and aggregating them to the program level.

QUESTIONS	YES	NO
1. (c.) International competitive benefits from MARITECH ship design and construction projects?	8	6
2. (a.) Were design, production/manufacture, operation, and repair Technologies developed or applied?	14	0
(b.) International competitive benefits derived from technologies developed or applied?	6	8
3. (a.) Facility modernizations or expansions?	11	3
(b.) International competitive benefits derived from these expansions or modernizations?	3	11
(c.) Foreign shipyards examined?	8	6
4. (a.) Commercial business practices developed/applied?	9	5
(b.) Business markets developed or expanded through commercial business practices?	7	6
(c.) International competitive benefits derived from business processes developed or applied?	4	9
5. (a.) Impact on Navy shipbuilding?	9	5
6. (a.) Cultural or process changes result from procedures employed in the MARITECH Program?	14	0
7. (b.) Will it become more viable for U.S. shipbuilders to compete in the global market?	7	7

TABLE 3. SHIPYARD RESPONSES

III. Shipyard Summaries

The14 Shipyards studied are listed below, in Table 4. Three of these are dedicated essentially to Navy business, while another three are exclusively in commercial business, and seven have both Navy and commercial customers. As indicated in this table, MARITECH has aided these shipyards to improve several aspects of their business, including building ships, developing designs, improving business and construction processes, enhancing facilities, and constructing and repairing Navy ships.

Shipyard	(1) Build Projects	(2) Design Projects	(3) Process Projects	(4) Facilities Projects	(5) Business Process Projects	(6) Navy Business Impacts	(7) Commercial Business Impacts
Alabama	X	X	X	X	X		X
Avondale	X	X	X	X	X	X	X
Bath Iron Works		X	X	X	X	X	
Bender	X	X	X	X	X	X	X
Bollinger	X	X	X		X	X	X
Electric Boat			X	X	X	X	
Gladding-Hearn	X	X	X	X	X		X
Halter	X	X		X	X	X	X
Ingalls	X	X	X		X	X	X
Marinette					X		X
NAASCO	X	X	X		X	X	X
Newport News	X	X	X	X	X	X	
Nichols		X	X	X	X		X
Todd			X	X	X	X	X

TABLE 4. INDIVIDUAL SHIPYARD SUMMARIES (X = MARITECH-SPONSORED ACTIVITIES)

Annex C presents case summaries of all 14 shipyards studied. These case summaries are synopsized in the following for the convenience of the reader. Business/market niches, the extent of Navy business, ongoing MARITECH projects, some important metrics and conclusions are summarized for each shipyard.

A. Alabama Shipbuilding Industries

Niche: Alabama Shipbuilding Industries (ASI), located in Mobile, Alabama, specializes in commercial vessels up to 400 feet long. The company is solely a commercial builder, but has the capacity to build Navy ships if called upon in wartime.

Its past portfolio consists of special purpose vessels such as casinos, asphalt carriers, and drilling rig service vessels. Under MARITECH, ASI bought rights to a 40,000 dwt chemical tanker design, modified the design, and built two vessels for Swedish operator Dannebrog Rederi.

Although the company still feels confident that other international market opportunities exist for tankers, product carriers, and small container ships, it is focusing its marketing efforts on Jones Act traffic.

Navy Business: None

MARITECH Thrusts: Initial MARITECH proposals focused on particular ship types; e.g., 40,000 dwt. product carrier, handy-sized (27,000dwt.) bulk vessel, 10-12,000 dwt. product tanker, and a 1,432 TEU container ship. All of the design projects were modified to focus on the development and application of process improvements. The design, estimation, materials handling, pipe fabrication, blast and coating, worker training, marketing, and material procurement processes were all evaluated and improved.

ASI derived large benefits by having foreign consortium member, SENER, benchmark its processes. Thirteen visits to yards in Japan and Europe influenced ASI's process improvement choices. Internally, teaming has become commonplace, and includes customer involvement in the design process.

Industrial engineering of new and existing facilities has complemented the process improvement effort. With MARITECH funding, ASI designed new facilities for pipe fabrication, and steel blast and coating. Design work is complete for an improved steel assembly building to take plates and webs from stock to modules ready to be transported to the construction dock.

Additional benefits will accrue from implementation of better business practices recommended in a recent Coopers and Lybrand study; e.g. vendor managed inventory, long-term contracts, and corporate-wide purchasing contracts.

Metrics:

- Two ships were designed, marketed, and sold in the international market
- Accuracy control improved from using CAD/CAM software and workstations to reduce interference and re-work saved 20% on production labor hours
- Quality was improved, and re-work reduced by use of dedicated pipe fabrication and blast and coating facilities

Conclusions:

- ASI's MARITECH involvement has been critical to its long-term competitiveness strategy. Its management feels that it has overcome early problems with cost estimation and market forecasting, and ASI is positioned to further improve processes.
- The company strongly supports MARITECH and recommends a second phase.

B. Avondale Industries

Niche: Avondale Industries, located in New Orleans, is Louisiana's largest private employer, builds a mix of large, sophisticated commercial and Navy ships, with the long range goal to maintain an even balance between the two. The company builds large ships most efficiently, with the maximum size approximately 185 feet wide and up to 1200 feet long.

Navy Business: Current Navy construction includes the Hope Class sealift ships. The LPD-17, for which Avondale won the contract last year, is in design. A recent study showed that Nimitz Class aircraft carriers could be built in the existing yard, if Avondale had nuclear facilities.

<u>MARITECH Thrusts</u>: The company had two projects, development of a 40,000 dwt product carrier, and development of a simulation design project. Both projects were focused on process improvement, with the former using the tanker as a means to that end. Avondale chose the tanker in the belief that OPA-90 would precipitate the construction of new, double-hulled tankers for the Jones Act routes. Unfortunately, the demand never materialized. With the help of consortium member *Astilleros Españoles, S.A. (AESA),* the company used the project to benchmark its material handling processes. That was primarily accomplished by construction of an optimized ten acre steel handling and module fabrication facility nicknamed "The Factory".

The simulation based design project will integrate upgraded CAD/CAM capabilities with teaming (IPPD) in a shared data environment (IPDE). The goal is a 3-D product model which would be useful for design, production, and business personnel. Early experience with teaming on this project revealed that application of the Navy IPPD structure to commercial projects was unsuitable. That lesson led to application of a leaner, more customer-focused teaming arrangement on the ARCO tanker project, now in construction. The IPDE structure is still in development, and will benefit the Navy's LPD-17 program.

<u>Metrics</u>:

- Avondale credits The Factory with immediate productivity improvements of 10-20% and forecast improvements of 2% annually
- Improvement of the company's "standard tanker design" in the early MARITECH tanker program enabled the company to be more competitive by 20-30% on the ARCO project
- Use of improved CAD/CAM enabled Avondale to meet scheduling goal of contract award to first steel cutting in 7 months
- Improved cost estimation software showed that Avondale's labor costs are within 5% of European competitors

<u>Conclusions</u>:

- Avondale's MARITECH experience has been extremely useful and the company is committed to increasing its commercial portfolio of complex ships. It is currently competing with Ingalls and NASSCO for the American Hawaii Cruise Lines contract award.
- Avondale management would be extremely supportive of another five year phase of MARITECH, particularly if the program's flexible, streamlined management procedures are preserved.

C. Bath Iron Works

<u>Niche:</u> Bath Iron Works (BIW), located in Bath, Maine, is solely a Navy shipbuilder, currently averaging one and one-half Navy ships per year. It is clear to the company that Navy production was declining and would continue to do so. Furthermore, BIW felt that the Navy was becoming much more sympathetic toward business and commercial

practices, even when performance tradeoffs must be made. At this time, BIW began an extensive foray into the commercial shipbuilding world but finally gave it up, deciding that the company's MARITECH-supported market and competition survey indicated that the Return On Investment (ROI) was insufficient to compensate for the extensive effort required to compete in the commercial market. BIW decided to pursue the commercial sector only if a loss of Navy business dictated that it had to do so. In the meantime, however, the shipyard is developing processes and facilities that will support commercial shipbuilding.

A future market deemed important by BIW is foreign naval shipbuilding. BIW is marketing the Aegis destroyer (the DDG51 series) to Spain, Korea, Saudi Arabia, and possibly Greece. Non-Aegis sales may be forthcoming in Turkey, Taiwan, and Saudi Arabia.

Navy Business: BIW has designed and constructed over 400 Naval surface combatants and commercial vessels since its birth in 1884. The shipyard constructed one to two ships a week during World War II. Since 1950, BIW has been the lead shipyard on 10 of the 20 cruisers, destroyers and frigates. Since the 1950's BIW has built five LST's, 22 merchant ships, and 76 Surface combatants.

In 1992, BIW had contracts for 14 AEGIS destroyer ships. At this time, BIW is working with Avondale Shipyard and the Navy on applying IPPD to constructing LPD-17s. The shipyard does little repair work, preferring ship construction. As of May 1997, BIW had contracts for 11 Navy destroyers and no reported commercial vessels.[25] The shipyard is looking toward new Navy programs, such as the SC-21 family of ships.[26] It plans to begin building four LPD-17s in 2000. Overall BIW expects about 118 Navy shipbuilding contracts through 2006. To date, 39 have been awarded.

MARITECH Thrusts

- Commercial Shipbuilding Focused Development Project: Established relationships with Kværner Masa- and Mitsui that remain intact today. BIW imported technologies and processes through these relationships that were applied to Navy shipbuilding.
- High Speed Monohull Focused Development and Contract Design: The company developed a number of concepts in high speed monohull designs, for applications such as feeder, truck/car ferry, and container ships.
- Projects participated in, but not led, by BIW included information systems projects sponsored by MARITECH, such as NIIIP(SPARS), SHIIP, and MariSTEP. BIW is revamping its business and design processes using these technologies.
- Self-adaptive Robotics Welding: If successful, the self-adaptive robotic welding project will automate BIW's welding of the 5,000-10,000 structural beam erection joints in a normal ship. This can save as much as $500K per ship. The high cost of rework and injury will be substantially reduced.

Metrics:

[25] According to *Marine Log*, June 1997.

[26] The SC-21 proposal was submitted by a team (BIW, Ingalls, Lockheed Martin), with the ship construction to be split evenly between BIW and Ingalls.

- Navy Ship construction savings: $11M to $15M on DDG-51 program
- Reduction in unnecessary statusing achieved a 30% reduction in number and frequency of status and performance reports
- Automation of self-adaptive welding process (CYBO): BIW has projected savings of 30% to 40% from normal welding costs (for welding 2,000 erection joints per ship).[27]

Conclusions: BIW has made some major gains in efficiency, and is currently continuing work on the commercial high speed monohull. MARITECH projects have had a measurable effect on Navy shipbuilding thus far, and will undoubtedly continue to pay off for that sector. However, it appears unlikely that BIW will enter the commercial market in the near term.

D. Bender Shipbuilding

Niche: Bender, located in Mobile, Alabama, is "second-tier" shipbuilder focusing on the production of mid-size steel and aluminum vessels (typically under 900 feet in length), and repair. They established themselves as a dominant supplier of fishing vessels to the Pacific Northwest, as well as a major supplier to foreign markets.

Navy Business: Bender is not a Navy yard and does not do much work for the Navy. In the past, it has completed several light landing craft. The company noted that there are not many opportunities to build smaller vessels for the Navy.

MARITECH Thrusts:

- Reefer and Multi-Mission Cargo Ships: The first project focused on creating an entirely new design for a reefer vessel, which then led to Bender's efforts to create a small cargo ship. Both of these projects led to the shipyard's next MARITECH effort.
- Organization of Work in a 2nd Tier U.S. Shipyard: Bender began this project to re-engineer the way it does its work, and to reduce the cost of shipyard operations and the time required for ship construction by 50%.

Metrics:

- Bender noted that the first two projects did result in the design of the Reefer 21, the construction of two OSVs with four more under contract, and a multi-mission cargo ship which is under design. Bender credits the first two MARITECH projects concentrating on design with improving its production planning. Through the Reefer 21 project Bender learned how to do a "build strategy" and began considering improvements to the yard's material flows and processes.
- The yard is fully networked using fiber optic cables and the company is now using 3-D Design Software, including AutoCAD. The new CAD and layout software has reduced the time spent re-piping and re-running pipe by 30%,

[27] CYBO projects a savings of $500K per ship for 5,000 to 10,000 structural beam erection joints per ship. This represents approximately 27,000 man hours of labor.

saving 4,000-5,000 man-hours per ship. The company is also creating better production packages.

Conclusions:

- Production Processes: Bender remarked that MARITECH has been indispensable in helping it re-create its processes. It noted that its first approach to MARITECH -- concentrating on designs -- was not the correct one. After examining various markets and foreign yards, the company realized that shipbuilding processes are the key to being competitive. This led to adopting new software systems, 3-D design and robotic welding, and networking the yard.
- Technology: Bender perceives that U.S. yards should be concentrating on technology implementation rather than technology development: in other words, the yards should learn to efficiently use the technology that they already have. Bender was greatly influenced by foreign yards' superior processes and accuracy controls. It sees itself moving in that direction. Many of its computer enhancements, automated welding and laser cutting projects are a direct result of this influence.
- Workforce: Bender was one of several shipyards that expressed concern regarding the future workforce of the industry. It feels that the industry as a whole should address the need for "new blood" and that MARITECH could assist with innovative recruiting and training programs.
- Government Programs: Bender would like to see MARITECH continue, and credits the program with significantly helping it to become more competitive. It also credit the Title XI program with assisting the U.S. yards in becoming more attractive internationally.

E. Bollinger Shipyards

Niche: Located in Lockport, Louisiana, Bollinger's niche is building offshore industry liftboats and supply vessels, Coast Guard Cutters, and Navy patrol boats.

Navy Business: Bollinger has built 62 high performance patrol boats and has a backlog of 52 Coast Guard Cutters. This keeps it from pursuing additional work at this time.

MARITECH Thrusts: Bollinger had two major projects within the MARITECH program.

- Offshore liftboats: Bollinger teamed with Halliburton, a UK company, to design and develop an offshore liftboat to be used in the Irish Sea. This design, the Sea Horse, was not accepted by the UK; Bollinger re-worked the design, using simulation to design for steel strength in the legs, and came up with a new design called the Irish Sea Pioneer. This design was accepted and built.
- SWATH: The plan was to redesign the SWATH superstructure to make it lighter, and therefore faster. After re-working the design, the team discovered that the original design had been optimized for weight.

Metrics:

- The Stewart and Associates Simulation Based Design Tool produced a savings of 10% on material and production costs, as well as reducing the time required to develop proposals by a factor of four.
- Also, Bollinger changed to AutoCAD (from CADAM) during the MARITECH program. This switch reduced the design process by a factor of five (CADAM took 10 seconds to regenerate a drawing, and AutoCAD takes 0.5 seconds).

Conclusions:

- Teaming: Bollinger learned to team with vendors from the start of the project. It discovered that including them as part of the team in the beginning committed them to the delivery of the entire product, not just their piece of it.
- The Navy needs to relax some of the standards that it places on the shipbuilding industry. For example, the Navy allows Bollinger to use a welding technique called pulse-arc welding. This technique significantly reduces distortion in the steel. However, the Navy does not allow other shipbuilders to do it.

F. Electric Boat Corporation

Niche: The business of Electric Boat (EB), located in Groton, Connecticut, is submarines. It has no discernible commercial business and there is little chance of successfully pursuing it under MARITECH.

Navy Business: In 1899, EB built the first practical submarine. The first four submarines built at Groton, Connecticut were sold to the Republic of Peru in 1924. During both world wars, EB delivered and repaired U.S. submarines. In 1952, EB constructed the world's first nuclear powered submarine, the Nautilus. This was followed by submarines, that range from Seawolf to Trident. In the early 1970's, EB built the SSN668 class. Today, EB is working on the new Seawolf (SSN21), the Connecticut (SSN22), and has secured a contract for a third boat, the Jimmy Carter (SSN23).

MARITECH Thrusts:

- New Shipbuilding Methodology Through SHIIP: Through this project, Electric Boat is deploying NIIIP throughout the shipbuilding industry. This will allow the sharing of information throughout an enterprise (among separate business areas). EB is addressing such difficult problems as heterogeneity of computing environments, legacy systems, and rapidly changing information technologies and protocols. Its approach is to set up a reference deployment at Electric Boat with ship construction as the principle target.
- EB participates in three other projects -- STEP Ship Product Models; NIIIP(SPARS); SBD as an Environment for Concept and Contract Design Using IPPD.

Metrics:

- EB projects cost avoidance from SHIIP at $6.5M per ship ($1M per ship for work order maintenance, $3M per ship for engineering records, $2.5M per ship for electronic information throughout the enterprise)
- EB projects a future cost avoidance from MariSTEP of $7.5M per ship
- EB projects a cost avoidance from SPARS of $7M per ship class

Conclusions:

- EB is doing superlative work under the SHIIP project that may create significant information skills and infrastructure in other shipyards that will be successful in the commercial market. EB is unlikely to become commercial, but it is manifesting benefits from information technologies and process improvements to the Navy. This is its key goal. As the Vice President for Innovation said, "If Navy ships become cheaper, there will be more Navy shipbuilding." So, the focus must be on ROI.
- Another major area of improvement must be design and construction processes. For example, the Seawolf submarine had 100,000 unique parts. NSSN is planned to have 18,000. This application of commercial parts, and the integration of commercial standards and processes, when they make sense on a submarine, will make a huge difference.
- Electric Boat helped to reengineer the NSRP, a technology-based consortium of nine shipyards, to take advantage of MARITECH principles in the technical arena (sharing among shipyards, adopting competitive practices, etc.). Their basic tenet is that the large shipyards, with Navy business, should be the focus of government attention, since the Navy will directly benefit from their success.

G. Gladding-Hearn Shipbuilding

Niche: For over 40 years, Gladding-Hearn (G-H), located in Somerset, Massachusetts, has produced more than 300 commercial vessels and custom yachts. G-H primarily builds fast passenger ferries, catamarans, pilot boats, and police/fire boats. They have become well-versed in high-quality aluminum construction in this market. A family business, G-H is one of six shipyards around the world licensed to build the Australian-INCAT designed catamarans. With in-house naval architecture and engineering capabilities, G-H has pioneered some of the industry's most advanced shipbuilding techniques such as pulse arc welding, fully rotational propulsion steering, and sound-deadening systems.

Navy Business: None

MARITECH Thrusts: G-H has applied the MARITECH projects toward becoming globally competitive by improving their business development, foreign market development, and business processes. Under MARITECH projects they sent people to foreign markets to look at prospects for entry into the fast ferry catamaran construction business, and began the process of updating their business and construction practices and infrastructure as well as their facilities.

Under the current MARITECH program, Gladding-Hearn is working with UCSD and INCAT to create a second generation design for composite hull ferries based upon the design used in building two ferries during the past two years. The new design will be lighter, stronger and fire-protected. It is also expected to reduce costs by one-third, to produce less than half the wake of a monohull, and to operate with 60 percent power at 30 Knots.

G-H will also adapt production and train crews to build the XP-300 (composite material) using ZOLT; strain gauge the hulls and conduct extensive full scale trials on the completed XP-300; and design an inexpensive intermodal docking system for the XP-300 (called the Patriot) that is necessary as a reliable loading interface between the ferry and the beach.

G-H has used the MARITECH projects to adopt modern business and construction practices, such as ZOLT, ISO-9000 Qualifications, and improvements to their computer/information system, CADCAM, and training. Facilities improvements include a 6 acre site addition, and a number of changes planned to improve workflow. Survey, planning, and permit processing were aided by MARITECH.

Metrics:

- Partly as a result of the MARITECH projects, G-H has seen a doubling of sales volume, and, consequently, a 30% increase in workforce. At this time, they have a two year backlog of orders (triple their pre-MARITECH backlog). They feel that their business looks good for the next ten years.
- Composite, low wake ferry design is projected to reduce operating costs by 1/3, less than half the weight of a monohull, 60% of monohull power requirement at 30 Knots.

Conclusions:

- G-H has applied the philosophy and spirit of the MARITECH program toward becoming more globally competitive by improving their business development, foreign market development, shipyard production and business processes. Prior to receiving MARITECH funding they had not been able to aggressively address the international marketplace. Under MARITECH they investigated foreign markets to identify potential clients and determine the needs for fast catamaran ferries.
- G-H has significantly improved their business and manufacturing processes, and improved and expanded their shipyard facilities resulting in reducing vessel construction time and costs.

H. Halter Marine Group, Inc.

Niche: Headquartered in Gulfport, Mississippi, Halter Marine's niche in the shipbuilding market is small to medium sized (50-400 feet) ocean going ships, of which they are the largest builder in the United States. In addition, Halter's yards are very experienced in building products to service the energy industry including rigs and OSVs. Halter also has a lucrative business building luxurious yachts.

Navy Business: Halter is the leading designer and builder of specialized oceanographic ships for the U. S. Navy, building all but one since 1988. Halter's experience includes building ocean surveillance ships, SWATH ocean surveillance ships, hydrographic survey ships and oceanographic research ships. In addition, they designed and built the Mark V patrol craft for the U.S. Special Operations Command. Halter has also built other patrol craft for the U.S. Navy.

MARITECH Thrusts:

- 23,000 dwt Container/Bulk Carrier Design
- Medium Size Multipurpose Ship Design
- Commercialization of E-CAT Technology
- Large Fast Ferry Technical Development

Metrics:

- Halter's MARITECH programs have resulted in the following designs: one 23K dwt Container/Bulk Carrier, three Container Feeders, and ten Fast Car Passenger Ferry designs.

- Halter is currently building a prototype 42.5m High Speed, Low Wake Pax Ferry which will be demonstrated at the IMATA conference in October 1998.

- Halter improved their material flow at their Pascagoula yard, realizing that they could build larger ships at that facility. In addition, they are now using light gage aluminum construction techniques and aluminum extrusions, and have reoriented a production facility to begin aluminum fabrication of ferries.

Conclusions:

- International Competitiveness: As a result of MARITECH, Halter has made a commitment to go into the Large Fast Ferry market internationally, using designs acquired through the program. They have been able to make a significant number of potential international customer contacts, and have three potential customers who are interested in various types of large fast ferries and high speed, low wake ferries.

- Foreign Associations and Teaming: Halter worked with foreign designers, test facilities, shipyards, and owners on their MARITECH projects. They stated that they will continue to do so and found the practice very useful. Furthermore, they have created alliances with these groups as well as vendors.

- Workforce: Halter was one of several shipyards which expressed concern regarding the future workforce of the industry. They noted that wages are increasing and they are competing with other employment areas for people. This hinders what work they are able to contract at their yards.

- Government Programs: Halter viewed MARITECH as very successful, and would like to see the program continue. They felt that the design efforts were more beneficial to them, and that product development encompasses process improvements. The MARITECH program also helped them to realize the advantages of the Jones Act and the MARAD Title XI Loan Program.

I. Ingalls Shipbuilding

Niche: Ingalls Shipbuilding, located in Pascagoula, Mississippi, builds both commercial and Navy ships (destroyers). They are very interested in entering the cruise ship market. They purchased a design through an early MARITECH project and developed a manufacturing plan for that design. The goal will be to compete for the American Classic Voyages contract for the Hawaiian Islands cruise ship development initiative. Ingalls also continues to build deep water supply vessels for the offshore oil industry, and has recently announced its licensing agreement with Zentech, Inc., for a new, state-of-the-art deepwater jackup drilling rig.

Navy Business: Ingalls is centered on Navy business, with a history of building multi-mission destroyers, amphibious assault ships (LHDs), and guided missile cruisers. In 1987, Ingalls was awarded the lead on a contract to build 17 Aegis guided missile destroyers; ten have been delivered. In March 1998, the Navy awarded a contract to Ingalls to build an additional eight Aegis guided missile destroyers. Ingalls is teaming with BIW, Lockheed Martin, and General Electric to compete for the SC-21 program.

MARITECH Thrusts:

- Cruise Ship Design: Purchased a design that will introduce them into the cruise ship market.
- MariSTEP: Project is very immature and the infrastructure is not in place yet to implement this concept; however, if successful, the project has the potential to provide for quick turnaround of data exchanged on product models and problem resolution.
- Structural Composites: Developing a composite superstructure that currently has no customer; the Navy has expressed interest in the superstructure for SeaLift ships and may possibly use this technology on their cruise ship design.
- Self-Adaptive Robotics Welding: If successful, the project could offer robotic welding with automatic programming for the portable and gantry welding systems.

Metrics: The use of robotic welding is currently 2-5%; self-adaptive robotic welding would increase that to 5-9%.

Conclusions:

- Teaming: MARITECH programs offered Ingalls their first opportunity to team with foreign yards (cruise ship design), as well as domestic yards (CYBO, Intergraph). Ingalls will continue teaming.
- Standards: The industry needs standard definitions, especially in the area of information technology and infrastructure.

- Process: Ingalls tried to adopt some of the commercial processes found in other yards; however, it has been difficult to get the Navy to employ some of those processes.

J. Marinette Marine Corporation

Niche: Marinette Marine Corporation (MMC) is a privately owned shipbuilding company located in Marinette, Wisconsin and founded in 1942 and located . Since its inception, the yard has built nearly 1,300 vessels, including tugs, ferries, buoy tenders, and research vessels. Current employment is approximately 600. Its primary niche vessel is up to 300 feet in length. Marinette's business base is primarily commercial and the Coast Guard.

Navy: MMC currently has no Navy work. The closest analog is Coast Guard, for which it is currently constructing buoy tenders. In the past, however, the company has constructed 108 foot patrol craft, berthing barges, and 66 foot workboats for the Navy. MMC could bid for Navy work again, if the Navy needed small vessels.

MARITECH Thrusts: The company had two projects under the title, "Transitioning to a 21st Century Advanced Manufacturing Facility, Phases I and II". Both projects were focused on process improvement to enable international competition within MMC's niche. As a way of benchmarking the company's capabilities and highlighting modernization areas, the company licensed designs from consortium member Pelmatic AB (Sweden) for a product tanker, an ethylene tanker, and an aluminum fast ferry. The first proposal identified some production processes for reform and benchmarked the company's entire business for other improvement areas. Changes were called for in marketing, manufacturing, training, and management. Cost estimation and material handling were singled out as particularly important.

The second phase analyzed the company's effort to "dramatically reduce the time-frame to manufacture ships by using concepts and processes used in auto and aerospace industries in Enterprise Resource Planning Techniques." MMC established an enterprise system software evaluation team comprised of representatives from all the company's business centers. Their task will be to establish a model of the shipyard information requirements, generate information system characteristics, and select software capable of meeting the requirements.

Metrics:

- Began all fabrication in re-work in a new facility and reduced delivery time for first buoy tenders to 14 months from contract award.
- Used upgraded CAD/CAM software and better re-work tracking processes to reduce re-work rate from 12% to 1%.
- Implemented computerized planning system to manage material requirements and drive work package scheduling.
- Applied regression analysis to previous projects to compile estimation tool for future work.

Conclusions:

- Marinette leadership feels that its MARITECH experience has been extremely useful. It has established an identity at foreign trade shows, begun a portfolio of commercial designs, and is proceeding to modernize its design and production processes. Improvements in phase I have generated strong corporate commitment going into phase II.

- The company supports the MARITECH program and supports a second phase.

K. National Steel and Shipbuilding Company

Niche: National Steel and Shipbuilding Company (NASSCO), located in San Diego, California, is one of the largest shipyards in the U.S. The yard can perform new commercial design, repair and overhaul, but is currently concentrated on Navy sealift ship construction.

NASSCO has built 296 ships for both commercial and government customers, including hospital ships, oil tankers, ferries, container ships, combat supply ships, tank landing ships, RO/RO ships, and oceanographic research ships.

No new commercial construction is in progress, but NASSCO is pursuing tanker contracts with British Petroleum (3 vessels with options for four more 125,000 dwt. for transit from Alaska to West Coast ports), and a contract for two cruise ships with American Classic Voyages under provisions of the FY1998 Defense Appropriations Bill. They expect the cruise ship order by the end of calendar year 1998.

Navy Business: Current Navy construction includes six 36,100 ton RO/RO and one 19,700 ton sealift replenishment ships. NASSCO is building all Navy construction on the West Coast. NASSCO is proposing to use a version of its vehicle carrier design as a replacement for aging Naval MarAd Ready Reserve Fleet RO/RO vessels.

MARITECH Thrusts: NASSCO leads three projects originally proposed to produce a shuttle tanker, a cruise ship, a RO/RO vehicle carrier, and a fourth to design an improved steel handling, fabrication, and outfitting facility.

- After the shuttle tanker market didn't materialize, NASSCO successfully developed a licensed 125,000 dwt. crude oil tanker design for sale to ARCO. Though NASSCO didn't build tankers for ARCO, it will use the design as a baseline for other customers like BP.
- The cruise ship project is NASSCO's most mature MARITECH project. The company developed a 1200 passenger, 58,000 grt., gas-turbine powered vessel for the intra-Hawaii market. It benchmarked European cruise ship construction processes, collaborated with consortium members Hopeman Brothers and GE to incorporate innovative accommodation and power plant features into the design, and validated the design's commercial suitability with consortium member American Classic Voyages. NASSCO is competing with MARITECH participants Avondale and Ingalls for a two-ship construction contract with American Classic Voyages, which is expected in fall 1998.
- NASSCO believed its Navy RO/RO sealift experience would uniquely enable it to build a competitive commercial auto and truck carrier for West Coast Jones Act use. Unfortunately, the market didn't materialize, so the project was re-directed to design an improved trailer ship for the same market. Totem Ocean Trailer Express (TOTE) of Seattle joined the trailer ship effort as owner/operator. NASSCO incorporated propulsion, navigation, and cargo handling technologies from its past commercial container ship and Navy sealift projects to optimize a vessel design TOTE could use. TOTE is evaluating the design and will make a production decision by mid-1998.
- The "Ship Factory Transformation" project is designed to thoroughly optimize NASSCO's steel handling, preparation, fabrication, and outfitting processes

and facilities. At the end of sixteen months, the company hopes that this project will result in a demonstration of system capabilities to enable pre-production functions to support an improved, i.e. “world-class” production process. If successful, NASSCO will commit $200 million to a 10 year, four-phase facilities and process modernization. MARITECH has co-funded the initial design studies.

Metrics:

- Use of improved CAD/CAM software and implementation of just in time inventory procedures have reduced time to build on the Navy sealift ships
- Use of improved block hot outfitting procedures decreased time from contract award to first steel fabrication from 12 to 3 months on Navy Sealift Ships
- Development of the Ship Factory steel handling process may provide up to 30% improvement over prior pre-outfitting process

Conclusions:

- Though a strong Navy builder, NASSCO has used its MARITECH projects to re-enter the commercial market in which it competed well before the mid-80s. It has transferred improved design and production processes to Navy construction and proposed to use commercial vessels and processes to save additional Navy construction funds.
- NASSCO management strongly supports MARITECH, believes it has benefited from its participation, but feels that the program should continue for another five year phase to complete its modernization process.
- Further, U.S. shipbuilders can be globally competitive:
  - only in complex ships,
  - only with multi-ship contracts can yards perfect their processes, and
  - if the Jones Act and the Passenger Vessel Act are preserved to maintain stability in the industry.
- The Navy should support the Jones Act as a way to preserve industrial base, accept more commercial practices and ship designs, decrease change orders, and resist shipyard consolidation in the name of efficiency.

L. Newport News Shipbuilding

Niche: Newport News Shipbuilding (NNS), located in Newport News, Virginia, is the largest privately owned shipyard in the United States. Since it was founded in 1886, NNS has built nearly 800 ships ranging from tugboats and passenger liners to aircraft carriers and submarines. Their niche is building large aircraft carriers. According to a recent press release (3/16/98), NNS will be concentrating solely on Navy business after June 1999, withdrawing from the commercial market. It has also been reported that NNS may lay off at least 400 workers from its commercial operations that had already reduced employment by 500.[28]

Navy Business: It is the only shipyard in the U.S. capable of building and servicing a full range of surface and submersible ships. NNS is the only U.S. yard that can build Nimitz-class nuclear-powered aircraft carriers, and one of only two that can build U.S. Navy nuclear-powered submarines.

MARITECH Thrusts:

[28] Mark Yost, "Newport News Sees Navy Work Offsetting Commercial Job Cuts," *Dow Jones News Wires*, 16 March 1998.

- Double-Hull Tanker: Designed and sold a double-hull product tanker in the international market.
- LNG Carrier: Determined the market needs for LNG Carriers and develop a design to fit that market.
- Information Technology: Through various MARITECH projects including MariSTEP, COMPASS, FIRST and Electronic Data Exchange, NNS wants to consolidate information and stop bottlenecks before they happen. NNS is working to have their entire shipbuilding process tied together using computer systems. This will include data sharing, databases of designs, vendors and materials, as well as integrated processes.
- Facilities Modernization and Process Improvements: After examining foreign yards, NNS implemented the use of process lanes. Additionally, NNS is an observer in the self-adaptive robotic welding MARITECH project and intends to increase their use of automated welding.

<u>Metrics:</u>

- NNS initially sold nine *Double Eagle* double-hulled product tankers, but has canceled the last three contracts. This MARITECH ship design resulted in NNS' first sale of a commercial ship in more than two decades.
- NNS' goal is to increase their robotic welding from 4% to 15-20%; this in turn will result in a 25-50% reduction in welding time.
- The Shared Data Environment and other IT being implemented at NNS will potentially reduce scheduling and costs by 50%.

<u>Conclusions:</u>

- MARITECH: In March 1998, NNS announced that it will exit commercial shipbuilding in June 1999, after declaring more than $150M in losses for 1997. These losses are related to their World Class Commercial Shipbuilder project, building Double-hulled product tankers. This is a blow to the MARITECH thrust to move shipyards into the marketplace. However, NNS feels that MARITECH has been a success, helping them to improve their infrastructure and information technology as well as benchmark foreign yards.
- Teaming: NNS found consortia, teaming and associations with foreign yards very useful. They will continue to use these approaches in future activities. They have formed relationships with four international yards and will continue to work with them in the future.
- Commercial Business Practices and Standards: NNS stated that U.S. shipyards must adopt commercial business practices as well as commercial standards in order to improve their efficiencies and become competitive. They commented that standards are key to international competitiveness.

M. Nichols Brothers Boat Builders

<u>Niche</u>: Nichols Brothers Boat Builders, headquartered on Whidbey Island in Puget Sound Washington, is a small yard engaged primarily in construction of one-of-a-kind specialty

boats. For 33 years Nichols has built ferries, excursion boats, charter vessels, fishing boats, tugs, pilot and patrol boats, and research vessels. The company is the dominant American aluminum fast ferry builder and markets ferries domestically as well as in Pacific Rim countries.

Navy Business: None. No small Navy vessel contracts are available for bid. Nichols has performed Navy barge repair in the past.

MARITECH Thrusts: Nichols Brothers' single MARITECH project's goal is to gain a "Commanding Share of the International Fast Ferry Market". The technical thrust is to develop a low-wake hull design for use by high-speed catamaran ferries in congested harbors or other environmentally sensitive areas. Nichols co-designed the hull with International Catamaran Designs (INCAT), an Australian firm with which the company has had a licensing agreement since 1982.

Realizing that the company's design and production processes must be optimized to compete internationally, Nichols' management applied ZOLT principles to hull outfitting, module construction, and painting. ZOLT precipitated facilities upgrades in effected areas, design-production employee training, and a more global management planning perspective.

Metrics:

- ZOLT application saved 3 months of production time on a recent tractor tug contract.
- Overall labor costs have declined 12% during the MARITECH project, improving domestic and international competitiveness.
- Optimized materials flow and inventory kitting procedures reduced the time workers must be away from the job site, thus cutting production time and labor costs.
- Pre-outfitting modules prior to final assembly has improved accuracy control and reduced re-work.

Conclusions:

- MARITECH enabled Nichols Brothers to participate in the global fast ferry market, something the owner admits he would not have done otherwise. Though current Asian market uncertainties have stalled ferry sales prospects in Indonesia, Philippines, and China, the company sees substantial Asian opportunities.
- Nichols' management is committed to ZOLT (PWBS) application in all its construction, and is executing a long-range facilities and process improvement plan. It feels that MARITECH involvement has unquestionably improved its competitiveness, stabilized its workforce, and improved profitability.

N. Todd Pacific Shipyards Corporation

Niche: Todd Pacific Shipyards Corporation (TPSC), founded in 1916 in Seattle, Washington, is largely in the repair and service business. They have also built a number of medium size commercial and Navy ships. In the commercial sector, TPSC has built large

(22,500 Ton) self-loading barges as well as a variety of smaller vessels. Recently, TPSC won a contract to build three Washington State Jumbo Mark II Ferries.[29] They have delivered one and have nearly completed the second. This Ferry contract, awarded on 12 January 1995, was a major vehicle for applying and evaluating the products flowing from MARITECH projects.

Navy Business: Several ships have been constructed for the Navy, including nearly a third of the Fast Frigate Guided Missile Ships (FFG) in service today. They maintain Navy Fast Combat Support Navy Vessels (AOE).

MARITECH Thrusts:

- Integration of Modern Manufacturing Methods and Modern Information Systems includes:
  - installation of a computer information network to support their manufacturing modernization (a transition has been made from the mainframe computer to the local area network (LAN),
  - introduction of modern manufacturing fundamental methodology to the shipyard,
  - re-engineering to a product-oriented organization,
  - application of ISO 9000,
  - improving estimating and marketing,
  - improvements to design, design/production integration, and
  - improvements to fabrication and installation processes.
- TPSC is involved in SHIIP and NIIIP/SPARS.

Metrics:

- Total Time Savings: 30% between Ferries 1 and 2, 20% between Ferries 2 and 3.
- Steel Shop Productivity: Overall 30% productivity increase 12 hours to 4 minutes on a T-beam slot-cutting operation 35% time & effort savings between Ferries 1 and 2, 17% more between 2 and 3.
- Sheet Steel Shop: 30% productivity increase.
- Accuracy Control: Ship-ways work reduction from 100,000 hours on Ferry to 50,000 on Ferry 2, to a projected 40,000 hours on Ferry 3.
- Increased alternatives and timely solutions (e.g., through allowing access to enterprise data).

Conclusions: TPSC went bankrupt in 1986 because, in their own words, "they had not implemented the kind of operational changes that would have made them commercially competitive in today's market." Their Board of Directors has made it clear that they must

[29] This was a welcome contract. TPSC's manning levels were around 400 when they won. At the height of the ferry construction they had about 1,000 people. Interestingly, if out-of-state bids had been accepted, TPSC would probably have been outbid by one of the Gulf Coast shipyards.

gain this competitiveness, and successfully address the commercial shipbuilding market or lose stockholder support.

- TSPC's major problems are in their organizational structure, outdated production methodologies, and uncertain future markets. Without significant advancements in all of these areas, they feel that they cannot compete in the global market.
- As much as any other shipyard studied, TPSC has employed MARITECH projects to enhance operations. MARITECH enabled TPSC to hire consultants from MEJ, which provided an important benchmark.[30]
- MARITECH has helped them to become much more efficient. They have invested between $12M and $14M to this end.

[30] TPSC suggests that the world market has surpassed the U.S. in shipbuilding as it did in building automobiles, because new skills and methods adopted overseas replaced those still being employed in the U.S.

III. Conclusions

After the general conclusion, all are organized under the project areas listed under Section II. Comments are made on how these conclusions reflect on the shipyards in general, and specific comments and examples on individual shipyard experience are offered in referenced tables.

A. General Conclusion: MARITECH has begun to create a globally competitive shipbuilding industry, but it has not happened yet.[31] ***It would be wildly optimistic to expect MARITECH to create a globally competitive shipyard industry in five years with $220M.*** In this respect, there are clear analogies between the U.S. shipbuilding industry's situation today, and the American automaking and steel industries during their periods of near-collapse and self-reinvention. The automotive industry, for example, lost market share to high quality, low-cost, fuel-efficient Japanese imports, with market-share erosion surging after 1974. Over 1979-1983, the "Big Three" – General Motors, Ford and Chrysler – laid off tens of thousands of workers (and in Chrysler's case, nearly disappeared) during a massive "first wave" of self-reconstruction. The industry saved itself largely by adopting Japanese manufacturing standards and methods, particularly those practiced by Japanese "transplant" factories in the U.S. This reconstruction, which was delayed by costly forays in robotic production lines at GM, cost tens of billions of dollars in capital investment before U.S. automakers began to match Japanese manufacturing and quality performance and concept-to-customer design cycle times. This recovery was greatly aided by alliances with Japanese automakers and suppliers. But not until 1994 did U.S. automakers out-produce their Japanese competitors on a worldwide basis.

Similarly, the U.S. steel industry has moved substantially away from the giant integrated plants that once symbolized the industry to the state-of-the-art "minimills" and large continuous-casting integrated mills that lead the industry today. The industry has also reinvented itself technologically since the mid-1960s, when its quality and productivity began lagging behind Japanese steelmakers. In 1994, U.S. steelmakers produced the same tonnage that they did in 1957 with one-third the workforce. The American Iron and Steel Institute believes that the industry became fully competitive and world-class in 1992-93: a recovery that took almost three decades. Today, when transportation costs are factored out, U.S. steelmakers are fully competitive in price and quality with other global suppliers. The industry is also innovating substantially in high-performance lightweight steels for cars, bridges and houses.

Although MARITECH failed to make U.S. shipyards competitive in the international marketplace, it has accomplished much. Its impact on the shipyards visited was surprisingly pervasive. Nearly every facet of shipyard operation is undergoing change, and much of that change is due to some degree to MARITECH. This is particularly impressive because the funding of the program was relatively low, considering the problems it tackled. Although we did not audit expenditures, we were convinced that MARITECH dollars were much more than matched by industry's contributions. The reason for this industry "buy-in" to the program was stated well by a number of shipyards: "This is a government program that has worked."

[31] MARITECH's involvement was so broad-based that it is difficult to single out one aspect of the shipyards that were particularly affected. We attempted to aggregate these and to highlight them, using specific success stories, but the case summaries, in Annex C, provide the best insight into MARITECH's influence.

1. Partly through MARITECH's leadership, consensus-building, and seed money, the industry has built 9 new ships (with 17 under construction) and has developed or acquired 31 ship designs. These are the most visible outcomes of the program. Perhaps more importantly, however, MARITECH provided the impetus for vital improvements in processes, technologies (especially information technologies), facilities, and the development of shipbuilding standards, all of which will form the foundation for future commercial success. It is for good reason that all shipyards contacted believe MARITECH has significantly helped them and should continue in some form.

While 11 out of the 14 shipyards surveyed are currently seeking commercial business, essentially all success has occurred in the domestic market (see Table 5). Moreover, of the six yards doing substantial Navy business, three of the largest have expressed little or no interest in pursuing commercial business.

Shipyard	**Global Business**
Alabama	Built two chemical carriers for Dannebrog.
Avondale	None
Bath Iron Works	Currently not pursuing the commercial market.
Bender	Building OSVs for a foreign owner. They are discussing feeder market in Reefers, Bulkers and Containers with foreign buyers under the Multi-Mission Cargo Ship MARITECH project.
Bollinger	MARITECH put Bollinger "on the map" in the offshore liftboat industry, certainly in the domestic market, but with limited exposure in the international market.
Electric Boat	Currently not pursuing the commercial market.
Gladding-Hearn	Applied MARITECH projects toward global competitiveness by improving business development, foreign market development and business processes. Prior to receiving MARITECH funding they had not addressed the international marketplace. Used MARITECH projects to gain impressive domestic market successes, but the international market continues to allude them.
Halter	Imported designs and became familiar with Large Fast Ferry designs and market opportunities. Committed to go into this market internationally. They are currently building a 42.5m High Speed Low Wake Pax Ferry, which will be debuted at the IMTA in New Orleans in October 1998.
Ingalls	Teamed with Finland for a cruise ship design for Disney, but schedule issues canceled the project.
Marinette	None
NAASCO	Currently not pursuing the international market.
Newport News	Acquired/designed a 46,000 dwt "Double Eagle" Tanker – Received 9 orders, 6 of which they have or will deliver [one is the first American-built ship to be sold in the international market since 1957 (to Eletson, a Greek firm)]. But NNS has subsequently abandoned plans to address the commercial market.
Nichols	Nichols is currently marketing aluminum ferries in Pacific Rim Countries.
Todd	None to date

TABLE 5. EXAMPLES OF EFFORTS TO GAIN GLOBAL BUSINESS

2. Benchmarking activities fostered by MARITECH have helped to judge progress, but most benchmarking has been somewhat ad-hoc. It is difficult to find metrics that allow external benchmarking indicators across an industry that produces such a wide variety of products. Man-hours per ton of steel or welding length per hour may be a perfectly good measure of performance for a tanker, but may not be suitable for Navy ship (or even cruise ship) construction, which are better characterized by other measures. However, external benchmarking is a worthy goal, for a way must be found to judge U.S. ability to compete. Internal benchmarking is always a good idea, since the shipyard is being measured against itself to determine its own learning curves, areas for improvement, and growing efficiencies. Both have been encouraged by MARITECH (see Table 6).

Shipyard	**Benchmarking Activities**
Alabama	With Coopers & Lybrand, Alabama performed business processes benchmarking activities and with SENER they conducted design and production benchmarking.
Avondale	Avondale benchmarked their own business processes and teamed with AESA to measure their design and production processes.
Bender Shipbuilding	After examining various markets and foreign yards, Bender realized that shipbuilding processes are key to competitiveness. This led to adopting new software systems, 3D design and robotic welding, and networking the yard.
Marinette Marine	Marinette benchmarked their own business, design, and production processes.
NASSCO	NASSCO with Kawasaki Heavy Industries performed benchmarking activities in the areas of design, production and business processes.
Nichols Brothers	Nichols Brothers benchmarked their application of ZOLT procurement and inventory control, and with the assistance of Professor Richard Storch (ZOLT) at University of Washington, they benchmarked their design and production processes.
Todd Pacific Shipyard	MARITECH enabled TPSC to hire consultants from MARITECH Engineering Japan (MEJ), composed of former employees of the Japanese firm IHI. This provided an important benchmark for them, as it has for numerous Asian and European shipyards,[32] and invaluable guidance to make the changes warranted in its shipyard operations.

TABLE 6. EXAMPLES OF BENCHMARKING ACTIVITIES

[32] TPSC suggests that the world market has surpassed the U.S. in shipbuilding as it did in building automobiles, because new skills and methods adopted overseas replaced those still being employed in the U.S.

3. Training and education at most shipyards have been dramatically influenced by MARITECH. Four training and education goals being pursued by nearly all shipyards are: i) to change the culture of the workforce (to include the executive suite) to accept new practices and values, ii) to gain skills needed for new processes and technologies being introduced, iii) to adopt teamwork that (combined with these new processes and technology) result in fewer man-hours per job, and iv) to ensure the availability of a skilled work pool.[33] Some of these are listed in Table 7. There is a widespread shift toward a multi-skilled workforce, participatory labor, and other important changes that are even being endorsed by some unions.

Shipyards have initiated large training efforts. Some of these are conducted in training centers, but more often training is accomplished through On-Job-Training programs. Nearly all shipyards reported that the cultural changes mentioned above are crucial, but difficult to impart and elusive to measure. Results of training included workforce participation in decisions and changes on the floor. But we suspect that the rate of suggestions from the workforce falls short of the IHI standard of 18 per employee per year.[34]

Shipyard	Comments on the Workforce and Training
Alabama	Formed an alliance with local school district to provide machinery, if schools would train students in welding, pipe fitting, and design.
Avondale	Training is in progress to re-engineer design and production processes around IPPD and IPDE concepts. Avondale has formed a consortium with University of New Orleans, and has built a Maritime Technology Center of Excellence at the shipyard. They are cross-training employees to save time and materials costs.
Bender Shipbuilding	Bender was one of several shipyards that expressed concern regarding the future workforce of the industry. They feel that the industry as a whole should address the need for “new blood,” and that MARITECH could assist with innovative recruiting and training programs. They have begun their own training initiatives.
Gladding-Hearn	Training has taken place throughout the yard to teach the use of Microsoft Project, to improve use of their CADCAM system, to gain familiarity with DNV welding procedures and to enhance business management knowledge.
Halter Marine	Halter expressed concern regarding the shipbuilding workforce in the future. They noted that wages are increasing as they compete with other employment areas and shipyards for people. They have recently opened a new training center in Pascagoula, Mississippi.
Marinette Marine	Marinette began classroom training and supervised OJT for welders and electricians. Cut defect rates dramatically. Will begin subcontractor and supplier electronic commerce training.
Newport News	They are continuing to implement multi-skilled training.
TPSC	Worker input resulted in changes to a T-beam slot-cutting operation that reduced its time from 12 hours to 4 minutes.

TABLE 7. EXAMPLES OF ONGOING TRAINING EFFORTS

[33] While layoffs of skilled workers were occurring in the Northeastern states, the Gulf Coast shipyards are short of the same skills. Yet, little migration was evident to correct the situation. Shipyards indicated this was normal. The solution – to replenish the workforce with local hires, trained by the shipyards.

[34] “A View of Japan’s Industrial Engine,” *Daily Journal of Commerce*, Seattle, WA, 29 July 1992.

B. Conclusions on Project Areas.

1. New Ship Design and Construction: Most designs were purchased from foreign sources, as opposed to being created by the U.S. shipyard. We were told that during the commercial shipbuilding hiatus, many shipyards eliminated organic design departments. Partly for this reason, most of the designs acquired under the MARITECH program were licensed from foreign design bureaus and shipbuilders, rather than being developed by the participating U.S. shipyards (see Table 8). *Although the designs attracted few customers, they often became vehicles for training, process-implementation, and design standards development (key to efficient ship construction).*

Shipyard	Ship Designs and Sources
Alabama	Purchased designs from Skipskonsultant AS (SK) for a Product Carrier and Chemical Carrier, Pelmatic for a Product Tanker, and MHI for a Bulk Vessel. • 16,000 dwt Chemical Carrier
Avondale	Used a “standard tanker” design as a baseline, which will enable Avondale Shipyards to produce the next tanker 20%-30% faster. • Standard Tanker Design
Bath Iron Works	Developed a design for: • High-Speed Monohull: various configurations
Bender Shipbuilding	Developed designs for: • Reefer 21 • Off-shore Supply Vessels • Multi-Mission Cargo Ship - under preliminary design
Bollinger	Bought the design for the Sea Horse from an UK organization. That design has been modified and Bollinger built the Irish Sea Pioneer (one was sold). • Irish Sea Pioneer • SWATH Super 4000
Electric Boat	NONE
Gladding-Hearn	Bought the design and license agreement to build the Australian catamaran fast ferry (INCAT); the INCAT was specifically funded to bring this foreign-based technology into a US shipyard. • Catamaran Ferry hull
Halter Marine	Purchased a design from IHI for a 23,000 dwt Container Bulk Carrier, and worked with foreign designers on Large Fast Ferries as well as E-CAT ferries. • 23K dwt Container/Bulk Carrier • Sea Shuttle Container Feeder (3 versions) • High Speed Low Wake Passenger Ferry (6 versions) • 110m Fast Car Passenger Ferry (10 versions)
Ingalls	Purchased a cruise ship design from Deltamarin and Finnyards of Finland. The plan for Disney to be the customer fell through, but Ingalls plans to propose a modified design for the American Classic Voyages competition. • Cruise Ship Design
Marinette Marine	Licensed a Pelmatic design for a Product Tanker • Product and Ethylene Tankers • Aluminum Ferry
NASSCO	Developed designs for: • Cruise Ship • Container Ship
Newport News	Developed design for: • 2 Double Eagle double hulled tanker
Nichols Brother	Acquired INCAT license for an aluminum ferry • Aluminum Low Wake Ferry

TPSC	Acquired designs for: • Washington State Jumbo Mark III Ferries • Power Barge • Anchor Handling Tugs

TABLE 8. SHIP DESIGNS AND SOURCES

2. New Shipbuilding Technologies or Processes: MARITECH has been successful in improving both business and shipbuilding processes, although there is much more to do. All shipyards visited understand that process inefficiencies lead to low productivity, a major barrier to global competitiveness. The real questions are: How hard will the shipyards continue to chase process improvements, and for which customer? These questions should be posed for every process area receiving attention. The first question is pertinent simply because the perfecting of processes is evolutionary, fed by a long-term, unchanging commitment by every level of the industry, particularly the corporate leadership. The Japanese and South Korean shipbuilders are disciplined and dedicated masters of the art, and are well ahead of U.S. yards in productivity, costs and building times. Catching up demands heroic labor, and delays lose precious ground. It seems likely that efforts to improve processes, so strongly supported by all shipyards, will continue at some level.

The recovery focus must not be Navy shipbuilding. If that occurs, the largest shipyards will remain captured by Navy metrics, processes and economies, which are very different from those in the commercial marketplace.

There are many examples in the case summaries of individual shipyard payoffs for improved processes. Some are offered in Table 9, below. As in any industry, shipyard processes are complex and often esoteric, but there are many lessons to be adopted from other (and seemingly different) industries, such as automotive, steel, and even electronics.

Our study found that enabling technologies, like information technologies and simulation-based design, can be vital tools for maximizing the benefit of efficient processes. But, process efficiency counts most, and the technologies needed are generally not "high tech."[35] Comments on some specific technologies and processes follow.

Shipyard	**Process Improvements**
Alabama	Designed and built new, dedicated facilities for pipe bending and blast & coating. Re-designed fabrication buildings to provide more efficient material flow from plate welding to block movement to dock.
Avondale	"Factory" materials handling facility resulted in an Avondale productivity improvement of 10-20% with future improvements of 2% annually.
Bender Shipbuilding	Laser cutting is planned to improve edge quality and accuracy. In addition, Bender is now maximizing pre-outfitting prior to erection, through crane-less erection of units up to 300 tons.
Halter Marine	Using aluminum extrusion in lieu of plate and welded stiffener to produce stronger a material and design.
Marinette Marine	Establishing enterprise IS to link design, production, business, subcontractors, and suppliers. Instituted "design for production" processes.
NASSCO	"Ship Factory" will revolutionize material handling and data flow in production centers. Will re-design yard layout, install enterprise IS, integrate design/production and business processes. Five-year, $200 million program.
Nichols Brothers	Implemented ZOLT in all design/production/business centers.
TPSC	Steel shop productivity showed an overall 30% increase. This produced a 35% time and effort savings between Ferries 1 and 2 and an additional 17% more between 2 and 3.

TABLE 9. EXAMPLES OF PROCESS IMPROVEMENTS

[35] Although, as in the case of accuracy control or information technologies, they may be complex and difficult to apply.

a. Product Work Breakdown System (PWBS) is being adopted by a number of the yards with MARITECH co-funding. PWBS is the arrangement and sequence employed to identify parts, subassemblies, and assemblies so they can be sorted according to the problems inherent in their manufacture and according to when they are required for construction, relative to one another. It is the way hull block construction, zone outfitting, and zone painting is most efficiently planned and accomplished. Intense planning of production sequencing and scheduling and workflow facilitate the use of Integrated Production Teams, and maximize build efficiencies. PWBS is simple in concept, but complex in application. It should be applied comprehensively to shipyard operations to realize its full potential to improve operations as diverse as fitting and welding time and reduction of required inventory. There is much activity in this area, as shown in Table 10.

We found that, most often, yards are selectively applying aspects of PWBS and rejecting other parts of the approach. In addition, both PWBS and its methodology are being described differently {e.g., PWBS versus ZOLT, module versus unit}. This adds confusion to the cross-industry communications being improved under MARITECH.

Much of the wisdom of the PWBS is being strongly supported by the Navy. While this is a great service to the goal of commercial competitiveness, the Navy tends to be overly-prescriptive. Many shipyards have modified their process considerably to fit commercial practices. The Navy should now learn from the shipyard's experiences.

Shipyard	**PWBS Status**
Avondale	Automated tracking and scheduling of work packages, employee assignments, and materials requirements are at the heart of the MARITECH Simulation-Based Design Engineering project.
Bath Iron Works	At this time, BIW is working with Avondale Shipyard and the Navy on applying the Integrated Product and Process Development (IPPD) to construct LPD-17s.
Gladding-Hearn	ZOLT is a subdivision of the PWBS, which consists of the Hull Block Construction Method, and the Zone Outfitting and Painting Methods. G-H, prior to MARITECH, was breaking the construction of the vessel into modules, but had not incorporated outfitting into the construction of those modules. ZOLT emphasizes a thorough advanced planning process that leads to segmenting a vessel into larger, fully outfitted construction modules, which are then broken down into component work packages. This facilitates accomplishing as much work as possible in the safest and most efficient way, thereby applying assembly line type design and production processes and efficiencies to one of a kind ship construction. This has resulted in improved material flow, accuracy, and reduced labor hours. Most of the savings have resulted from doing "zone" piping electrical outfitting, painting and installation of components on units and modular structures prior to final assembly.
Marinette Marine	Integration of production and design processes is focus of Phase II of the Advanced Manufacturing facility MARITECH project, just underway.
NASSCO	PWBS-like production-oriented design process is at the heart of the Ship Factory Transformation MARITECH project. Will result in a major re-design of the yard's material's handling, engineering design, and block outfitting/assembly processes.
Nichols Brothers	ZOLT application resulted in 20-30% production time reduction between vessels of the same type. Better materials flow saved 3 months production time on tugs and aluminum ferry.

TABLE 10. PWBS STATUS

b. The integration of the design and production functions has important payoffs. This is particularly true if the industry expects to develop new designs for the commercial market that can be built efficiently and affordably (see Table 11 for examples). It seemed to us that many gains made in successive builds that were attributed to the learning curve may have been realized in the first build through more production considerations by the designers.

We found some useful innovation in this area, particularly in smaller yards where, in many cases, the design division is also the production division. According to several shipyards building Navy vessels, the "distance from loft-to-ways" is often long for Navy designers. It will be interesting to see if this situation changes as the Navy downsizes its design staff and shipyards take over some of their design duties.

Shipyard	Design/Production Integration
Alabama	Design data is provided to production work centers on diskette. Ultimately, data will pass over an enterprise system.
Avondale	Integration of the design and production processes and exchanging design data electronically within the yard and with sub-contractors and suppliers are features of the MARITECH Simulation-Based Design Engineering project.
Bender Shipbuilding	Through the MARITECH project, Organization of Work in a 2nd Tier U.S. Shipyard, Bender is re-engineering the way they do their work, and reducing the cost of shipyard operations and the time required for ship construction by 50%. Bender credits the first two MARITECH projects concentrating on design with improving their production planning. Through the Reefer 21 project, Bender learned how to do a build strategy and began considering improvements to the yard's material flows and processes. Bender remarked that MARITECH has been indispensable in helping them re-create their processes. They commented that their first approach to MARITECH, concentrating on designs, was not the correct one.
Bollinger	Bollinger worked with a simulation software tool developed by Stewart Technologies and Associates; this model could determine the most efficient build for liftboat legs. It saves them approximately 10% in material and production (cost and time). Bollinger uses this software for every proposal when determining the cost and time to develop the legs and they estimate that using this software reduces the time to prepare proposals by a factor of four.
Gladding-Hearn	G-H used MARITECH funds to adopt modern business and construction practices, such as ZOLT and ISO-9000.
Marinette Marine	MMC designers currently provide data to production centers, but true integration will be accomplished during phase II of the "Transitioning to a 21st Century Advanced manufacturing Facility" MARITECH project. There, the Design for Manufacture & Assembly method will attempt to integrate CAD/CAM, material handling, and scheduling, and supplier relations.
NASSCO	Integration of design and production, as well as business practices, is the outcome of the "Ship Factory Transformation" MARITECH project. A shipyard-wide enterprise information system will facilitate electronic information transfer. Additionally, NASSCO will re-design the materials flow path.
Nichols Brothers	As a small yard, Nichols currently can exchange design and production information very effectively by using teams of production workers and engineers. The company is developing plans for an automated electronic data interchange system. Nichols believes its ZOLT application effort will be most effective with an automated system.

TABLE 11. EXAMPLES OF DESIGN/PRODUCTION INTEGRATION

c. Shipyard standards are vital to commercial competitiveness, but it is not clear that they are being developed and used pervasively. Although some yards are developing and using commercial standards (see Table 12), we were not convinced that this was true of most shipyards. This bears more examination because of the importance of good commercial standards in marketing and in efficient construction. Material, design, production engineering, and inspection standards reflect an accumulation of experience that in turn ensures functionality and good quality in the product. Standards save man-hours and cost, reduce error, ease change, and enable maximum benefit from computer application. There is great promise for applying commercial standards to Navy shipbuilding. Standards become more valuable as their products acquire a history of use. This history, and the efficiency and affordability built into the standard designs, will be the selling point for both the commercial and military sectors.

Shipyard	Standards Development
Alabama	With no Navy construction, Alabama uses commercial standards as a normal business practice.
Ingalls	Ingalls feels that the industry needs to define standards, especially in the areas of information technology and infrastructure. Also, there is no standard definition for basic parts (nuts, bolts, scaffolding, etc.) in domestic yards; this makes it even more difficult when dealing with foreign yards.
Marinette Marine	Marinette built an international vendor data base to have current price and performance information on customers preferred vendors (build lists). Adopted "just in time inventory" practices.
NASSCO	NAASCO teamed with commercial cruise ship designers and component builders for their cruise ship project. They may use commercial cruise ship stateroom designers for Navy projects. NAASCO wants to use commercial leasing or "charter and build" for Navy support ships.
Newport News	NNS stated that U.S. shipyards must adopt commercial business practices as well as commercial standards in order to improve their efficiencies and become competitive. They commented that standards are key to international competitiveness.
Nichols Brothers	With no Navy construction, Nichols' uses commercial standards as a normal business practice.

TABLE 12. EXAMPLES OF STANDARDS DEVELOPMENT

d. Accuracy control, considered important by nearly all shipyards, is being well supported by MARITECH. In words familiar to the military, accuracy control is a "system of systems." It consists of approaches, pervasive across shipyard design and building processes, which are designed to minimize dimensional variances between the "as-designed" and "as-built" ship. In fractal fashion, similitude exists in the application of accuracy control procedures at each level of the build, from a single T-beam, to the length and beam of the entire ship. Statistical methodologies to track and reduce variances are maintained at all these levels, as are the cutting, welding, and handling technologies applied to ensure that pieces and modules are dimensionally correct.[36] In particular, laser cutting is being considered because of its improved accuracy. Interestingly, the fate of robotic welding is somewhat tied to the ability to cut, fit, and hold pieces together with allowable gap tolerances.

As discussed in the report and shown in Table 13, shipyards are placing much emphasis on this complex area. The results have been some impressive reductions in fitting and welding times and in rework demands.

Shipyard	**Accuracy Control Improvements**
Alabama	Alabama improved their CAD/CAM software and hardware twice; built dedicated pipe fab facility with improved 3D capability in order to reduce interference. Welding and cutting machines are now driven by CAM data.
Avondale	Their Intergraph design software generates NC tool tapes. The company uses robotic cutting machines.
Bender Shipbuilding	Bender was greatly influenced by the foreign yards' superior processes and accuracy controls. They see themselves moving in that direction. Many of their computer enhancements, automated welding and laser cutting projects are a direct result of this influence, and an effort to improve accuracy.
Bollinger	The Navy allows Bollinger to do pulse-arc welding on their patrol boats construction; this leaves little-to-no distortion in the steel.
Marinette Marine	Designers work one-on-one with production workers to implement changes immediately. This dramatically lowers re-work rates: 1% vs. 12%.
NASSCO	The company expects accuracy control to be a major benefit from the Ship Factory project. Data will be interpreted and manipulated by fewer workers, materials will be handled less, and production time will fall.
Nichols	No specific programs, but the company credits ZOLT implementation with accuracy improvements.
Todd Pacific Shipyard	Working to improve accuracy control, TPSC's ship-ways work has reduced man-hours from 100,000 on Ferry 1 to 50,000 on Ferry 2, to a projected 40,000 hours on Ferry 3.

TABLE 13. EXAMPLES OF ACCURACY CONTROL IMPROVEMENTS

[36] A U.S. consultant, L.D. Chirillo, an expert in Japanese shipyard processes, asked IHI Tokyo, how an as-built length overall typically compares to the design dimension for destroyer-type vessels. The answer was one centimeter. U.S. dimensional LOA's for the FFG series, on the other hand, reportedly vary from 1.75 to 13.25 inches.

e. Self-adaptive robotic welding reviews were mixed, but perhaps this was due to problems with the CYBO project. Despite these problems, expectations of a successful self-adaptive robotic welding system are high, as indicated in Table 14. These expectations were often expressed in quantitative terms, an indication that shipyards have given much thought to how the systems will be used.

Shipyard	Robotic Welding Projects
Alabama	Alabama uses an alternative automatic welding process. They could not afford to wait for the MARITECH welding project to mature. Robotic welding would provide safety and productivity improvements. Currently, work time is limited in hot, humid weather because of the required protective mask and clothing. A robot welder could work in confined spaced indefinitely, whereas a human welder is limited to 15-30 minute sessions.
Avondale	Very little robotic welding is done at Avondale.
Bath	If successful, the CYBO self-adaptive robotic welding project will Automate BIW's welding of the 5,000 to 10,000 structural beam erection joints in a normal ship. This can save as much as $500K per ship, or 30-40% for welding 2,00 erection joints per ship. The high cost of rework and injury will be substantially reduced.
Bender Shipbuilding	Bender is planning to use portable arm robot welding which can be moved around the yard and withstand the "conditions." It will reduce labor time as well as get rid of the "dirty" jobs, and increase efficiency.
Bollinger	Bollinger stated that by the time you set up the robotic welder, you could have already done the welding by hand.
Ingalls	According to Ingalls, the CYBO robotic welding project is flailing; they have the right idea, though. The software isn't advanced enough yet. Ingalls feels that CYBO will increase the robotic welding from 2-5% to 5-9%.
Marinette Marine	Their robotic welding evaluation found it is not cost effective for a small yard.
NASSCO	Participated in CYBO project, but little robotic welding performed.
Newport News	NNS' goal is to increase their robotic welding from 4% to 15-20%. This will result in a 25-50% reduction in welding time.
Nichols Brothers	No robotic welding performed.

TABLE 14. EXAMPLES OF ROBOTIC WELDING

f. Information Technologies could be a major U.S. competitive advantage.
MARITECH is sponsoring many projects in information technology in order to improve the ability of shipyards to share information (internally and externally), and to strengthen process efficiencies. Clearly, the latter goal must be pursued only after realizing effective processes. Computers and networking do not supplant the need to improve processes (which are often made poorer with computer assist).[37] But they can dramatically magnify the benefit of efficient processes. Standards are also implemented better through a fully-networked CAD/CAM system.[38] The application of information technologies has always been a particular American strength and competitive advantage in world markets.

As shown in Table 15, MARITECH information technology projects are helping to embed this strength in the U.S. shipyards. Although there is a long way to go, virtually every yard we visited was revamping, or establishing, a system of networked computers. We were convinced that most productivity gains from such information technology investments promises to be considerable, in large part because the industry has lagged so badly in their adoption.

Shipyard	Information Technologies Projects
Alabama	3-D modeling software, acquired with MARITECH funds, decreased interference and saved 20% in production labor hours on the Dannebrog chemical tankers.
Avondale	CAD/CAM reduced ARCO contract award-to-steel fabrication time to 7 months.
Bath Iron Works	BIW is participating in a number of information systems projects sponsored by MARITECH, such as NIIIP(SPARS), SHIIP, and MariSTEP. They are revamping their business and design processes using these technologies.
Bender	Their yard is fully networked using fiber optic cables, and they are now using integrated 3D Design Software including AutoCAD. The new CAD and layout software has reduced the time spent re-piping and re-running pipe by 30%, saving 4-5,000 man-hours per ship, using software with their plasma machine to cut the pipe holes in advance. They are also creating better production packages.
Bollinger	AutoCAD was purchased under MARITECH. This tool was shared with all of the engineers/designers and reduced the design process by a factor of five.
Electric Boat	Projects cost avoidance from SHIIP ($6.5M per ship) MariSTEP ($7.5M per ship), SPARS of $7M per ship class.
Halter Marine	Halter procured commercial databases and put them on its computer network to be tasked by multiple users. This results in being more marketplace knowledge, and allows them to evaluate potential customers better and more quickly. In addition, the company now e-mails drawings internationally via the Internet, in lieu of direct modem or mailing, which saves postage and time in responding to customer requirements and questions.
Marinette Marine	Its Phase II MARITECH project will link design, production, and business practices. Software and architecture design study is in final stages.
NASSCO	The Ship Factory program will install enterprise IS, linking all production, design, and business centers, sub-contractors, vendors, and customers.

[37] Mr. Chirillo suggested that many of Japan's efficiency gains were realized prior to the adoption of computers.

[38] According to the Japanese Shipyard, IHI, "Standards…show their greatest advantage when integrated with a comprehensive computer system…a comprehensive computerized design system, consistent from design through production, could not be effectively realized without standards.

Newport News	Through various MARITECH projects including MariSTEP, COMPASS, FIRST and Electronic Data Exchange, NNS wants to consolidate information and stop bottlenecks before they happen. NNS is working to have their entire shipbuilding process tied together using computer systems. This will include data sharing, databases of designs, vendors and materials, as well as integrated processes. They estimated 50% reduction in schedule and costs when all computers have been networked into an overarching computerized management decision tool developed under MARITECH.
Nichols Brothers	Application of ZOLT and CAD/CAM reduced labor costs 12%-15%(actual labor cost reduction of 20-30% on tractor tugs between ship #1 and #2).

TABLE 15. EXAMPLES OF INFORMATION TECHNOLOGIES BENEFITS

3. Facilities Expansion and Modernizations: Facilities modernization is needed and is being pursued by most shipyards. A glance at Table 16 shows that many shipyards took advantage of MARITECH projects to improve their facilities. Essentially all others have modernization efforts ongoing outside of MARITECH. MARITECH often provided funds for studies and plans, but not for infrastructure. These improvements to the shipyards' physical infrastructure are needed to enable the benefits of much of the work being done in all other project areas, particularly in facilitating workflow through rearranging yards and adding better materials handling, cutting and welding equipment.

Shipyard	Facility Modernizations
Ingalls	Litton Industries plans to invest $25M in a major facilities programs at Ingalls. Ingalls' President, Jerry St. Pe' indicated that, " this investment will enhance Ingalls' already-extensive capacity for naval ship construction and modernization, and will significantly broaden our shipyard's capability to produce commercial vessels, offshore drilling rigs, and production platforms."
Gladding-Hearn	Improvements include a six acre site addition and a number of changes planned to improve workflow. Survey, planning, and permit processing were aided by MARITECH.
Halter Marine	Halter upgraded its Pascagoula yard through an IHI study and now has deepwater capability to build vessels up to 650'. In addition, they are enhancing their Gulfport location to build large aluminum RO/RO ferries, and it has been adapted to build lightweight aluminum vessels.
Newport News	NNS expanded their dry dock to accommodate the dual production of commercial and military ships. They also built a State-of-the-art Automated Steel Cutting and Fabrication Facility to reduce time and costs.
Todd Pacific	Facilities modernization is being done on their own. Wisdom drawn from the MARITECH projects is being employed. TPSC has spent nearly $20M on facility upgrades to: rebuild launchways, relocate departments, purchase new welding equipment, expand LAN, convert the ordinance building to module shop, create a pipe manufacturing facility, level old buildings, create steel shop jigs, convert the Sheet Metal Shop to cell manufacturing, upgrade the paint Shop, and modify layout onboard ships. More facility improvements are planned.

TABLE 16. EXAMPLES OF FACILITY MODERNIZATIONS

4. Commercial Business Practices: Surveys of competition and market, co-sponsored by MARITECH, were crucial. MARITECH was particularly helpful to all shipyards in enabling contacts with prospective customers, partners, and consultants. It has also allowed them to assess the reason many competitors outperform them (see Table 17). Perhaps most importantly, these surveys often led to mentor relationships with foreign shipyards, which transferred new technologies and processes much faster than if the yards were forced to develop the ideas independently. In the case of many small yards surveyed, leadership credited MARITECH with allowing them to begin to compete internationally.

Much of MARITECH's effort has been directed towards encouraging U.S. yards to adopt business process improvements that are "standard operating practice" in other U.S. industry sectors, from intermodal transportation and airlines to retailing and automaking. These "soft" improvements may be as important to many yards as far costlier "hard" improvements (e.g., better construction facilities or yard equipment). Moreover, they can also be adopted more rapidly. Achieving "agility" and faster business tempos, for example, is all-important in fast-moving industries like software and publishing. U.S. yards' achievement of similar agility in business processes can potentially pay off handsomely, given the lower starting point for most of the yards interviewed.

Although shipyards want more funding for marketing efforts, and we believe more marketing efforts are needed, we feel that this is a less appropriate place for government help than, for example, technology development.

Shipyard	Market and Competition Surveys
Alabama	Alabama surveyed 19 foreign yards in two years. Formed consortia with foreign designers and operators on each of its three design projects. Hosted MHI's trainers to train ASI design and production personnel. All customers for its design projects were foreign (Dannebrog, BaltTanker, TRITEA, and China Ocean Shipping Co.).
Avondale	Avondale marketed to BP, though for Jones Act west coast traffic. Consortia member AESA (Spain) provided inspiration for "The Factory", which Avondale feels is its major MARITECH benefit.
Bollinger	Bollinger went to Vosper (shipbuilder in the UK) to purchase their process design, short arc welding techniques, cutting plate techniques, and production detail design.
Gladding-Hearn	Under MARITECH, G-H sent people to foreign markets to look at prospects for entry into the fast ferry catamaran construction business and began the process of updating their business and construction practices and infrastructure.
Halter Marine	Halter visited Austal shipyard (Henderson, Australia) which builds large fast ferries. Also IHI visited three of its shipyards with a view towards building for the 23,000 ton Container/Bulk Carrier. IHI's plan was useful for incorporating other vessels as well. Halter also examined exterior photo coverage of a 250 DWT High Speed car/passenger vessel under construction at Danyard (Aarlbourg, Denmark).
Ingalls	Ingalls surveyed cruise ship designers in Finland.
Marinette Marine	MMC marketed product tanker design for Great Lakes international trade. They visited Scandinavian yards, but found little useful. Consortia members Pelmatic and Simonship provided tanker designs, which MMC adapted.
NASSCO	Shipyard processes benchmarked by consortium member KHI, surveyed Scandinavian yards for cruise ship design and production insights.
Nichols Brothers	Nichols built on a previous relationship with INCAT. They attended international trade shows and marketed fast ferry designs to Pacific Rim customers. MARITECH enabled them to enter the international market, where they wouldn't have been able to do so otherwise.

TABLE 17. EXAMPLES OF BENEFITS OF MARKET AND COMPETITION SURVEYS

Teaming under MARITECH has been extremely successful and will continue. This includes integrated product teams, multi-skilled work teams, inter-company teams to accomplish large tasks, and teaming with a foreign shipyard to learn better ways to build. The broad application of consortia is new to most shipyards. These arrangements have added an important dimension to the way shipyards do business and both consortia and teaming have been made a part of the shipyard lexicon (see Table 18). We learned the value of horizontal consortia to the shipyards in facilitating the development and sharing of pre-competitive technologies and capabilities. There was even more activity to form and maintain vertical consortia to promote teamwork between shipyards and their suppliers (or even among various tier levels of suppliers). Individual shipyards will make their own decisions about when and how much to team outside the program. There is good evidence that the U.S. shipyards will continue many of the arrangements begun under MARITECH, and implement new ones.

We believe that this commitment will not change even if shipyards become discouraged with their attempts to penetrate the international market. At least three factors oppose a return to the normal "every man for himself" mode. First, MARITECH has shown the advantage of pre-competitive consortia to pursue improvements in processes, information systems, and so on. When government contributions are conditional upon the formation of such consortia, it is hard for the industry to resist. Second, it has become obvious that meeting just-in-time deliveries and fostering off-ship outfitting is easier with a close relationship, and a shared responsibility between supplier and shipyard. Teaming clearly develops such a relationship. Finally, business ebb and flow often calls for a distribution of work among competitors that responds to a teaming arrangement.[39]

Shipyard	**Teaming Efforts**
Alabama	Alabama formed consortia with foreign designers and operators on each of its 3 design projects.
Bath Iron Works	Through their Commercial Shipbuilding Focused Development Project, BIW established relationships with Kværner Masa- and Mitsui that remain intact today. BIW imported technologies and processes through these relationships that were applied to Navy shipbuilding, claiming an annual cost avoidance of $11M to $13M on construction of AEGIS destroyers currently built at BIW.
Bollinger	Teaming is crucial to the Bollinger operation; they see their vendors as team members, which makes everyone feel responsible for a successful outcome, not just a "delivery".
Electric Boat	Teaming is here to stay in their business. It provides the vehicle to rapidly assemble the expertise to a business opportunity.
Halter Marine	Halter worked with foreign designers, test facilities, shipyards, and owners on their MARITECH projects. They stated that they would continue to do so and found the practice very useful. Furthermore, they have created alliances with these groups and vendors.
Ingalls	Before MARITECH, Ingalls had never teamed with another shipyard.
Marinette Marine	Consortia members Pelmatic and Simonship provided tanker designs, which MMC adapted.
Newport News	NNS found consortia, teaming, and associations with foreign yards very useful. They will continue to use these approaches in future activities. They have formed relationships with four international yards and will continue to work with them in the future.

[39] We do not mean to include the practice of "dividing the spoils" in responding to a Navy shipbuilding solicitation by distributing builds of particular vessels among a "team."

Todd Pacific Shipyard	TPSC's relationship with IHI (supported by MARITECH) produced superb insights. An American consultant to TPSC, Mr. L.D. Chirillo, developed some extremely cogent analyses of what must be done to improve TPSC's competitiveness.

TABLE 18. EXAMPLES OF TEAMING

5. Benefits to the Navy: The Navy can benefit from commercial success. It is reasonable to ask if the quest for commercial competitiveness will benefit the Navy. Our discussions yielded a persuasive case that it does, with several specific examples presented in Table 19. Commercial success, by the U.S. shipyards, can be of great benefit to the Navy by:

- sustaining the industrial base (increasing competition),
- offering commercial economies of scale,
- providing commercial practices and standards for Navy adoption (better, cheaper, faster), [For example, in every shipyard we visited, which built or repaired naval vessels, design change orders were singled out as large cost drivers. Managing for change orders only by exception is a process change that would greatly benefit the Navy.], and
- producing innovative designs (e.g., Arsenal ship, commercial designs for Navy non-combatant ships).

Shipyard	**Navy Benefits**
Alabama	Believes their modern yard is capable of building Naval ships in wartime.
Avondale	Believes "The Factory Project" will save LPD-17 production costs. The Navy should streamline their IPPD processes and cut down number of members. Attempts to get the Navy to use commercial products/processes have been very difficult.
Bath Iron Works	BIW felt that the Navy was becoming much more empathetic toward business and commercial practices, even when performance tradeoffs must be made.
Electric Boat	Their basic tenet is that the large shipyards, with Navy business, should be the focus of government attention, since the Navy will directly benefit from their success. An approximate cost avoidance of $20M per Navy ship was realized through SHIIP, MariSTEP, and SPARS.
Halter Marine	Halter believes that costs would go down. They noted that there are many DoD procedures, for example the sub-contractor consent clauses in Fixed Price Incentive Fee contracts, which contribute nothing to the product and substantially detract the management's attention from the shipbuilder. Usually, the local government oversight activity is the last to recognize the benefits of using "commercial" business methods.
NASSCO	NAASCO felt that the Navy could save production funding by using commercial ships operated by civilian crews in their support fleet, leasing instead of buying support ships, "charter and build," award multi-year construction contracts.

TABLE 19. EXAMPLES OF NAVY BENEFITS

a. Navy shipbuilding can be detrimental to commercial success, but these detriments could be mitigated. The very nature of combatant vessel design, construction, and use demands certain differences in design approaches and standards. This unavoidably impacts shipyards trying to build Navy and commercial ships (see Table 20). But in our discussions with these shipyards, it became clear that the Navy could do much to reduce this impact.[40] Because of time and resource constraints on the study, it was not given the attention it deserved, but some actions that shipyards feel the Navy could take to minimize this impact are:

- adopting commercial practices when possible,
- maximizing adoption and adaptation of COTS components,

[40] One shipyard, engaged in both commercial and Navy shipbuilding, declared that it physically separates the two because commercial customers are wary of doing business with a yard performing Navy work, fearing Navy-imposed overhead, work rules, and resource allocation priorities.

- reducing number of change orders per ship build,
- reducing oversight,
- allowing performance specifications in contracts,
- investigating the possibility of commercial ship designs for logistical support vessels, and
- sharing realistic Navy shipbuilding projections.

Shipyard	Navy's Effect on Commercial Business
Bath Iron Works	Commercial Shipbuilding Focused Development Project: Established relationships with Kværner Masa- and Mitsui that remain intact today. BIW imported technologies and processes through these relationships that were applied to Navy shipbuilding, claiming an annual savings of $11M to $13M on construction of AEGIS destroyers currently built at BIW.
Electric Boat	There are 100,000 unique parts to the Seawolf submarine; there will be 18,000 for NSSN. This increased application of COTS parts represents significant financial savings for the Navy. This benefit did not come from a MARITECH project, but it is important to adopting commercial values and products.
Ingalls	Ingalls is researching using composite materials for ship superstructures. The Navy has expressed interest in those composites for sealift ships.
Newport News	Yard layout simulations and the same process lanes are being used in Navy and commercial contracts. Starting with CVN-77, NNS hopes to use MariSTEP. Eventually, NNS would like to see the Navy move to commercial standards. They perceive that the Navy is using more performance specifications and requirements, leaving the designs to the shipyard. Using commercial practices would result in a reduction in costs and delivery time of Navy vessels.

TABLE 20. EXAMPLES OF THE NAVY'S EFFECTS ON COMMERCIAL BUSINESS

b. The Navy is not taking full advantage of commercial shipbuilding practices and standards. We were unable to find any shipyard where the Navy consistently and proactively sought to incorporate commercial practices and products into their repair or new construction projects. In fact, many shipyard employees cited numerous examples where less expensive alternatives were refused, even though those alternatives met reasonable standards. These are only vignettes (and there are some to the contrary), but our judgment was that the Navy has great difficulty in accepting any risk if it runs counter, or is even neutral, to Navy standards and regulations. While this attitude may be understandable at this phase of the transition to a more commercial base, our feeling is that it is costing the Navy time and money. At the root of the problem is an apparent lack of incentive to change.

IV. Recommendations

A. Initiate a MARITECH follow-on program, MARITECH ASE, in the Navy. Both the Institute's review of 14 shipyards and ESI's economic analysis, strongly support the continuation of the efforts begun under MARITECH. Every shipyard visited also favored a follow-on program. International competitiveness of our shipyards is a crucial goal that remains unmet. Industry has begun the journey to commercial competitiveness, but it will take another five or more years to complete. We have cited reasons why it is important to continue to address this goal, from the standpoint of the nation, the Navy, and the shipyards.

We concluded that the Navy would benefit from adopting the efficiencies of commercial shipbuilding.[41] However, differences in business and construction philosophies between the Navy and the commercial sector make it difficult for Navy shipyards to enter the commercial market. These differences also impact the Navy. The Navy will receive full benefit of commercial wisdom only when U.S. shipyard processes and practices are up to international standards. But, these standards are best attained through global competitiveness -- possible for Navy shipbuilders only if the Navy reduces the shipyard's dualism by accepting commercial processes and practices to the degree possible. This "catch 22" must be resolved by the Navy, and the ASE can be an excellent vehicle for that resolution.

- The best way to accelerate the adoption of commercial practices is for the Navy to identify differences in processes and procedures through the ASE, and to actively question those differences (maybe through an outside panel made up members from both the Navy and commercial sectors).[42] *Given proper visibility*, this could create a dynamic and proactive environment with impressive advantages for the Navy, such as those listed under conclusions.

<u>Comments on the ASE.</u> An important issue is the focus of the ASE. Its principal focus must remain on global commercial competitiveness, or it will lose considerable impact on the shipyards and Navy shipbuilding alike. But this is not enough, for if the program is successful in improving shipyard performance, but the Navy fails to apply commercial practices to naval shipbuilding, benefits to the Navy will be indirect, at best.[43] For this reason, the Navy should be responsible for the second program goal – the adoption of commercial practices into the Navy.

If ASE does remain consistent with the vision of MARITECH, the President, and Congress, another dilemma occurs. The government's funding share will come from the Navy's budget. Such a program may end up favoring non-Navy yards.[44] Under these

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[41] Studies have been done to determine cost differences between naval vessels built in the U.S. versus those built overseas (where more commercial practices are reportedly employed). The examination of the DDG-51 Destroyers licensed for construction by the Japanese is a good example. Although there were some differences in the products, it would be enlightening to analyze "apples-to-apples" comparisons that could be drawn from these studies, eliminating fixed costs of weapons and ancillary systems.

[42] Other steps may be taken. For instance, while the role of the Agent Officer's Technical Representative (AOTR) seems relatively ad-hoc to us, varying from one AOTR to another, these managers could be a major force for change, if they felt responsible for identifying opportunities for adopting commercial standards and practices successfully demonstrated in their projects.

[43] In fact, the program may end up favoring non-Navy yards. Partly because they cannot rely on Navy business for survival, virtually all of the these yards see their future in the global commercial market (as opposed to three out of the "Big 6" Navy yards). This, and the fact that they do not have to accommodate Navy practices, has allowed them to optimize their operations for commercial success.

[44] Non-Navy yards were often the most entrepreneurial players in MARITECH. While virtually all of these yards are pursuing the global commercial market, three out of six of the Navy shipyards are not planning to do so. The non-Navy yards see their future in the global market and have made impressive changes in their operations to address it, partly because they cannot rely on the Navy for survival. The fact that they

circumstances, Navy gains would be indirect -- for instance, from the raising of standards across the entire shipbuilding industry. Even then, principal Navy yards could simply eschew participation, continuing to service the Navy in the same manner as before. Clearly, the Navy could benefit from creating world class competitors among the non-Navy shipyards, if it expanded the competitive pool for Navy shipbuilding. But there is insufficient business for those shipyards that are currently building Navy ships. The game will remain zero sum and someone would have to leave. So, the Navy would have to adopt a second strategy – to reward Navy yards who join in the quest for commercial excellence. This would constitute a major, and probably painful, shift in Navy policy.

The problem seems intractable, but it must be solved if the Navy is to realize better, faster, more affordable shipbuilding by encouraging better shipbuilding practices. ***One way to deal with this dilemma is to declare two principal ASE objectives:***

- ***U.S. shipbuilders must attain a position of competitiveness in the global commercial marketplace, and***
- ***the Navy must proactively adopt many of those commercial practices and processes.***

The difficulty with this approach is obvious. Either objective demands a Herculean effort, and a program that embodies both will be extremely challenging. It is probably the only way to accomplish the job, however, and it is a job worth accomplishing. Divided responsibility should generally be avoided, but it may be advantageous to enlist MARAD's help on addressing the first goal.

MARITECH should be a major part of the deliberations by the Executive Control Board of the NSRP and the Navy, as they define the ASE Program. Recommendations that follow are specific suggestions for the ASE, using the MARITECH program as a "roadmap." Throughout our study, we looked to the MARITECH projects to provide insight into options for the next phase of projects. We have recommended some changes in emphasis where particular project areas seemed to have large payoffs, or alternatively, where benefits did not seem to justify more expenditures.

B. Some specific MARITECH ASE Recommendations:

- **Place less emphasis on marketing and new ship designs.** Both are vital to the shipyards' success. But, marketing is generally considered less a government role than, for example, technology development. New ship designs serve important purposes, but investment to develop or buy new designs should be undertaken only after an intensive consideration of the commercial marketplace. Government aid can sometimes reduce that scrutiny.

- **Place more emphasis on business and construction processes, technology improvements, and training and education.** The latter should include sharing lessons among shipyards and resolving terminology differences in business/design/production processes.

- **Develop and acquire supporting technologies as justified by the processes they enable.** Some are information technologies and automated welding.

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are free to optimize their processes and standards for the commercial market (rather than trying to accommodate Navy practices) gives them a flexibility that the Navy yards lack.

- **Institute an ongoing assessment process from the beginning of the program.** Metrics should be determined to measure the baseline of the shipyards' performance. Some areas that are particularly critical to measure are:

  – <u>International competitiveness.</u> Some of the indicators of international competitiveness are market share, productivity and other benchmarking factors for individual shipyards.

  – <u>Navy benefits.</u> The incentives for pursuing commercial leveraging are poorly expressed and implemented at nearly every level of the Navy. As the Navy becomes more involved in the follow-on program, they should assess the adequacy of the their organizational structure and processes to facilitate commercial leveraging, and then measure their own performance in doing so. It would be helpful to analyze domestic and foreign construction techniques, regulations, technologies, for a few types of common allied ships and U.S. combat and support ships, and to derive data on practices and cultural differences which may promise savings for U.S. Navy construction on three ship types: large combatant, small combatant, and support ship.

  – <u>Other Important Areas.</u> We have identified some issue areas that could not be covered adequately, given time and resources dedicated to the MARITECH Review Project.

- Information Technology: We are developing a suggested plan for guiding information technologies projects to ensure optimum proliferation and economy.

- Design Standards: The acquisition of new ship designs was justified to a great extent by the need to develop and employ design standards. A survey of standards adopted and how they are being used would be valuable.

- Benchmarking. In order to measure competitiveness, there has to be commonly accepted performance metrics, which can be applied to domestic and foreign shipyards. These metrics would generalize the usefulness of benchmarking practices. MARITECH's fundamental goal is to raise the competitiveness of domestic shipyards, yet there are no accepted metrics to measure it. Without such, Congress cannot measure the success of the program, the Navy cannot measure the benefits of employing some commercial practices, and the shipyards cannot determine how well they are closing the gap with their foreign competitors. Analysis should be done to propose appropriate metrics for types of ships most likely to be built in the U.S.

- Teaming: A crucial MARITECH contribution, the teaming and consortia experiences, is a story worth collecting and relating.

- Specific Economic Questions: e.g., under the present FYDP, how many yards are needed to completely service the Navy?

Annex A. Contributing Individuals and Shipyards

This annex provides a schedule of trips, and lists some of the people we talked to.

3 December 1997
Ed Schimler, Maritime Administration (MARAD)
Jim Kuny, Office of Naval Research (ONR)
Andrew Dallas, ONR

5 December 1997, 21 January 1998, 6 March 1998
Bob Schaffran, MARITECH Program Office
Don Fraser, MARITECH Program Office
Michael Ferguson, MARITECH Program Office

19 December 1997
Dale Rome, Naval Surface Weapons Center (NSWC)

22 December 1997, 20 March 1998
Tom Conroy, MARAD

8 January 1998 - Newport News Shipbuilding
Michael Powell, Director, Engineering Development, Carrier Innovation Center
Joseph Baumer, Systems Engineer
Mark Reidelbach, P.E., Project Engineer, Innovation Center
Alan Titcomb, Manager, Research and Concept Development
Dan Wooley, Program Administrator

27 January 1998 - NPSR/ASE Meeting

3 February 1998
Dick Volker, MARAD

3 February 1998 - Bath Iron Works
Steve Laskey, Senior Program Manager (PM), Engineering Business Development
Jim Demartini, Technology Research Program PM
Brent West, Director, Strategic Planning
Ken Brill, New Shipbuilding Methodology
David Forrest, Chief Welding Engineer
Greg Harrison, NIIIP SPARS
James Baskerville, Chief Engineer, Advanced Technology
Joseph Theriault, Materials Division
James Faverau, Director, Facilities
Mike Duquesnoy, Manager, Machinery Sec.

4 February 1998 - Gladding-Hearn Shipbuilding
John F. Duclos, Vice President
Bernard Giroux, Director of Sales/Marketing
Geoffrey S. Rivinius

5 February 1998 - Electric Boat Corporation
Michael Toner, Vice President, Innovation
William S. Gibbs, Manager, Information Technology
James S. Boudreaux, Manager of Engineering Computer Systems Technology
Bradford W. Burgess, Business Development
Daniel L. Williams, Senior Software Engineer, Computer Systems Analyst

5 February 1998
Dave Heller, MARAD

9 February 1998 Alabama
Tom Neyhart, Program Manager, Business Development
George Gibbs, CEO, Atlantic Marine Holdings
Thomas P. Jones, Jr., Vice President, Atlantic Marine Holdings
Mark Asbury, President, Alabama Shipyard Industries
David A. Enman, Vice President, Business Development
Anand Ramamurthy, Industrial Engineer
Timothy G. Berkel, Marketing Strategist
Thomas Perrine, Production Engineering Manager
Stephen M. Miller, Senior Naval Architect
W.R. "Bob" Doyle, Materials Manager

10 February 1998 - Bender Shipbuilding and Repair
Tom Bender, President
Bruce Croushore, Corporate Secretary
Patrick Cahill, Project Engineer
Joseph Comer, Engineering Manager
Michael Cook, Central Planning and Control Manager
Lee Douglas, Information Systems Group Manager

11 February 1998 - Halter Marine Group, Inc.
William Pfister **-** Program Manager, Advanced Programs
Perron Chatham **-** Program Manager, Advanced Programs
Chris Oliver **-** Program Manager, Advanced Programs
Eric Richards **-** Yard Manager, Pascagoula Division

11 February 1998 - Ingalls Shipbuilding
Roger Banks, Manager, Contract Administration
Danny Bruhl, Manager, Production Control
Judy Wheat, Program Manager, Cruise Ship Design
Walt Whitehead, Engineer, Composites
Gerry Embry, Engineer, Advanced Technology
George Vogtner, Analyst, CAD/CAM
Peter Presel, Director, Business Development
John Sizemore, Engineer, Robotics

12 February 1998 - Bollinger Shipyards, Inc.
Dennis Fanguy, Technical Director
Bob Latas, Mechanical Engineer

13 February 1998 - Avondale Industries (November 24, 1997, January 28, 1998)
Ron J. McAlear, Vice President, Advanced Programs & Marketing
Mark Gasson, Proposal Manager, Advanced Programs & Marketing

23 February 1998
L.D. Chirrillo, Consultant

24 February 1998 - Nichols Brothers Boat Builders
Ron Young, Young Associates Project Services, Ltd.
Matt Nichols, President, Nichols Brothers Boat Builders

25 February 1998 - Todd Pacific Shipyards Corporation
Roland H. Webb, President and CEO
Camilla DiBarra, Program Manager, Process Improvement
Gene Kegley, Assistant General Superintendent
Gene Henley, General Superintendent
Ludwig R. Marz, Director, Human Resources

26 February 1998 - NASSCO
Steve Clarey, Manager, Advanced Programs
Richard H. Vortmann, CEO, NASSCO
Gary M. Hatherington, Advanced Programs Engineer
Peter Jaquith, Director, Production Engineering
Malcom Bell, Senior Consultant, First Marine International, Ltd.

23 March 1998 - Marinette Marine Corporation
Pete Anderson, Marketing Director

Annex B. Overarching Economic Considerations

Contributed by the Economic Strategy Institute

Chapter I. Introduction

The United States shipbuilding industry is one of America's anomalies. In terms of employment levels, it is still one of the world's largest; yet, its production levels are relatively low. The industry is capable of producing some of the world's most sophisticated naval vessels; yet, for years it was unable to produce less technologically challenging merchant vessels at an affordable price.

The U.S. shipbuilding industry emerged from World War II as the world's largest in terms of output. U.S. yards made the transition from building military vessels to building commercial ones, but lost global market share because they could not compete on a cost basis with their overseas rivals. To compensate for the lower costs of overseas builders, the U.S. government provided generous construction subsidies. This lifeline was cut in 1981, and, within six years, the U.S. industry had disappeared altogether from the market for large, oceangoing, commercial vessels.

At the time, the impact of this precipitous decline in the commercial market was masked, in part, by the large increase in the construction of naval vessels. But with the military downsizing that has accompanied the end of the Cold War, major U.S. shipbuilders now find their long-term survival endangered. Greater penetration of the commercial market has become a business necessity for many yards, and a matter of national security as well.

Policymakers recognized that reentering the market would not be easy. The industrial policies of many countries promote the shipbuilding industry, even though chronic excess capacity has kept profits low for most participants. Worse, the gap in productivity widened during the 1980s. As U.S. yards were focused on serving military and Jones Act demand, non-U.S. yards were busy trying to improve efficiency in order to compete in the global marketplace.

The U.S. government has adopted a five-pronged strategy aimed at assisting U.S. industry efforts to convert from defense to civilian markets through improved technologies and production processes for building commercial ships. The plan, put forth in the National Shipbuilding and Shipyard Conversion Act of 1993, consist of the following elements:

1. ensuring fair international competition through an OECD multilateral agreement prohibiting unfair subsidies;
2. improving commercial competitiveness through Maritech;
3. eliminating unnecessary government regulations that inflate costs;
4. financing ship building projects through Title XI loan guarantees;[45] and
5. assisting international marketing of US shipyards and facilitating cooperative arrangements and alliances between US and foreign yards.

[45] Initially a program for domestic buyers of U.S. vessels, the Title XI loan guarantees now provide long-term loans at favorable terms and conditions to foreign purchasers of U.S. vessels as well.

These efforts are now in their fifth year, and the Maritech program is now up for review. Hence, now is an appropriate time to evaluate the effect of programs such as Maritech to determine whether they are worth continuing.

There are two ways to evaluate the prospects of government programs such as Maritech and the broader U.S. efforts to revitalize the domestic shipbuilding industry. One method is to monitor changes, at the firm level, in manufacturing and process technology, labor management relations, productivity, and other variables that the programs in question are supposed to affect. A second tack is to step back and examine the U.S. industry as a whole and the global environment in which it operates. This view takes into account other factors that have an impact on the U.S. industry's ability to succeed in the commercial market. Important variables for this level of analysis include an analysis of supply and demand for ships, prices, shipbuilding capacity levels, subsidies, wages, and exchange rates. In other words, proper analysis requires looking at both the forest and the trees.

The focus of this paper is on the forest, or, more accurately, the jungle. The shipbuilding industry is one of the most policy-distorted industries the world has too offer. It has been subsidized at high levels for decades in most, if not all, major shipbuilding nations; it has been the target industry of many developing country industrial policies; and it has gone through one of the most wrenching and time-consuming periods of restructuring in the history of the global economy without fully eradicating the scourge of excess capacity.

Nevertheless, this report concludes that overall conditions warrant the continuation of Maritech and other revitalization efforts for at least the next five years. Industry-wide statistics show some positive trends in variables, such as per employee investment and per employee sales, which forebode productivity improvements down the road. In other words, major U.S. yards, though not yet on par with the word's top shipbuilders, appear to be making progress. The global market for oceangoing commercial vessels has improved markedly since U.S. yards exited the business during the 1980s. And, despite some trouble spots, industry dynamics that precipitated the creation and maintenance of excess capacity in earlier decades are beginning to change in ways that make a repeat of the 1970s, when commercial demand collapsed, less likely.

More broadly, limited and market-oriented cooperation between government and the private sector has benefited the United States in the past. Sematech, a venture combining the government money and the U.S. semiconductor industry, was instrumental in the renaissance of the U.S. semiconductor and semiconductor equipment industries. Current public-private efforts to increase automotive fuel efficiency and reduce greenhouse gas emissions have also yielded positive results.

The remainder of the paper will lay out the rationale for continuing these limited efforts to revitalize the U.S. shipbuilding industry. Chapter II looks at the current competitiveness of U.S. yards, and whether industry productivity could reasonably be expected to rise to international levels within a reasonable period of time. Chapter III and Chapter IV examine trends affecting the supply of, and demand for, ships. Chapter V attempts to quantify some of the potential gains from successfully reentering the commercial shipbuilding market. Chapter VI summarizes the study's main findings.

Chapter II. Competitiveness of U.S. Shipbuilding and Repair

The U.S. shipbuilding industry consists of 17 major shipbuilders, referred to as the Major Shipbuilding Base (MSB).[46] The MSB yards account for roughly two-thirds of U.S. shipbuilding and repair employment. Of the 17, there are six yards that also perform naval construction. In addition to the MSB are more than 500 small and medium-size shipyards known as second-tier shipyards, which are used primarily in supporting inland waterway and coastal operators.

This study is primarily concerned with the MSB. The second-tier yards are currently benefiting from the retirement of dry cargo barges and are expecting increased demand for double hull barges, which are required by the Oil Pollution Act of 1990 to replace single-hull barges by 2015.[47]

Where Do We Stand?

It is widely acknowledged that the U.S. shipbuilding industry lags behind that of Japan, many European countries, and Korea in terms of competitiveness, defined as the ability to produce ships at costs low enough to supply a reasonable share of global commercial demand. For decades, however, conventional wisdom held that the noncompetitive status of the U.S. industry was driven by factors beyond the industry's control, such as the volatility of U.S. orderbooks, the absence of orders requiring serial construction, and high wages.[48]

The conventional wisdom held such sway that the U.S. government provided subsidies to U.S. yards in order to compensate for other yards' lower labor and material costs. During the 1960s and 1970s, this so-called construction differential subsidy provided yards with hundreds of millions of dollars annually (if adjusted for inflation) until it was eliminated in the early 1980s.[49] (See Exhibit II.1)

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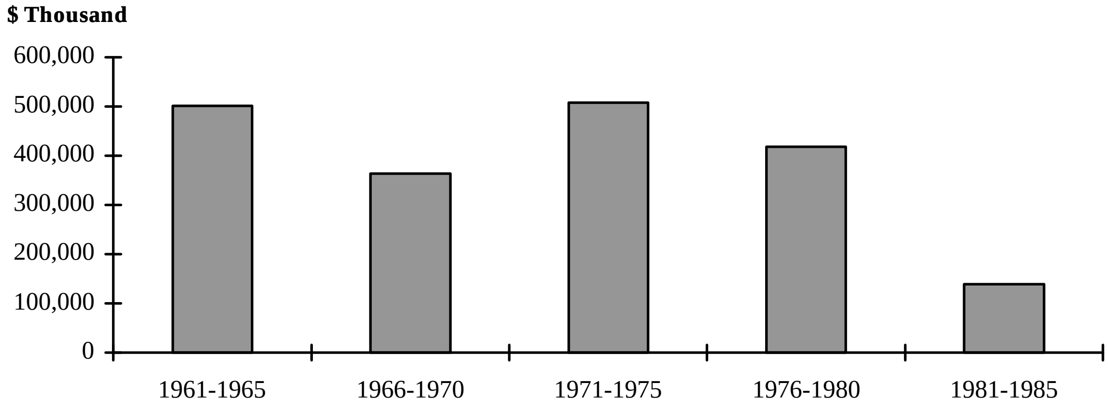
[46] MSB yards are privately owned and possess at least one shipbuilding position capable of accommodating a vessel 122 meters in length or over.

[47] The second-tier yards have been operating at close to capacity and raising prices. Attractive business prospects in this sector and declining military orders have spurred some MSB yards to serving the barge market. See DRI/McGraw Hill, Standard & Poor's, and U.S. Department of Commerce/International Trade Administration, *U.S. Industry and Trade Outlook 1998* (DRI/McGraw Hill, 1998), 22-7 and 22-12.

[48] Weiers, Bruce J., "The Productivity Problem in U.S. Shipbuilding," Report No. DOT-TSC-OST-84-2, (Washington, DC: U.S. Department of Transportation, December 1984), 2.

[49] The nominal subsidy figures were deflated by the chain-type price index for federal consumption expenditures.

Exhibit II.1
Real Construction Differential Subsidies*
1992 Chain-Weighted Dollars, Annual Averages



*The last subsidy outlay occurred in 1988. The real subsidy from 1986 to 1988 averaged less than half a million dollars and was omitted from this exhibit.
**The nominal subsidy was deflated by the chain-type price index for federal consumption expenditures.
Source: U.S. Maritime Administration, *MARAD '96 - The Annual Report of the Maritime Administration*; *Economic Report of the President, 1998*

Beginning in the late 1970s, several carefully conducted studies convincingly refuted the conventional wisdom.[50] A 1979 study by A&P Appledore found that the best Japanese and Scandinavian yards were twice as productive as good U.S. shipyards. Another study conducted by a U.S. builder concluded that it required three times the man-hours as Japan's Ishikawajima-Harima Heavy Industries to construct a similar bulk carrier. This study also found that the U.S. firm's materials costs were much higher than IHI's. A third study conducted during the mid 1980s by a major U.S.-based tanker owner reached a similar conclusion: the U.S. industry had a high cost structure and was behind the world's best yards in terms of labor productivity.

Thus, it was not surprising that once the construction subsidy was eliminated, the commercial presence of U.S. yards, not very large to begin with, practically disappeared. The U.S. orderbook for oceangoing ships weighing 1,000 gross tons and over declined from 62 ships in 1979 to zero in 1987, where it remained until 1990. (See Exhibit II.2) The domestic industry survived on Jones Act tonnage and on the very substantial business provided by the Navy, which undertook a massive buildup during the 1980s.

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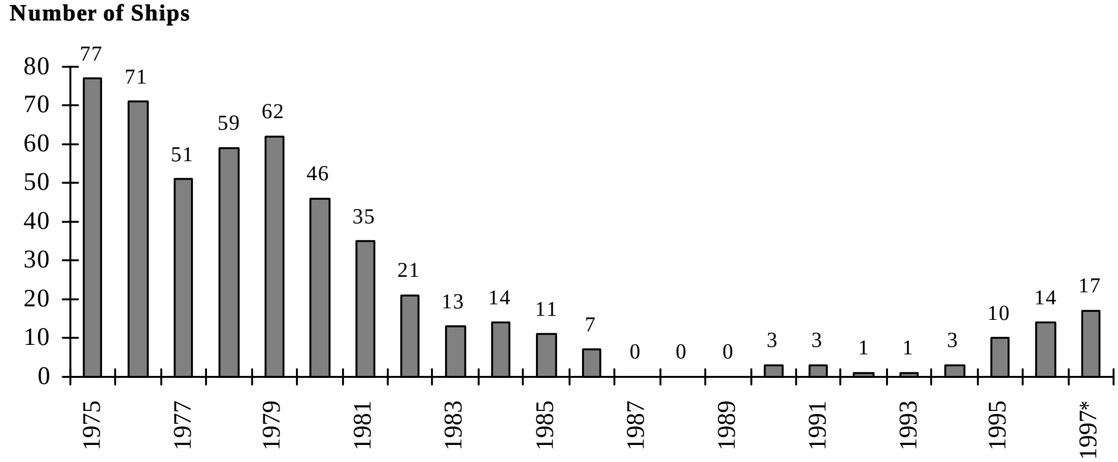
[50] A summary of these studies can be found in Weiers, 4-7.

Exhibit II.2
Yearend Commercial Orderbook for Oceangoing Vessels
1,000 Gross Tons and Over



*As of April 1, 1997.
Source: U.S. Maritime Administration (MARAD), *Outlook for the U.S. Shipbuilding and Repair Industry 1997*

The commercial performance of U.S. yards has improved during the 1990s. As of April 1, 1997, there were 17 oceangoing vessels, one oceangoing ferry, and three non-oceangoing ferry on U.S. orderbooks valued at almost one billion dollars. With Navy purchases declining substantially since 1991, commercial vessels are accounting for a greater share of U.S. yards' business. As of April 1997, the commercial share of the U.S. orderbook was 36 percent, up from a 4.3 percent share in 1991. As of June 1997, the U.S. orderbook, for ships 100 gross tons or larger, totaled more than 640,000 gross tons, good enough for thirteenth place in the global rankings, compared to less than 220,000 gross tons for a twenty-third place ranking as recently as December 1995.[51] Encouragingly, some of the contracts are for export orders, which have benefited from the extension of Title XI financing (previously reserved exclusively for domestic buyers) to international buyers of U.S. vessels.

It is, however, too early to pop the champagne. The U.S. effort to reenter the commercial market received a cold dose of reality in March 1998 when Newport News announced that major losses on its current contracts and high labor and material costs were forcing it to exit the commercial market.[52] The cost-competitiveness of U.S. yards has also been damaged by the vagaries of foreign exchange. The huge devaluation that has visited the currencies of Southeast Asia and Korea, as well as weakness in Japanese yen and many European currencies, has increased U.S. labor and material costs in relative terms.

An even greater disappointment to U.S. hopes for a return to the commercial market is the continuing productivity gap between U.S. yards and their major competitors. Measuring productivity in the shipbuilding and repair industry is complicated by several factors, yet the standard measures of productivity, such as value added per employee, shipments per employee, or volume per employee, offer enough evidence to support the conclusion that U.S. productivity is lagging.[53]

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[51] Lloyd's Register, *World Shipbuilding Statistics* (June 1997).
[52] Anna Wilde Mathews, "Top Shipyard Falters in Commercial Test," *The Wall Street Journal* (March 17, 1998).
[53] The preferred measure of productivity measurement is compensated gross tons per man-hour, which adjusts gross tonnage by coefficients that reflect the complexity of a given ship. Up-to-date cross country estimates on

Exhibit II.3 below lists the results of several productivity studies (some of which were mentioned earlier), conducted during the past two decades, which compared the man-hours required to build a given ship. Each of these analyses concluded that Japanese and European yards possess a substantial advantage in labor productivity. As recently as the early 1990s, labor productivity in U.S. yards was found to be one-fourth to one-third as high as that of their Japanese counterparts, and two-fifths to one-half as high as that of their European counterparts. In other words, the typical U.S. yard would take almost four times as many man-hours as a Japanese yard to build the same ship.

Exhibit II.3
Productivity Comparisons among U.S. Japanese, and European Yards
Ratio of European and Japanese Labor Hours to U.S. Labor Hours

A&P Appledore, Ltd.	
Years of Comparison	1976-79
Type of Comparison	Typical U.S. vs. best Japanese and Scandinavian
Japan	0.5
Europe	0.5
Levingston Shipbuilding, IHI Maritime Technology	
Years of Comparison	Late 1970s
Type of Comparison	Levingston vs. Japan's IHI (bulk carrier only)
Japan	0.27
Europe	NA
Allen Jenks and John E. Larner, Exxon International	
Years of Comparison	1981-1983
Type of Comparison	Typical U.S. vs. typical Japanese and European
Japan	0.46
Europe	0.57
U.S. Maritime Administration	
Years of Comparison	Mid 1980s
Type of Comparison	Typical U.S. vs. typical Japanese
Japan	0.43
Europe	NA
J. Anderson, Odense Shipyards	
Years of Comparison	Early 1990s
Type of Comparison	Typical U.S. vs. typical Japanese and European
Japan	0.28
Europe	0.54
J. Anderson, Odense Shipyards	
Years of Comparison	Early 1990s
Type of Comparison	Best U.S. vs. best Japanese and European
Japan	0.33
Europe	0.43

Sources: Bruce J. Weiers, "The Productivity Problem in United States Shipbuilding," and Ernst G. Frankel, "Economics and Management of American Shipbuilding and the Potential for Commercial Competitiveness"

productivity by this measure could not be located by the authors, the U.S. government, or several consultants we contacted.

Korean yards, as of 1996, were less efficient than Japanese yards. A study by Merrill Lynch found that Hitachi Zosen, perhaps the world's most efficient producer of very large crude carriers (VLCCs), builds a VLCC within 480,000 man-hours, compared to 700,000 to 800,000 man-hours for Korean yards.[54] That is, Korean yards are about two-thirds as productive as Japan's best yard. On an aggregate basis, Merrill Lynch estimates that Japanese yards have a 30 percent productivity edge versus Korean yards.

Though behind Japan, Korean yards appear to have an edge on their U.S. competitors. According to a study cited by Japan's Association for Structural Improvement of the Shipbuilding Industry (ASISI), it takes about 700,000 to 800,000 man-hours – about as much time as it takes for a Korean yard to construct an average size VLCC -- for U.S. yards to build a 45,000 dwt double hulled tanker, which is not even half the size of a small VLCC.[55]

Another measure of productivity, revenue per employee, is a less accurate indicator of productivity, but was used nonetheless to compare recent productivity levels in Japanese, Korean, and U.S. yards for various years. These measurements, shown in the following table, are imprecise because the Japanese and Korean figures may reflect revenue derived from other sources, while the U.S. measures are exclusively for shipbuilding and repair, a substantial amount of which is for the Navy. Nevertheless, this comparison does little to alter the picture painted throughout this chapter of lagging U.S. productivity.

Exhibit II.4
Revenue per Employee in Japanese, U.S., and Korean Yards

Company	**Year**	**Revenue per Employee** (Own-currency basis)	**Revenue per Employee** (U.S. dollar basis)
All U.S.	'95	100,481	100,481
Newport News	96	104,254	104,254
Hyundai	'96	112,400,000	139,599
Daewoo	'96	142,500,000	176,983
Samsung	'96	155,200,000	192,756
Hanjin	'96	89,100,000	110,661
6 major Japanese yards	'87	38,100,000	263,456
19 largest Japanese yards	'96	84,417,392	775,788
6 major Japanese yards	'97	61,100,000	504,479

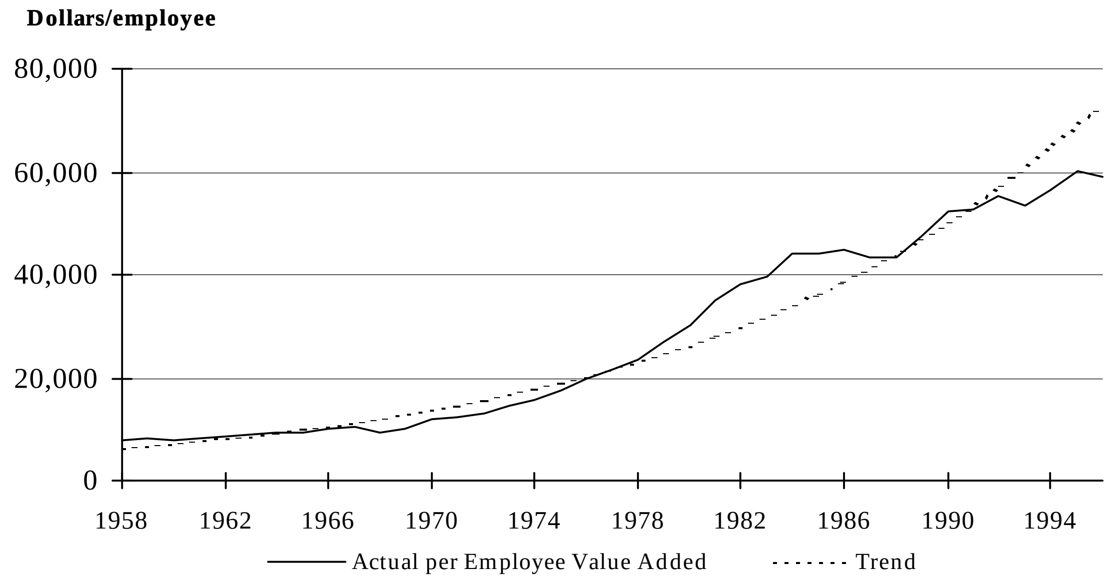
Sources: Newport News Annual Report, Bureau of the Census, Merrill Lynch, Japan's Ministry of Transportation, and Nomura Research Institute.

Clearly, if the United States is to have a chance in this industry, it must improve its productivity levels substantially. Data from the Bureau of the Census going back to 1958 indicates that U.S. shipbuilders have increased productivity (measured in terms of value added per employee) by about 6.7 percent per year. A look at the figure below, which shows actual trend productivity, illustrates that U.S. per employee value added stagnated during the 1980s, coinciding with the end

[54] K. Han, Shipbuilding, Korea: VLCC Impact, New Picks - Industry Report, Merrill Lynch Capital Markets June 26, 1997, p. 13-14.
[55] Association for Structural Improvement of the Shipbuilding Industry, Japan (ASIS), *Forecast on World Shipbuilding Demand* (March 1996), 58.

of the construction differential subsidy program (CDS) and the increase in naval construction. Though productivity growth has revived since 1989, it remains below trend.

Exhibit II.5
U.S. Shipbuilding Productivity, Actual and Trend Values



Source: Bureau of the Census

But given the lagging U.S. efficiency levels detailed in this chapter, it is obvious that getting back on trend will not be sufficient to make the U.S. industry internationally competitive. Japan's ASISI concluded that U.S. productivity would need to improve by roughly 15 percent per year for seven years just to catch up to international levels.[56] In value-added terms, this implies more doubling the traditional rate of productivity growth – no small feat.

Can the Productivity Gap be Closed?

Despite the enormity of the task, there are reasons for optimism. For one, many of the factors hindering U.S. productivity growth are being addressed through Maritech and efforts by labor and management to improve on-the-job flexibility. Productivity increases, in turn, would begin a virtuous cycle leading to even more productivity growth. For instance, reducing construction time would lower construction financing costs, thereby providing yards with more money to invest in efficiency-enhancing equipment.

Another reason for optimism is that the wage differentials that worked against U.S. yards in the 1950s and 1960s are now more favorable. According to U.S. Bureau of Labor Statistics data for 1994, the latest year for which data are available, U.S. hourly compensation costs are relatively low. They are still higher than those of South Korea and certain Asian yards, but are substantially lower than those of Japan, Germany, and other major European yards. As the following table demonstrates, this conclusion holds even if the appreciating dollar is taken into account, though the advantage over Japan is reduced from about eight dollars per hour to about four. The dollar's substantial appreciation is not a complete anathema, however. Since the United States has been out of the commercial market for quite some time, it will have to import, at least initially, a significant share of marine outfitting equipment. The stronger dollar means savings for U.S. builders and higher import prices for industries in countries that have experienced a sharp depreciation, such as Korea. Korean yards will also be burdened by higher interest cost for debt

[56] ASIS, 58.

denominated in foreign currencies and higher energy costs -- both are likely to slow the massive investments for which Korean yards are infamous and erode for their labor cost advantage.

Exhibit II.6
Hourly Compensation in the Shipbuilding Industry, 1994

	Based on 1994 Exchange Rates	Based on 1997 Exchange Rates
HONG KONG*	5.43	5.42
PORTUGAL*	7.80	7.38
SINGAPORE*	8.60	8.84
KOREA*	9.43	7.94
GREECE	10.06	8.94
TAIWAN	10.44	9.60
UNITED KINGDOM*	14.80	15.83
CANADA	14.96	14.75
ITALY	16.89	15.98
UNITED STATES	18.08	18.08
FRANCE	18.18	17.28
SWEDEN	18.80	18.98
FINLAND	20.05	20.21
NETHERLANDS*	20.42	19.04
NORWAY	22.56	22.48
DENMARK	23.75	22.85
BELGIUM	24.04	22.46
JAPAN	26.15	22.07
GERMANY (West only)	29.74	27.82

*1994 data was extrapolated by applying manufacturing industry compensation trends to pre-1994 shipbuilding industry data.
Source: U.S. Bureau of Labor Statistics

Moreover, productivity jumps such as that required by the U.S. industry are not unheard of in the annals of industrial history. Research performed on U.S. industries (at the 4-digit, SIC level) between 1980 and 1995 indicate that 10 industries experienced productivity growth of 15 percent per year for seven consecutive years. (See Exhibit II.7) Though most of these industries were small subgroups of the steel and aluminum industries, the much larger semiconductor and motor vehicle industries also made the cut. The aircraft industry, though it did not experience 15 percent productivity growth over any seven-year period, was able to improve value added per employee at a 10 percent rate from 1967 to 1979.

Exhibit II.7
Durable Goods Industries Experiencing Rapid Productivity Growth
Sustained for Seven Years*

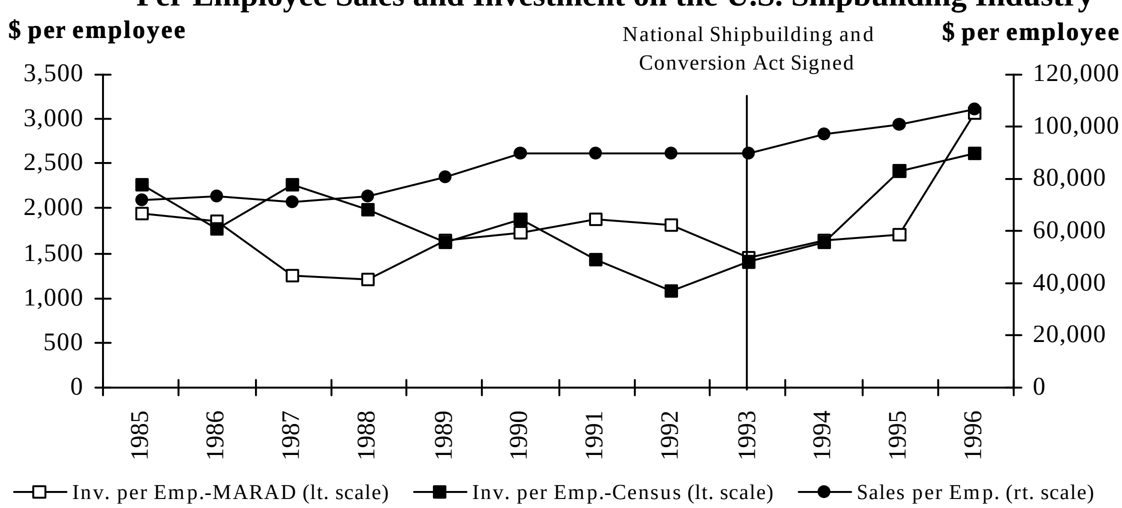
SIC Category	High Growth Periods	Growth Rates
Semiconductors and Related Devices	1987-1994, 1988-1995	15.4 %, 17.2 %
Primary Copper	1982-1989, 1984-1991, 1986-1993	19.8 %, 32.2 %, 21.0 %
Other Primary Nonferrous Metals**	1981-1988, 1985-1992	15.8 %, 16.1 %
Motor Vehicles and Car Bodies	1981-1988, 1982-1989	15.6 %, 16.5 %
Electrometallurgical Products	1982-1989	16.3 %
Cold Finishing of Steel Shapes	1982-1989	15.1 %
Primary Aluminum	1982-1989	17.7 %
Secondary Nonferrous Metals	1982-1989	16.3 %
Aluminum Drawing and Rolling**	1982-1989	24.9 %
Primary Batteries	1981-1988	16.1 %

*Value added per employee in these industries expanded at a compound average growth rate of at least 15 percent annually over a seven-year period beginning in 1980 or later.
**Primarily reflects high volatility of industry sales.
Source: Bureau of the Census

Though the United States shipbuilding industry has yet to experience a major productivity jump, industries in other countries have. Polish yards, for instance, averaged 15 percent growth in productivity over a recent four-year period. In 1990, the Italian industry produced 300,000 compensated gross tons with 21,000 direct employees. Last year, it produced twice as many tons with less than half as many workers, which translates into a compound average growth rate of 22 percent.

In short, the goal of sustained and rapid productivity growth is no pipe dream. It can, and has, been done. Though it remains too early to render any firm conclusion about the U.S. industry's potential, positive trends are clearly in place. Since 1993, the year that Maritech and the Title XI extensions were put in place, per employee shipments and investment have begun to rise after years of stagnation.

Exhibit II.8
Per Employee Sales and Investment on the U.S. Shipbuilding Industry



Source: Bureau of the Census

But even if U.S. yards possessed all these attributes, success would not be assured. There would still have to be sufficient demand for U.S. ships. Freight prices would have to be high enough to induce ship owners to add new tonnage or replace older vessels. Ship prices would have to be high enough to generate profits for builders. The playing field would have to be level, which means an end to the massive subsidies that have plagued the industry for decades. In other words, in today's environment, increased competitiveness is no guarantee of commercial success for U.S. yards.

Dynamics of Newbuilding Demand

A profitable market starts with ship prices high enough to generate a reasonable return on investment. At first glance, trends in ship demand seem pretty easy to forecast. Population and economic growth lead to increased industrial production, increased transport of raw materials such as oil and coal, and increased trade in intermediate inputs and finished goods. All of this translates into greater demand for shipping services and, thus, demand for ships. Like any other piece of capital equipment, ships age or become obsolete and must be replaced, creating an additional source of newbuilding demand.

Although these factors seem conducive to a steady, relatively predictable increase in long-term demand, in practice, the newbuilding market has suffered through a long period of weakness that locked the world's market for merchant vessels into a seemingly permanent state of oversupply.

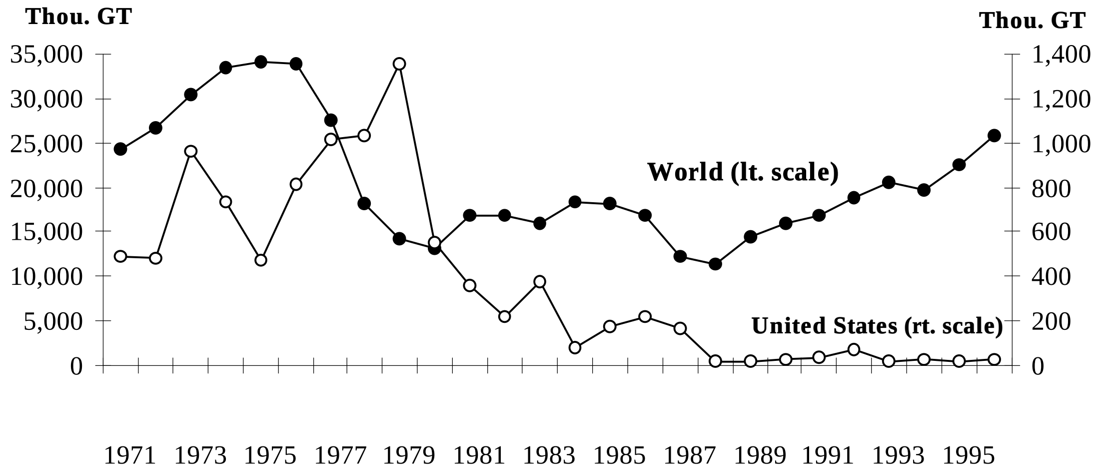
Market Turmoil

The global merchant shipbuilding industry experienced a prolonged boom from about 1962 to the mid 1970s, driven by the dramatic rise in international trade. Annual output rose from about 8 million gross tons to about 34 million gross tons. The boom ended during the mid-1970s as the first oil crisis slowed the rise in oil trade. After the second oil crisis, oil trade fell and dry bulk trade (trade in commodities such as grains, ores, and fertilizers) stagnated as well. Thus by 1983, the volume of sea trade had dropped below 1974 levels.[57]

The impact on the global shipbuilding industry was devastating. With too many ships chasing after too few goods, both freight rates and demand for new ships plummeted. Newbuilding levels dropped by 50 percent, putting tremendous pressure on shipbuilders to reduce capacity. (See Exhibit III.1) The number of trading shipyards, more than 400 in 1982, was less than 200 by 1987, and some countries, including the United States, withdrew from the world commercial market completely.

[57] Hans, J. Peters, *The Maritime Transport Crisis* (Washington, DC: The World Bank, 1993), 6.

Exhibit III.1
World Shipbuilding Deliveries, 1971-1996



Source: Lloyd's Register

Nevertheless, the industry's adjustment to the new supply and demand conditions was protracted. Even though withdrawals helped the supply situation, demand remained weak because the existing fleet was more than ample. Thus, the size of the world merchant fleet, which had expanded from 207 million gross tons to nearly 430 million gross tons between 1970 and 1982, actually declined to about 400 million gross tons by 1988.[58]

The severity of shipbuilding crisis compelled many governments in ship producing countries to increase construction subsidies and other handouts to their yards. These subsidies appear to have prolonged the process of capacity reduction worldwide, and have proven durable in most countries even as the worst part of the crisis seems to have past.

A Tentative Revival

Though the newbuilding market has not reached the heights of the 1970s, there has been a noticeable revival in the market for new merchant vessels. The size of the fleet has been growing since 1988, primarily due to the scrapping of older vessels built during the pre-oil crisis boom years, and the renewed growth in international trade. (See Exhibits III.2 and III.3) The number of active yards has begun to increase along with the size of the merchant fleet. Though prices remain soft in many product categories, signs are clearly looking up for the industry.

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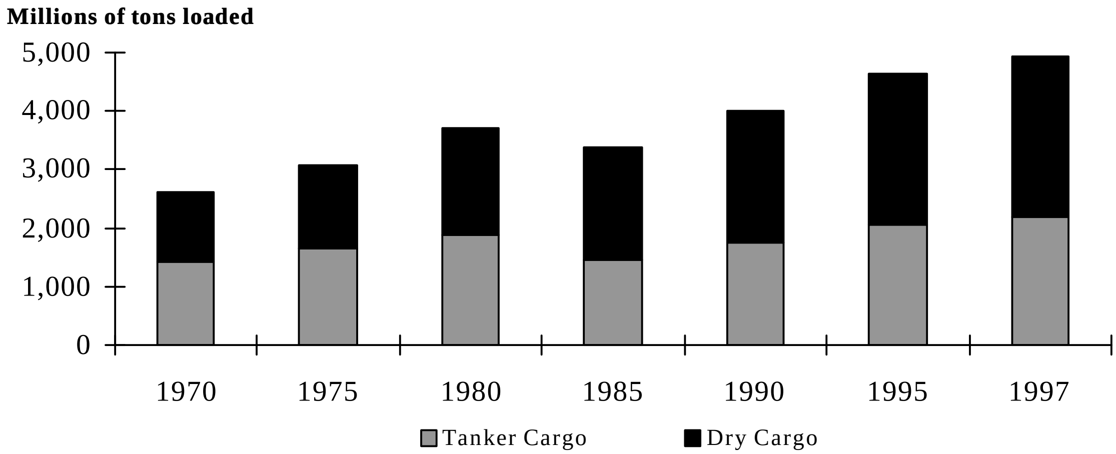
[58] A&P Appledore International Ltd, *U.S. Shipbuilding International Market Study* (National Shipbuilding Research Program, June 1995), 2.

Exhibit III.2
Ship Demolition and Newbuilding, 1991-1996
Millions of Deadweight Tons

	Sold for Demolition	Newbuilding Contracts	Excess of Newbuildings
1991	4.7	34.8	30.1
1992	19.0	22.0	3.0
1993	16.9	43.0	26.1
1994	20.8	42.1	21.3
1995	15.3	43.2	27.9
1996	18.1	37.4	19.3

Source: United Nations, *Review of Maritime Transport*, various issues

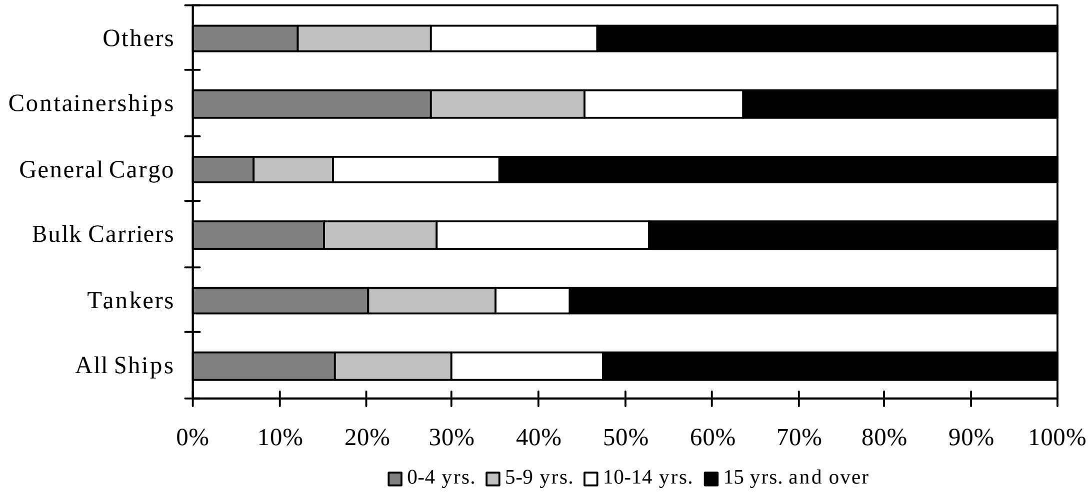
Exhibit III.3
International Seaborne Trade, Selected Years



Source: United Nations Conference on Trade and Development (UNCTAD), *Review of Maritime Transport 1997*

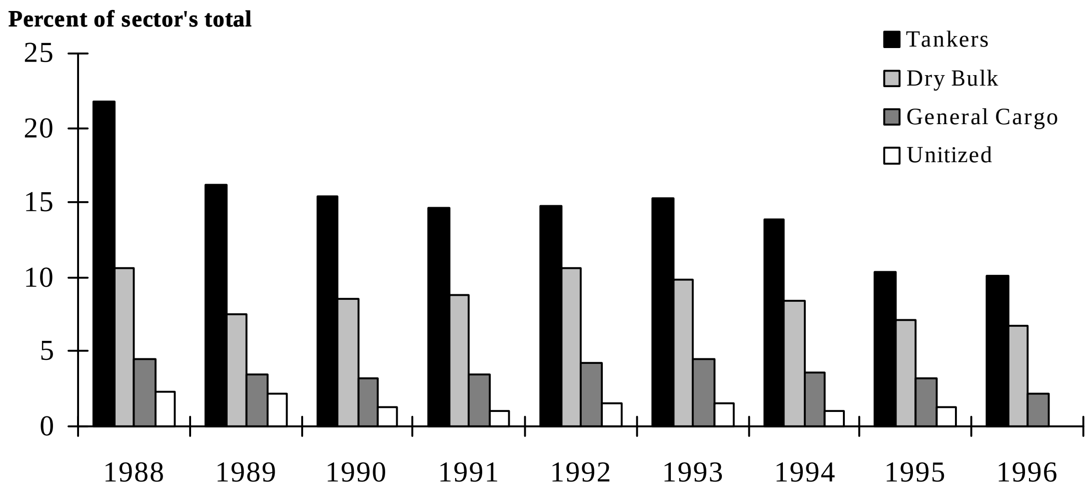
First, the two trends that have been driving the industry's recovery remain positive. A significant share of tonnage across broad array of categories will need to be scrapped during the next decade. In fact, as of yearend 1996, more than half the merchant fleet was at least fifteen years old. (See Exhibit III.4) Moreover, trade volumes are expected to rise almost 4 percent annually through 2006, with containerized cargo expanding at a 6.6 percent rate. The combination of scrapping and growing trade has reduced surplus fleet capacity substantially since 1988, and the continuation of this trend should produce higher demand and better pricing power for shipyards. (See Exhibit III.5)

Exhibit III.4
Age Distribution of the World Merchant Fleet, by Type of Vessel
Percentage of Total in Terms of Deadweight Tons as of Yearend 1996



Source: UNCTAD, *Review of Maritime Transport 1997*

Exhibit III.5
Trends in Surplus Capacity, by Main Vessel Type



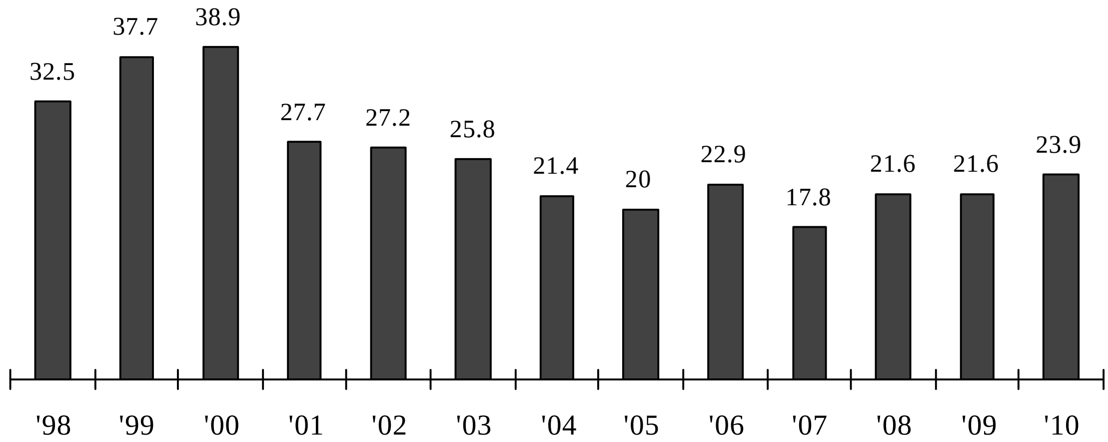
Source: UNCTAD, *Review of Maritime Transport 1997*

Demand for new tonnage during the next three years is forecast to be exceptionally high, continuing the steady rise of the past decade. Newbuilding orders are expected to peak in the year 2000, as the last of the tankers built during the early 1970s are replaced. However, the drop off in forecast demand is mostly due to declining demand for tankers. Orders for tankers, for which Japanese and Korean yards are the dominant suppliers, are expected to drop from 21 million dwt per year during 1998-2000 to 9 million dwt per year during 2001-2004. This fall accounts for two-thirds of the predicted drop in newbuilding demand. From 2001 to 2004, demand for ships other than tankers is expected to be 23.3 million dwt, 160 percent above demand for tankers.[59] In other words, a U.S. industry that is capable of producing vessels at

[59] Office of Ship Construction, U.S. Maritime Administration, *Outlook for the U.S. Shipbuilding and Repair Industry 1997* (Washington, DC: U.S. Department of Transportation, April 1997) 42-43.

attractive prices will have no shortage of demand for its product, at least though the middle of the next decade.

Exhibit III.6
World Newbuilding Demand, Projected Orders, 1998-2008
Millions of Deadweight Tons



Source: Drewry Shipping Consultants

Potential Threats on the Horizon
There are some troubling clouds dotting the horizon, however. First, freight rates do not appear to be rising as fast as expected. The economic trouble in Asia, as well a Korean overbuilding, has bred uncertainty and resulted in lower rates for use of certain vessels. For instance, by the end of 1997, freight rates for modern VLCCs had crashed from $50,000 per day to $23,000 per day within just a few months – a bad sign for tanker builders because weak rates discourage ship owners from placing orders.[60] Moreover, the Chinese government has made it know that it wants to increase the international profile of its merchant shipbuilding industry, which is already the world's third largest.

Another problem facing U.S. yards is that ship owners in many countries, especially in Asia, have a strong tendency toward domestic ordering. The U.S. Jones Act, which limits shore-to-shore U.S. traffic to U.S.-built vessels, legislates what appears to be an informal government policy or collusive business practice in foreign countries.[61]

The biggest danger to the long-term recovery of the global market for ships, however, is the continued subsidization of yards in just about all shipbuilding countries.

The Subsidy Question
The continued, large-scale subsidization of the shipbuilding industry worldwide distorts investment decisions and maintains capacity that would otherwise disappear. Without a significant reduction in subsidy levels, it is hard to envision the commercial shipbuilding industry becoming a normal, commercially contestable industry.

Subsidies have flowed to this industry throughout the postwar period. The industry has attracted government largess because it traditionally has been a major employer and closely entwined with

[60] Emily Redding, "Cautious Approach Hits Hoped-For Tanker Market Boom," *Lloyd's List International* (January 21, 1998) 3.
[61] The Jones Act, section 27 of the Merchant Marine Act of 1920, and several related laws, require that cargo transported by water between points in the United States be carried on U.S.-built, -owned, -crewed, and -registered ships.

national security. Thus, when demand dropped during the 1970s, governments were reluctant to allow market mechanisms to decide which yards would survive. Subsidies were seen as a way to minimize economic dislocation and to keep industries afloat until better times returned. In developing countries seeking to emulate the success of Japan, support for the shipbuilding industry became an essential part of industrial policies seeking to promote the development of heavy industry. Shipbuilding was a natural candidate because it employed many people and served as a growth driver by providing demand for the output of nascent steel industries.

Countries confer a variety of subsidies on their yards, including construction grants, favorable loans, export credits, restructuring aids, and even direct support through government ownership.[62] (see Appendix Exhibit A.1) Once in place, these subsidies are difficult to remove. Moreover, because subsidy regimes in many cases are not transparent, it is difficult to gauge their full impact on competitiveness.

Europe is an exception, due to an explicit policy of making its subsidies transparent. The European Union limits construction subsidies to 9 percent per year. The actual level of European subsidies is much higher, however. According to a study undertaken by the British government, maximum subsidy benefits reached 30 percent of the contract price in Spain, 29 percent in Denmark, 16 percent in the UK, and 14 percent in Germany, exclusive of aid for restructuring, which is substantial.[63]

Exhibit III.7
European Union Construction Subsidies to Shipbuilding in 1994
Percent of Contract Value of Ships

	Small Ships*	Large Ships*	Total
Belgium	0.0	4.3	4.3
Denmark	4.1	8.1	7.3
Germany	4.1	6.8	6.1
France	0.0	9.0	9.0
Spain	4.3	8.3	6.6
Greece	NA	NA	NA
Italy	3.8	9	8.2
Netherlands	3.7	4.5	3.8
Portugal	0.0	8.8	8.8
United Kingdom	4.5	0.9	1.1
EUR 10	4.1	7.7	6.6

*Small ships have a contract value less than ECU 10 million; large ships have a contract value greater than ECU 10 million.
Source: European Commission, *Fifth Survey on State Aid in the European Union in the Manufacturing and Certain Other Sectors.*

Governments have recognized that the global industry is damaged by subsidies, and since 1969 have tried to fashion multilateral agreements to limit subsidies, but to no avail.

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[62] Not every country provides every type of subsidy for a description of national subsidy regimes for shipbuilding. For a country-by-country listing of subsidies by type, see U.S. Maritime Administration, *Maritime Subsidies* (Washington, DC: Department of Transportation, September, 1993).
[63] Stephan Wagstyl, "Leaky Lifeboat of Subsidies: Help from Governments for Ailing Shipbuilders Has Failed to Create a Competitive Industry in Europe," *Financial Times* (22 February 1996), 21.

The experience of the United States during the 1980s underscores why governments have been reluctant to cut the subsidy lifeline. The United States eliminated the construction differential subsidy in 1981 – the last outlay was in 1988 – and was soon out of the commercial market. The U.S. commercial orderbook for oceangoing vessels (1,000 gt and over) plummeted. U.S. global market share, which was not high to begin with but nevertheless reached 9.5 percent in 1979, became infinitesimal, supported only by Jones Act Tonnage. The impact on U.S. employment of axing the CDS was mitigated by the explosion in naval orders throughout the decade.

Having done away with its construction differential subsidy, the United States took the logical next step: it sought to convince other major shipbuilding countries to do the same. In 1989, the United States launched the negotiations among countries of the Organization of Economic Cooperation and Development (OECD) that produced the 1994 "Agreement respecting normal competitive conditions in the commercial shipbuilding and repair industry," signed by governments representing about 80 percent of the world shipbuilding market.

The agreement sets parameters for future government direct and indirect assistance to shipbuilding. In particular, it prohibits direct subsidies, loans and guarantees on terms and conditions that do not reflect commercial realities, certain equity infusions, and certain assistance to suppliers. The agreement does permit certain types of official assistance, however, and restructuring efforts under way in several countries can continue but are not permanent. (See Appendix Exhibit A.2) The Agreement's 'Injurious Pricing Code' applies antidumping laws to shipbuilding for the first time. Unlike GATT discipline, the injurious pricing charge must be paid by the exporter, not the importer. The accord will not go into effect until the ratified all parties to the agreement.[64]

There are serious questions about the ability of the Agreement to limit subsidies and the dumping of ships. The British government study suggests that even if EU members abide by the agreement and eliminate construction subsidies altogether, yards in some European nations would still benefit from subsidies greater than ten percent. At any rate, the point is currently moot because the U.S. government has not yet ratified the agreement. Though the United States accounts for only about one percent of the commercial market, the European Commission used U.S. inaction as a pretext for extending its 9 percent subsidy cap through yearend 2000, a move that violates the spirit of the OECD accord. Moreover, with China bent on capturing ten percent of the global market by 2000 and other non-signatory developing countries seeking to develop their industries, one could make a strong argument that the OECD accord, like its predecessors, will fail to control subsidies in the global shipbuilding industry.

In sum, the positive trends on the demand side could be overwhelmed by subsidies and industrial policies that breed excess capacity. In fact, a recent OECD workshop concluded that adverse trends could lead to excess capacity levels of 40 percent by 2005. In view of the already massive capacity reductions that have occurred since the mid-1970s and the untold amounts of taxpayer funds that have been poured into the shipbuilding industry, another period of crisis in the industry would be a tragic example of snatching defeat from the jaws of victory.

[64] See Organization for Economic Cooperation and Development, "Agreement Respecting Normal Competitive Conditions in the Commercial Shipbuilding and Repair Industry," (Paris: OECD, 21 December 1994); and Wilhelm Kurth, "An Agreement on Shipbuilding," *The OECD Observer* No. 192, February/March 1995, 44-46.

Chapter IV. The Trend toward Less Government Involvement and More Rationale Investment Patterns

Whereas the potential productivity gains and the growing market for merchant vessels seems to justify a continuation of U.S. efforts, such as Maritech, to improve U.S. competitiveness, the potential for yet another capacity crisis during the middle of the next decade urges caution.

The overcapacity situation can become a reality only if countries continue their large scale subsidies and market distorting industrial policies. Fortunately, the mid-term outlook in both these areas is for a reduction in market-distorting activities.

Industrial Policies – A Downside Revealed

In the 1950s, Japanese government adopted a form of economic development that relied more on bureaucratic discretion and less on free markets than the U.S. economy. This model helped produce the world's second largest economy, and a series of industrial powerhouses that excelled in the production products ranging from semiconductors to cars to consumer electronics.[65]

Japan's success spawned many imitators in Asia. Though these countries by no means became economic clones of Japan, their governments did adopt certain features of the Japanese economy such as targeting particular industries, promoting selected exports, and protecting domestic industry. They also came to rely on debt rather than equity and relation-driven finance not capital markets.[66] The countries that embraced Japan's model for decades looked as if they would match Japan's success.

Yet during the 1990s, signs emerged that the Japanese model was collapsing under the weight of its own success. In Japan, years of poor lending practices during the bubble economy of the 1980s finally caught up to the banking system, revealing $600 billion in non-performing loans. Other Asian countries, which had been investing more than one-third of their GDP, found themselves burdened by excess capacity that undercut the their exports prices and spooked their foreign lenders. The result has been prolonged stagnation in Japan and financial crises in Korea and Southeast Asia that have almost certainly caused regional actors to re-think growth strategies that rely on unconstrained investment. Though companies and governments in the region are unlikely to junk a system that produced decades of rapid growth and rising living standards, they are likely to be more careful in the future.

Perhaps more importantly, the Asian crisis presents an opportunity to rationalize capacity in the region, particularly in Korea, perhaps the most reckless investor in shipbuilding capacity. In December 1997, as the Korean economy came dangerously close to default, Halla Shipbuilding and Halla Heavy Industries, members of one of Korea's largest business conglomerates, collapsed due to high debt levels accumulated during the recent capacity build-up. Two medium sized yards and fifty other manufacturing companies associated with marine and shipbuilding equipment also failed.[67]

[65] See, for example, Clyde V. Prestowitz, Jr., *Trading Places – How We Allowed Japan to Take the Lead* (New York: Basic Books, 1988).
[66] "Emerging from Crisis: The Beginnings of a New Asia," Prepared Remarks of Lawrence H. Summers, Deputy Secretary of the Treasury, at the Economic Strategy Institute, February 11, 1998.
[67] "Keeping the Maritime Sector Afloat," *Lloyd's List International* (6 January 1998), 2.

This bankruptcy was not Korea's first high profile marine bankruptcy. In 1989, the shipbuilding arm of the Daewoo conglomerate nearly collapsed for the same reason, and had to be rescued by the government. In order to prevent excessive investment in the industry, Seoul went to the extreme step of prohibiting capacity expansion until 1993. Once the ban was lifted, the Korean industry went on an investing binge that almost doubled its newbuilding capacity.

The Halla bankruptcy could benefit the global industry if it leads to capacity reduction. Shipbuilders in Europe and Japan are pressuring their government to ensure that none of the IMF bailout funds goes toward keeping the excess capacity of bankrupt firms alive.[68] If no extraordinary help is forthcoming, the Halla yards will at some point have to halt operations (the company is currently operating under court receivership status).[69] Another possibility is for a foreign or domestic shipbuilder to replace its older capacity with newer yards purchased from Halla. Either outcome would result in a net loss of global capacity.

The Halla debacle, and the region's financial crisis, appears to have had an impact on the country routinely considered to be Asia's next great shipbuilding nation, China. In 1996, China announced plans to double its shipbuilding capacity by 2000. Though China has not renounced its plans, the weakness of Japanese and Korean currencies is hampering China's goal. Though 1997 was a record year in terms of output for the industry, new orders declined from 1996 levels. To cope, the government run China State Shipbuilding Corporation (COSCO) announced in January that it would slash its workforce by 90,000 during the next three years and reorganize its operation.[70] Though this move does not doom China's goal of doubling capacity by 2000, it does indicate that China's industry is becoming more bottom-line-oriented and, therefore, less likely to engage in reckless expansion.

Subsidies – Going Down, but not Away

COSCO's decision to reduce employment levels by one-third points to another trend in the industry that promises to facilitate capacity reduction -- falling subsidies. As discussed earlier, high employment levels in the ship building industry have been a driving force behind governments' efforts to subsidize their shipping industries. The large reduction in yard employment that began in the mid-1970s -- employment in European yards fell from 460,000 in 1975 to 120,000, while employment at U.S. yards fell from 179,000 in 1981, the year the CDS program was eliminated, to 92,000 – have made the calls for support less potent than they once were.

Moreover, the industry's current focus on raising productivity portends continued shrinkage of the shipbuilding workforce. The lavishly subsidized yards of Europe are focusing on raising their productivity. Because the global market for vessels will not grow to accommodate the yards' ability to produce more ships, greater efficiencies will eventually translate into higher market shares for successful yards, but also lead to some consolidation of yards and employment adjustments. This trend should smooth the road for subsidy reductions in the European Union.

[68] "Japan Shipbuilders Look to Block IMF Aid to Korean Rivals," Dow Jones News Service (18 February 1998).
[69] As part of negotiations to join the OECD, the Korean government assured European members that it would not rescue Korean yards that experienced financial difficulties due to reckless capacity expansion. See Europe Information Service, *Shipbuilding/European Policy-Industry Report* (The Investext Group, 1997), 11.
[70] "State Shipbuilders to Axe Nearly a Third of Workforce over the Next Three Years," *Lloyd's List International* (21 January 1998), 1.

Other forces are nudging governments toward reducing subsidies. The OECD agreement on shipbuilding has been criticized for allowing many subsidies to persist. Though this criticism is not unfounded, the accord does represent a commitment by governments of the most of the world's major shipbuilding countries to eliminate construction subsidies. In the European Union, this commitment translates into a 7 percent point reduction in subsidies. True, the E.U. subsidy level after the agreement goes into effect will still be high, but a major advantage of European yards will be eliminated. In addition, the elimination of construction subsidies should produce further consolidation among Europe's 103 yards, easing the global capacity overhang.

High European subsidies will remain a problem during the next several years --in 1997, the European Commission announced that the current subsidy regime will continue for three more years. Yet evidence is growing that its high subsidy regime is coming under pressure. Certain E.U. countries that rely less on subsidies have been complaining about the high level of subsidies provided by the governments of Germany and southern Europe.[71] Moreover, the E.U.'s reluctance to abandon its high subsidies is explained in part by its slow growing economy and high unemployment. Any pickup in economic growth and job creation should lead to a greater willingness on the part of European governments to reduce its massive financial support of shipbuilders.

In summary, recent developments portend that conditions are right for alleviating two scourges of the shipbuilding industry: the creation of overcapacity due to reckless investment, primarily in Asia, and the preservation of excess capacity through subsidies. These trends offer the best chance for the merchant vessel industry to become a commercially viable, stand alone industry that does not require expensive government handouts. The U.S. government should do everything in its power to ensure these trends continue.

[71] "Living with South Korea and Subsidies," Financial Times (20 December 1995), 6; Hilary Barnes and Judy Dempsey, "Denmark Seeks Curb on State Aid to Germany's Shipyards," *Financial Times* (6 February 1996), 3; and "Dutch Resent Delay on Shipyard Subsidy Ruling," Lloyd's List International (18 February 1998), 3.

Chapter V. Economic Impact of a Successful Commercial Shipbuilding Industry

The information presented thus far implies that conditions are right for the modest efforts underway to produce a U.S. shipbuilding industry that can compete in the global commercial market. This chapter looks at the potential gains to the U.S. economy from the productivity enhancing efforts now underway, and discusses the costs of doing nothing.

The Employment Picture

According to the *Annual Survey of Manufacturers* for 1996, the U.S. shipbuilding and repair industry (SIC3731) employs 92,400 people, about half as much as employed by the U.S. semiconductor industry (SIC 3674). Thus, U.S. yards employ about 0.5 percent of the U.S. manufacturing workforce.

The 17 yards that make up the U.S. major shipbuilding base employ about 65 percent of the shipbuilding workforce. The remaining workers are employed at more than 500 other establishments, including so-called second and third tier yards, that construct, repair, and otherwise service smaller vessels that travel along the coast and inland waterways.

Though the shipbuilding industry is not a major national employer, it is a major employer in the states and counties where yards exist. For example, according Bureau of Census data from 1995, the latest date for which state and local data are available, the industry employs 13.8 percent of manufacturing employees in Orleans Parish County, Louisiana, and 6.9 percent of all manufacturing employees in the entire state. The industry is an important employer in other states and counties as well. (see See Exhibit V.1)

Exhibit V.1
Shipbuilding and Repair Employees
As a Share of Manufacturing Employees, 1995

	Shipbuilding Share
San Diego County	5.1%
Orleans Parish County	13.8%
Lousiana	6.9%
Alabama	5.0%
Mississippi*	4.0-10.0%
Virginia	5.8%
Memorandum:	
United States	0.5%

* Due to disclosure rules, the Census Bureau only reports a range of values for people emplyeed by SIC 3731 in Mississippi.
Source: Bureau of the Census

With naval procurement down from an average of 19 vessels annually in the 1980s to 5.7 vessels between now and 2003, the areas shown above could be hard hit if U.S. yards are not able to make any headway in the market for commercial vessels. A leaked draft of a Pentagon study acknowledged that there is currently not enough work to keep the six major private yards busy, and that consolidation might be necessary.[72] In a potential sign of things to come, Newport News

[72] David Lerman, "Navy Disappointed in Virginia Shipyard's Withdrawal from Commercial Work," KRTBN Knight-Ridder Tribune Business News (20 March 1998).

Shipbuilding, the nation's largest yard and major naval supplier that is exiting the commercial market, will lay off at least 400 workers from its commercial operations that had already reduced employment by 500.[73] Though Newport News claims its naval contracts will keep its capacity busy and potentially lead to more hiring in the future, the Pentagon study suggests that it does not have enough nuclear submarine orders in the pipeline to support the sub manufacturing arms of both Newport News and its major competitor, Electric Boat of Connecticut. Clearly, without some success in the commercial arena, dwindling naval orders could lead to severe decline in the shipbuilding workforce, with adverse consequences to certain state economies as well as national security.

But it would be a mistake to think that these employment losses would stop at yard's end. Lower output would also reduce employment in the industries that supply inputs to the shipbuilding and repair industry. The direct and indirect job losses would lead to declining incomes and, thus, less spending on local goods and services.

The industry has already shed more than 85,000 workers during the past 16 years. Productivity increases alone would probably reduce employment steadily during the next decade. Add to this picture declining naval orders and a failure to reenter the commercial market, and the prospects for shipbuilding employment look bleak indeed. Commercial success, on the other hand, would minimize unemployment, enrich surrounding economies, and preserve enough of an industry to service the Navy's needs.

Economic Impact

The economic impact of any industry is determined by the change of output, income, and employment of an economy that results from final demand of that industry. Typically, there are three levels of economic effects that are measured: the *direct effect* refers to the impact on an industry caused by an autonomous change in demand for that industry's products; the *indirect effect* refers to the impact that such a change in final demand has on all sectors of the economy due to the interrelationships among different economic sectors; and the *induced effect* refers to the increase in spending that results from the expansion of personal income which typically accompanies a rise in output.

This section makes use of Bureau of Economic Analysis' recently released input-output tables for 1992 to estimate the direct and indirect impact of an autonomous $5 billion increase in final demand for U.S.-built merchant vessels.[74] It also uses multipliers derived from a 1979 MARAD study to derive induced impacts on the economy as a whole.

According to the 1992 input-output tables, the total requirements multiplier for the shipbuilding and repair industry is 1.74. That is, for every dollar of final demand for this industry in 1992, nearly $1.74 worth of direct plus indirect outputs were generated throughout all U.S. industries. This relationship implies that an additional $5 billion in final demand for U.S.-built ships would produce an additional $8.7 billion in direct and indirect output throughout the U.S. economy. The exhibit below shows some of the industries that would benefit most from a more vibrant

[73] Mark Yost, "Newport News Sees Navy Work Offsetting Commercial Job Cuts," Dow Jones News Wires (March 16, 1998).

[74] For a description of the 1992 I-O accounts and summary tables with industry data at the 4-digit industry level, see Ann M. Lawson, "Benchmark Input-Output Accounts for the U.S. Economy, 1992, *Survey of Current Business* (November and December, 1997). The calculations in this report made use of the 6-digit industry by commodity total requirements data available from the Bureau of Economic Analysis.

shipbuilding industry. Included are the steel, turbine engine, and machinery industries. A complete industry breakdown can be found in Appendix Exhibit A.3.

Exhibit V.2
Estimated Increase in Output of Select Industries Resulting from a $5 Billion Increase in Demand for U.S. Merchant Vessels--Direct and Indirect Impacts

Industry	$ Thousand
Primary iron and steel manufacturing	403,692
Electrical industrial equipment and apparatus	207,844
Other business and professional services, except medical	207,362
Heating, plumbing, and fabricated structural metal products	177,277
General industrial machinery and equipment	164,259
Primary nonferrous metals manufacturing	129,258
Other Fabricated metal products	119,039
Engines and turbines	98,083
Electric services	86,969
Miscellaneous machinery, except electrical	69,641

Source: Bureau of Economic Analysis, 1992 Industry-by-Commodity Total Requirement Table

A direct, indirect, and induced impact multiplier was estimated by adjusting the MARAD study's direct, indirect, and induced impact multiplier (4.701) to reflect the lower shipbuilding direct and indirect output multiplier from the 1992 input-output table.[75] The resulting multiplier suggests that the total economic impact of an additional $5 billion in demand for U.S.-made merchant vessels would lead to an additional $20.7 billion in additional economic activity.

Budgetary Impact

Though the federal budget deficit has all but disappeared, there are likely to be some members of Congress who oppose the continuation of modest Maritech outlays on account of its budgetary impact. However, even a cursory examination of the budgetary impact of such programs shows conclusively that a small increase in shipbuilding competitiveness would offset the modest budgetary outlays resulting from the program.

The program calls for $220 million in project funding over a five-year period, which is matched by an additional $220 million in private-sector funds. These budgetary outlays are extremely small, especially when compared to the hundreds of millions of dollars spent annually on the CDS program.

The budgetary impact of these funds depends on two variables: the success of Maritech in facilitating to commercial sales and reductions in the cost of naval ships due to spin-on efficiencies gained from competing in the commercial market.

Maritech appears to have had a major impact on inroads made recently by U.S. shipbuilders in the commercial market. As of April, there were 21 commercial ships on U.S. orderbooks, each of which were developed under Maritech, with a total contract value of approximately $1 billion.

The budgetary impact of these sales is derived in the table below. The $1 billion in sales, using to the output multiplier from the 1992 I-O table discussed above, generates about $1.74 billion in direct and indirect economic activity. Assuming a 14 percent import share and a 47 percent

[75] The MARAD direct and indirect output multiplier was 1.974, 13.4 percent higher than the multiplier calculated by the Bureau of Economic Analysis based on the 1992 I-O tables. For simplicity's sake, the MARAD study's direct, indirect, and induced multiplier was adjusted by multiplying it by the MARAD direct and indirect multiplier, and dividing the product by the 1992 direct and indirect multiplier.

value-added share of output yields an additional $0.7 billion in GDP. A tax-revenue share of GDP of 25 percent produces $0.18 billion in additional tax revenue. In other words, the direct and indirect activity that will result from just one-year of Maritech-induced orders should produce enough tax revenue to pay for nearly the whole five-year program! In reality, collected taxes would be much higher because the income generated by the direct and indirect activity would be spent and saved, leading to additional activity and, thus, tax revenue.

Exhibit V.3
Estimating the Budgetary Impact of Increased Shipbuilding Activity
Direct and Indirect Effects

Shipbuilding Sales		Output Multiplier		Direct and Indirect Economic Activity
$ 1.0 billion	x	1.74	=	$ 1.74 billion

Direct and Indirect Economic Activity		Domestic Share		Domestic Economic Activity
$ 1.74 billion	x	86%	=	$ 1.50 billion

Domestic Economic Activity		Value-Added Share of Output		Additional GDP
$ 1.50 billion	x	47%	=	$ 0.70 billion

Additional GDP		Tax Revenue Share		**Additional Tax Revenue**
$ 0.70 billion	x	25%	=	**$ 0.18 billion**

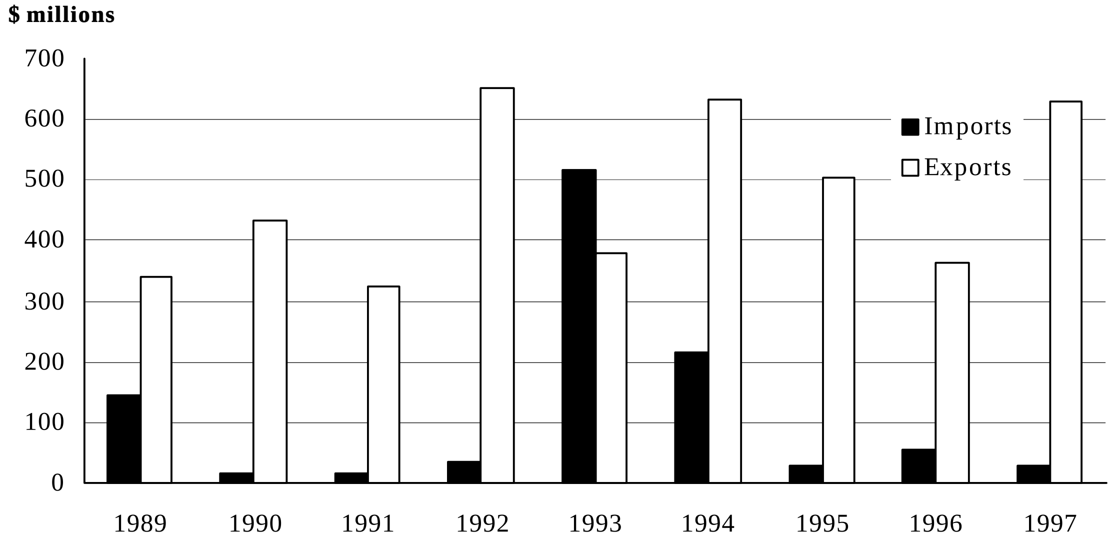
Source: ESI Estimates

The Maritech program should also affect the spending side of the ledger by leading to saving on future naval purchases. Though it is too soon to conclude definitively that experience and knowledge acquired from commercial efforts have been translated into lower priced naval vessels, anecdotal evidence is encouraging. In interviews given prior to its withdrawal from the commercial market, Newport News officials asserted that despite their commercial losses, they had learned much from their venture that could be applied to the construction of naval vessels. And, as mentioned earlier, certain indicators of future productivity growth, such as capital investment, are already rising.

Trade impact

Ironically, given its lack of competitiveness, the shipbuilding and repair industry typically runs a trade surplus. (see Exhibit V.4) In 1997, for instance, the surplus reached $600 million. The United States was completely out of the export market for larger vessels, indicating that repair activities generated the bulk of these exports. For most years, imports have been minimal, in large measure due to the Jones Act's prohibition of imports to serve inland and coastal trade.

Exhibit V.4
U.S. Trade in Shipbuilding and Repair (SIC 3731), 1989-1997



Source: Bureau of the Census

Commercial success, if it occurs, will produce rising exports of merchant vessels to a host of different countries. Export volumes will probably rise to countries outside of Asia, because the region's major builders, Japan and especially Korea, have a tendency to purchase from home builders.[76] Early indicators are that Chinese vessel owners, on the other hand, are willing to buy from non-Chinese builders, but the government's policy of doubling its global market share may result in pressure to "buy Chinese."[77]

How much export volumes rise depends on the level of U.S. commercial success, but a reasonable expectation would be doubling or even tripling of current export volumes. Given the currently large U.S. trade deficit, and the fact that the Asian crisis will increase imports from Asia and reduce U.S. exports to the region, an increasing surplus in the shipbuilding industry could serve to mitigate the size of the overall deficit during the next several years. However, this impact will initially be muted by the need to import certain marine outfitting equipment that is no longer built in this country.

The Costs of Doing Nothing

The costs of doing nothing, though not fatal to the industry, are still substantial. The current level of naval orders can only support about two or three of the six largest U.S. yards. If half of the major yards close down, industry employment could be reduced by 20,000 to 30,000 workers. As noted, employment in the industry is fairly concentrated; thus, whole communities would suffer, not withstanding the relatively buoyant state of the national economy. Employers in supplier industries would also suffer.

The cost in terms of national security would also be substantial. The navy of the world's foremost maritime power would lose the chance to benefit from both potentially useful commercial

[76] See, for example, Europe Information Service, *Shipbuilding/European Policy – Industry Report* (1 October 1997), 3-4.
[77] David Hughes, "China's Shipbuilding Ambitions and Korean Yards' Problems," *Shipping Times* (22 January 1998).

developments and the lower costs that commercially competitive industry could provide. Worse, the Navy would lack the facilities and healthy industrial base necessary to conduct a major build-up, if one is required.

The country as a whole would have to forgo the economic benefits that a vibrant industry would bring. The United States has the engineering talent, the technological capacity, and the skilled labor necessary to succeed in this industry. It is already a global player in the two other major transportation industries, automobiles and aircraft. A concerted industry effort to raise competitiveness should bear fruit, though obviously not for every company. As discussed earlier in this chapter, the benefits of even modest commercial success are significant.

Finally, a failure to make it in the global market or, more accurately, the failure to even try, would signal to foreign governments that industrial policies and ridiculously high subsidies, if conducted over a long enough period of time, can succeed in driving the United States out of an industry, even if that industry is important to national security. The United States did not pursue such a course when foreign dumping threatened to put its semiconductor industry out of business during the 1980s, and it should not pursue that course now.

Chapter VI. Conclusions

Based on a top-down analysis of the U.S. shipbuilding industry and the global environment in which it operates, this report has argued for the continuation of Maritech and other limited efforts aimed at improving the commercial competitiveness of major U.S. yards. To summarize:

1) Low productivity of U.S. yards, trade-distorting government policies carried out on a global scale, and the end of the construction differential subsidy in the United States forced U.S. shipbuilders to exit the commercial market for large, oceangoing vessels in the 1980s.

2) It follows logically that for unsubsidized U.S. yards to succeed in the global market, the conditions that compelled them to exit would have to be reversed. In particular, the excess capacity in the market and intrusive foreign government policies must be reduced and U.S. productivity must rise. This study has documented that such changes are under way.

3) The chronic gap between the supply of, and demand for, ships is narrowing. An aging fleet, the expected long-term rise in seaborne trade, and declining surplus capacity suggest healthy demand for many vessel categories through 2010.

4) Current trends suggest that many of the foreign government policies that produced a global epidemic of excess capacity are beginning to change.

   - In Europe, the combination of a declining yard employment, rising productivity, and consolidation are beginning to erode political support for large subsidies to sustain excess capacity.
   - The economic turmoil in Asia is forcing companies and governments in the region to become more bottom-line oriented, and less inclined to pursue reckless capacity expansion in shipbuilding and other industries.
   - OECD countries have fashioned an agreement that would reduce subsidies from their current levels. Though critics of the accord rightly point out that subsidies will be possible even after the agreement goes into effect, it is clear that the rate of subsidy will be much lower than it is now.

5) Thus, the global shipbuilding industry is on track to becoming a commercially viable, stand-alone industry that does not require expensive government handouts. Under these conditions, it makes sense for U.S. yards to begin devoting a greater share of their resources to penetrating the global market.

6) In order to succeed in global markets, the U.S. industry must overcome the substantial productivity advantage of the many foreign yards that did not exit the commercial market. Studies suggest that U.S. productivity levels are below those of Japanese, European, and even Korean yards, and that catching up will require a prolonged period of rapid productivity growth.

7) ESI's analysis of other U.S. industries at the three-digit SIC level indicates that the required level of productivity increase is attainable. For instance, the U.S. semiconductor and automobile industries expanded productivity 15 percent per year, on average, for eight consecutive years.

8) After stagnating during much of the 1980s, U.S. shipbuilding productivity is rising once again. The ongoing Maritech program and other federal efforts are likely behind this revival, but, given the comprehensive nature of the needed improvements, the initial five-year window provided by the National Shipbuilding and Shipyard Conversion Act is insufficient. Under the circumstances, it seems that Maritech deserves another five-years.

9) The U.S. economy would benefit substantially if the U.S. shipbuilding industry regains its competitiveness and becomes a greater force in international markets. ESI's analysis implies that a $5 billion increase in demand for U.S. merchant vessels would lead to an additional $20.7 billion in economic activity. Further analysis suggests that the additional $1 billion added to U.S. orderbooks by Maritech-related projects will produce enough tax revenue to pay for the whole five-year program.

10) The costs of having an noncompetitive industry would also be substantial. Absent a greater international presence, reduced naval orders would force a further contraction of the shipbuilding industrial base. Because shipyards are major employers in their communities and support many jobs indirectly, the failure to expand into commercial markets would have sizable human costs as well.

A Final Word

This study's endorsement of federal efforts to revitalize the commercial competitiveness of the U.S. shipbuilding industry is not meant to support a prolonged and heavy-handed federal involvement. As the experiences of countries in Asia and Europe have shown, sustained efforts to override free markets can be extremely costly.

Fortunately, Maritech and other federal programs are relatively modest compared to government efforts in other countries. Nonetheless, these U.S. programs should be reviewed periodically to ensure that they are fulfilling their mandates, and to determine what works and what does not. If the U.S. industry does benefit from a sustained rise in productivity and becomes internationally competitive, these programs should be scaled back, eliminated, or redirected. If the expected increases in productivity and competitiveness do not materialize within a reasonable period of time, the U.S. government may have to reconsider its strategy.

In the end, the success of U.S. yards in cracking international markets will depend on individual companies, not the government. But at this time, in this industry, and in view of the massive distortions that have plagued the global shipbuilding industry for decades, current U.S. government involvement is appropriate and likely necessary for commercial success.

Appendix

Exhibit A.1
Common Types of Shipbuilding Subsidies

Construction Grants - Government grants used for conversion and new construction.

Restructuring Aids - Direct aid for the restructuring of shipyards and associated social costs.

Financing Programs - Favorable loans varying in requirements and restrictions granted to nationals and/or non-nationals by private and public institutions.

Scrap and Build Aids - Government interest subsidy promoting the development of the ship-breaking industry.

Export Aids - Export credits through favorable subsidies and insurance

Tax Benefits - Deferments and exclusions for shipbuilding varying in type and terms.

Customs Duty, Levies, and Restrictions - Materials used for shipbuilding are exempt from customs duty.

Cabotage Trade Support - Favorable tariffs, loans, tax exemptions, construction benefits, and customs allowance for cabotage trades.

Research and Developmental Aids - Government funded research and development in shipbuilding, ship yard modernization, and maritime projects.

Other Aids - Government ownership, governments requiring nationally flagged vessels be built, repaired, and serviced domestically, and government funded retraining for displaced shipyard workers.

Source: Maritime Administration, *Maritime Subsidies*

Exhibit A.2
OECD Shipbuilding Agreement
Prohibited and Permissible Official Support

Prohibited Official Support	Permissible Official Support
Export Subsidies -Officially supported export credits inconsistent with the OECD's Understanding on Export Credits for Ships -Subsidies contingent on export performance	**Export Subsidies** -Officially supported export credits consistent with the OECD's Understanding on Export Credits for Ships
Direct Domestic Support -Grants -Loans on terms and conditions more favorable than those of a more comparable commercial loan available on the market -Guarantees that support commercial loans at terms and conditions more favorable than those available on the market without the government guarantee -Forgiveness of debts -Provision of equity capital inconsistent with normal investment practice -Provision of below market-value and services -Tax policies and practices benefiting the shipbuilding and repair industry	**Direct Domestic Support** -Assistance to cover the cost of measures that benefit workers who permanently lose their jobs due to firm closure, bankruptcy, or shift away from shipyard activities
Indirect Domestic Support (via a third party) -Grants -Loans and guarantees, on terms and conditions described above, and including home credits linked to the contract value of a new vessel -Tax policies and practices benefiting the shipbuilding and repair industry -Forgiveness of debts -Any assistance provided to suppliers of the shipbuilding and repair industry which ultimately benefits the industry	
Research and Development -Assistance for basic industrial research greater than 50 percent of eligible costs -Assistance for applied research greater than 35 percent of eligible costs -Assistance for development greater than 25 percent of eligible costs	**Research and Development** -Assistance for fundamental research -Assistance for basic industrial research up to 50 percent of eligible costs -Assistance for applied research up to 35percent of eligible costs -Assistance for development up to 25 percent of eligible costs -Aid intensity can be 25 percentage points higher for safety and environmental related R&D

Source: OECD, "Agreement Respecting Normal Competitive Conditions in Commercial Shipbuilding and Repair Industry"

Exhibit A.3
Direct and Indirect Activity, by Industry, Required to Provide $5 billion of Shipbuilding and Repair (SIC 3731) Output

Industry	Thousands of Dollars
Livestock and livestock products	2,740
Other agricultural products	5,132
Forestry and fishery products	2,822
Agricultural, forestry, and fishery services	6,089
Metallic ores mining	27,130
Coal Mining	21,567
Crude petroleum and natural gas	54,717
Nonmetallic minerals mining	4,308
Maintenance and repair construction	55,761
Ordnance and accessories	796
Food and kindred products	12,241
Tobacco products	8
Broad and narrow fabrics, yarn and thread mills	7,443
Miscellaneous textile goods and floor coverings	3,461
Apparel	1,520
Miscellaneous fabricated textile products	15,891
Lumber and wood products	38,964
Furniture and fixtures	4,973
Paper and allied products	19,682
Paperboard containers and boxes	10,265
Newspapers and periodicals	12,348
Other printing and publishing	23,017
Industrial and other chemicals	49,013
Agricultural fertilizers and chemicals	2,354
Plastics and Synthetic materials	18,855
Drugs	423
Cleaning and toilet preparations	1,959
Paints and allied products	34,320
Petroleum refining and related products	45,398
Rubber and miscellaneous plastic products	42,882
Footwear, leather, and leather products	750
Glass and Glass products	2,826
Stone and clay products	22,052
Primary iron and steel manufacturing	403,692
Primary nonferrous metals manufacturing	129,258
Metal containers	2,375

Exhibit A.3
Direct and Indirect Activity, by Industry, Required to Provide $5 billion of Shipbuilding and Repair (SIC 3731) Output
Continued

Industry	Thousands of Dollars
Heating, plumbing, and fabricated structural metal products	177,277
Screw machine products and stampings	40,968
Other Fabricated metal products	119,039
Engines and turbines	98,083
Farm, construction, and mining materials	22,800
Materials handling machinery and equipment	2,346
Metalworking machinery and equipment	27,196
Special industry machinery and equipment	2,693
General industrial machinery and equipment	164,259
Miscellaneous machinery, except electrical	69,641
Computer and office equipment	10,917
Service industry machinery	9,950
Electrical industrial equipment and apparatus	207,844
Household appliances	1,742
Electric lighting and wiring equipment	7,954
Audio, video, and communication equipment	10,692
Electronic components and accessories	39,759
Miscellaneous electrical machinery and supplies	33,902
Motor vehicles	604
Truck and bus bodies, trailers, and motor vehicle parts	19,038
Aircraft and parts	25,619
Shipbuilding and repairing	4,974,068
Other transportation equipment	22,858
Scientific and controlling instruments	20,599
Opthamalic and photographic equipment	3,729
Miscellaneous manufacturing	3,322
Railroads and related services; passenger ground transportation	28,434
Motor freight transportation and warehousing	113,405
Water transportation	7,483
Air transportation	41,615
Pipelines, freight forwarders, and related services	12,844
Communications, except radio and TV	38,598
Radio and TV broadcasting	8,254
Electric services	86,969
Gas production and distribution	37,698
Water and sanitary services	9,433
Wholesale trade	366,577
Retail trade	7,808

Exhibit A.3
Direct and Indirect Activity, by Industry, Required to Provide $5 billion of Shipbuilding and Repair (SIC 3731) Output
Continued

Industry	Thousands of Dollars
Finance	87,569
Insurance	18,997
Real estate and royalties	165,641
Hotels and lodging places	26,491
Personal and repair services	12,316
Computer and data processing services	20,064
Legal, engineering, accounting and related services	72,538
Other business and professional sevices, except medical	207,362
Advertising	8,980
Eating and drinking places	35,632
Automotive repair and services	27,936
Amusements	8,891
Health services	136
Educational and social services, and membership organizations	8,553
Federal government enterprises	15,001
State and local government enterprises	22,010
Grand Total	**8,701,143**

Source: Bureau of the Census 1992 Industry-by-Commodity Total Requirement Table, authors' calculations

Exhibit A.4
Glossary of Maritime Terms

Bulk Carrier/Bulker/Dry Bulk/Dry Bulkers **-** All these references denote vessels that range in size from small coastal craft to ships of over 150,00 deadweight capacity which are designed for the carriage of bulk commodities, like grain, ores, or fertilizers.

Compensated Gross Tons (cgt) **-** This unit of measurement was developed for the purpose of measuring the level of shipbuilding output, as output measured in dwt or gt could be misleading because some ships have a much higher work content per gross ton than others. For example, a passenger ferry of 5,000 gt may involve the shipbuilder in as much work as a bulk carrier of 15,000 gt. To overcome this problem the new standard cgt was established. The ctg of a vessel is calculated by multiplying its gt by a conversion factor for that ship type, which is differentiated by ship size. The factors were agreed by OECD members. In the case of tankers these factors range between 1.15 for a vessel of 10,000 gt and 0.30 for a vessel of 250,000 gt. Similar factor variations apply to other vessel categories.

Container Ships **-** Vessels designed to carry full loads of containers in fixed cell guides. Containers are frequently carried on deck where they required to be lashed and secured. The carrying capacity of these ships is specified in TEU, and may range from 300 to 500 for feederships to 4500 TEU for the most modern deep-sea linehaul units.

Deadweight Tonnage (dwt) **-** The weight of cargo, water, bunkers, and constant-weight (a fixed allowance for stores, spare parts, and the crew's effects) that may be carried when a vessel is down to its load-line mark. Since the load line varies, depending whether the ship is in a winter, summer, or tropical zone, it is important to specify to which condition the figure applies, although it is normal practice to utilize summer deadweight when describing deadweight tonnage.

General Cargo Ships **-** Most vessels under this category in today's market are tweendeckers, i.e. ships with two or more decks because of the number of ports served and the range of products carried. With the main engine located in the aft and thus avoiding the necessity of a shaft tunnel, the cargo spaces tend to be box shaped to assist the stowing of containers, boxed and palletized cargo, whilst on deck most designs allow for storage of containers. This vessel category is the most versatile in the merchant fleet as individual units can also carry bulk cargo.

Gross Tonnage (gt) **-** The total of all the enclosed spaces within a ship, expressed in tons, each basis unit of which equals 100 cubic feet (2.831 cu. m).

Light Displacement Tonnage (ldt) **-** The actual weight of an empty ship. It is this particular tonnage figure that is used by sale and purchase brokers when negotiating the disposal of a vessel for demolition.

Tankers (Oil and Product) **-** These vessels are principally involved in the carriage of crude oil and its derivatives. The oil tanker category essentially comprises three types: (1) the Ultra Large Crude Carriers (ULCCs) which are used in long hauls; (2) the Vary Large Crude Carriers which are used on the same routes as the ULCCs but with greater flexibilities in discharging port options, owing to their size; (3) the medium size Crude Carriers of 70,000 to 130,000 tons deadweight are mainly used on short hauls from Mediterranean, West African, Indonesian, and North Sea loading terminals to major nearby consuming areas. Product tankers with 26,000 to 40,000 tons deadweight are used primarily for the distribution of oil products from refinery to consumer.

Tankers (Chemicals) **-** Class of vessel specifically designed to cater for the liquid chemicals market, capable of transporting various grades of chemicals, solvents, and acids in a variety of cargo compartments ranging from mild steel-lined, through tanks provided with different coatings, such as rubber-lined tanks for phosphoric acid.

Tankers (Gas) **-** There are two categories: (1) Liquid Natural Gas (LNG) Tankers, and (2) Liquid Petroleum Gas (LPG) Tankers. The first category includes vessels designed to carry LNG, mostly methane, which is held in a liquid state by pressure and refrigeration. The cargo spaces consist of special tanks whose upper sections often protrude above deck height in domed or cylindrical form. The second category are vessels designed to carry LPG, such as butane or propane. These are also carried in special tanks under pressure and at very low temperatures. The tanks are often rectangular in section and may be flanked by wing tanks used to carry ballast water. The carrying capacity of both tanker categories is specified in cubic meters; typical tanker sizes range between 25,000 and 75,000 cubic meters.

Ultra Large Crude Carriers **-** Large tankers of no official size but variously described as being one between 350,000 dwt and 550,000 dwt.

Vary Large Crude Carriers **-** Large tankers of no official size but variously described as being one between 100,000 dwt and 350,000 dwt.

Source: Hans J. Peters, *The Maritime Transport Crisis*

Annex C. Case Summaries

Shipyard	Summary of MARITECH Accomplishments and Impacts
Alabama Shipyard Mobile, AL	• Acquired 16,000 dwt. chemical carrier design and built 2 chemical carriers for Dannebrog • Designed/built pipe bending and blast/coating facilities – Redesigned fabrication buildings for more efficient material flow from plate welding to block movement to dock • Improved CAD/CAM software – Built pipe fabrication facility with 3D capability to reduce interference – welding and cutting machines driven by CAM data – Saved 20% on production labor hours on Dannebrog tankers • Design data now provided to production work centers by diskette – Enterprise IS is next step • Surveyed 19 foreign yards in 2 years – Formed consortia with foreign designers and operators on each of its 3 design projects
Avondale Industries New Orleans, LA	• Acquired standard tanker design • New steel handling and fabrication facility yielded 10-20% productivity improvement (+ 2% annually), and will save LPD-17 production costs • Automated tracking and scheduling of work packages, employee assignments, and materials requirements • Integrated design and production processes – Enabled exchange of design data electronically within the yard and with sub-contractors and suppliers • CAD/CAM reduced ARCO contract award-to-steel fabrication time to 7 months
Bath Iron Works Bath, ME	• Acquired High-Speed Monohull design • BIW, Avondale and Navy applying IPPD to constructing LPD-17s • Self-adaptive robotic welding project which will automate the welding of 5,000 to 10,000 structural beam erection joints, would save about $500K per ship and reduce the high cost and injury of rework • Established relationships with Kværner Masa and Mitsui that remain intact today -- Imported technologies & processes that are applied to Navy shipbuilding (claiming annual savings of $11M to $13M on construction of AEGIS destroyers)
Bender Shipbuilding Mobile, AL	• Building OSV for a foreign owner • Acquired Reefer 21, OSV, and multi-mission cargo ship designs • Reduced cost of operations and ship construction time by 50% • New CAD and layout software reduced re-piping and re-running pipe time by 30%, saving 4-5,000 man-hours per ship (uses software with plasma machine to precut pipe holes) • Maximizing pre-outfitting prior to erection, by crane-less erection of units up to 300 tons
Bollinger Shipyards Lockport, LA	• MARITECH put Bollinger "on the map" in the domestic offshore liftboat industry • Acquired Irish Sea Pioneer, SWATH Super 4000 designs • Liftboat leg construction simulation saves 10% in material and production (cost & time) -- Using this software reduces proposal preparation time by a factor of four • AutoCAD shared with all engineers/designers—reduced the design process by a factor of five • Purchased process design, short arc welding techniques, cutting plate techniques, and production detail design from Vosper (UK)
Electric Boat Groton, CT	• Cost avoidance projections: SHIIP - $6.5M per ship, MariSTEP - $7.5M per ship, SPARS - $7M per ship class

Gladding-Hearn Somerset, MA	• Visited foreign markets to enter fast ferry catamaran construction business -- began updating business and construction practices —Gained impressive domestic market successes • Acquired catamaran ferry hull designs • Adopted ZOLT and ISO-9000 • 6 acre site addition plus changes to improve workflow aided by MARITECH
Halter Marine Gulfport, MS	• Currently building a 42.5m High Speed Low Wake Pax Ferry, which will be debuted at the IMTA in New Orleans in October 1998 • Acquired 23K dwt Container/Bulk Carrier, Sea Shuttle Container Feeder (3 versions), High Speed Low Wake Passenger Ferry (6 versions), 110m Fast Car Passenger Ferry (10 versions) designs • Facility modernization aided by MARITECH • Worked with foreign designers, test facilities, shipyards, and owners -- created vendor alliances
Ingalls Shipbuilding Pascagoula, MS	• Surveyed cruise ship designers in Finland – Acquired cruise ship design • Self-adaptive robotic welding could increase the robotic welding from 2-5% to 5-9% of ship • Researching composite materials use for ship superstructures -- Navy interested for sealift ships
Marinette Marine Marinette, WI	• Acquired product and ethylene tankers, and aluminum ferry designs • Marketed product tanker design for Great Lakes international trade • Visited Scandinavian yards • Initiated enterprise IS to link design, production, business, subcontractors and suppliers • Instituted "design for production" processes • Integrating CAD/CAM, material handling, scheduling, and supplier relations • Built international vendor data base for current price and performance information on customer-preferred vendors—Adopted "just in time inventory" practices • Integrated design/ production change process—re-work rates are now 1% vs. 12%
NAASCO San Diego, CA	• Acquired cruise ship and container ship designs • Will re-design yard layout, install enterprise IS, integrate design/production and business processes (a five year, $200 million program) • May use commercial cruise ship stateroom designers for Navy projects and commercial leasing or "charter and build" for support ships and identified potential cost saving if Navy used them • Surveyed Scandinavian yards for cruise ship design and production insights
Newport News Newport News, VA	• Developed 2 Double Eagle double hulled tanker designs—Received 9 orders, will deliver 6 • Increase robotic welding from 4% to 15-20% will yield 25-50% reduction in welding time • Estimated 50% reduction in schedule and costs when all computers have been networked into a MARITECH overarching computerized management decision tool • Facilities modernization aided by MARITECH • Consortia/teaming with foreign yards will be continued—formed four international relationships • Yard layout simulations and process lanes being used for Navy and commercial contracts—Starting with CVN-77, NNS hopes to use MariSTEP
Nichols Brothers Freeland, WA	• Designed aluminum Low Wake Ferry—Currently marketing ferries in Pacific Rim Countries • Implemented ZOLT (PWBS) in all design/production/business centers—yielded 20-30% production time reduction between vessels—Better materials flow saved 3 months production time on tugs and aluminum ferry

Todd Pacific Seattle, WA	• Acquired Jumbo Mark III Ferries, Power Barge, and Anchor Handling Tug designs • Worker input changed T-beam slot-cutting operation from 12 hours to 4 minutes • 30% steel shop productivity increase (35% time and effort savings between Ferries 1 & 2 -- an additional 17% between 2 and 3) • Ship-ways work man-hours reduced from 100,000 on Ferry 1 to 50,000 on Ferry 2, to projected 40,000 hours on Ferry 3, through accuracy control improvements • Relationship with IHI produced superb insights

<u>Administrative Data</u>

Lead Shipyard: **Alabama Shipyard Inc.**
660 Dunlap Drive, Pinto Island, Mobile, AL 36652

Date of Shipyard Interview: February 9, 1998

Tom Neyhart, Program Manager, Business Development
George Gibbs, CEO, Atlantic Marine Holding
Thomas P. Jones, Jr., Vice President, Atlantic Marine Holdings
Mark Asbury, President Alabama Shipyard Industries
David A. Enman, Vice President, Business Development
Anand Ramamurthy, Industrial Engineer
Timothy G. Berkel, Marketing Strategist
Thomas Perrine, Production Engineering Manager
Stephen M. Miller, Senior Naval Architect
W.R. "Bob" Doyle, Materials Manager

AOTR: Dick Voelker, MARAD

Date of AOTR Interview: 3 February 1998

MARITECH BAA/Projects:

1. <u>BAA 94-09. Focused Technology Development Proposal (Development of a 40,000 dwt Double Hulled Product carrier)</u>
   Consortium Members:
   - Design Agent: Burmeister & Wain Shipdesign A/s (BWSD)
   - Owner/Operator: American Automar Inc. (AAI)
     - <u>Proposal Modification #1- 16,000 dwt Chemical Carrier</u>
     - Design Agent: Skipskonsultant AS (SK), Bergen Norway
     - Owner/Operator: Dannebrog Rederi, American Automar, Inc.

2. <u>BAA 95-02. Handy Size (27,000dwt) Bulk Vessels</u>
   Consortium Members:
   - Design, Technology Transfer and Training: Mitsubishi Heavy Industries (MHI)
   - Owner/Operator (Customer): TRITEA Maritime Ltd., Piraeus, Greece
     - <u>Proposal Modification #1- 16,000 dwt. Chemical/product Tanker</u>
     - Owner/Operator: Balttanker, LTD.
     - <u>Proposal Modification #2- Facilities and Process Modernization</u>

3. <u>BAA 96-01. 10-12,000 dwt. Product Tanker</u>
   Consortium Members:
   - Owner/Operator (Customer): Rederi AB Veritas Tanker, Goteborg Sweden
   - Design Software Integrator: Proteus Engineering
   - Robotic Welding: CYBO Robot, Inc.
   - Ship Modeling Software: Sener Ingenieria y Sistemas SA "SENER"
   - Welding Technology: Edison Welding Institute

4. <u>BAA 96-42. Advance Technology Demonstration for Construction of (4) 1,432 TEU Container Ships (23,850 dwt.)</u>
   Consortium Members:
   - Owner/Operator: China Ocean Shipping Co. (COSCO), Beijing
   - Designer: Imbari Shipbuilding Co., Ltd. Imbari City, Japan
   - Engineering: Proteus Engineering, Inc.
   - Production Software: Sener Ingenieria y Sistemas SA "SENER"
   - Production Process Software: Decision Dynamics, Inc. (DDI)

5. <u>Projects participated in, but not lead by, Alabama:</u>
   BAA 96-05. EB: SHIIP

Researcher: M. Hammon

Case Summary

A. Background

Alabama Shipyard, Inc. (ASI), is a wholly owned subsidiary of Atlantic Marine Holding company of Jacksonville, Florida, employing approximately 750 personnel. Most employees have been with the company less than 2 years, thus the energy and spirit of innovation in the workforce is quite noticeable. ASI's 650 acre facility is located on Pinto Island on the east bank of the Mobile River, directly opposite the city of Mobile. The property was purchased from a defunct shipyard and has been thoroughly redeveloped and upgraded. Its facilities include two dry docks, the greatest of which has the capability to hold a 50,000T vessel, and a 275 short ton Goliath bridge crane to service the erection area. The company is considering the addition of a graving dock. ASI's business base is totally new construction. The Jacksonville-based parent corporation Atlantic Marine operates a co-located repair and overhaul business adjacent to ASI in Mobile.

Since acquiring ASI, Atlantic Marine, has spent over $35 million to modernized ASI's facilities, with an additional $10.6 million planned for rehabilitation of existing buildings and new construction. They planned to spend an additional $11.7 million for the double-hull product carrier project.

While the facilities were being modernized, ASI wanted to use its involvement with MARITECH to improve its commercial design and production processes. Alabama's portfolio is all commercial, but until MARITECH, it produced only smaller special purpose vessels, e.g., oceanographic research, casino, etc. With MARITECH's help, ASI would gain the ability to design and construct commercial merchant vessels and accelerate its ability to compete in the world market.

In parallel, ASI wanted very much to improve marketing and estimation processes. In almost all cases where proposals were modified, it was because ASI hadn't been able to accurately forecast the time to build the purchased design, thus proposed an unacceptable schedule. Further, contract price was too high, because the company couldn't estimate the cost of production accurately. The effort will be to focus on niche markets where ASI can build 2-3 ships annually over 3-4 years competitively.

ASI has also found that a major area for competitive improvement is supplier processes:

- Foreign vendors form working relationships and propose as a group with the major supplier acting as system integrator; e.g. MAN will integrate all power plant components and market the engine, pumps, and electrical as a system, after forming relationships with the sub-component manufacturers. American vendors sell components individually to the shipbuilder and expect the shipyard to be the integrator, a much more costly and problematic method.
- American component manufacturers aren't aggressively marketing to the foreign operators, therefore they are not capturing the market for new construction. The owner/operator typically specifies a majority of components onboard new construction, consequently, the American component manufacturer must market directly to the owner/operator to capture this market.
- Equipment is 20% of a ship's volume, but 80% of its cost, hence American equipment builders are losing a great deal of business to foreign.

Overall, MARITECH has been very beneficial for Alabama in its effort to become a competitive merchant vessel constructor. The move from small vessels to larger ones has not been without growing pains. For various reasons, all of Alabama's four MARITECH proposals have been modified. The BAA 94-09 project is complete, the MARAD AOTR has approved modifications to BAA 95-02, is reviewing proposal modifications 96-01, and ASI is preparing a modification request to its BAA 96-42 proposal. Funding for the modified proposals has been withheld, until the proposals are approved by MARAD.

B. Summary of MARITECH Projects Managed or Participated in by this Shipyard

1. BAA 94-09. Focused Technology Development Proposal (Development of a 40,000 dwt Double Hulled Product carrier)

Objective: Modernize facilities, processes, and purchase a marketable ship design.

Background: In its first project to improve its competitive standing, Alabama completed a market study of the world shipping market and decided that OPA-90 and the increasing age of the fleet would drive significant product carrier modernization. At the time of the proposal, 46% of the world oil and bulk carrier tonnage was greater than 15 years old. U.S. vessels' age averaged over 20 years, with an expected 25 year service life.

ASI concluded that the logical market point for those vessels was in the 30,000-40,000 dwt. and the construction target was 20-50 tankers annually. Therefore, ASI chose to focus their modernization and marketing efforts toward the sale of 40,000 dwt double hulled product carriers. Possible cargoes are lube oil, vegetable oil, molasses, palm oil, and caustic chemicals. ASI purchased a design from Burmeister & Wayne for sale to TEXACO. Unfortunately, the market for Jones Act product carriers never materialized.

In 1995, using MARITECH-funded improved marketing tools, ASI identified a market for smaller chemical tankers, modified this project's objective to construct and sell a 16,000 dwt. chemical tanker. All aspects of the proposal remained the same, except the ship to be designed. Two tankers were sold to Dannebrog and are under construction. ASI delivered the first ship in March 1998.

Process Improvement: To save time to production, ASI purchased a proven design from Skipskonsultant AS (SK) of Bergen, Norway, and began an engineering effort to improve the design for use in Jones Act and international trade, including operations in ice.

One of ASI's process modernization goals was improved CAD/CAM hardware and software capability. Using MARITECH funding, the company purchased the FORAN ship design software and installed it on new corporately-funded IBM workstations. That improvement enabled ASI to quickly evaluate areas for improvement in the basic tanker design. In particular, by creating a detailed 3-D model of the engine room, the ASI engineers were able to check tolerances for the complex piping network typically found in engine rooms. ASI estimates that by using the 3-D modeling process to eliminate interferences, it saved 20% in production labor hours.

Often, foreign customers have preferred vendors and the ability to research products and prices would improve response to future customer requests. Using MARITECH funds, the company began development of a database centered around the Skipsteknisk Forskningsinstitutt (SFI) estimating group numbering system.

Facilities Modernization: ASI knew additional facilities upgrade was necessary. Using MARITECH funding for design and corporate funding for fixed assets, ASI improved the erection area infrastructure:

- Dry dock structural improvements
- New gas, air, and electrical utilities
- Improved rails, supports, hydraulics, and electrics for the 275 ton crane
- Installation of two 150 ton cranes
- ASI also found that an improved capability to fabricate curved plates and webs was critical to future construction of commercial merchant vessels. With help from Mitsubishi Heavy Industries, it used MARITECH funding to design the curve plate/web facility. The design was finalized and bids are in hand for equipment, however the company has decided to defer construction pending additional commercial business.

Impact:

- Reduced re-work because of improved CAD/CAM software and hardware
- Improved marketing using the foreign vendor database
- Orders with Dannebrog for two of these chemical tankers

2. BAA 95-02 . Handy Size (27,000 dwt) Bulk Vessels

Objective: To continue design and production process modernization begun in a previous MARITECH program by designing a handy size (27,000 dwt) bulk vessel for domestic and international customers.

Background: ASI believed that there was an emerging market for "handy size" (10,000-50,000 dwt) bulk vessel capable of carrying dry bulk cargo on Jones Act, and east and southeast Asian routes. Extensive marketing studies showed the need for a vessel in the 20-30,000 dwt range. To save time, ASI would purchase rights from consortium partner MHI for a proven "handy sized" design. The strategy appeared to pay off when the Greek shipper TRITEA signed a letter of intent with ASI for four vessels, contingent on TRITEA receiving Title XI loan guarantees, but the deal was never consummated.

Subsequently, the program underwent two revisions:

1. ASI requested permission to re-focus the project on acquisition of a 16,000 dwt. chemical/product tanker design for sale of five ships to Balttanker, Ltd. of St. Petersburg, Russia, a wholly owned subsidiary of LUKoil Arctic Tanker. The company modified the Dannebrog design for the Russians, but that deal was not consummated, because of Russian currency export restrictions. Further, subsequent marketing studies showed that the world-wide bulk carrier market would not mature at the previously expected rate. ASI has, however, resumed discussions with BALT Tanker.

2. The company then re-directed the project's objective away from a particular vessel or market and concentrated the remaining $1.5 million of this project's funding on design software, facilities modernization, and training.

- Purchased additional FORAN software.
- Designed Pipe fabrication and bending shop (New)-- constructed with corporate funds.
- Designed Unit Blast & Coat Facility (New)-- constructed with corporate funds.
- Designed and instituted a formal training program in classroom, on-site, and OJT.
- Commissioned Coopers and Lybrand to benchmark the company's business practices. The company will adopt most of the study's recommendations in its corporate strategy as "best practices":
    - vendor managed inventory,
    - sole-source contracts,
    - partnership agreements with suppliers, and
    - long-term contracts.
- Corporate-wide contracts on items common with Atlantic Marine.
- Electronic data interchange and funds transfer.

3. BAA 96-01. 10-12,000 dwt. Product Tanker

Objective: This project was originally proposed to improve the company's design and production processes in four steps:

- Improve CAD/CAM capability using the FORAN software from SENER.
- Reduce production costs through incorporation of robotic welding capability, ultimately integrated with the CAD/CAM software.
- Realize the concepts on a proven Pelmatic design.

Background: ASI hired Pelmatic to perform a study of prospective markets that could provide a niche for the company in its efforts to break into the commercial merchant market. Pelmatic identified the "short-sea" shipping market (routes of less than 1,000NM) using small product tankers on Mediterranean, Scandinavian, U.S., and southeast Asian routes.

Both Pelmatic and ASI felt that this design was smaller and easier to build competitively than those in the other MARITECH projects. Pelmatic and ASI improved over the original design by adding state-of-the-art systems for machinery control, navigation, cargo management and pollution avoidance that will enable the ship to be operated safely with about 12 people. The design has also been ice-strengthened, thus providing for year-round operation and improving the customer's profit potential. ASI purchased the rights to a Pelmatic design and marketed it to Rederi AB Veritas Tankers, which signed a letter of intent, contingent upon Title XI funding. Unfortunately, the deal did not go through.

ASI requested MARAD approval on January 8, 1998, to re-focus the project on those tasks regarding improvement of design and production processes, but without regard to any particular design effort. Specifically, the company wants to:

- Build a standard vessel and component design database accessible by vendors
- Continue design of the modern profile and web shop
- Continue design and testing of automated fixed and portable welding, driven by CAD data
- Continue design and testing of automated robotic welding, driven by CAD data

The MARAD AOTR is reviewing the proposal, as it relates to ASI and Atlantic Marine's long-term corporate strategy.

4. BAA 96-42. Advanced Technology Demonstration For Construction of (4) 1,432 TEU Container Ships (23,850 dwt)

Objective: This project will enable portions of ASI's strategic plan to become competitive with foreign shipyards, i.e., become a "world-class" builder of commercial merchant ships.

Background: This project followed the philosophy of ASI's others: modernize processes and training, analyze emerging niche markets, purchase a proven design for that market, but don't build unless orders arrive. The project sought to improve design and production processes using a container ship as the vehicle. Marketing surveys showed that the same design Imbari had used for its Asian customers could be improved upon by Alabama and sold for use on Jones Act, Caribbean, and southeast Asian routes.

The technical approach would center on four steps:

1) Design to market

   - Perform a marketing survey of the Imbari design looking at areas for improvement and smaller versions for other markets

2) Procurement and material management process improvement

   - Continue improvement of yard material handling, i.e., just in time steel delivery

3) Worker training

   - Improve the shipfitter apprentice program begun in 1996 and expand to welding and pipe fitting skills
   - Begin Management training
   - Benchmark ASI skills with other U.S. and foreign yards, and other U.S. industries like aerospace and automotive

4) Customer relations for international customers

Unfortunately, the deal with COSCO did not materialize and the company is developing a new proposal right now. The new proposal, valued at $17.3M (government share = $8.0M) is not focused on design of a particular ship type, but strategic process improvement and quality in four areas:

1. Workforce Stability
2. Business Development
3. Processes & Procedures
4. Integration of new technology

C. Overall Shipyard Goals and Strategies:

Goal/Strategy 1: Become a world-class, internationally competitive shipyard.
Goal/Strategy 2: Improve and integrate design and production processes to gain competitive edge.
Goal/Strategy 3: Improve marketing and financial processes to identify niche markets and win contracts from shippers in those markets.

D. QUESTIONS[78]

1. Ship Design and Construction Strategies:

a. What ships have been sold, built, are under construction, or have been designed as a result of MARITECH?

ASI constructed two chemical carriers for Dannebrog.

Supporting Data for Ship Design and Construction Strategies:

Status	Description of Vessel	Metric Benefits[79]
Completed (Built)	16,000 dwt Chemical Carrier (1)	
Under Construction	16,000 dwt Chemical Carrier (1)	
Designed	All designs were licensed from offshore designers	
Under Design	None	

b. What changes in construction strategies have been developed?

- Blasting and Coating are performed inside a single facility instead of outdoors; profiles are processed in a dedicated facility
- Webs are constructed in a dedicated facility
- Designs are in-place for a steel facility that optimizes material flow from cutting and welding through block assembly
- Welding and cutting will be driven by and integrated with the CAD/CAM system, without a successful CYBO project (ASI is currently searching for a replacement robot vendor.
- Eventually, need to baseline production processes so future processes can be compared parametrically

c. Were any international competitive benefits derived from MARITECH ship designs and construction projects, and if so, what were they?

No. All business is directed at Jones Act work, though ASI continues to market internationally.

2. Technologies Developed or Applied to Improve Design, Production/Manufacture, Operation, and/or Repair of Ships[80]:

a. What technologies have been developed or applied to the design, production/manufacture, operation, and/or repair of ships through MARITECH?

CAD/CAM; Pipe Fabrication; Blasting and coating; Steel fabrication and handling

[78] These footnotes pertain to all case summaries in this Annex, and were provided to the Shipyards to further clarify the questions.
[79] Includes sales, orders / customers, cost savings, reduced construction/design time.
[80] Includes production processes (e.g., simulation, CAD/CAM/CIM) and system-wide, integrated design and production technologies. Emphasize technologies that enable dual-use (integrated Navy/Commercial) ship production.

Supporting Data for Technologies to Improve Design, Production/Manufacture, Operation, and/or Repair of Ships:

Technologies	Description	Metric Benefits[81]
CAD/CAM	Purchased FORAN CAD system from SENER. Attempting to integrate the design data with steel cutting and welding NC machines, and throughout the Yard in an enterprise system linking CAD/CAM with inventory control and manufacturing. Currently, though, manufacturing and inventory personnel still use paper	Improved accuracy control, decreased re-work

b. Were any international competitive benefits derived from technologies developed or applied under MARITECH projects, and if so, what were they?

Yes. Through the improved production process technologies installed at ASI, e.g. Unit Blast and Coat Facility and the Pipe Fabrication and Bending Shop, ASI was able to decrease the man-hours required in building the Dannebrog ships. The production processes related to these technologies will continue to be refined and, thus, allow ASI to become more competitive in the international marketplace.

3. Facility Expansion or Modernizations and Process Enhancements Made to Improve Design, Production/Manufacture, Operation and/or Repair of Ships:

a. What facility modernizations or expansions or process enhancements (e.g., yard layout) have taken place as a result of MARITECH?[82]

Facilities: Engineering Facility (upgrade)- $391,300; Erection Area Infrastructure (upgrade)- $3,466,000; Pipe fabrication and bending shop (new)- $764,110; Unit blast and coat facility (new)- $1,396,156

Processes: Training- $1,046,200; Industrial Engineering- $140,000

Supporting Data for Facility Expansion/Modifications and Process Enhancements to Improve Design, Production/Manufacture, Operation and/or Repair of Ships:

Task	Description	Metric Benefits[83]
Facilities' Expansion	Engineering facility design: Facility was expanded to accommodate additional FORAN CAD/CAM terminals and provide upgraded meeting room for design team	Consolidated Engineering functions in one facility
Facilities' Modernization	• Erection area design: -Utilities were upgraded, crane rails footings and pilings were upgraded, asphalt and drainage upgraded. -Extended crane rails into the bulkhead construction area • Pipe fabrication and bending shop design. • Unit blast and coat facility	• Improved speed and efficiency of constructing and moving modules from fabrication facility to ship construction site • Consolidated and automated pipe fabrication next to module fabrication location improving work flow. Installed a clean room to reduce pipe contamination after assembly • Located pre-production steel processes near module construction facility improving work flow
Processes Planned	Industrial Engineering- This task re-designs the shipyard work flow. By	Metric collection continues

[81] Includes sales, orders / customers, cost savings, shipyard application, reduced construction/design time.
[82] Includes amounts invested as well as a description of the work.
[83] Includes dollars invested, dollars to be spent and extent of modernization.

	analyzing work flow, process improvement will dictate additional training needs, and facility expansion or upgrade.	
Processes Implemented	Training- implemented classroom, OJT, and on-site production training in pipe fabrication and unit blast facilities, where no organized training had existed before	This training is critical for improving construction quality, reducing re-work, cutting costs, and improving competitiveness

b. Were any international competitive benefits derived from these expansions, modernizations, or enhancements, and if so, what were they?

Because of marketing skills, ASI was able to win the Dannebrog contract. Metric contributions for any one facility or upgrade are difficult to identify, but there is no disputing that the cumulative effect of the process and facility upgrade, especially the profile ship and the pipe facility, enabled ASI to complete the second Dannebrog ship more efficiently than the first.

c. Did you examine foreign shipyards as part of a MARITECH project, and if so, how did your findings influence your facility expansion or modernization or the planned enhancement of your processes?

Yes. Europe- 12, Japan- 7 in two years; Benefits: - Observe and analyze advanced facilities and equipment, - Learn advanced and improved building methods, - Learn quality and accuracy control methods and implementation techniques, - Adopt effective planning & scheduling control techniques.

4. Commercial Business Practices Developed or Applied for requirement analysis, supplier relations and material procurement, human resource management, customer relations and marketing, and cost estimating and financial management systems (or others applicable to your shipyard):

a. What new commercial business practices have resulted from your MARITECH projects?

ASI commissioned Coopers and Lybrand to study the shipyard and recommend improved business practices. They recommended those shown below. ASI will use the FY97 project to implement these recommendations, so metrics will be available after implementation in FY98-00.

Supporting Data for Commercial Business Practices Developed or Applied:

Commercial Business Practices	Description	Metric Benefits[84]
Vendor Data Base	Maintain foreign and domestic supplier data base for “makers lists”	Keeps ASI and customers current on vendor technology, cost and schedule.
Partnership with vendors	Qualify selected vendors’ products	Decrease testing and integration costs
Long-Term Contracts	Sign multi-year contracts with suppliers, providing stable relationship	Lock in better pricing and delivery schedules
Vendor-managed inventory	Suppliers of high rate consumables will measure yard use and be responsible for maintaining stock levels	Decreased inventory management cost
Corporate-wide purchase agreements	Purchase agreements with suppliers of components and consumables used by both ASI and Atlantic Marine	Reduced purchase and shipping costs
Electronic Data Interchange and funds transfer	Improved design, production, bid, contracting, and inventory data flow Receivables and payables using	Unknown

[84] Includes sales, orders / new customers, cost savings, or new approaches to requirement analysis, supplier relations and material procurement, human resource management, customer relations and marketing, cost estimating and financial management systems, and reduced construction/design time.

	electronic methods	

b. What new business markets have been developed or expanded through commercial business practices developed or applied through MARITECH?

TBD.

c. Were any international competitive benefits derived from business processes developed or applied under MARITECH projects, and if so, what were they?

TBD.

5. Impact on Navy Shipbuilding[85]:

a. What is the impact of the MARITECH projects on Navy shipbuilding?[86]

ASI currently has no plans to compete for Navy construction. Sister company Atlantic Marine does repair for the Navy in Mobile and Jacksonville.

ASI corporate officers feel strongly that ASI's yard is capable of Navy construction and by funding improved commercial capability at ASI, the Navy keeps the industrial base capable of efficiently building Naval vessels in a surge.

In Jacksonville, Atlantic Marine has found that commercial customers perceive that there will be increased problems and costs doing business with shipyards doing both Navy and commercial business, i.e. shipyard employees working on Navy ships will carry a Navy-work standards cultural mindset to the commercial site.

b. What commercial practices are you now using in Navy contracts?

N/A

c. What positive impacts could be manifested if the Navy agreed to adopt commercial business methods identified or used in MARITECH projects?

There could be a tremendous boost to the baseline work. The effect on the way Navy procures ships would be dramatic. It currently takes hundreds of shipyard employees, especially on aircraft carriers, to administer Navy contracts, but commercial yards employing less than one-thousand people can build up to ten ships per year

6. MARITECH Program Process:

a. What cultural and process changes have resulted from procedures employed through the MARITECH Program?

1. Consortia **-** *Has forming consortia become a normal approach in your commercial and Navy business practices?*

See Teaming.

2. Teaming **-** *Has teaming become a normal approach in your commercial and Navy business practices?*

Teaming internal to the yard and externally with suppliers will become more common as the Coopers & Lybrand recommendations are implemented.

3. Were your associations with foreign partners useful, and if so, do you plan to use such associations in future commercial and Navy contracts?

ASI's relationship with SENER was critical to implementation of improved design processes. They have a continuing relationship, and SENER did some design work on the Dannebrog and COSCO ships.

The 19 visits to European and Japanese shipyards were very informative and graphically showed areas for improvement. The visits strongly influenced ASI's process improvement and facilities upgrades.

b. What MARITECH Program processes did you particularly like/dislike, and do you have any suggestions for such future programs?

BAA process should be driven by process improvement, not to build a particular design. Centering the project around a design causes modifications and turbulence if market changes.

The AOTR's role is as a partner in innovation, not a government inspector and cost accountant.

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[85] This series of questions is directed at determining the effect of the project on Navy shipbuilding.

[86] Provides indications of the Navy's interest and involvement in the outcome of the MARITECH effort (e.g., are Navy funds budgeted to take advantage of the outcomes; have cost savings resulted for the Navy; or are processes faster, better, cheaper; or have you (or will you) use the products of this effort in proposals to the Navy?). The technology transfer process is described, and technologies, products, or processes that have been transferred as a result are identified.

Successful ideas from other projects should be shared among participating shipyards to accelerate the industry's modernization

Innovation is most likely when MARAD allows the shipyard to manage the projects flexibly

The process is only partially complete. The program should continue for another five years.

7. Comments on the Global Shipbuilding Market[87]:

> *What must be done for the U.S. to successfully compete in the global market and what should be the role of programs such as MARITECH?*

MARITECH has been beneficial in two ways:

Facilitated the shipyards' entry into the commercial market. ASI knew it could build ships for the global market, but wasn't capable of taking the first step.

Once involved in the program, process improvement quickly was identified as fundamental to long-term viability, **not production of specific ship types**. MARITECH enabled the firm to invest in new CAD, modernize material handling, training, marketing, wet & dry docks, and structures. The Jones Act should continue in force.

[87] The Shipyards were asked to reference their overall objectives and strategic plan.

Administrative Data

Lead Shipyard: **Avondale Industries**
P.O. Box 50280, New Orleans, LA 70150-0280

Date of Shipyard Interview: 13 February 1998

Also November 24, 1997, January 28, 1998 (by telephone)

Ron J. McAlear, Vice President, Advanced Programs & Marketing
Mark Gasson, Proposal Manager, Advanced Programs & Marketing

AOTR: Tom Conroy, MARAD

MARITECH BAA/Projects:

1. BAA 94-09. Focused Technology Development Proposal (Development of a 40,000 DWT Product carrier)

Consortium Members:

Trading Company:	Mitsubishi Corp.
Builder:	Mitsubishi Heavy Industries (MHI), replaced by Astilleros Espanoles, S.A. (AESA)
Broker:	MCA
Design Agent:	JJMA
Owner/operator:	Kirby corporation
Constructor:	American Heavy Lift Shipping Co. [Forebody replacement parts]
Shipyard Processes:	Astilleros Espanoles, S.A. (AESA)

2. BAA 96-01. Simulation Based Design for Integrated Product and Process Development (IPPD) and Integrated Product Data Environment (IPDE) (3-D Modeling)

Consortium Members:

Shipbuilding Software evaluation:	Gulf Coast Marine Technology Center (GCRMTC)
CAD/CAM s/w & h/w design:	Intergraph Corp.
Cargo Handling Products:	MacGregor (USA), Inc.
Shipbuilding Process Analysis:	Bart Huthwaite
IPPD Experience:	Electric Boat

3. Projects participated in, but not lead by, Avondale:

a.	BAA 94-44. Intergraph	MariSTEP
b.	BAA 94-44. CYBO	Automatic Welding of Structural Beam Erection Joints
c.	BAA 96-05. Hughes	MAAST
d.	BAA 96-05. EB	SHIIP
e.	BAA 96-42. NIIIP	NIIIP for SPARS
f.	BAA 96-42. UCSD	International Competitive Fast Ferries & Computer Technology

Researcher: M. Hammon

Case Summary

A. Background

Avondale Industries is a diversified, employee-owned company and is the largest private employer in Louisiana, with about 6,500 employees. The company consists of several divisions, including Shipyards, Modular Construction, Steel Sales, and Boat. In operation for 60 years, the company has constructed vessels of all types, including destroyers, frigates, fleet oilers, landing ship docks, oceanographic research vessels for the Navy, Coast Guard cutters, tankers, LASH ships, dredges, drill ships, and container ships for commercial customers. The Boat Division has constructed ferries, gaming vessels, tugs, towboats, tug-supply boats, large fishing vessels, and other workboats.

Avondale began building barges and small craft in 1938 and during the 1950's expanded into large oceangoing vessels. In the 60's, Avondale produced a string of Navy combatants as well as commercial ships. In the late 70's, the business basis was almost entirely commercial and, with the elimination of builder subsidies in the 80's, the company spent ten years building strictly naval vessels.

Now the company builds commercial and Naval ships up to 185' wide and 1200' long. The goal is to obtain a 50/50 mix of commercial and government construction and this should be reached next year. The company feels that its labor rates are competitive world-wide, but knows it can't be competitive with those companies whose host nations heavily subsidize their operations. For that reason, their commercial business is mainly targeted at Jones Act markets and at specialized, high-tech markets.

Avondale has chosen not to compete with the Chinese, Koreans, and Japanese for simple ships like bulk carriers and large tankers. The company feels, however, that its Naval experience enables it compete for complex commercial construction, and is competing against Ingalls and NASSCO for the U.S. cruise ship contract. MARITECH fits the corporate strategy to become more commercially competitive.

In August of 1993, Avondale's CEO, Albert L. Bossier, Jr. launched a new strategic plan aimed at getting the company more commercially competitive. The goal is to reduce costs and schedules. Avondale's participation in these two MARITECH proposals is in line with that corporate plan.

The two projects are complementary in that they concentrate on shipbuilding process re-engineering. The former project aimed to apply advanced production processes to build a "world-class design" for a 40,000 dwt. product carrier. After the project began, the focus was shifted to design of a SuezMax. tanker. The second project uses 3-D design software and workstations to re-engineer shipyard design and construction processes. The application for that project was the design of a medium-sized commercial RO/RO ship.

B. Summary of MARITECH Projects Managed or Participated in by this Shipyard

1. BAA 94-09. Focused Technology Development Proposal (Development of a 40,000 DWT Product carrier)

<u>Objectives:</u> To become internationally competitive in the product carrier market in the next 15 months.

<u>Background:</u> At the time of its proposal, Avondale could not competitively design and build a product carrier in this class. Therefore, it chose to rely upon a technical approach that leveraged its consortium members' experience and expertise to get it into this market as quickly as possible.

The technical approach was in four steps:

1. Purchase rights to a competitive design from a foreign yard, originally Mitsubishi
2. Examine the design for features [benchmarks], which could be improved
3. Have Mitsubishi benchmark Avondale's production processes *[Preliminary reports confirmed that Avondale's greatest need was <u>process controls</u>, not hardware or new processes.]*
4. Have consortium members perform metrification and standardization studies

Market forecasts indicated that, as of 1994, the Oil Pollution Act of 1990 (OPA-90) would force 35 Jones Act tankers out of service by year end 2000. New or converted double-hulled tankers would replace them. Additionally, some foreign made tankers may need conversion.

Avondale felt that its experience with the Texaco new ship construction competition would provide a competitive edge over American and foreign yards. Though it wasn't selected in that competition in 1991, the design it offered Texaco evolved into what was called the "standard tanker design." It was the basis for what was used in this project.

Early in 1993, Avondale's leadership realized that the company could not be competitive in the commercial sector without radically modernizing its design and construction processes. They believed that the yard was fundamentally capable, but needed outside help to accomplish that level of process improvement. MARITECH provided the means to accomplish that.

This project was proposed as a means to re-engineer the design and construction processes, and refine a design for penetration into a niche of the commercial market where Avondale could first be competitive. Management suspected that it would not be profitable to design a product carrier from within, so it sought help from Mitsubishi Heavy Industries to confirm that assumption by benchmarking Avondale's processes. If the assumption proved true, Avondale would license a suitable Mitsubishi design and would market an improved version as its own.

As it turned out, the licensing arrangement with Mitsubishi was never consummated and Avondale revised this MARITECH project proposal. Instead , the company chose to use its Texaco tanker design as a platform to improve processes. In addition to Mitsubishi, Avondale turned to AESA to evaluate Avondale's processes for improvement, due to AESA's similarities to Avondale. Avondale chose to benchmark its own production technologies and techniques.

Impact: Avondale considers this project a huge success, but not for what it built, so much as what it learned about commercial design and construction processes. Technology transfer from AESA proved to be very valuable and resulted in more efficient pricing, material handling, and fabrication processes.

Avondale considers the most important technology transfer to be a new modular structure (steel block) fabrication facility. Though they had been building modules (blocks) since 1970s, they learned from AESA more efficient material flow methods for module construction . As a result, they constructed a modern 10 acre steel block "Factory" through which steel is moved, prepared, and assembled. Prior to construction of the Factory, those processes were handled at different locations in the yard. Avondale found that significant time and money were spent simply moving steel plate from point to point. With the central processing facility, steel movement is minimized and done only when it is productive. Ultimately, the Factory process will effect other material finishing, procurement, and design processes.

Metrics provided by the Factory process provided for improved construction time and cost estimates when BP and ARCO recently opened discussions with Avondale for new tankers.

Avondale forecasts productivity improvements of 10-20% now and future improvements of 2% annually, simply because of the new processes and the Factory. They believe this to be the result with the most long range potential benefit for the Navy and commercial construction, and the most significant benefit of MARITECH.

2. BAA 96-01. Simulation Based Design for Integrated Product and Process Development (IPPD) and Integrated Product Data Environment (IPDE) (3-D Modeling).

Objectives: To adopt Navy IPPD/IPDE techniques to re-engineer shipyard design and construction processes for a commercial RO/RO ship. The project will develop a design and integrate commercial IPPD/IPDE methods into the design leading to a simulation-based design process.

Background: IPPD is the company's name for concurrent engineering. Such attempts to integrate design, production, and customer requirements throughout the program's life cycle have been successfully accomplished in some military and civilian aerospace and automotive programs. The company wanted to evaluate the benefits and pitfalls of Navy teaming practices applied to the marketing, design, and construction of a commercial ship.

IPDE is a shared information environment. Ship design data would be shared in all phases of the development and production process, including engineering, procurement, production, testing, and maintenance. The major feature of the IPDE is use of the 3-D product model, leading to the full-up simulation based design environment (SBD).

These efforts are classic TQM projects and are sensitive to resistance by those threatened by change. In Avondale's case, that was mitigated by strong corporate support for the implementation for these processes.

Avondale completed the contract RO/RO design and worked with two customers for production agreements. Unfortunately, Congress didn't fund the "Charter and Build" program which would have enabled the sales.

Out of this project came four major lessons learned:

1. Use concept design engineers for IPPD, not design engineers.
2. Production processes must improve
3. Estimating processes must improve
4. Requirements analysis is critical

Approach: The company wanted to build upon its experience in Navy Sealift construction and in other MARITECH projects. They would use the team concept from the Navy to become more customer focused during marketing, design, and construction of commercial ships. The project would be organized into a

Program Management Team and three sub teams, Marketing, RO/RO, and Environment with these responsibilities:

- Market- analyze current, near-future, and long-range market trends and give analyses to the RO/RO team for design and cost/schedule inputs, and the Environmental team for information requirements.
- RO/RO- provides alternative designs to the marketing team to address other customers like containers and heavy lift.
- Environment- provides H/W and S/W tools for marketing, and concept/contract design efforts, i.e. information flow requirements.

The teaming concept was modified after learning that the Navy IPPD model didn't work in the commercial world. Avondale experimented with the use of detail designers instead of concept designers during the project. The attempt resulted in a narrower design view and inhibited cooperation and collaboration. Afterwards, management decided to return to the use of designers more oriented to viewing the ship design more globally. Teaming was a success with the customer involved from the beginning, particularly in design aspects that affected cost. The lesson learned here was that the Company must choose team members' skills very carefully.

Unfortunately, the market for the RO/RO didn't materialize in the way Avondale's forecasts had predicted, so it is now transferring the lessons learned on this project to other projects.

The degree to which customers want to be team members is variable. Some customers don't have the people to spare nor the talents to bring to the problem; they may be involved only occasionally. Others have staff at the yard and are involved in every team issue. Not surprisingly, however, the number of customer representatives involved is far less, in any case, than comparable Navy construction; about 75% less.

<u>Impact:</u> If successful, the program could result in: 1) Development time reductions on the order of 30%, 2) Cost reductions of 20-30%, and 3) a signed contract for a RO/RO 24 months after project start.

The greatest potential impact for Avondale will come from the successful integration of the IPPD and IPDE concepts. As the Factory integrated steel pre-production and production processes, the integration of IPPD and IPDE will enable rapid design, production, and estimating, information transfer amongst internal and external team members. That integrated system, a simulation based (SBD) design tool, is the long-term objective.

The company recognizes that the biggest challenge to realizing SBD is development of the interfaces for internal and external design tools. As an example, MAN B&W must submit its power plant and related component product model in Intergraph format. Intergraph must then generate interfaces with the NC tool software to build the propulsion room structural components. Avondale is a member of the EB SHIIP consortium and will evaluate its results for implementation.

C. Overall Shipyard Goals and Strategies:

1. <u>Process Innovation:</u> Re-engineer design and production processes using IPPD and IPDE design technologies to reduce cost and schedules
2. <u>Commercialization:</u> Improve competitive standing in the commercial shipbuilding marketplace

D. QUESTIONS

1. Ship Design and Construction Strategies:

a. What ships have been sold, built, are under construction, or have been designed as a result of MARITECH?

Crude Tankers for ARCO under construction

Supporting Data for Ship Design and Construction Strategies:

Status	Description of Vessel	Metric Benefits
Completed (Built)	AHL forebodies	
Under Construction	ARCO 1 million bbl. Tanker (2, options for 3 more)	20%-30% reduction in construction costs because process improvements developed

		during the Standard Tanker Design
Designed	Standard Tanker Design,	
Under Design	LPD 17	

b. What changes in construction strategies have been developed?

Better materials and process flow resulted in Factory concept; better estimating and purchasing processes

c. Were any international competitive benefits derived from MARITECH ship designs and construction projects, and if so, what were they?

Not yet:

Russian customer was lost due to his inability to obtain timely financing

Cruise ship market will probably be U.S. only, since foreign cruise ship builders and operators are heavily subsidized.

2. Technologies Developed or Applied to Improve Design, Production/Manufacture, Operation, and/or Repair of Ships:

a. What technologies have been developed or applied to the design, production/manufacture, operation, and/or repair of ships through MARITECH?

All projects, especially the IPPD/IPDE project, will institute better pre-production (design) and production processes to reduce costs and time to build. Those processes include CAD/CAM, NC tool instructions, tracking of shop orders, and work packages, and improvements to estimating, purchasing and subcontracting.

Supporting Data for Technologies to Improve Design, Production/Manufacture, Operation, and/or Repair of Ships:

Technologies	Description	Metric Benefits
CAD	PC-based design package for concept & contract sub-component design database, including 3-D models for use on Intergraph stations	Speed-up the design process
CAM	Integration of Intergraph software to lofting process and generation of NC tool programming tapes, CYBO welders	Improve accuracy and streamline construction process

b. Were any international competitive benefits derived from technologies developed or applied under MARITECH projects, and if so, what were they?

Not yet. Commercial business is still primarily targeted at Jones Act market.

3. Facility Expansion or Modernizations and Process Enhancements Made to Improve Design, Production/Manufacture, Operation and/or Repair of Ships:

a. What facility modernizations or expansions or process enhancements (e.g., yard layout) have taken place as a result of MARITECH?

Focused Technology Development proposal transferred a new steel block fabrication process from AESA, which required a new 10 acre covered "Factory."

Supporting Data for Facility Expansion/Modifications and Process Enhancements to Improve Design, Production/Manufacture, Operation and/or Repair of Ships:

Task	Description	Metric Benefits*
Facilities' Expansion	Univ. of New Orleans Maritime Technology Center of Excellence will be on-site. Primarily focused on LPD 17, but will be used for commercial and education.	Bring an organic R&D capability to the yard, thus reducing the need for outside design help.
Facilities' Modernization	Steel Block Fabrication "Factory"	Improved productivity 20% now and in future years 2% annually
Processes Planned	Integration of CAD/CAM data with marketing, pricing, and estimating	To be developed
Processes Implemented		

b. Were any international competitive benefits derived from these expansions, modernizations, or enhancements, and if so, what were they?

Unknown.

c. Did you examine foreign shipyards as part of a MARITECH project, and if so, how did your findings influence your facility expansion or modernization or the planned enhancement of your processes?

AESA materials flow techniques lead to Factory concept

4. Commercial Business Practices Developed or Applied for requirement analysis, supplier relations and material procurement, human resource management, customer relations and marketing, and cost estimating and financial management systems (or others applicable to your shipyard):

a. What new commercial business practices have resulted from your MARITECH projects?

Supporting Data for Commercial Business Practices Developed or Applied:

Commercial Business Practices	Description	Metric Benefits*
Simulation Based Design (SBD), an outgrowth of Navy IPDE	Want to use SBD data for estimation, pricing, and marketing, as well as commercial design	Expected ability to bid more competitively, track production costs and schedule accurately
CAD/CAM	Investigating the use of new Intergraph tools for contract design as well as detail design	Improved accuracy control. Enabled company to meet schedule time from contract award to steel fabrication of 7 months.
IPDE	Sharing information on commercial contracts is forcing re-organization of the engineering office.	Substantially improved communications with internal and external team members and customers
Accuracy Control	Robotic cutting	Improved fit and less re-work
Requirements Analysis	Tailoring design to customer needs existing design and components	Reduced re-design costs
Cost Estimation	MARITECH involvement has enabled Avondale to better estimate its production costs by bringing estimators into the IPPD team.	Identified and eliminated conflicting pre and post contract award estimation procedures. Found that its labor costs are within 5% of foreign yards

b. What new business markets have been developed or expanded through commercial business practices developed or applied through MARITECH?

Signed a contract for six product tankers with Russian customer, but fell through due to financing.

Currently competing for AMCV cruise ship contract

c. Were any international competitive benefits derived from business processes developed or applied under MARITECH projects, and if so, what were they?

Production costs are decreasing, thus closing the gap with Europeans because of Factory, better material handling, and robotic cutting

5. Impact on Navy Shipbuilding:

a. What is the impact of the MARITECH projects on Navy shipbuilding?

Avondale feels that everything they have done in MARITECH is transferable to Navy contracts

Impossible to determine; a function of how much the Navy allows commercial processes and items in their construction.

Factory processes should yield savings on LPD 17

b. What commercial practices are you now using in Navy contracts?

IPPD processes used on USCG Polar Icebreaker and LPD 17 early design

Navy has permitted Avondale to use ISO 9000 as acceptable QC method, which should yield unknown savings on LPD 17

Design software used on LPD 17 will be used for commercial projects, but the savings are difficult to predict

c. What positive impacts could be manifested if the Navy agreed to adopt commercial business methods identified or used in MARITECH projects?

Unknown, since the Navy is often restricted by the FARs and DFARs from using many of the commercial practices.

6. MARITECH Program Process:

a. What cultural and process changes have resulted from procedures employed through the MARITECH Program?

1. Consortia - Has forming consortia become a normal approach in your commercial and Navy business practices?

Teamed with MHI and Hopeman Brothers on the Alaska Ferry contract.

Use equipment vendors as consortium members and hold them responsible for maintaining proposal specifications.

Purchasing and estimating processes are re-designed. The company no longer estimates the pre-contract design and build something different after contract award, forcing the purchasing department to re-do vendor/supplier contracts and agreements. Company insists on a clean yard, to cut down on production time, injuries, and improve material flow.

Multi-skilled workers save production time. They perform whatever tasks are appropriate to the job, instead of waiting for successive workers to perform single skill tasks.

2. Teaming - Has teaming become a normal approach in your commercial and Navy business practices?

Yes, but the degree of the teaming is a function of the ship type, capability of its owner, the design complexity.

Internally, teaming on commercial projects is very dependent upon team members skills and commitment to participate.

Externally, teaming is well implemented and is going well on ARCO tanker construction and BP proposal. There will be others like LPD 17, but their composition is to be determined.

The company feels that it is best to team now on simpler programs and get the practice perfected, before moving on to more complex projects.

The Navy IPT teaming model doesn't work for commercial contracts--Requires too much customer presence and commercial customers may resist increased oversight and accountability.

3. Were your associations with foreign partners useful, and if so, do you plan to use such associations in future commercial and Navy contracts?

Yes, looking at other partners, now.

Avondale recognized early that in order to become commercially competitive it had to learn from those who already were, i.e., foreign yards.

Not under consideration for Navy construction, because of security and programmatic concerns.

b. What MARITECH Program processes did you particularly like/dislike, and do you have any suggestions for such future programs?

Positive:

Program has much improved Avondale's capabilities to build complex ships, such that the Cruise Ship contract is viewed as a "graduation exercise."

The degree of flexibility shown by MARITECH and MARAD when real-world requirements required a change to the proposal.

Negative:

Accounting procedures make it difficult to track research and consultant costs at this yard since the shipyard's internal procedures are set up for a yard with organic R&D capability (minor problem).

AOTR involvement has been very limited because of funds limits.

Future:

Appoint experienced AOTRs. Both Tom Conroy and Carl Setterstrom have a wide-view.

Program should continue and focus on process improvement and training; e.g. sponsor industry-wide training seminars on common subjects which improve competitive edge for everyone, like contracting, procurement, design, production processes.

Keep the program flexible- the economy, markets, and inexperience force changes in proposals.

Add program management funding to increase AOTR involvement.

Don't focus on specific designs.

7. Comments on the Global Shipbuilding Market:

What must be done for the U.S. to successfully compete in the global market and what should be the role of programs such as MARITECH?

Help with training, but keep the program as flexible as possible, allowing for project changes driven by changes in markets and technology.

Maritech Review
Case Summary #3

Administrative Data

Lead Shipyard: **Bath Iron Works (BIW)**
700 Washington Street, Bath, ME 04530

Date of Shipyard Interview: 3 Feb. 1998
Steve Laskey - Senior Program Manager, Engineering Business Development
Jim Demartini - TRP Program Manager
Brent West - Director, Strategic Planning
Ken Brill - New Shipbuilding Methodology
David Forrest - Chief Welding Engineer
Greg Harrison - NIIIP SPARS
James Baskerville - Chief Engineer, Advanced Technology
Joseph Theriault - Materials Division
James Faverau - Director, Facilities
Mike Duquesnoy - Manager, Machinery Section

Date of AOTR Interview: 3 December 1997

MARITECH BAA/Projects:

1. 1994 TRP Project: Commercial Shipbuilding Focused Development Project ($10.196M)
Consortium Members: Kværner Masa -Yards (KMY), Finland
Mitsui Engineering and Shipbuilding, Tokyo, Japan
Shipyard POC: Joseph Fortin and Jim DeMartini
AOTR: Ed Schimler

2. 94-09/95-02. Near-Term Technology Applications: High Speed Monohull Focused Development and Contract Design ($6.7M)
Consortium Members: Kværner Masa Marine; Annapolis, MD
General Electric Company (GE); Schenectedy, NY
American Automar, Inc (AAI); Washington, DC
Shipyard POC: Russell Hoffman
AOTR: Jim Kuny, ONR

3. Projects participated in, but not led by, BIW:
   a. Advanced Technology Development: STEP Ship Product Models
   b. Advanced Technology Development: Automated Welding of Structural Beam Erection Joints
   c. Electronic Commerce/Computer Integrated Enterprise: New Shipbuilding Methodology Through the Shipbuilding Information Infrastructure Project (SHIIP)
   d. Electronic Commerce/Computer Integrated Enterprise: NIIIP Shipbuilding Partners And Subcontractors (SPARS)

Researcher: J. Richardson

Case Summary

A. Background

Bath Iron Works (BIW), located on the Kennebec River in Bath, Maine, is a 58 acre, full service shipyard. Fabrication of steel and outfit (pipe, vent, etc.) occurs at facilities in East Brunswick, ME (approximately 4 miles distant). Materials/components are shipped to Bath, assembled in both enclosed facilities and outside building platens, and ultimately erected on inclined building ways (total of three). Ships are end launched into the river and moved to an outfitting pier for final installation and testing of systems. Because there is no ship retrieval facility in Bath, newly launched Navy ships (presently the DDG 51 Class Aegis Destroyers) transit to BIW's Portland, ME repair facility (approximately 40 miles) where installation of sonar domes is accomplished in a floating dry dock.

As of May, 1997 BIW had contracts for 11 Aegis destroyers, commercial new construction contracts[88] and a minimal ship repair backlog. The Shipyard is looking toward new Navy programs, such as the SC-21 family of ships. They plan to begin building four LPD-17s in 2000. To date, BIW has been awarded 27

[88] According to *Marine Log*, June 1997.

DDG-51 Destroyers.   BIW lists four major challenges for 1998: DDG-51 Flight IIA construction, LPD-17 design completion, DD-21 proposal and contract award, and a major facility modernization effort.

A future market deemed important by BIW is foreign Navy shipbuilding. In conjunction with PMS400 and LM they are marketing the Aegis Destroyer to selected "Aegis Approved" countries and non-Aegis sales with several other countries.

The MARITECH program influenced planned facility modernization efforts described later.

BIW has designed and constructed over 400 Naval surface combatants and commercial vessels since its birth in 1884. The shipyard constructed one to two ships a week during World War II.[89] It has been the lead shipyard, since 1950, on 10 of the 20 Cruiser/Destroyer/Frigate Ship classes. Since the 1950's BIW has built 5 LST's, 22 merchant ships, and 76 Surface combatants.

In 1992 BIW employed about 9,000 people and had contracts for 14 AEGIS Destroyer follow ships. The company now has approximately 7,300 employees (including 250 engineers and 650 designers). In 1992 it was clear to the company that Navy production was declining and would continue to do so. Further, BIW felt that the Navy was becoming much more empathetic toward business and commercial practices, even when performance tradeoffs were needed.

Plans that would eventually involve Technology Reinvestment Project (TRP) and MARITECH began to form during the early 1990's, when BIW decided to pursue the international market for high technology commercial vessels. In March 1993, D.D. Fitzgerald, then President of BIW, issued the following set of priorities:

> "1. Our mission is to ensure the viability of the corporation, and, therefore secure jobs for the future.
>
> 2. Together, we will do so by becoming the world's best designer and builder of complex surface combatants including their life cycle support.
>
> 3. We will supplement this core business through diversification.
>
> 4. Thus by 1997, our goal is to be firmly established in the international competition for the design and construction of high technology commercial vessels [The goal was to bid on commercial ship construction at world competitive prices. With four ships under construction by the end of 1997, the first production ship to be delivered by 1998].
>
> 5. We will also become a volume producer of selected industrial products and a leader in providing technical services in the global market." [ ] indicate researcher's remarks.

The strategy to reach these goals was called "BIW Strategic Plan for Competitive Commercial Shipbuilding" and was to be addressed in four stages:

- Stage I (with TRP funding) -- Commercial Shipbuilding Focused Development Project. This stage was dedicated to performing a comprehensive market survey and analysis of global universal shipbuilding trends; technology transfer; and creating executable shipbuilding plans; time and cost reduction models; and plans for ship operation, contracting, marketing, and financing. The outcome is discussed later in this summary.
- Stage II -- Commercial Shipbuilding Deployment. Development and enhancement of human resources, facilities, technologies, and planned ship construction were addressed during this stage.
- Stage III (with MARITECH funding) -- New Product Development. Commercial ship design and build strategies were formulated. The High Speed Monohull projects, cost-shared with MARITECH are being conducted under this stage, which was scheduled to end in 1997.
- Stage IV -- Commercial Ship Production.

Two events had a large effect of BIW's plans. First, TRP and MARITECH were initiated and offered government help in reacting to the new market realities. Second, BIW was privately owned until 1995, when it was bought by General Dynamics, a corporation with heavy emphasis on Defense markets.

In the final analysis, results from a TRP project "Commercial Shipbuilding Focused Development Project" (CSFDP) convinced BIW that the Return On Investment (ROI) was insufficient to justify the extensive amount of effort required to compete in the commercial market. They concluded that a business case to pursue commercial shipbuilding could not be made at that time.

Relationships that were created with Kværner Masa-Yards and Mitsui Engineering and Shipbuilding under the Technology Reinvestment Project (TRP) remain intact today. Further, technologies, processes, and facilities modernization planning gained from these relationships have served BIW well. These

[89] Now, BIW is averaging about one and one-half Navy ships per year.

outcomes, coupled with experience gained under the High Speed Monohull project, have been extended into recent programs such as ARPA's Arsenal ship and current DD-21 competitions. Unfortunately for BIW, the Arsenal Ship was under-funded by Congress and was canceled by the Navy.[90]

At this time, BIW is working with Avondale Shipyard and the Navy on applying many of the commercial practices observed under the TRP program within the Integrated Product and Process Development (IPPD) environment of LPD-17.

B. Summary of MARITECH Projects Managed or Participated in by this Shipyard

1. 1994 TRP Project: Commercial Shipbuilding Focused Development Project

Background: The first task of this project was to conduct a technology transfer with two foreign shipyards, Kværner Masa-Yards (Finland) and Mitsui Engineering and Shipbuilding (Japan). The second task was to develop shipbuilding plans, the third to implement a Shipbuilding Time and Cost Reduction Model, followed by formulating product-driven Executable Ship Operating, Contracting, Marketing, and Financing Plans. A proposal was submitted to the TRP, requesting that the government furnish 33% of the necessary funds to accomplish this stage, which was to end in 1995. Stage II, to follow, was planned to be an effort to develop human resources, modernize facilities, implement technologies, and build ships.

Objective: The objective of this activity was to:

- Lead the U.S. Shipbuilding industry's reentry into the global commercial shipbuilding market.
- Reduce the cost of Navy ships [through economies of scale, efficiencies, and technologies gained through stages I and II of their strategy].
- Preserve the shipbuilding industrial base (represented by BIW) through success in the commercial market.
- Provide dual-use merchant marine vessels (to be used for Navy purposes during a conflict) through innovative ship designs.
- Provide a number of benefits to the U.S. economy, yielded by the expansion of this industry.

Defense would benefit from lower cost, better availability of on-shore sources of Naval ships through a more economically stable U.S. shipbuilding industry, and a larger merchant fleet to serve national defense. Some of these merchant ships were to be designed to be adaptable for Roll-on/roll-off. Adoption of commercial standards by the Navy would help to reduce costs.

The commercial benefit was to be the U.S. Shipbuilding industry's reentry into the global commercial shipbuilding market, with benefits to the industrial base, dual-use merchant marine vessel, and U.S. economy, discussed earlier.

Approach and Status: Excellent working relationships were established with Kværner Masa-Yards (KMY) (a Finnish shipyard) and Mitsui Engineering and Shipbuilding (a Japanese shipyard). Through direct interaction with these yards, BIW was able to gain extensive insight into global commercial shipbuilding market conditions and competitive commercial shipbuilding practices. Based on this insight and a market and competition survey, the probable Return On Investment (ROI) was deemed to be insufficient to justify expenditures for extensive facility and process changes that would be required to compete in the commercial markets. Additionally, the company asserts that dominance of low technology ships in the market, plus continuing foreign subsidies of their shipbuilding industries, and a 40% worldwide production over capacity (may get to 65% by 2000) make the present market unassailable. Given these conditions the decision was made to concentrate on the Navy ship market. This decision recognized that continuing downsizing of the shipyard may result, until market conditions improved and/or commercial viability was proven (the market could shift toward higher complexity, which may favor entry by BIW).

However there was some very good news. The relationships created with Kværner Masa- and Mitsui were largely a success -- they remain intact today. Further, technologies and processes were imported through these relationships that were applied to Navy shipbuilding, more than compensating the government for its TRP investment (the project has claimed an annual savings of $11M to $13M in material handling and management and production labor on construction of the AEGIS destroyers currently built at BIW). Some of the technologies successfully transferred enabled:

[90] Among the lessons learned from their Arsenal Ship experience were the benefits of government/industry cooperation and industry control over design.

- Reclassification of material increased the amount of low-valued material available to mechanics, thus reducing the need to kit such materials in work order packages. Thus, more efficient material management, and ready availability of high use/low-value material to the mechanic.
- Unit construction at floor level for selected units resulted in cost savings.
- Elimination of unnecessary statusing achieved a 30% reduction in the number and frequency of status and performance reports.
- A surface preparation and coating project that minimizes rust on ship products in support of limited blast on block, integrates cost effectiveness with ship outfit completion requirements through a surface preparation and prime coating plan, and applies interior final coatings in the most cost effective manner as late as possible to support milestones.
- A facility design effort which enabled BIW to develop a capital investment strategy focused on improvements that would maximize productivity gains.
- The development of in-house commercial design and design management capabilities, based on an understanding of commercial standards that did not exist previously.

2. 94-09/95-02. Near-Term Technology Applications: High Speed Monohull Focused Development and Contract Design:

Background: This project assumes that there is a market for high speed commercial transport ships in the 200 meter and greater length category. The challenge is to satisfy that market in terms of speed, while retaining realistic commercial ship power requirements, cargo capacity, and operating costs. The consortium included a U.S. shipyard (BIW) teamed with an international shipbuilder (Kværner Masa - KMY), a large engine manufacturer (General Electric), and a U.S. Ship operator (American Automar).

Objective: To develop innovative designs for fast commercial cargo and passenger ships that will reduce individual ship design, construction time, and cost and market it by the end of 1997. The project will also integrate commercial shipbuilding within existing Navy ship construction processes at BIW. The product will be dual-use in that it will serve the Navy through providing merchant ships with improved delivery speeds at reduced operating costs, using RO/RO, container, or troop transport modes. It also aims to preserve an important industrial base by opening business opportunities in high speed ferries, passenger ships, 21st century combatant and sealift for the Navy, and military and commercial application of a number of technologies.

Approach and Status: Phase I began the development of a high-speed monohull for a high speed sea transportation and cargo movement system envisioned to meet the growing needs for fast, reliable, movement of ocean cargo. Phase II continues this work, deploying the commercial shipbuilding processes and technologies within the shipyard and implementing the executable plans developed in phase I. The results will be to increase productivity and reduce the cost of Navy ship construction projects. It will also support construction of commercial ships at globally competitive prices. Responsibilities of the various consortium members include:

- BIW: Senior management, design, construction technology, market information
- KMY: Market and feasibility studies, concept design, Performance studies, model tests and performance reports
- GE: Propulsion
- AAI: Represent the perspectives of the ship owners

Thus far, a number of concepts have been developed, such as feeder, truck/car ferry, and container ships.

Impact: The end product will be a new ship concept for a new commercial market niche with potential sealift application.

Of more commercial significance, BIW and KMY are developing designs for hybrid high speed monohulls which feature BIW's technology and design/construction experience in fast, slender naval combatants combined with KMY's development of fast passenger RO/RO and cruise ships. These designs may be applied to both commercial and defense applications.

3. Projects participated in, but not led by, BIW:

a. Advanced Technology Development. STEP Ship Product Models:

Objective and Background: MariSTEP is a MARITECH sponsored program targeting prototype implementations of the emerging STEP shipbuilding application protocols. The objectives are to enhance the global competitive position of the U.S. shipbuilding industry, enable the virtual shipyard, accelerate the implementation of STEP throughout the U.S. marine industry, assess the ability to implement STEP application protocols, and enable a product model definition and exchange capability to support simulation based design initiatives.

Analysis: MariSTEP is important to BIW for the reasons given in our report on this project. As stated, there are many reasons why applying STEP to the shipyards may not work. The keys to success, enumerated in the MariSTEP report, are the same for every yard.

b. Advanced Technology Development. Automated Welding of Structural Beam Erection Joints:

Objective and Background: TRP began this project, with a follow-on by MARITECH. The objective of this project is to deliver a fully integrated prototype system (consisting of a clamping fixture and a robotic head) to each of the three participating shipyards. The lead, CYBO Welding, will then market the systems to other shipyards. Automating the process of welding the 5,000 to 10,000 structural beam erection joints in a normal ship can save as much as $500K per ship.[91] The high cost of rework and injury will be substantially reduced.

BIW Comments: BIW will be a Beta site for Tee Bar weld testing. Beta tests will probably begin in August. There are approximately 2000 joints and bars (T-beams) per ship. The implementation of Cybo's robotic welders to BIW's welding operation would reduce the amount of hand welds (with or without automatic feed) from 85% to somewhat less (not projected). They would expect a 30 to 40% cost reduction from an integration of these systems into their operation (assuming the robotic welding sets live up to Cybo's promises). Despite this, probably because of Cybo's failure to deliver a prototype system, BIW has no plans to adopt robotic welding. The have not calculated ROI, and did not offer any predicted schedule reduction benefits. At this time, BIW has one robotic welder. It is ten years old -- a point -to-point-teach robot with no sensor.

Analysis: Cybo is considerably behind in its delivery of equipment, allegedly because of software and internal amplifier problems. This has deflated BIW's enthusiasm. On the other hand, it was disturbing that the shipyard did not have a cost/benefit analysis that set criteria for a buy decision. BIW seems less convinced than other shipyards that robotic welding would make their structural beam erection joint welding much more efficient. This is not a reluctance to automate. One hundred percent of BIW's plate cutting is automated through CNC and they are working toward automating their beveling process as well (although neither operation is driven directly from the CAM/CAD as yet). BIW feels that the Cybo equipment is more viable for simpler commercial ships than for Navy ships, particularly where there are many changes from ship to ship. They also indicated that they did not see much robotic welding in the overseas shipyards. They are encouraged by Cybo's gantry under-hung mode.

c. Electronic Commerce/Computer Integrated Enterprise. New Shipbuilding Methodology Through the Shipbuilding Information Infrastructure Project (SHIIP):

Objective and Background: Electric Boat will attempt to deploy National Industrial Information Infrastructure Protocols (NIIIP) throughout the shipbuilding industry. This will allow the sharing of information, now difficult because of the heterogeneity of computing environments. The approach is to set up a reference deployment at Electric Boat in Groton, CT. The principal target is ship construction (assembly and installation), since information infrastructure technologies have been successfully introduced to design, engineering, and manufacturing. They are:

- establishing the SHIIP methodology group,
- defining new shipbuilding processes and their requirements,
- deploying NIIIP,
- developing process enablers, integrating and testing,
- documenting design and deployment, and
- demonstrating results.

BIW Comments: This project is being conducted under Electric Boats lead. Although the two shipyards do not employ the same CADCAM system, it is hoped that translators will allow them to share data.

Analysis: From our report on the SHIIP project, it is clear that there are many advantages for both shipyards. Again, it is too early to tell how successful this will be, but it is an especially important goal for both shipyards since the General Dynamics buy of BIW.

[91] This corresponds to about 27,000 man hours of effort.

d. Electronic Commerce/Computer Integrated Enterprise. NIIIP Shipbuilding Partners And Subcontractors (SPARS):

Objective and Background: The objective of this project is to establish Virtual Enterprise (VE) technologies for shipbuilding. The VE will represent customers, partners, subcontractors, and suppliers using NIIIP technologies. BE will enable electronic-based business interoperations that are transparent to the underlying processes and computing environments of the participants. The shipbuilding VE is to accomplish the following.

- Enable implementation of advanced business practices in requirements analysis, supplier relations, material procurement, resource and financial management through the application of information technologies to the inter-operation of shipyards and their IPTs.
- Enable total process systems by establishing system-wide integrated design and production facilities, thereby reducing total time and cost of ship design and construction.

The approach is to:

- Establish shipyards as VE gateways to provide near-turnkey shipbuilding business processes to their supply chains, thus product teams can cost effectively work together.
- Establish interoperability mechanisms to link heterogeneous computer environments of different companies for rapid communication, accurate monitoring, and responsive control of shipyard activities.
- Provide secure, easy-to-use internet-based supplier information.
- Provide the ability to share design information.
- Manage complex schedules.
- Establish proof-of-production feasibility of assembly and disassembly.
- Build a robust VE knowledge base.

BIW Comments: BIW's objective is to apply the NIIIP SPARS project output to their procurement functions, allowing them to perform necessary actions electronically over the internet and in such a manner as to support commercial best practices. Their specific applications at this time are i) the transmission and receipt of object oriented CAD drawings, and ii) text documents for workflow management. As an example, they showed their materials acquisition system. When completed, this process will transform their entire acquisition process, establishing electronic commerce links for market sourcing, solicitation and proposals, ordering, supplier management, shipping, and invoicing and payments.

Analysis: The shipyard has a good plan for accomplishing their purpose. It is too early to tell how successful they will be, but it is a goal that is accepted throughout the company as important, so it seems to well supported.

C. Overall Shipyard Goals and Strategies:

Two overall BIW goals and strategies that are affected by MARITECH and TRP efforts can be discerned from the above and from an examination of BIW-proposed TRP and MARITECH projects.

Goal/Strategy 1: To offer total surface Navy solutions for the customer through: innovation, shipbuilding, and life cycle support services. To address the foreign Navy market in all three areas. Part of this goal will be realized through applying commercial technologies and processes in designing and building Navy ships, which would save DoD procurement dollars. The primary source of these technologies and processes is the technology transfer conducted with the foreign shipyards under the TRP project. As will be discussed, this has been done to a large extent, resulting in savings of $11M to $15M on Navy programs.

Goal/Strategy 2: A shipyard-level goal was to become competitive in the building of high technology commercial ships. Although this goal is a far second to Navy shipbuilding, BIW states that they will address the commercial market, if and when it is viable for them to do so. At that time, the strategy to attain this goal will likely be based on three factors:

- BIW performed a market and competition survey, established relationships with some overseas shipyards, and imported technologies and processes pertinent to their operations (partially funded under the TRP project). As stated earlier, the market survey did not have optimistic results and, at this time there has been no entry into the commercial market.

- Next, designs were to be completed on commercial ships, which would then be built and sold in the worldwide commercial market. The MARITECH projects, "High Speed Monohull Focused Development" and "High Speed Monohull Contract Design" were proposed to further this second goal. There could be several potential benefits to the Navy from the pursuit of this goal, as discussed earlier.
- Finally, several MARITECH projects were joined (but not led) by BIW with the purpose of upgrading information technologies and processes necessary for more efficient operations (helpful to Navy construction as well).

D. QUESTIONS

1. Ship Design and Construction Strategies:

a. What ships have been sold, built, are under construction, or have been designed as a result of MARITECH?

Under the High-Speed Monohull Focused Development Project, there has been major ship design activities. The end product is a ship concept for a new market niche and potential sealift application.

Of more commercial significance, BIW and KMY is developing designs based on the hybrid high speed monohull which feature BIW's technology and design/construction experience in fast, slender naval combatants combined with KMY's development of fast passenger RO/RO and cruise ships. These designs will be applied to both commercial and defense applications.

However, no commercial ships have been or are under construction or contract at this time.

b. What changes in construction strategies have been developed?

The purpose of this effort is to develop innovative designs for fast commercial cargo and passenger ships that will reduce individual ship design, construction time, and cost. The project will also integrate commercial shipbuilding within existing Navy ship construction processes at BIW. This is a large departure from BIW's normal product line.

c. Were any international competitive benefits derived from MARITECH ship designs and construction projects, and if so, what were they?

None have occurred.

2. Technologies Developed or Applied to Improve Design, Production/Manufacture, Operation, and/or Repair of Ships:

a. What technologies have been developed or applied to the design, production/manufacture, operation, and/or repair of ships through MARITECH?

See table below.

Supporting Data for Technologies to Improve Design, Production/Manufacture, Operation, and/or Repair of Ships:

Technologies	Description	Metric Benefits
COMMERCIAL SHIPBUILDING FOCUSED DEVELOPMENT PROJECT		
Material Reclassification	This effort has increased the amount of low-valued material available to mechanics, thus reducing the need to kit such materials in work order packages.	1) More efficient material management through reduced material tracking and handling, and 2) ready availability of high-use/low value material to the mechanic
Unit Construction	BIW identified units that could be built on the floor as contrasted with using raised mocks	Cost Savings by reducing: 1) need for transportation beams, 2)amount of external staging. and 3) need for safety railing and nets on lower levels of upright units and inverted units
Reduction in unnecessary statusing	Procedures to reduce number and frequency of status and performance reports by reviewing all status reports (275), streamlining multiple statusing systems, and identifying and agreeing upon the level of statusing on key shipyard performance indicators	30% reduction in the number and frequency of status and performance reports
Surface preparation and coating project	This project has examined several surface preparation processes and coatings to reduce rust. Lessons learned include: Managed preservation efforts that allow for weld damage pickup and a reduction in secondary surface preparation and integrated paint planning both reduce rework significantly	Minimizes rust on ship products in support of limited blast on block, integrates cost effectiveness with ship outfit completion requirements through a surface preparation and prime coating plan, and applies interior final coatings in the most cost effective manner as late as possible to support milestones
Facility design effort	This was an effort to develop a facility plan based on world class standards from which all current facility modernization and expansion projects are derived	Enabled BIW to develop a capital investment strategy focused on improvements that would maximize productivity gains
In-house commercial design and design management capabilities	These commercial design and design management capabilities are based on an understanding of commercial standards that did not exist previously	As part of the technology transfer partnership with KMY, BIW was able to use this new capability to receive a second MARITECH-funded project, the High-Speed Monohull Focused Development Project

b. Were any international competitive benefits derived from technologies developed or applied under MARITECH projects, and if so, what were they?

None to date

3. Facility Expansion or Modernizations and Process Enhancements Made to Improve Design, Production/Manufacture, Operation and/or Repair of Ships:

a. What facility modernizations or expansions or process enhancements (e.g., yard layout) have taken place as a result of MARITECH?

Based in part upon the lessons learned in the CSFDP, a planned 200 million dollar modernization will include creation of a Land Level construction facility with launch and retrieval capability in Bath using a re-positionable floating dry dock, creating a support shop near the dock, and improving and expanding the blast and painting shop. Four Land Level building stations will reduce overall facility footprint, improve efficiency and reduce overall costs to the USN. This modernization has its in a $500M Dual-use facility concept developed under the CSFDP.

b. Were any international competitive benefits derived from these expansions, modernizations, or enhancements, and if so, what were they?

No

c. Did you examine foreign shipyards as part of a MARITECH project, and if so, how did your findings influence your facility expansion or modernization or the planned enhancement of your processes?

Based on observations made of eight foreign shipyards, including the development of the new Kværner Warnow shipyard in Germany, BIW developed a World Class Dual-Use shipyard concept design. This design, while unaffordable given commercial market conditions world wide, provided a blue print for current modernization efforts.

4. Commercial Business Practices Developed or Applied for requirement analysis, supplier relations and material procurement, human resource management, customer relations and marketing, and cost estimating and financial management systems (or others applicable to your shipyard):

a. What new commercial business practices have resulted from your MARITECH projects?

None

b. What new business markets have been developed or expanded through commercial business practices developed or applied through MARITECH?

None directly, although BIW indicates that the MARITECH program has moved their operations and processes closer to the efficiencies required for global commercial competitiveness. These are principally information infrastructure tools gained through the MariSTEP SPARS, and SHIIIP projects described earlier.

c. Were any international competitive benefits derived from business processes developed or applied under MARITECH projects, and if so, what were they?

None to date

5. Impact on Navy Shipbuilding:

a. What is the impact of the MARITECH projects on Navy shipbuilding?

The TRP project resulted in resulting in savings of $11M to $15M on Navy programs (calculated from BIW's CPI). As a result of programs such as these, Brent West indicated that Navy ships are becoming less expensive to build.

b. What commercial practices are you now using in Navy contracts?

Much of the technology obtained through the TRP project has been applied to the Navy (see 4.a.).

c. What positive impacts could be manifested if the Navy agreed to adopt commercial business methods identified or used in MARITECH projects?

Quality testing requirements are specialized and difficult in Navy shipbuilding. The Navy encouraged BIW to adopt ISO 9000 for quality control and BIW is ISO 9000 certified. This should save time and money in the long run. More affordable off-the-shelf acceptance and control processes are also being sought. It was emphasized that there are some limitations in adopting commercial standards for Navy ship design (e.g., combatant survivability requirements are too stringent for commercial hulls). Another unique feature of Navy shipbuilding is the number of changes from one ship to another. Over 2000 Engineering Change Proposals often result between the construction of one ship and another of the same class.

Government auditing functions have undergone some consolidation, but they still maintain a high level of oversight. This was not true of the Arsenal Ship contract which was conducted under Section 845 procurement authority, thereby considerably streamlining contractual requirements/cost and it would have saved money.

6. MARITECH Program Process:

a. What cultural and process changes have resulted from procedures employed through the MARITECH Program?

1. Consortia - Has forming consortia become a normal approach in your commercial and Navy

Teaming has become a major part of BIW's way of doing business. They seem to understand and value teaming.

2. Teaming - Has teaming become a normal approach in your commercial and Navy business practices?

Yes

3. Were your associations with foreign partners useful, and if so, do you plan to use such associations in future commercial and Navy contracts?

The relationships created with Kværner Masa- and Mitsui were largely a success -- they remain intact today. Technologies and processes were imported through these relationships that were applied to Navy shipbuilding, more than compensating the government for its TRP investment.

b. What MARITECH Program processes did you particularly like/dislike, and do you have any suggestions for such future programs?

- Flexible Cooperative Agreements
- Cost Sharing
- Teaming

7. Comments on the Global Shipbuilding Market:

BIW feels that current business conditions within the global shipbuilding market cannot produce an acceptable business case which would justify the Return On Investment (ROI) for the extensive amount of effort required to compete in the commercial market. Additionally, the company asserts that dominance of low technology ships in the market, plus continuing foreign subsidies of their shipbuilding industries, and a 40% worldwide production over capacity (may get to 65% by 2000) make the present market unassailable.

Based on today's circumstances, BIW sees little opportunity for commercial shipbuilding outside of specialized niche markets which require development.

What must be done for the U.S. to successfully compete in the global market and what should be the role of programs such as MARITECH?

BIW's answer seemed to be that MARITECH's role was to assist in developing U.S. shipyard capability to compete in the commercial market and to continue to encourage the importation of appropriate technologies, processes and facilities modernization plans for application to the Navy market.

Administrative Data

Lead Shipyard: **Bender Shipbuilding & Repair Co., Inc. (Bender)**
265 South Water Street, P.O. Box 42, Mobile, AL 36603

Date of Shipyard Interview: 10 February 1998

Tom Bender - President
Bruce Croushore - Corporate Secretary
Patrick Cahill - Project Engineer
Joseph Comer - Engineering Manager
Michael Cook - Central Planning and Control Manager
Lee Douglas - Information Systems Group Manager

Shipyard Contact: Bruce Croushore

AOTR: Dave Heller, MARAD

Date of AOTR Interview: 5 February 1998

MARITECH BAA/Projects:

1. BAA 95-02. Reefer 21 ($1.6M - total cost)

Consortium Members: Columbia Group
Nordvestconsult AS

2. BAA 96-01. Multi-Mission Cargo Ships: Systematic Construction of Design Variants ($2M - total cost)

Consortium Member: Kværner Masa Marine (KMM)

3. BAA 96-042 Organization of Work in a 2nd Tier U.S. Shipyard ($7.4M - total cost)

Consortium Members: Caterpillar Inc.
Cybo Robots
Thompson Power Systems

Researcher: S. Tennyson

Case Summary

A. Background

For more than 75 years, family owned Bender Shipbuilding and Repair, Inc., has been known for solidly built vessels, delivered on time and at a competitive price. Bender, a "second-tier" shipbuilder, is one of the leading ship repair facilities on the Gulf of Mexico and is known as a leading builder of mid-size steel and aluminum vessels. Centrally located in Mobile, AL, just 30 miles from open water, it is convenient to all major gulf shipping. Their yards stretch along the Mobile River at the head of Mobile Bay, covering more than a mile of waterfront.

Bender established themselves by becoming the dominant supplier of fishing vessels to the Pacific Northwest, as well as a major supplier to foreign markets . They have converted more vessels than any other American yard. In addition, they are also build casino riverboats and dockside casino barges. To accommodate the growing demand for these vessels, Bender bought a yard on the Mississippi River in Braithwaite, LA in 1993. They then delivered the 260-ft. *Star Casino*, the first riverboat casino to operate in Louisiana, eight months after opening the yard.

Bender is now able to service and repair Panamax size ships due to recent expansions and improvements at its main yard in Mobile including, the dedication of a 545-foot floating steel dry dock, the Pete B, with lifting capabilities to 20,000 tons. The same dry dock was lengthened in 1994 to increase its capacity to 24,350 tons. In 1992, Bender expanded south along the river with construction of Yard 8. Bender also added a 700-foot concrete wet dock with 35 feet of water depth to Yard 9 that same year. To meet the growing demand for aluminum boats, they renovated a 40,000 square-foot covered assembly area specifically for the construction of aluminum vessels. Bender maintains an in-house staff of estimators, naval architects, engineers, designers, planners and schedulers , as well as enlists the assistance of various subcontractors and vendors. They employ approximately 660 people.

At Bender, repair work continues to be one of the company's major components. However, Bender also builds all types of ships and craft that are under 400 feet in length for both commercial and military markets. Their products include offshore supply and service vessels, passenger vessels, tugboats, fishing vessels, factory trawlers, riverboats and patrol boats. There are currently more than 800 Bender-built ships operating worldwide.

B. Summary of MARITECH Projects Managed or Participated in by this Shipyard

Some General Comments:

Dave Heller, Bender's AOTR, commented that if MARITECH were to end today, he believes that Bender has derived more from their MARITECH experience than any other shipyard he has seen. He noted that they are a completely different shipyard today from what they were one year ago. In agreement, Bender disclosed that MARITECH has been indispensable in helping them do what they needed to do, re-create their processes.

Bender noted that their first approach to MARITECH, concentrating on designs, might not have been the correct one. After examining various markets under two MARITECH projects, they realized that shipbuilding processes are the keys to being competitive. The company realized that a work flow plan was more important than CAD/CAM, and are still in the process of organizing their shipyard. Furthermore, they asserted that robotic welding (CYBO) is not the panacea, rather there are other important processes that must be addressed, such as accuracy control, prior to implementing robotics.. Also, Bender remarked that programs such as MARITECH should be concentrating on technical implementation in U.S. shipyards because "technical development without an implementation plan is ineffective."

Bender also stated that they do not see the Far East yards as affecting what they are doing at their yard. They remarked that the Asian yards are huge, both in size and workers, and are mainly dedicated to building larger ships requiring great amounts of steel. Norway is their biggest competitor, building smaller ships similar to their designs.

Bender also expressed concern regarding the future of the MARITECH program. The concept of a NSRP approach to a follow-on MARITECH effort was discussed. They disclosed that this would not be a favorable alternative in their opinion. They asserted that the larger yards, "the big players", have full time staff devoted to the NSRP to guarantee that their interests are being represented. Bender commented that they don't have the resources to do that; therefore, their concerns would be lost.

1. BAA 95-02. Reefer 21:

<u>Objective:</u> Develop an entirely new design for a cost-effective small ship that can compete in different sectors of the Refrigerated Cargo Ship ("Reefer") market worldwide.

<u>Approach and Status:</u> Bender approached this project by separating the goal into three overall objectives or tasks. The first task was to define the market requirements for small reefer ships and then to develop the marketing aids needed to sell the Reefer 21 design internationally. Secondly, they developed the Reefer 21 design to the level necessary for economic construction. Finally, Bender was to develop a manufacturing plan for the competitive construction of the Reefer 21 in large numbers. However, this project stalled because of a misunderstanding regarding the nature of the vessel; the government thought it was a fishing boat rather than a ship designed to carry refrigerated cargo, such as fish.

<u>Impact:</u> Although no contracts resulted from this project, Bender credits the project with improving their production planning. From this project, they learned how to do a build strategy, which they never had done before. Also they began considering improvements to the yard's materials flow and processes. The Multi-Mission Cargo Ship proposal was a result of this project as well.

2. BAA 96-01. Multi-Mission Cargo Ships: Systematic Construction of Design Variants:

<u>Objective:</u> To penetrate the international market for small cargo ships using different types of the same ship design, using the same general dimensions as the Reefer 21.

<u>Approach and Status:</u> After engaging in discussions with several potential buyers of the Reefer 21 class of small refrigerated-cargo ship, Bender realized that there was a potential market for a long series of cargo ships which are of the same general dimensions but not all of the same type. Therefore, they decided to complete a market analysis to determine the broad spectrum of the international market requirements for cargo ships of around 10,000 gross tons. They wanted to determine enough commonality in the requested designs that they could build a mix of types without losing shipbuilding productivity. Bender would then develop a set of contract designs for the required variations on the basic design. Eventually, they would develop a detailed plan for manufacturing of a mix of multi-mission cargo ships without a loss of efficiency. KMM has completed a preliminary design which Bender is using to develop a build strategy. This project is still on going.

Impact: This project has helped to support all of the new engineering software at their shipyard, allowing them to implement as well as learn to use it. This included their 3-D modeling capability and fully networking their yard.

3. BAA 96-042 Organization of Work in a 2nd Tier U.S. Shipyard:

Objective: Overall objectives of this project are to: reduce the cost of shipyard operations by 50%, and to reduce the time required for ship construction (from contract to delivery) by 50%.

Approach and Status: In comparing its operations with European yards of similar size and capacity, Bender became aware of a number of major shortcomings related to their current business practices, and specifically the organization of production within their shipyard. To achieve their objectives, Bender noted that they had to: (1) completely re-engineer their conversion of production requirements from the engineering package to production work instructions; (2) convert to modern material procurement practices including "just-in-time" delivery of materials; (3) explore a "make vs. buy" decision to production; and (4) create strategic alliances with key suppliers. The project is organized into three phases. The first, Diagnosis, was intended to identify those specific areas that require modification or enhancement, and has been completed. The second phase, Process Modification, involves developing and installing the necessary improvements to integrate Bender's engineering, production and materials systems. This phase started in March 1998 and is ongoing. The final phase, Evaluation, will compare the modified procedures with the original ones to evaluate their effectiveness and efficiency. Bender is currently in the process of defining benchmarks/metrics to compare with the data once all of their processes and facilities have been upgraded.

Impact: Bender has switched to a new accounting and cost systems which will change the focus of reporting from the project foreman to the team. They will be able to tell where the bottlenecks are and how long it takes to make a product or piece of the overall project, rather than the old way of just knowing how long it takes to build the whole ship. Another direct result of this project is a training program which included management training, computer training, welding training, etc. They have integrated the software that will allow them to use the plasma machine to cut the hole in advanced for the pipe to be inserted, reducing the amount of time spent re-piping and re-running pipe (30%). In addition, they have saved 4-5,000 man-hours per ship using 3D models to show where parts fit together and how. They have greatly improved their material flow and handling, which is the most expensive part of shipbuilding. They implemented their supervendor concept in which Thompson Power Systems becomes a one stop shop for engine room construction. They will feed the whole package (including auxiliaries and technical data) to Bender at the right time during the production cycle.

C. Overall Shipyard Goals and Strategies:

Goal/Strategy 1: Completely overhaul their internal systems as well as refine their relationships with vendors to overcome shortcomings in their current business practices.

Goal/Strategy 2: Using new technological advances to reduce shipyard operations costs and construction time by 50%.

D. QUESTIONS

1. Ship Design and Construction Strategies:

a. What ships have been sold, built, are under construction, or have been designed as a result of MARITECH?

- Reefer 21 - Contract Design Level
- Multi-Mission Cargo Ship - Preliminary Design
- Off-Shore Supply Vessels (OSVs) - Under Contract

Supporting Data for Ship Design and Construction Strategies:

Status	Description of Vessel	Metric Benefits
Completed (Built)		
Under Construction	Off-shore Supply Vessels (OSVs)	4 for Candies 2 for Gulf Mark
Designed	Reefer 21	
Under Design	Multi-Mission Cargo Ship	

b. What changes in construction strategies have been developed?

Bender used to literally stick build their ships, but now they have switched to using group technology..

c. Were any international competitive benefits derived from MARITECH ship designs and construction projects, and if so, what were they?

Bender is building OSVs for a foreign owner and has been in discussion with several foreign buyers regarding the feeder market in Reefers, Bulkers and Containers under the Multi-Mission Cargo Ship MARITECH project.

2. Technologies Developed or Applied to Improve Design, Production/Manufacture, Operation, and/or Repair of Ships:

a. What technologies have been developed or applied to the design, production/manufacture, operation, and/or repair of ships through MARITECH?

- Simulation and lay-out planning software
- 3-D CAD and Sim; they are working on CAM
- Laser cutting (Under Development)
- NC cutting steel for pipe penetration using new software

Supporting Data for Technologies to Improve Design, Production/Manufacture, Operation, and/or Repair of Ships:

Technologies	Description	Metric Benefits
Networked Yard	Bender has networked their entire shipyard, running Fiber Optic cables to computers in Yard 5.	Better communication and faster turn-around on corrections to designs and building plans. Save time and money
3D Design Software AutoCAD	Using new CAD and layout software, Bender now completes production packages in the computer. The packages consist of 3D isometric drawings of the entire assembly which are part level after that, including construction sequence, budgeted man-hours and process flow. It is all linked to their inventory/material process.	They are creating better production documents than ever before as well as production packages. Save time and money - reduced by 4,000-5,000 man-hours per ship. Reduce time spent re-piping and re-running pipe by 30%.
Portable Arm Robot Welding	Robot that can be moved around the yard and withstand the "conditions."	It will reduce labor time as well as get rid of the "dirty" jobs. Increased efficiency.
Laser cutting	Currently under development with assistance from Caterpillar Inc.	Improved accuracy and edge quality; No clean-up; Efficient usage of power.

b. Were any international competitive benefits derived from technologies developed or applied under MARITECH projects, and if so, what were they?

Bender noted that foreign yards have implemented accuracy control programs which will enable them to integrate robotic technology.

3. Facility Expansion or Modernizations and Process Enhancements Made to Improve Design, Production/Manufacture, Operation and/or Repair of Ships:

a. What facility modernizations or expansions or process enhancements (e.g., yard layout) have taken place as a result of MARITECH?

In the recent past, Bender has invested in all kinds of upgrades and have re-built berths, expanded dry and wet docks and created an area for aluminum work. However, none of the facility expansions are a direct result of MARITECH. They have asked for a Title XI upgrade loan of $12.3M. In addition, they have acquired more land, but are very constrained by their geography.

Supporting Data for Facility Expansion/Modifications and Process Enhancements to Improve Design, Production/Manufacture, Operation and/or Repair of Ships:

Task	Description	Metric Benefits
Facilities Expansion		
Facilities Modernization		
Processes Planned	Laser Cutting	Improved edge quality and accuracy; Environmentally friendly
Processes Implemented	Crane-less erection of units up	Maximize pre-outfitting prior to

	to 300 tons	erection

b. Were any international competitive benefits derived from these expansions, modernizations, or enhancements, and if so, what were they?

Overall upgrades will enable Bender to build vessels in a cost effective manner so that Bender can compete in the international marketplace; however, they have not yet received any foreign contracts as a result of this process.

c. Did you examine foreign shipyards as part of a MARITECH project, and if so, how did your findings influence your facility expansion or modernization or the planned enhancement of your processes?

Bender's 1997 MARITECH project with Flensburger resulted in a sub-contract with the German yard to provide assistance in integrating engineering, planning, material procurement, and production.

4. Commercial Business Practices Developed or Applied for requirement analysis, supplier relations and material procurement, human resource management, customer relations and marketing, and cost estimating and financial management systems (or others applicable to your shipyard):

a. What new commercial business practices have resulted from your MARITECH projects?

Supporting Data for Commercial Business Practices Developed or Applied:

Commercial Business Practices	Description	Metric Benefits
SuperVendor Concept	Bender will use one person/firm to act as a system integrator who is responsible for the whole picture rather than just their small piece of the entire project. They intend to link digitally with the vendor to enable rapid transport/update of data including schedules and inventory.	Improve quality control; reduce labor costs; Just-in-time delivery of materials - reduced costs
New Accounting / Cost System	Bender will be able to track cost, man-hours and time for each part/piece of ship rather than for the entire project.	Improved accuracy, reduce costs

b. What new business markets have been developed or expanded through commercial business practices developed or applied through MARITECH?

None to date

c. Were any international competitive benefits derived from business processes developed or applied under MARITECH projects, and if so, what were they?

None to date

5. Impact on Navy Shipbuilding:

a. What is the impact of the MARITECH projects on Navy shipbuilding?

Bender is not a Navy yard and does not do much work for the Navy. In the past they have completed a few light landing crafts and patrol boats, and noted that there aren't many opportunities for smaller vessels.

b. What commercial practices are you now using in Navy contracts?

N/A

c. What positive impacts could be manifested if the Navy agreed to adopt commercial business methods identified or used in MARITECH projects?

N/A

6. MARITECH Program Process:

a. What cultural and process changes have resulted from procedures employed through the MARITECH Program?

1. Consortia - Has forming consortia become a normal approach in your commercial and Navy business practices?

Bender had not used consortia prior to MARITECH which was a good incentive to do so. To date they have gotten a lot out of this practice, especially in their dealings with Caterpillar. They noted that the consortia is just in the embryonic stage.

2. Teaming - Has teaming become a normal approach in your commercial and Navy business practices?

Bender has not used teaming as a result of the MARITECH program. In their super-vendor concept they have achieved a partnership with Thompson Power Supply and are pleased with this level of cooperation.

3. Were your associations with foreign partners useful, and if so, do you plan to use such associations in future commercial and Navy contracts?

Bender formed an association with German subcontractor, Flensburger, which they had not done prior to their involvement in MARITECH. Because of the good results, they see a lot of possibilities in such associations including the free exchange of ideas and information.

b. What MARITECH Program processes did you particularly like/dislike, and do you have any suggestions for such future programs?

They commented that MARITECH was a good program and worked well. Bender preferred the “in-kind” or 50/50 match that occurred in the ‘96 and ‘97 BAAs. They believe that the matching forces a commitment, and made them invest in the program and its outcomes. In addition, they also liked the set-up of the ’97 projects which entailed progress payments. The BAAs were clearly written and they liked the fact that they were able to go to D.C. and explain their proposals in person. Bender stated that their AOTR had been very supportive and very active in their projects. They appreciated his assistance and credit his involvement with making a significant difference. In their opinion, they benefited from having a MARAD agent rather than one from NAVSEA because of MARAD’s understanding of the commercial shipping arena.. Bender also noted that Bob Schaffran and his team were enlightened leaders. They would like to see their involvement continue in some capacity.

7. Comments on the Global Shipbuilding Market:

Bender notes that many of the world’s fleets are close to replacement in the near future.. Especially with the off-shore oil boom, the Jones Act and the Title XI loan guarantees American shipyards will certainly have ships to build. It is their opinion that small container ships or feeders are the future.

If subsidies are eliminated or the Title XI program continues, Bender perceives that the U.S. Shipyards will be able to compete in the increasing global market. However, they have also observed difficulties in working with foreign buyers because the buyers want foreign equipment and parts used in their ships. This in turn increases the cost of the shipbuilding and limits their scheduling flexibility. They note that this is a problem because the majority of U.S. suppliers do not market themselves internationally, and have not “proven” themselves in the world market.

What must be done for the U.S. to successfully compete in the global market and what should be the role of programs such as MARITECH?

- Bender would like to see MARITECH continue and credits that it has significantly helped them become more competitive.
- They asserted that money should be invested for the shipyards to implement technology rather than develop it. However, technology development should not be entirely university controlled because it must address actual shipyard situations and the yards must be able to implement it.
- Automation should be a priority for MARITECH, particularly the robotic technology in foreign yards that focuses on accuracy control.

Maritech Review
Case Summary #5

Administrative Data

Lead Shipyard: **Bollinger Shipyards, Inc.**
PO Box 250, Lockport, LA 70374

Date of Shipyard Interview: 12 February 1998

Dennis Fanguy - Technical Director
Bob Latas - Mechnical Engineer

AOTR: Jim Kuny, ONR

MARITECH BAA/Projects:

1. BAA 94-09. Sea Horse Development Project ($3,000,000)
   Consortium Members: Bollinger Machine Shop & Shipyard, Inc.; Halliburton Energy Services, Inc.
   Shipyard POC: Dennis Fanguy
2. Projects Participated in, but not led by, Bollinger:
   - BAA 94-44. SWATH: Light Weight Structure for SWATH High Speed Ferry
   Consortium Members: SWATH International; Bollinger Shipyard; Altair Engineering

   Shipyard POC: Bob Latas

Researcher: L. Worcester

Case Summary

A. Background

1. General. For the early Cajuns of South Louisiana, boat building was spawned by the need to navigate the maze of waterways which served as primary transportation routes and as a means of survival for a culture that depended heavily upon harvesting the fruits of these waters. On the banks of Bayou Lafourche in the small town of Lockport, the boat building craft has remained a legacy being passed down from one generation to another in the Bollinger family. Bollinger Shipyards, Inc., was founded in 1946 with a total investment of $17,353. Bollinger Shipyards today proudly operates out of eight facilities, providing shipbuilding construction and repair, as well as service to each vessel throughout its life cycle.

The Lockport yard is the "New Construction Facility." Situated on 250 acres, Bollinger's new construction site offers over 400,000 square feet of indoor fabrication shops for under roof construction. Bollinger Shipyard employs CAM in cutting and machining along with CAD capabilities to enhance the construction skills. Bollinger can design, build, and deliver vessels of up to 400 feet in length in aluminum, steel, and fiberglass.

In the 1960s and 1970s, Bollinger was one of the country's leading builders of floating equipment for the offshore oil and gas industry. In the early 1980s, the demand for offshore equipment collapsed and many Gulf Coast shipyards closed. Bollinger turned its skills to the defense market, becoming the government's leading supplier of high-performance patrol boats. Over the past ten years, Bollinger has built 62 high-performance patrol boats and 26 other small craft for the government. Currently, Bollinger is actively seeking ways to return to commercial markets. Bollinger's costs are not far from being internationally competitive; Bollinger's management is confident that with technologically advanced products and some improvements to its manufacturing systems, the company can compete with European and Singaporean shipyards and help to re-establish US dominance in the world of offshore equipment.

By mid-1997, Bollinger was to have invested $3M on new automated steel prefabrication equipment and enclosed sandblast and painting facilities. These facilities were expected to reduce the fabrication and painting costs by 10%. These lower operating costs will translate into lower product costs to Bollinger's commercial and government customers. Bollinger Shipyard Vice President for Governmental and International Affairs, Mr. Marc Stanley, attributes these cost reductions to the MARITECH Program.

Bollinger has three major contracts (one Army, one Navy, and one Coast Guard) to build patrol boats and barges. Bollinger has a backlog of 52 Coast Guard cutters which keeps them from pursuing too much other work.

Bollinger participated in two projects under the MARITECH Program. They are the lead shipyard for the Sea Horse—a self-elevating offshore support platform—which was to be developed from competition in international markets. This project design did not meet international requirements for offshore vessels. So, the design was modified and the project renamed as the Irish Sea Pioneer. The Sea Horse design had four tubular legs that would elevate the platform using hydraulics. The Irish Sea Pioneer has four lattice type legs using electric motors to elevate the platform. Applications include, subsea well service and maintenance, offshore construction, support undersea pipe laying and maintenance, support oil spill recovery, support drilling, and support salvage operations. The Irish Sea Pioneer was delivered in December 1996. This $60M vessel was the largest export project ever constructed by Bollinger in its 50 year history. This same design technology has been applied to four additional projects under construction, the contract value of which exceeds $20M. The second MARITECH project that Bollinger participated in was the Light Weight Structure for SWATH High Speed Ferry development project.

2. Shipyard Discussion Results. Bollinger discussed some lessons learned from the Sea Horse/Irish Sea Pioneer program. The most valuable lesson resulted from the leg construction on the liftboats. When the liftboat legs did not meet UK safety standards, Bollinger had to re-design the legs. They worked with a simulation software development firm called Stewart Technologies and Associates. Bollinger supplied the measurements, engineering and physics parametrics associated with the steel legs on the liftboats, and Stewart developed a model that could determine the most efficient build for the legs. The issues regarding the legs are: (1) steel strength; (2) what types of braces to use (x-brace or z-brace); and (3) the stress points where those braces should be placed. Bollinger is required by the Coast Guard to construct the legs using a 2.0 k-factor for measuring the ability to withstand stress. The k-factor effects the steel strength required when the legs are in the worst possible position. (This includes modeling severe weather, 30 ft waves, and blast effects.) Stewart's software allowed Bollinger to design the legs in simulation, visualize the weather phenomena effects on the steel strength, and re-design as required prior to construction. Bollinger stated that this process for simulating the leg construction on the liftboats saves them approximately 10% in material and production (cost and time). Bollinger uses this software for every proposal when determining the cost and time to develop the legs (the liftboats have differing leg lengths which means the parameters must be modified, depending on what length the customer wants), and they estimate that using this software reduces the time to prepare proposals by a factor of four.

Another MARITECH lesson learned came from the SWATH project. The original plan was to re-design the SWATH catamaran superstructure to make it lighter and therefore faster. Bollinger and SWATH worked with the original design and did come up with a lighter superstructure. However, the construction of that design would be too costly in man-hours. Bollinger and SWATH determined that the original design was the most optimum weight design. They re-designed using the original targets for the weight, and actually increased the weight by 1%. They compensated for that by increasing the hull diameter which balances out the payload distribution effect. And, they were able to reduce the projected man-hours to build this SWATH by 20% (they have not yet constructed a SWATH, so that number is a projected reduction).

In the area of design process, another shipyard change resulted from MARITECH. For the Irish Sea Pioneer program, Bollinger was using Microcadam and Cadam as their engineering software design tool. Bollinger realized during that project that they needed to implement a new design tool, and they chose AutoCAD. The capital investment totaled approximately $113,000. They researched the prospect of using CAD/CAM, but that investment would not only total between $750K-$1M, it would take six months to train the shipyard personnel on how to use it. With AutoCAD, the training time takes 12 weeks for a person who has never used a computer before. Every contract that Bollinger has received subsequently has required AutoCAD, which has greatly increased the speed of the design process (the regeneration of a drawing in AutoCAD13 takes about 10 seconds; in AutoCAD14, regen takes .5 seconds).

B. Summary of MARITECH Projects Managed or Participated in by this Shipyard

1. BAA 94-09. Irish Sea Pioneer Development Project
Background: Bollinger has teamed with Halliburton Energy Services, Inc., the world's largest operator of self-elevating, self-propelled, offshore support vessels, known as liftboats. The original design that was

implemented failed the UK (international) requirements for safety of life at sea (SOLAS); once the design was modified, which included re-designing the liftboat legs, the Irish Sea Pioneer was produced.
Objective:. The team has jointly developed a concept for a new generation liftboat that represents a quantum leap in both size and capability as well as opening new applications for liftboats. An additional objective was to provide a detailed study for improving production techniques that save production costs.
Unique features of the new Irish Sea Pioneer design:

- a ship-shaped hull, 176 feet in length by 100 feet in breadth, for improved hydrodynamic performance when in transit
- able to withstand extraordinary climatic conditions, i.e., including 43-foot waves, 9-foot tidal surges, and will be able to stay on location through long storm periods
- 7,500 square feet of usable deck space with a variable load capacity of 250 tons, and about 60,000 gallons of storage capacity for fuel, potable water, and other liquids
- three onboard cranes
- accommodations for 42, including a crew of 10, and
- meets UK standards

Approach and Status: The Irish Sea Pioneer project was divided into two phases. Phase I focused on developing the prototype Sea Horse. The prototype design development was accomplished in parallel with manufacturing systems development using concurrent engineering practices. Stewart Technologies and Associates used simulation software to assist in the mathematical and engineering issues associated with steel strength for leg development.
Phase II focused on developing additional opportunities for the Irish Sea Pioneer and Sea Horse concept. The Irish Sea Pioneer was built and delivered to the UK.
Impact: This effort has the potential to enhance Bollinger's commercial shipbuilding competitiveness by reducing ship design and construction time and cost. This project also provided Bollinger with lessons learned regarding international standards for vessels. This is important because the US standards will soon be modified to closely reflect the stricter international standards and Bollinger will be ahead of their competition.

2. BAA 94-44 SWATH: Light Weight Structure for SWATH High Speed Ferry
Objective: Develop a lightweight producible structural design that increases the payload weight capacity of the design. Small Waterplane Area Twin Hull (SWATH) is an advanced, displacement-type surface ship hull form which has the proven ability to deliver big ship ride quality in a much smaller vessel in coastal ocean conditions and to sustain its normal operating speed in degraded coastal seas. Above water, the SWATH resembles a catamaran. The difference is that the SWATH's working deck areas are connected to two parallel-submerged hulls by relatively thin vertical hull members, or struts. Since struts are the only parts of the ship that usually contact surface waves, the powerful forces resulting from buffeting waves are drastically reduced. As a result, heave, pitch and roll are reduced to such an extent that motions and vertical accelerations on the SWATH compare to those on a monohull or catamaran of up to 10 times the SWATHs displacement. A key disadvantage to the SWATH ship configuration is the substantially greater structural surface area per ton of buoyant volume (higher structural weight and larger full load displacement than other high speed ferries). This project seeks to reduce the structural weight of existing SWATH designs, through the use of advanced optimization techniques.
Approach and Status: The method of structural optimization is based on the innovative homogenization method, which is the iterative removal of structural material by the insertion of microscale voids and performing subsequent strength analysis of the modified structure.
Impact: This effort has the potential to substantially advance the capability of the US marine industry to design and construct highly efficient structures for SWATH vehicles as well as for other types of ships.

C. Overall Shipyard Goals and Strategies:

- Teaming: Bollinger will continue to team with vendors; actually include them as part of the proposal team so they are involved at the beginning and have an investment in the success of the program.

- Commercial: Bollinger will continue to look for applications for the Sea Horse and Irish Sea Pioneer offshore vessel designs in an international market.

- Navy/Coast Guard: The Navy and Coast Guard are the primary customers and Bollinger will continue to produce high quality cutters and patrol boats as required by the Navy and Coast Guard.

D. QUESTIONS

1. Ship Design and Construction Strategies:

a. What ships have been sold, built, are under construction, or have been designed as a result of MARITECH?

Supporting Data for Ship Design and Construction Strategies:

Status	Description of Vessel	Metric Benefits
Completed (Built)	Halliburton, Global, Montco, and Cardinal sponsored liftboats with legs ranging from 175 ft to 230 ft in height	
Under Construction	Cardinal and Montco liftboats with 200 ft legs	
Designed		
Under Design	Mersea SWATH Super 4000	

b. What changes in construction strategies have been developed?

Lightweight alternative construction techniques used on the Mersea Super 4000 design

Leg construction/evaluation of liftboats have been enhanced from lessons learned on the Halliburton liftboat design *c. Were any international competitive benefits derived from MARITECH ship designs and construction projects, and if so, what were they?*

Bollinger has been able to break into the worldwide commercial market as a result of the Halliburton Irish Sea Pioneer program. However, they have not been able to exploit the market due to the commercial Gulf Coast oil boom and the government jobs that Bollinger has been awarded.

2. Technologies Developed or Applied to Improve Design, Production/Manufacture, Operation, and/or Repair of Ships:

a. What technologies have been developed or applied to the design, production/manufacture, operation, and/or repair of ships through MARITECH?

Bollinger has implemented the use of flange plate construction in the liftboat design as a result of the design development on the Irish Sea Pioneer program. This process is well suited for the panel line facility installed in 1996-1997.

Supporting Data for Technologies to Improve Design, Production/Manufacture, Operation, and/or Repair of Ships:

Technologies	Description	Metric Benefits
AutoCAD	Design tool used instead of CAD/CAM; more affordable to a small yard like Bollinger	Reduces design development time by a factor of 5
Stewart Associates Simulation Tool	Visualization and SBD tool used to design the liftboat legs according to sponsor-requirements	Reduces proposal writing by a factor of 4; saves 10% material/production costs

b. Were any international competitive benefits derived from technologies developed or applied under MARITECH projects, and if so, what were they?

None

3. Facility Expansion or Modernizations and Process Enhancements Made to Improve Design, Production/Manufacture, Operation and/or Repair of Ships:

a. What facility modernizations or expansions or process enhancements (e.g., yard layout) have taken place as a result of MARITECH?

N/A

b. Were any international competitive benefits derived from these expansions, modernizations, or enhancements, and if so, what were they?

N/A

c. Did you examine foreign shipyards as part of a MARITECH project, and if so, how did your findings influence your facility expansion or modernization or the planned enhancement of your processes?

N/A

4. Commercial Business Practices Developed or Applied for requirement analysis, supplier relations and material procurement, human resource management, customer relations and marketing, and cost estimating and financial management systems (or others applicable to your shipyard):

a. What new commercial business practices have resulted from your MARITECH projects?

Supporting Data for Commercial Business Practices Developed or Applied:

Commercial Business Practices	Description	Metric Benefits
Microsoft Project Premavera Project Planning	Bollinger had implemented project planning software as a result of the number of benefits derived during the Irish Sea Pioneer program	

b. What new business markets have been developed or expanded through commercial business practices developed or applied through MARITECH?

Bollinger has been successful in the government market through the use of scheduling, production, and ISO certification, all of which were enhanced by participation in MARITECH *c. Were any international competitive benefits derived from business processes developed or applied under MARITECH projects, and if so, what were they?*

Bollinger was able to obtain ISO 9001 certification with the contributions of the lessons learned from the Irish Sea Pioneer program

5. Impact on Navy Shipbuilding:

a. What is the impact of the MARITECH projects on Navy shipbuilding?

As a result of the design evolution on the Irish Sea Pioneer program, Bollinger was able to use lessons learned on high strength steel on the Coast Guard Patrol Boats program and was able to save 9 tons or 1/3 structural weight of 30 tons.

b. What commercial practices are you now using in Navy contracts?

Bollinger is using a commercial scheduling package, Premavera, and are also using commercial standards in the design processes such as ABS, USCG, and IEEE-45.

c. What positive impacts could be manifested if the Navy agreed to adopt commercial business methods identified or used in MARITECH projects?

The Navy could save money by adopting commercial standards in lieu of military standards as seen through the PC program.

6. MARITECH Program Process:

a. What cultural and process changes have resulted from procedures employed through the MARITECH Program?

1. Consortia **-** *Has forming consortia become a normal approach in your commercial and Navy business practices?*

Yes, Bollinger sees the benefits of forming consortia by recognizing Bollinger's strengths and the strengths of potential partners in order to generate a winning product/program

2. Teaming **-** *Has teaming become a normal approach in your commercial and Navy business practices?*

Yes, Bollinger sees that through the use of team concepts, not only will the customers benefit by using multiple team members, but also the performer benefits by getting a team effort, team concept and quality product

3. Were your associations with foreign partners useful, and if so, do you plan to use such associations in future commercial and Navy contracts?

Bollinger has always used available resources as seen in our products and design efforts, and will continue to use foreign partners as necessary.

b. What MARITECH Program processes did you particularly like/dislike, and do you have any suggestions for such future programs?

The MARITECH program allowed for complete flexibility by the shipyard and as a result we were able to manage the program without any undue pressure put on the shipyard to meet artificial deadlines

7. Comments on the Global Shipbuilding Market:

What must be done for the U.S. to successfully compete in the global market and what should be the role of programs such as MARITECH?

US shipbuilders have to be more flexible in teaming in order to be a part of the world market; also, MARITECH needs to be tailored toward programs rather than potential designs. MARITECH should look into technology for handling materials

Administrative Data

Lead Shipyard: **Electric Boat (EB) Corporation**
75 Eastern Point Road; Groton, CN 06340-4989

Date of Shipyard Interview: 5 Feb. 1998

Michael Toner - Vice President, Innovation
William S. Gibbs - Manager, Information Technology
James S. Boudreaux - Manager of Engineering Computer Systems Technology
Bradford W. Burgess - Business Development
Daniel L. Williams: Sr. - Software Engineer, Computer Systems Analyst

Date of AOTR Interview: 3 Dec. 1997

MARITECH BAA/Projects:

1. Electronic Commerce/Computer Integrated Enterprise: New Shipbuilding Methodology Through the Shipbuilding Information Infrastructure Project (SHIIP)

   Consortium Members: Alabama Shipyards
   C. L. Harshman & Assoc.
   NASSCO
   Avondale Shipyards
   Todd Pacific Shipyards
   BIW Computer Sciences Corp.
   Structured Technology Corp.
   Deneb Robotics

   Shipyard POC: Bill Gibbs

   AOTR: Andrew Dallas, ONR

2. Projects participated in, but not led by, EB:
   a. Advanced Technology Development: Standard for The Exchange of Product Model Data (STEP) Ship Product Models:
   b. Electronic Commerce/Computer Integrated Enterprise: National Industrial Information Infrastructure Protocol (NIIIP) Shipbuilding Partners And Subcontractors (SPARS)
   c. Simulation Based Design (SBD) as an Environment for Concept and Contract Design Using Integrated Product and Process Development (IPPD) (Lead: Avondale Shipyards)

Researcher: J. Richardson

Case Summary

A. Background

Founded in 1899, Electric Boat built the Holland, the first practical submarine. The Holland, invented by John Holland, the “father” of the Submarine, was accepted by the Navy on 11 April 1911. The boat was 54 feet in length and was propelled by a 50 horsepower gasoline engine. The first four submarines actually built at Groton, Connecticut were sold to the Republic of Peru in 1924.

During the first World War, EB delivered 85 submarines to the Navy and overhauled another 30. The Groton facility built diesel engines, high pressure air compressors, torpedo tubes, conning towers, and periscopes.

During World War II, the Electric Boat (EB) workforce at Groton grew to over 12,000. This facility, with 21 ways, launched a new submarine every two weeks. In 1952, EB was chosen to build the world’s first nuclear powered submarine, launched on 21 January 1954 and designated the Nautilus. This was followed by later types of nuclear submarines: Seawolf, Skate, Skipjack, Triton, Tullibee, and subsequently, the George Washington, Patrick Henry, Polaris, Lafayette, and Trident.

In the early 1970’s EB built the newly approved “attack” submarines, to become the SSN668 class. This latter class was faster and better armed than its predecessors and led to the Improved SSN 668 in 1988, which was able to surface through arctic ice.

Today, EB is working on the new Seawolf (SSN21, a contract awarded in January 1989 and a second submarine the Connecticut (SSN22) and has secured a contract for a third boat (SSN23). The shipyard employs 15,111 people and continues to build and repair submarines. Their six dry docks have lengths up to 174 meters and widths of 24 meters.

Interview with Mike Toner, Vice President for Innovation: Electric Boat helped to reengineer the NSRP, a technology-based consortium of nine shipyards, to take advantage of MARITECH principles in the technical arena (sharing among shipyards, adopting competitive practices, etc.). CEO's of companies represented in the NSRP want to see MARITECH continue, but if it cannot, the NSRP will continue its work. If MARITECH continues, the NSRP would like to take advantage of it by planning projects and distributing funds received from the government to perform them -- the implication being that the consortium would take on a MARITECH Program Office-like role, or would at least represent the industry to the government.[92] The current Executive Control Board (ECB) of the NSRP will serve as the initial industry governing body for this initiative. The present ECB will conduct this role through Articles of Collaboration signed by the ECB yards. The Articles contain language which allows for additional EBC members following an initial start-up period. A five-year Strategic Investment Plan in being formulated with input from all industry stakeholders including ECB yards, other yards - including repair, suppliers, academia, and government. The plan will outline several initiative areas for the industry to focus on. Similar to MARITECH, BAAs will be issued and all stakeholders will be given opportunity to respond. Project portfolios will be selected using an independent Blue Ribbon Panel.[93]

Mr. Toner sees the principal advantage of MARITECH, and whatever is to follow it, as reducing the cost of Navy shipbuilding, saying, "if Navy ships become cheaper, there will be more Navy shipbuilding." So the focus must be on Return On Investment (ROI). If government makes EB more efficient, government wins because subs are more affordable. Hanging steel only represents about 3 percent of EB's shipbuilding costs, but the benefits of effective data transfer are pervasive and large. For this reason, information technologies must be worked hard, allowing the industry to communicate within and outside itself. The only way the industry can do this is through programs like MARITECH. Through these projects, EB is learning to work with other shipyards, like Newport News.

Another major area of improvement must be design and construction processes. For example, the Seawolf submarine had 100,000 unique parts. NSSN is planned to have 18,000. This application of commercial parts, and the integration of commercial standards and processes, when they make sense on a submarine, will make a huge difference.

From their largest workforce of 28,000, the manning level was reduced until it reached 13,000 in 1992. Their problems in competing in the international commercial shipbuilding market are impressive. Besides those faced by other U.S. shipyards (e.g., foreign subsidies), EB also has a limitation due to their focus on building submarines, a very unique construction process. The workforce is fully unionized, and due to this and EB's location, wages are high relative to most of the industry (about $25 Vs $10 per hour).

B. Summary of MARITECH Projects Managed by this Shipyard

1. Electronic Commerce/Computer Integrated Enterprise: New Shipbuilding Methodology Through the Shipbuilding Information Infrastructure Project (SHIIP). The information infrastructure work being performed at EB shows an impressive competence. We would suggest that this project, along with its linkages to SPARS and MariSTEP, is one of the best, and certainly the most extensive efforts funded by MARITECH in this area.

<u>Background:</u> The principal objective of the Shipbuilding Information Infrastructure Project (SHIIP) is to break down the information and cultural barriers between the business, design, and manufacturing sectors of the shipyard and the shipbuilder, reducing time and labor now expended in such tasks as brokering and reformatting needed information and distributing it to those who need it. Through this project, Electric Boat will attempt to deploy National Industrial Information Infrastructure Protocols (NIIIP) throughout the shipbuilding industry. This will allow the sharing of information throughout an enterprise (among separate business areas). This is difficult because of the heterogeneity of computing environments, the

[92] Although it is not clear how the government plans to replace MARITECH, an Advanced Shipbuilding Enterprise (ASE) has been proposed which would include the NSRP on its Executive Steering Council to represent the shipbuilding industry. The purpose of the ASE would be to continue the work of MARITECH.

[93] Smaller shipyards, non-members of NSRP, are quite dismayed at this prospect and, predictably oppose such a loss of representation. They feel that they are the part of the industry making the longest strides toward international competitiveness, and by virtue of the taxes they pay and the import benefits they may bring to the country, they should have at least an equal chance at future government funding.

pervasiveness of legacy systems, and the rapidly changing information technologies and protocols. The approach is to set up a reference deployment at Electric Boat. The principal target is ship construction (assembly and installation), since information infrastructure technologies have been successfully introduced to design, engineering, and manufacturing through standards affecting CAD/CAM (although unlike most CAD/CAM data structures, that adopted for SHIIP must be object-oriented). It is premised that there are numerous data stores and applications within each business area, beyond design, engineering, and manufacturing that needs to be accessed through out the shipbuilding enterprise. This is particularly true now that shipyard-wide Integrated Product and Process Teams (IPPT) are beginning to manage the construction of the ship. These teams, consisting of shipbuilders, supervisors, engineers, planners, and so on often need access to information that used to exist only within one or two business areas. Further, teams will eventually include vendors and sub-contractors, and other shipyards, since more consortia are expected in future shipbuilding. Challenges include scalability, robustness, and the ability to use legacy applications and data stores. EB either has or will:

- establish the SHIIP methodology group;
- develop, demonstrate and evaluate methods to re-engineer the shipbuilding processes;
- change the organization of shipbuilding and the way people perform work (e.g., re-engineer the shipbuilding organization into collaborative concurrent work teams to exploit open standards-based enterprise integration technologies);
- document the design and deployment; and
- demonstrate results.

The results of these actions will be a new shipbuilding methodology, with new shipbuilding processes and organizational paradigms, such as a team-based approach to shipbuilding. Validation of these products will be accomplished through testing.

Objective: SHIIP goals are to:

- Deliver information to the shipbuilder on the waterfront to enable use of the enterprise information, and reduce construction times and improve production quality by accessing design databases.
- Maximize the use of standard-based information technologies through available protocols and software components that simplify the development of shipbuilding applications.
- Deliver a library of shipbuilding information components that can be used as building blocks for sharing product and process objects, building applications that can be customized, scaleable to small or complex processes.

These objectives are to be applied to both commercial and navy shipbuilding. The delivered system will be production-grade. An interesting example of the magnitude of change and benefit sought from this effort is EB's attempt to reduce resolution time for a "deckplate problem" from current 24 days to 4 hours.

Approach and Status: To develop, deploy, and standardize a new shipbuilding methodology for the US shipbuilding industry, leveraging advanced information infrastructure technologies and the new shipbuilding processes, along with workforce cultural and organizational changes that result. The approach is to deliver enterprise-wide information to the shipbuilding workforce, using advanced object-oriented information infrastructure. The enterprise information structure must be consistent with NIIIP, STEP, NIIIP-TIMA, and HLA/CORBA protocols. These are all employed by teams that are becoming increasingly cross functional.

During the first year, the ORB-enabled intranet has been essentially completed, and work has progressed on adopting JAVA. A Business Object Framework has been partially developed for some of the legacy data and programs. During the next year, the information infrastructure will be integrated into the Enterprise, to include a desktop for accessing documents and a workflow server interface. An on-line work package of both 2D and 3D graphics, along with construction sequences will also be made available on the Enterprise.

Information modeling (defining properties, behavior, and interaction of data objects) is being developed which can adapt to the changes in processes which the data objects undergo as a result of changes in the shipbuilding business environments. The following steps are being followed:

- Within each business area to be represented within the enterprise-wide information model, teams of modeling and domain experts will be formed. The teams will identify the processes to be incorporated from their business area and build the models by identifying objects, relationships, and constraints from the processes chosen. The model will be reviewed by a quality control group. Some of these business areas are:
  - configuration controlled design,
  - manufacturing resource planning,
  - master production scheduling,
  - procurement, and
  - production control.
- Then the information models from all business areas will be integrated into an enterprise-wide information model.

Impact: If this project is successful, the shipbuilding industry will be able to share information throughout the shipbuilding enterprise. This will include reaching other shipyards, vendors, and subcontractors, if SPARS works. Profound changes in organization and workforce culture will result, through the ability to communicate and to assemble complex systems in a coordinated and efficient manner. These capabilities should be especially helpful in improving the efficiency of low rate production, a major factor in high cost of Navy shipbuilding.

EB projects cost avoidance from SHIIP to total $6.5M per ship ($1M per ship for work order maintenance, $3M per ship for engineering records, $2.5 Mper ship for electronic information throughout the enterprise).
According to EB, this project has already reduced construction span time and cost for Navy ships. These efficiencies stem from the following:

- Re-engineered processes (e.g., construction workforce access to 3-d graphics and text information regarding ship design).
- Reducing non-value-added functions (e.g., the elimination of the organizations that currently deliver the information described above to the workforce can be eliminated).
- Greater workforce efficiency (e.g., accessibility of enterprise information allows the workforce access to more cultural change activities, such as leadership training and team building).
- Increased alternatives and timely solutions (e.g., by allowing access to enterprise data, the workforce is able to consult with design data and design personnel, collectively reducing risk in reaching solutions that are less conservative).

In order to reach the next level of connectivity, SHIIP will output through SPARS via the Internet.

- Enterprise: Shipyard SHIIP information to customers, partners, and suppliers
- Business Processes: Assembly SHIIP information to design and maintenance
- Technology: Infrastructure information to supplier management and electronic commerce

2. Projects participated in, but not led, by EB:

a. Advanced Technology Development – Standard for The Exchange of Product Model Data (STEP) Ship Product Models: MariSTEP is a MARITECH sponsored program targeting prototype implementations of the emerging STEP (ISO 10303 - industrial automation systems and integration) shipbuilding application protocols. The objectives are to enhance the global competitive position of the U.S. shipbuilding industry, enable the virtual shipyard, accelerate the implementation of STEP throughout the U.S. marine industry, assess the ability to implement STEP application protocols, and enable a product model definition and exchange capability to support simulation based design initiatives.

EB is using the output of MariSTEP, some of which they are contributing, to make their CAD/CAM data and programs connective through the SHIIP and SPARS infrastructure. This will ensure data exchange between various elements during the life cycle of the ship, access to legacy data, and migration of next generation tools. Prototype translators are being developed, along with a prototype Product Model Database. EB projects a future cost avoidance from MariSTEP of $7.5M per ship.

Impact: EB projects a future cost avoidance from MariSTEP of $7.5M per ship.

b. Electronic Commerce/Computer Integrated Enterprise -- NIIIP Shipbuilding Partners And Subcontractors (SPARS): This is a deployment project to establish Virtual Enterprise (VE) technologies for shipbuilding. The VE will represent customers, partners, subcontractors, and suppliers using NIIIP technologies. VE will enable electronic-based business interoperations (electronic commerce) that are transparent to the underlying processes and computing environments of the participants. The shipbuilding VE is to accomplish the following.

- Enable implementation of advanced business practices in requirements analysis, supplier relations, material procurement, resource and financial management through the application of information technologies to the interoperation of shipyards and their IPPTs.
- Enable total process systems by establishing system-wide integrated design and production facilities, thereby reducing total time and cost of ship design and construction.

The approach is to:

- Establish shipyards as VE gateways to provide near-turnkey shipbuilding business processes to their supply chains, thus product teams can cost effectively work together
- Establish interoperability mechanisms to link heterogeneous computer environments of different companies for rapid communication, accurate monitoring, and responsive control of shipyard activities
- Provide secure, easy-to-use internet-based supplier information
- Provide the ability to share design information
- Manage complex schedules
- Establish proof-of-production feasibility of assembly and disassembly
- Build a robust VE knowledge base

Impact: EB projects a cost avoidance of $7M per ship class

c. Simulation Based Design (SBD) as an Environment for Concept and Contract Design Using Integrated Product and Process Development (IPPD) (Lead is Avondale Shipyards): The objective of this project is to develop a new medium size roll-on/roll-off (RO/RO) ship for the commercial market. The Integrated Product and Process Development (IPPD) will be used in designing the ship (including 3-D modeling). The Avondale Shipyard will identify and evaluate new Simulation Based Design tools to support the marketing, design, construction, and maintenance of future designs in an IPPD environment.

The EB portion of this effort is the development of a Synthetic Shock and Acoustic Environment in an SBD mode. This will allow an IPPD Team to investigate the effects of a particular S&V environment on a product, by modeling both. The CAD and CAE systems will be an integral part of the model, allowing design solutions to emerge directly on the Product Model. CORBA will probably be used as the server architecture.

The model was demonstrated by driving a virtual M1A1 Tank onto a virtual RO/RO ship. Fire and smoke simulation was demonstrated and the Lockheed Martin High Level Architecture was tested as a possible substitute for CORBA.

C. Overall Shipyard Goals and Strategies:

Goal/Strategy 1: As stated by EB, their top business priorities are to become the lead design agent for the New Attack Submarine and to secure the lead ship contract, which are anticipated milestones for the future story of Electric Boat.

Goal/Strategy 2: To encourage teaming, internally, through initiating Integrated Product and Process Teams (IPPT), and externally, through the encouragement of consortia.

Goal/Strategy 3: Gaining efficiency of operation, and a change of organizational and work force culture through the development and application of information system technology such as that being pursued by the Shipbuilding Information Infrastructure Project (SHIIP) and other related projects.

D. QUESTIONS

1. Ship Design and Construction Strategies:

a. What ships have been sold, built, are under construction, or have been designed as a result of MARITECH?

None, EB does not plan to address the commercial market.

b. What changes in construction strategies have been developed?

See 2.a.

c. Were any international competitive benefits derived from MARITECH ship designs and construction projects, and if so, what were they?

EB does not plan to address the commercial market.

2. Technologies Developed or Applied to Improve Design, Production/Manufacture, Operation, and/or Repair of Ships:

a. What technologies have been developed or applied to the design, production/manufacture, operation, and/or repair of ships through MARITECH?

According to EB, efficiencies are beginning to flow from the SHIIP project. Examples are:

- Re-engineered processes (e.g., construction workforce access to 3-d graphics and text information regarding ship design)
- Reducing non-value-added functions (e.g., the elimination of the organizations that currently deliver the information described above to the workforce can be eliminated)
- Greater workforce efficiency (e.g., accessibility of enterprise information allows the workforce access to more cultural change activities, such as leadership training and team building)
- Increased alternatives and timely solutions (e.g., by allowing access to enterprise data, the workforce is able to consult with design data and design personnel, collectively reducing risk in reaching solutions that are less conservative)

Enterprise information systems are being developed through EB's SHIIP project.

- Technologies being applied include browsers, high performance organizations, distributed visualization, gateways to legacy data, electronic workflow interoperability, agents.
- Technologies that are under consideration include object-oriented interface to legacy data (for both read and write/update capabilities), CORBA compliant agents, CORBA compliant JCALS accessible via browser and distributed access to graphical design data via browser.

Supporting Data for Technologies to Improve Design, Production/Manufacture, Operation, and/or Repair of Ships:

Technologies	Description	Metric Benefits
SHIIP	See Section B.1.	EB projects cost avoidance of: • $1M per ship for work order maintenance • $3M per ship for engineering records • $2.5 Mper ship for electronic information throughout the enterprise
SPARS	See Section B.2.b.	EB projects a cost avoidance from SPARS of $7M per ship class
MariSTEP	See Section B.2.a.	EB projects a future cost avoidance from MariSTEP of $7.5M per ship.

b. Were any international competitive benefits derived from technologies developed or applied under MARITECH projects, and if so, what were they?

EB does not plan to address the commercial market, but both SHIIP and SPARS would offer advantages to any shipyard who does.

3. Facility Expansion or Modernizations and Process Enhancements Made to Improve Design, Production/Manufacture, Operation and/or Repair of Ships:

a. What facility modernizations or expansions or process enhancements (e.g., yard layout) have taken place as a result of MARITECH?

EB does not plan to address the commercial market, but technologies being adopted under both SHIIP and SPARS will be beneficial to those who do. Some specifically helpful process enhancements are: 90/10 Ops projects (SHIIP-related), such as ER/Browser, Desktop, Order Maintenance, Electronic Work Package, and Distributed Visualization.

b. Were any international competitive benefits derived from these expansions, modernizations, or enhancements, and if so, what were they?

None, EB does not plan to address the commercial market.

c. Did you examine foreign shipyards as part of a MARITECH project, and if so, how did your findings influence your facility expansion or modernization or the planned enhancement of your processes?

No

4. Commercial Business Practices Developed or Applied for requirement analysis, supplier relations and material procurement, human resource management, customer relations and marketing, and cost estimating and financial management systems (or others applicable to your shipyard):

a. What new commercial business practices have resulted from your MARITECH projects?

None

b. What new business markets have been developed or expanded through commercial business practices developed or applied through MARITECH?

None, EB does not plan to address the commercial market.

c. Were any international competitive benefits derived from business processes developed or applied under MARITECH projects, and if so, what were they?

EB does not plan to address the commercial market, but there will certainly be commercial advantages to some of the participating shipyards from the information infrastructure.

5. Impact on Navy Shipbuilding:

a. What is the impact of the MARITECH projects on Navy shipbuilding?

According to EB, efficiencies are beginning to flow from the SHIIP project. Examples are:

- Re-engineered processes (e.g., construction workforce access to 3-d graphics and text information regarding ship design)
- Reducing non-value-added functions (e.g., the elimination of the organizations that currently deliver the information described above to the workforce can be eliminated)
- Greater workforce efficiency (e.g., accessibility of enterprise information allows the workforce access to more cultural change activities, such as leadership training and team building)

- Increased alternatives and timely solutions (e.g., by allowing access to enterprise data, the workforce is able to consult with design data and design personnel, collectively reducing risk in reaching solutions that are less conservative)

b. What commercial practices are you now using in Navy contracts?

N/A

c. What positive impacts could be manifested if the Navy agreed to adopt commercial business methods identified or used in MARITECH projects?

In discussions, EB indicated that there were undoubtedly changes the Navy could make to gain efficiencies for themselves and to make it easier for shipyards with Navy business to succeed in the commercial market, but no specifics were offered. This is probably due to EB's lack of interest in pursuing the commercial sector.

6. MARITECH Program Process:

a. What cultural and process changes have resulted from procedures employed through the MARITECH Program?

1. Consortia **-** *Has forming consortia become a normal approach in your commercial and Navy business practices?*

MARITECH has accelerated EB's emergence as an active member of the U.S. shipbuilding industry. They are now actively involved in a number of industry initiatives that affects more than the traditional submarine community.

2. Teaming **-** *Has teaming become a normal approach in your commercial and Navy business practices? [Please explain why or why not.]*

According to EB, teaming is here to stay in their business. It provides the vehicle to rapidly assemble the expertise to a business opportunity.

3. Were your associations with foreign partners useful, and if so, do you plan to use such associations in future commercial and Navy contracts?

N/A

b. What MARITECH Program processes did you particularly like/dislike, and do you have any suggestions for such future programs?

The shipyard had no criticisms to offer. They liked the assistance provided by MARITECH to bring members of the industry together. MARITECH's style of management is to facilitate and guide, not direct, allowing the shipyards to take primary responsibility for the projects.

7. Comments on the Global Shipbuilding Market:

Electric Boat does not plan to address the global commercial market.

What must be done for the U.S. to successfully compete in the global market and what should be the role of programs such as MARITECH?

Electric Boat does not plan to address the global commercial market.

Maritech Review
Case Summary #7

Administrative Data

Lead Shipyard:	**Gladding-Hearn Shipbuilding (G-H)** dba Duclos Corporation ,1 Riverside Avenue P.O. Box 300, Somerset, MA 02726
Date of Shipyard Interview:	4 February 1998

John F. Duclos, Vice President
Bernard Giroux, Director of Sales/Marketing
Geoffrey S. Rivinius

MARITECH BAA/Projects:

1. BAA 96-01 and 96-42. Further Capture a Commanding Share of the International Fast Ferry Market Through Advanced Ship Design and Shipbuilding Technology and Composite Ship Technologies (total both projects $9.5M)

Consortium Members:	Gladding-Hearn Shipbuilding (G-H) Nichols Brothers Boat Builders (NB) University of California, San Diego (UCSD)
Other Participants:	U.S. Coast Guard (USCG) International Catamaran Designs Ltd. (INCAT) Worcester Polytechnic Institute (WPI) Tillotson Pearson, Inc. (TPI) VTEC Labs (VTEC) Trans Science Corp. (TSC) National Steel and Shipbuilding Co. (NASSCO) Young Associates Project Services (YA) PPG, Inc.
Shipyard POC:	Bernard Giroux, Director of Sales/Marketing
AOTR:	Dick Voelker, MARAD

2. Projects participated in, but not led by, Gladding-Hearn:

BAA 95-02. Capture a Commanding Share of the International Fast Ferry Market Through Advanced Ship Design and Technology)

Consortium Members:	Nichols Brothers Boat Builders Gladding-Hearn Shipbuilding

Researcher: J. Richardson/ L. Worcester

Case Summary

A. Background

For over 40 years, Gladding-Hearn (G-H) has produced more than 300 commercial vessels and custom yachts. G-H primarily builds fast passenger ferries, catamarans, pilot boats, and police/fire boats. They have become well-versed in high-quality aluminum construction in this market. A family business, G-H is one of six shipyards around the world licensed to build the Australian-INCAT designed catamarans. With vessels operating throughout the U.S., G-H feels that its high-speed passenger vessels are efficient, dependable, and profitable. The shipyard employs about 80 employees. The shipyard is comprised of a 180 feet long, 40 feet high metal fabrication building, various fabrication shops, administration building, marine railway, docks and storage yard. The facility is equipped to build almost any type of steel or aluminum vessel, including fire boats, rescue/patrol boats, and research vessels. More than 20 years ago, G-H joined forces with C. Raymond Hunt Associates to produce the first deep-V pilot boat. That effort spawned a whole new class of pilot boats that cut commuting time in half and permitted boarding ships at high speeds. Now an industry standard, these boats, as well as G-H's high speed catamarans, are characterized by their rugged construction, high speed, low upkeep, and reliability. G-H builds more pilot vessels than any other shipyard in North America.

With in-house naval architecture and engineering capabilities, G-H has pioneered some of the industry's most advanced shipbuilding techniques such as pulse arc welding, fully rotational propulsion steering, and sound-deadening systems.

G-H takes great pride in their vessel warranty and their ability to meet and often exceed guaranteed speeds. Examples of the vessels built by G-H are:

- Fireboat for New York City: Fifty-two foot, all aluminum fireboat; designed to accommodate five-person crew, but can be operated easily by two firefighters; exceeded the rated pump capacity of 5,000 gallons per minute by over 20%; and can travel at 28 knots.
- G-H is currently designing a 70 foot long and a 100 foot long standard platform fireboat.
- Ferries: G-H has built a variety of ferries, including the 368 passenger, jet-driven catamaran, Victoria Clipper III, operating in Washington State. Others have been built for passenger transport and commuting in Boston Harbor, Lake Michigan, Lake Erie, Catalina Channel, and the Bay Shore area of New Jersey and New York; they range from 80-feet to over 120-feet; and carry between 300 and 400 passengers. Composite hull with aluminum superstructure catamarans were built for Water Transportation Alternatives, Inc., in Quincy, MA, transporting commuters between Quincy, MA, Logan Airport, and Boston.
- Pilot Boats: Fifty to sixty-five foot aluminum vessels built for various customers, including Virginia Pilot Association, Biscayne Pilots and San Francisco Pilots as well as the Government of Bermuda. New pilot boats are in the planning stages for six pilot organizations.

G-H has applied the philosophy and spirit of the MARITECH program toward becoming more globally competitive by improving their business development, foreign market development, shipyard production and business processes. Prior to receiving MARITECH funding they had not been able to aggressively address the international marketplace. Under MARITECH they investigated foreign markets to identify potential clients and determine the needs for fast catamaran ferries. G-H has significantly improved their business and manufacturing processes, and improved and expanded their shipyard facilities resulting in reducing vessel construction time and costs. This case summary collectively reports the effects of MARITECH program on all of these goals.

B. Summary of MARITECH Project Managed or Participated in by this Shipyard.

Objective: MARITECH projects under way at G-H are dedicated to penetrating the international fast ferry business. Opening this sector has meant that they must develop or acquire more competitive designs, improve construction and business practices, and expand shipyard facilities and equipment. Training of management and shipyard workers is a top priority.

Approach and Status: The remainder of this section is divided into four parts: marketing, development of designs and materials technologies, business and construction process improvements, and facilities modernization.

Marketing: There are 4000 coastal ferries worldwide (20% of the world merchant fleet). Half carry passengers and vehicles, the other half carry passengers only. There are 1,000 fast ferries, 100% are aluminum; 950 of those carry passengers only, and 50 carry passengers and cars. Projected demand for all-passenger fast ferries (internationally) is 85 new builds per year. There is a growing international market demand for creating more fast ferries with low-wake capability.[94] Many narrow-width routes and congested harbors have had speed limitations placed on vessels due to wake generation and the resulting damage proving the need for low wake, fast transportation.

MARITECH facilitated G-H's outreach into the international fast ferry community through: travel to potential international customers; assisted in development of advertising and promotional materials; and participation in international trade-symposia. G-H sent their representatives worldwide to determine and research applicable markets.[95] They focused on Indonesia as a test case, the Indonesian government asked G-H to prepare a transportation study to help determine the country's fast ferry needs. Indonesian is an excellent market for water transport because of the many volcanic islands which drop directly into the sea, and defy road or airstrip construction. Unfortunately, Indonesia's current economic problems may preclude near term business. Other areas investigated were Venezuela, Mexico and Bermuda. Gladding-Hearn's investigation indicated that there is a significant worldwide market for properly designed and

[94] Other important features include speed and sound levels.
[95] G-H had not addressed the global market, prior to MARITECH.

competitively constructed commercial vessels (especially high speed catamarans) built of aluminum and composites.

Partly as a result of the MARITECH program, G-H has seen a doubling of sales volume, and, consequently, increased its workforce by 30 percent. At this time, they have a two year backlog of orders (triple their pre-MARITECH backlog). They estimate that the current market should drive the fast ferry business for approximately the next ten years.

<u>Acquisition of Designs and materials technologies:</u> Gladding-Hearn investigated the viability of a composite hull design for high speed commercial vessels. Prior to this investigation and project, composite structures of various designs had been widely used, primarily in the production of recreational vessels. The durability of the various composite materials and techniques were well proven as was evidenced by the fact that well over 90% of the production built vessels, under 100 feet long, were and are built of composites. In fact, it has been over 30 years since the early fiberglass vessels eclipsed wood as the primary building material for small craft. As composite technology has advanced, composites have been accepted by more segments of the marine industry. In 1983, the race for the America's Cup was conducted by the most advanced aluminum vessels yet to be built. There were no composite vessels in that competition. In 1987 one entry was built of composites. Since then, all America's Cup vessels have been of composite construction. The current America's Cup allows for vessels of about 75 feet in length that perform at speeds of over 15 knots under sail power alone. The stresses placed upon these lightweight hulls are very high and design safety factors are low. The result of this aggressive approach to composite design is a series of extremely lightweight and strong vessels with impressive performance capabilities. There is a consequence to the low safety factor design approach of the racing yacht designs in that by pushing the materials ever closer to their theoretical limits, the loads on the vessel sometimes exceed the mechanical properties of the materials. Observers such as G-H have benefited from the knowledge or lessons learned by the America's Cup yacht builders. One of the primary reasons for the failures in the America's Cup yachts was that the global stresses were not considered in the designs. G-H has applied those lessons learned in the use of composite materials and fabrication processes to the commercial market by increasing the designed safety factor and taking a slightly more conservative approach to the designs. They successfully produced two high-speed catamarans with composite hulls and aluminum superstructures.

Under the current MARITECH program, Gladding-Hearn is working with UCSD and International Catamarans (INCAT) to create a second generation design for composite hull ferries based upon the design used in building two ferries during the past two years. The new design will be lighter, stronger and fire-protected. It is also expected reduce costs by one-third, to produce less than half the wake of a monohull and to operate with 60 percent of the power at 30 Knots. The participants in the development of this composite technology include USCG, TPI, TSC, VTEC, PPG, Worcester Polytechnic Institute.

G-H is assisting the design effort as an in-kind contribution. INCAT was reimbursed through the DARPA MARITECH funding. INCAT was specifically funded to bring this foreign-based technology into a US shipyard. G-H is working with the participants listed above to optimize the composite materials and fabrication technology to allow the hulls to be built to the strict weight and quality tolerances required by the project goals. Also, G-H has the goal of developing and bringing to the international market a vessel that will be revolutionary in its performance, price, and availability by the use of composite construction of the hulls, combined with an aluminum superstructure and advanced propulsion and outfitting components. G-H will complete the information acquisition in the foreign market; do the production design of the composite hull based on the INCAT full design; model-test the hull, including comparing its wake with that of comparable monohull vessels; apply to Det Norske Veritas society for certification to the IMO/HSC rules and obtain USCG formal approvals of the composite hull and full scale plans; adapt production and train crews to build the XP-300 using Zone Outfit Logic Technology (ZOLT);[96] strain gauge the hulls and conduct extensive full scale trials on the completed XP-300; and design an inexpensive intermodal docking system for the XP-300 (called the Patriot). A simple low cost intermodal docking system is an integral part of marketing these vessels to developing countries and is necessary as a reliable loading interface between the fast catamaran ferry and the beach.

The following is a list of basic materials that are proposed for use in optimizing the construction of the composite hull:

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[96] See section on Business and Construction Processes.

- resin: material in a composite structure that locks the fibers and core materials into the structural shape defined by the mold. The resin must hold the fibers in the design orientation in order to maintain the strength of the structure. Resin is non-water absorbent and has superior compressive strength.
- fiberglass: the fiber content in the laminate is fiberglass, which has excellent mechanical properties. The fiberglass used here is specifically woven and knitted in order to add necessary strength without adding unnecessary weight.
- carbon fiber: a material where very long fibers are glued together in parallel with a starch adhesive to form a sheet of fibers.
- balsa core: comparatively inexpensive and light weight core material.
- foam core: lightweight core material with excellent impact resistance, and provides superior adhesion to the resin in laminate skins.
- plywood core: material used for construction of bulkheads.

Aluminum is one-third the density of steel, but it is also three times the cost and is difficult to fabricate, requiring hours of intensive work. Under the MARITECH program, G-H is improving the aluminum hull and attempting to gain Coast Guard approvals to build a 70 meter (50 car) all aluminum fast catamaran ferry. This could be a major new business niche.

Low Wake Fast Ferry Technology: G-H and Nichols proposed to achieve a 30-35 knot, 350 passenger, 40 meter catamaran ferry where wake dissipates in four boat lengths against normal wake decay of ten boat lengths or more. Many narrow-width passages and environmentally sensitive areas have had speed restrictions placed on them in order to reduce wake height and energy. Wake radiates as a function of surface wake energy and (considering water depth) submerged (wake) energy. A preliminary design was developed and model testing carried out. This design developed a 25% lower wake than other conventional catamaran designs. In the current project novel new approached to wake reducing or wake canceling hull designs are being researched with the goal being to develop a hull design which develops almost no wake.

<u>Business and Construction Processes:</u> G-H has used the MARITECH program to greatly improve their ability to compete through the adoption of modern business and construction practices. A few of these improvements are noted in the following:

- Zone Outfit Logic Technology (ZOLT): Under BAA 95-02 (Nichols led), ZOLT was implemented at G-H and Nichols. ZOLT is a subdivision of the Product-Oriented Work Breakdown Structure (PWBS) which consists of the Hull Block Construction Method, and the Zone Outfitting and Painting Methods. G-H, prior to MARITECH, was breaking the construction of the vessel into modules, but had not incorporated outfitting into the construction of those modules. ZOLT emphasizes a thorough advanced planning process that leads to segmenting a vessel into larger, fully outfitted construction modules which are then broken down into component work packages. This facilitates accomplishing as much work as possible in the safest and most efficient way, thereby applying assembly line type design and production processes and efficiencies to one of a kind ship construction. This has resulted in improved material flow, accuracy, and reduced labor hours . Most of the savings have resulted from doing "zone" piping electrical outfitting, painting and installation of components on units and modular structures prior to final assembly. The 96-01 and 96-42 projects continues and expands the implementation of the ZOLT methodology.
- Computer/Information System Improvements: Computer programs and hardware are being adopted that will organize all of the parts of the vessel according to ZOLT, and make parts lists accessible for the development of bid proposals. Bar code systems are being put in place to automatically feed materials information into databases for automatic inventorying and distribution to vendors. These automatic inventorying procedures will also identify the location of the material in the shipyard and what work package, module or zone the part belongs to. G-H is develop a business plan to developing a plan to upgrade their business systems.
- CADCAM: G-H has a 3D CAD Key system that produces floppy discs to drive numerically - controlled plate cutting equipment (soon to become a Wireless Area Network). They use the internet to communicate with INCAT. This allows them to download design information created

in Australia during the previous night, send the information to the fabrication shop and start NC cutting parts during the same day.

- Training in the use of CADCAM software, Microsoft Project scheduling software, DNV welding procedures and business management is ongoing at G-H.

Facilities Improvements: These include a new 13,800 square foot fabrication building to be constructed on a 3 acre site. A number of changes are planned to improve workflow. Surveying, planning, permit processing and engineering development are being aided by MARITECH.

C. Overall Shipyard Goals and Strategies:

Goal/Strategy 1: G-H will succeed in the international boat building market, particularly in the fast ferry catamaran sector.

Goal/Strategy 2: G-H is leading the market in the U.S. for large (70 meter/50 car) ferries with aluminum hulls and is perfecting their composite hull production techniques.

Goal/Strategy 3: G-H is improving its business practices and construction processes, employing information systems technologies that will enable the company to organize all aspects of the construction process according to the requirements of the particular boat that is being built. Training of the work force in these systems is considered to be an important focus.

Goal/Strategy 4: G-H is planning to undergo a large modernization of their yard, to include improving workflow and expanding their covered and heated fabrication facilities.

D. Questions

1. Ship Design and Construction Strategies:

a. What ships have been sold, built, are under construction, or have been designed as a result of MARITECH?

Although no international commercial business has been realized yet, G-H has seen a doubling of sales volume, and, consequently, an increase in workforce of 30 percent. At this time, they have a two year backlog of orders (triple their pre-MARITECH backlog). They feel that their business looks good for the next ten years. They are currently trying to penetrate the global market.

Supporting Data for Ship Design and Construction Strategies:

Status	Description of Vessel	Metric Benefits
Completed (Built)	2 composite hulled catamaran Ferries	$8.4M sales
Under Construction		
Designed	Composite hull for catamaran ferry	
Under Design	Improved composite materials	

b. What changes in construction strategies have been developed?

- New composite hull production technologies are emerging
- Aluminum hull design for large (50 car) ferry

c. Were any international competitive benefits derived from MARITECH ship designs and construction projects, and if so, what were they?

Not Yet

2. Technologies Developed or Applied to Improve Design, Production/Manufacture, Operation, and/or Repair of Ships:

a. What technologies have been developed or applied to the design, production/manufacture, operation, and/or repair of ships through MARITECH?

G-H has used the MARITECH projects to greatly improve their ability to compete through the adoption of modern business and construction practices. A few of these improvements are noted in the following:

- Zone Outfit Logic Technology (ZOLT): Under BAA 95-02 (Nichols led), ZOLT was implemented at G-H and Nichols. This is an integrated production/design process developed to improve productivity (production time and costs) through planning of work flow. It is analogous to the Product Work Breakdown System (PWBS). The 96-01 and 96-42 proposal and contract expands the implementation of the ZOLT methodology.

- CADCAM: G-H has a 3D CAD Key system that produces floppy discs to drive numerically - controlled equipment (soon to become a Wireless Area Network). They use the internet to communicate with INCAT.

- Training in the use of CADCAM software, Microsoft Project scheduling software, DNV welding procedures and business management is ongoing at G-H..

b. Were any international competitive benefits derived from technologies developed or applied under MARITECH projects, and if so, what were they?

Not yet.

3. Facility Expansion or Modernizations and Process Enhancements Made to Improve Design, Production/Manufacture, Operation and/or Repair of Ships:

a. What facility modernizations or expansions or process enhancements have taken place as a result of MARITECH?

These include a new 13,800 square foot fabrication building to be constructed on a 3 acre site. A number of changes are planned to improve workflow. Surveying, planning, permit processing and engineering development are being aided by MARITECH.

b. Were any international competitive benefits derived from these expansions, modernizations, or enhancements, and if so, what were they?

The increased efficiencies and reduced costs have allowed both G-H and NB to become much more internationally competitive in price although no vessel orders have been finalized at this point.

c. Did you examine foreign shipyards as part of a MARITECH project, and if so, how did your findings influence your facility expansion or modernization or the planned enhancement of your processes?

Yes. Australian shipyards were studied and the resulting discoveries will be incorporated into the shipyard's production processes as appropriate.

4. Commercial Business Practices for requirement analysis, supplier relations and material procurement, human resource management, customer relations and marketing, and cost estimating and financial management systems (or others applicable to your shipyard):

a. What new commercial business practices have resulted from your MARITECH projects?:

- Computer/Information System Improvements. Computer programs and hardware are being adopted that will organize all parts of the boat according to ZOLT, develop parts lists from previous inventories and display parts lists at bid levels. Bar code systems automatically feed into databases for automatic inventory and distribution to vendors for quotes are also under development. These automatic inventories also include location in shop and flow to kits for ship assembly. They are developing a business plan to upgrade their business systems.

- Training has taken place throughout the yard, in using Microsoft Project to schedule, in using the CADCAM system, in DNV welding procedures and in business management.

b. What new business markets have been developed or expanded through commercial business practices developed or applied through MARITECH?

Both the catamaran ferry and pilot boat business has been enhanced.

c. Were any international competitive benefits derived from business processes developed or applied under MARITECH projects, and if so, what were they?

Not yet.

5. Impact on Navy Shipbuilding:

a. What is the impact of the MARITECH projects on Navy shipbuilding?

N/A

b. What commercial practices are you now using in Navy contracts?

N/A

c. What positive impacts could be manifested if the Navy agreed to adopt commercial business methods identified or used in MARITECH projects?

N/A

6. MARITECH Program Process:

a. What cultural and process change have resulted from procedures employed in the MARITECH Program?

1. Consortia **-** *Has forming consortia become a normal approach in your commercial and Navy business practices?*

Yes (for commercial).

2. Teaming **-** *Has teaming become a normal approach in your commercial and Navy business practices?*

Yes, their teaming arrangements with Nichols Brothers and INCAT have proven quite beneficial to all.

3. Were your associations with foreign partners useful, and if so, do you plan to use such associations in future commercial and Navy contracts?

Their association with INCAT was invaluable.

b. What MARITECH Program processes did you particularly like/dislike, and do you have any suggestions for such future programs?

G-H feels that MARITECH should continue. They made the following suggestions:

- The government should eliminate prohibition against buying hardware with government funds.

- There is a concern that small shipbuilders will be cut from the next MARITECH program. Gladding-Hearn feels this would be a grave mistake, since it would ignore what is perhaps the most vigorously commercial part of the shipbuilding community.

- The AOTR should know what the project is about. He should approve invoices in a timely manner, rather than hold it up while he determines how well the project is doing and the value of the milestone. Guidelines should be set for project participants and the AOTR so that everyone knows what is expected. This was not done. MARAD required reports that were not helpful to the project. A handbook would be helpful for derivation and application of performance milestones, so that invoice payments would not be so contentious.

7. Global Shipbuilding Market:

In G-H's sector, the Jones Act and the MARAD loan guarantee program have been vital. The shipyard feels that these shelters will have to serve until foreign subsidies are discontinued. For example, the Australian company INCAT receives a subsidy of approximately 9 percent, which if removed, according to G-H, would solve their international competitiveness hurdles.

G-H is still trying to penetrate the global market, but the comments above are reality.

What must be done for the U.S. to successfully compete in the global market and what should be the role of programs such as MARITECH?

The MARITECH program has been a major contributor in helping these shipyards become more internationally competitive. Tax credits or other tax incentives oriented toward encouraging facilities development, process improvements, and international marketing efforts would go a long way toward offsetting the competitive advantage that government subsidized foreign shipyards have enjoyed.

Administrative Data

Lead Shipyard: **Halter Marine Group, Inc. (Halter)**
14055 Seaway Road, Gulfport, MS 39503

Date of Shipyard Interview: 11 February 1998

William Pfister - Program Manager, Advanced Programs
Perron Chatham - Program Manager, Advanced Programs
Chris Oliver - Program Manager, Advanced Programs
Eric Richards - Yard Manager, Pascagoula Division

Shipyard Contact: Bill Pfister

AOTR: Dave Heller, MARAD

Date of AOTR Interview: 5 February 1998

MARITECH BAA/Projects:

1. BAA 94-09. 23,000 ton Container/Bulk Carrier ($5.9M - total cost)

   Sub-Contractors: Connell Finance Co.
   IHI Marine Technology

2. BAA 94-09. Medium Sized Multipurpose Ship ($2.2M - total cost)

   Sub-Contractors : Pacific Marine Leasing
   Summers Financial Services
   Norasia

3. BAA 94-09. Commercialization of E-CAT Technology ($4.1M - total cost)

   Subcontractor: Summers Financial Services

4. BAA 94-09. Large Fast Ferry Technical Development ($5.1M - total cost)

   Sub-Contractors: Kværner Masa Marine
   Fry Design & Research
   Maritime Dynamics
   Band Lavis & Associates
   GE Capitol Inc.
   Vosper International
   Advanced Multihull Designs

Researcher: S. Tennyson

Case Summary

A. Background

Halter Marine Group, Inc. (Halter), headquartered in Gulfport, Mississippi, comprises 21 shipyards in Texas, Louisiana, Mississippi and Florida, and employs approximately 5,500 shipbuilders. Halter is the seventh largest shipbuilder in the U.S. and the largest U.S. builder of small to medium sized (50-400 feet) ocean going ships. Halter specializes in the design, construction, conversion, and repair of a wide variety of vessels for government, energy, commercial, and other markets.

Halter's main products include offshore support vessels (OSVs), offshore double hull tanker barges, offshore tugs, harbor tugs, towboats, oil spill recovery vessels, oceanographic research and survey ships, high speed patrol boats, ferries, and luxurious megayachts. Over the past 40 years, the Halter Marine Group has designed, built, repaired or converted more than 2,600 vessels. They build in steel, aluminum, and composites. They have built boats for 28 foreign governments and/or their armed forces, as well as for the U.S. Navy, Army, Air Force, Special Operations Command, Coast Guard, NASA, and the Department of the Interior, separating their commercial and government (Navy) work between yards. Halter is the largest producer of advanced diesel-electric vessels in the United States, and has built vessels with propulsion systems ranging from propellers and paddlewheels to water jets and steerable Z-Pellers and cyclodial propulsion. Halter attributes its success to its ability to deliver high quality vessels, on-time, within contract price, and without concern for their financial stability.

Some of Halter's shipyards are equipped with specialized machinery for building custom components. This allows them to supply other Halter yards with these parts, thereby reducing costs and equipment redundancy. In addition, they do not just design and build vessels, but they also have dry docks, large graving docks and shipways specifically for repair and conversion. Halter has also incorporated this into their overall corporate strategy, acquiring shipyards which concentrate on ship repair and conversion.

Halter's Trinity Yacht division, in New Orleans, designs and builds luxurious, one-off fishing boats, megayachts, and superyachts. The technology developed by Trinity in the design and construction of high speed military patrol boats and special purpose vessels is transferred to all Trinity yachts. Interior outfitting and finishing is carried out by the yard's cabinet makers and specialized sub-contractors. They are able to complete assembly at their yard or wherever the customer desires.

Halter's Gulf Coast Fabrication and its Equitable Shipyard are capable of building any type of barge from 110 to 550 feet, with as many cargo tanks, decks and support systems as required. Last year, Halter's Gretna Machine & Iron Works facility which had specialized in the construction of large cargo carrying vessels since 1935, switched to repair and maintenance in anticipation of the current upswing in marine activity (which is forcing many older vessels back into operation). Halter has also re-opened the former Eastern Marine yard in Panama City, Florida, part of an acquisition, for new construction.

Halter notes that the key to all its vessels is simplicity in design and equipment. This allows for greater reliability and efficiency, longer service life, reduced maintenance, lower manning requirements, reduced training requirements, and greater fleet readiness. Their Engineered Products Group combines human experience and intuition with advanced computer technology to design and construct products. Using three dimensional imaging to see each component of a vessel before it is built, they eliminate costly errors or flaws which could negatively impact the vessel's operation and effectiveness. They have hundreds of designs that can be modified to each client's needs using virtual computer technology. Halter uses standard, off-the-shelf machinery and components whenever possible in their vessels. In addition, they use advanced technology and manufacturing techniques in the building of vessels, such as computer aided design and manufacturing (CAD/CAM), modular construction, advanced welding, panel line fabrication, computerized plasma arc cutting, automated sandblasting and painting, and zone outfitting.

In June 1997, Halter acquired Texas Drydock, Inc. (TDI), now called TDI-Halter, Inc. TDI, operating six shipyards in Southeast Texas, is known worldwide for its design, construction, conversion, and repair of mobile offshore drilling units. Other Halter shipyards enable TDI-Halter to expedite deliveries because they can fabricate components for final assembly at one of the TDI-Halter yards. TDI-Halter operates one of only three dry docks in the U.S. capable of dry-docking jackup and semi-submersible rigs. Besides their offshore work, TDI-Halter has a one of the broadest ranges of ship repair capability in the Gulf region.

In July 1997, Halter announced that it had entered into an agreement to purchase Bludworth Bond Shipyard (BBS) which operates two shipyards in Texas. BBS specializes in ship repair and conversion, part of Halter's corporate strategy to expand and increase their presence in the ship repair business. Furthermore, in October 1997, Halter announced that it would acquire equipment manufacturers, AmClyde Engineered Products (designer of cranes and mooring systems), Utility Steel Fabrication (subcontractor for cranes and winches), and Fritz Culver (designer and manufacturer of towing winches, windlasses, tuggers and related equipment). In December 1997, Halter announced the acquisition of McElroy Machine & Manufacturing Company, Inc., Gulfport, MS, a designer and manufacturer of marine deck equipment. McElroy, as well as the others, will be incorporated into Halter's Engineered Products Group.

In January 1998, Halter announced that it intended to acquire Calcasieu Shipyard, Inc. of Sulphur, LA. This shipyard is a full-service shipyard providing repair and conversion services, vessel gas freeing and cleaning services, and specialized construction. Halter will continue the yard's current multi-million dollar capital expansion program to increase additional repair stations.

Halter has also begun a multi-million dollar program to upgrade and increase ship repair and conversion services at several of its yards. They are adding new cranes, heavy duty fabrication equipment, and are completing other improvements at two of their yards in the New Orleans area, their Pearlington, MS yard, and at their yard in Texas City, TX. Halter has spent $14.5M on capital improvements for its existing facilities during FY97 and has budgeted over $20M for capital improvements, not including acquisitions, in their FY98 budget. Approximately $10M of the budgeted expenditures are ear-marked for their Pascagoula, MS facility to enable them to accommodate the construction of mobile offshore drilling units and to support the work of TDI-Halter projects.

In a speech to Norwegian Shipbuilders, John Dane III, Chairman, President and CEO of Halter, listed what he considers Halter's five Factors of Success:

1. Medium size shipyards in which government and commercial work is kept separate, and each yard specializes in certain aspects of the shipbuilding process.
2. Halter's strong work ethic and their commitment to their customers.
3. Their diverse product line.
4. They maintain a strong balance sheet remaining financially stable and continually invest in their facilities and new technologies.
5. The company operates within a favorable government climate, noting their good relations with their customers, the excellent support they receive in Congress, and an Administration that has targeted help to the shipyards as a priority.

Halter announced in January that their FY98 third quarter earnings resulted in a 100% increase over the prior year fiscal quarter, ending with a net income of $8.8M compared to $4.2M. FY97 revenue from the Company's government customers was $216M or 53% of total revenue (of which the U.S. Navy accounted for approximately 37.4%). Energy customers represented 21% of their total revenue or $86M while commercial (non-energy) customers accounted for 20% of the total FY97 revenue or $81M. Halter's repair and conversion work as well as their construction of megayachts accounted for $24M, representing 6% of the total FY97 revenue. Halter's current assets are $472M, with a current backlog of $700M representing about one year's worth of work. There are currently 83 vessels (not counting rigs) under construction in Halter's yards (this figures does not include options which are under contract).

Some General Comments:

In a discussion with Eric Richards, the Yard Manager at the Pascagoula yard, several interesting points were made. He commented that overall shipbuilding does not lend itself to a lot of automation. He noted that each ship is different and that some require you to use manual process controls. Mr. Richards remarked that blasting and painting are the processes best suited to automation. He expressed interest in the government exploring technological advances in pre-construction primers. He stated that coating and painting are major areas for improvement in the shipbuilding industry. Both processes involve a lot of manual work as a result of losing the layout cuts on the steel during coating. Furthermore, he observed that a primer is needed that is compatible with everything. Mr. Richards commented that as you automate, all things must evolve as well. He noted that IHI's study of his yard enhanced what they were already doing, and confirmed their flexibility and capabilities.

It is important to noted Halter's unique situation. Each of its 21 yards are managed separately and are semi-autonomous. (Each yard has a capacity of about 500 people.) As a marine "group" Halter is able to have yards set aside for specific purposes. Various yards are the steel centers where they receive, store and process all the steel for the other Halter yards in their geographic area. Other yards are set-up for modular outfitting where they build pieces (modules) of vessels that are then assembled at erecting facilities. Currently, large amounts of aluminum construction is only being done at their Halter Equitable facility in New Orleans, LA, but they have opened a second aluminum construction area at the Halter-Gulfport (in Gulfport, MS) shipyard.

Halter was also among the shipyards which expressed concern regarding the future workforce of the shipbuilding industry. They noted that wages are increasing and that the industry is having to compete for workers, i.e. with casinos in the Gulf Coast region. The yards have to be careful what work they contract because they might not have the employee resources to support it. Halter recently broke ground on a state-of-the-art training center for its Pascagoula area yards. There is also a training center at its Gulfport yard.

Some additional points Halter discussed was their focus on product designs under the MARITECH program. They explained that they did so because of the different things they do, noting that an internal group will focus on process problems. Halter also commented that the price of aluminum is rising while steel remains competitive.

B. Summary of MARITECH Projects Managed or Participated in by this Shipyard

1. BAA 94-09. 23,000 DWT Container Bulk Carrier:

Objective: The goal of this project was to produce a U.S.-made, medium sized bulk carrier for the dry cargo trade which could successfully compete with foreign made vessels.

Approach and Status: Halter intended to combine a proven design, imported from their team member IHI, with innovative concepts of construction, outfitting, production management, material management, and productivity improvement to create a new generation of medium sized Bulk carrier/container vessels for the dry cargo trade. While the design that IHI provided had been built successfully 84 times previously, it required extensive redesign to incorporate regulatory body changes in the 12 years since design inception. Furthermore, after completing market surveys as part of their plan, they discovered that the design had characteristics and capabilities that were not desirable in the current market and therefore not competitive. They determined that the design required a significant amount of revisions to comply with current class and Safety of Life at Sea (SOLAS) rules; therefore, after this realization, Halter stopped the project between phases.

Impact: Despite the project outcome, Halter credits the program with some beneficial results including a review of Japanese design, production and estimating practices, and the assessment of Halter Marine Group’s yards by Japanese experts for production enhancement. The layout and equipment study of the Pascagoula, MS yard was a direct result of this project and has resulted in increased efficiencies concerning the handling and flow of material, particularly steel, at the yard. In addition, they noted that they became a better international buyer as a result of this project. This is the only MARITECH funded design that Halter would not considering building.

2. BAA 94-09. Medium Sized Multipurpose Ship:

Objective: The purpose of this project was to create a new generation of medium sized multi-purpose ships which can compete with foreign made vessels.

Approach and Status: This project is proceeding. By January 1997, Halter had proved their design thesis, a wide shallow hull can be more efficient than a slender one. Their marketing feedback is driving the remainder of the design. In this particular project, while Halter concentrated on the slow speed container feeder (16-18 knots), they also examined the fast feeder (25-35 knots), and very fast container feeders (60-70 knots). This was done in order to examine all aspects of the containerized freight market today, and to predict what ship characteristics the trade will require in the near (3-5 years) and middle (5-10 years) future. Halter has engaged in discussions with several potential owners, and reviewed their costing and production practices to ensure they are able to manufacture a competitive product. In addition, they are looking at RO/RO adaptability for the slow and very fast vessels.

Impact: Halter has three versions of the *Sea Shuttle* Container Feeder as a result of this MARITECH project. Their unique design incorporating the concept of low length-to-beam and high beam-to-draft ratio resulted in a substantial increase in the payload and stability of the vessel with negligible increase in its resistance/power requirement. The innovative design allows for a high degree of flexibility for the owner in the final layout design of the ship. Halter is ready to build this ship, and it is the type of vessel that they want to be building; however, they note that they "can't compete with China in this market, because the Chinese are basically giving ships away." Halter added that no one is buying or selling certain types of feeder ships due to the current market being down. They noted that only what is already under contract is being built. Halter also obtained data and design licenses for the fast container feeders, and is in the process of obtaining them for the very fast feeders.

3. BAA 94-09. Commercialization of E-CAT Technology:

Objective: The purpose of this project was to produce U.S.-made, low wake, high speed "E-CAT" ferry which could be marketed competitively in both international and domestic markets.

Approach and Status: Halter wanted to combine a low wake, high speed "E-CAT" vessel design with innovative concepts of construction, outfitting, production management, material management and productivity improvement. Their design had been model tested and also verified by Computational Fluid Dynamics. After completing an initial design and testing it, Halter re-designed their product including additional refinements. The hulls were extended forward to maximize waterline length, forward sections were refined, form drag was minimized and other additional refinements completed. Market introduction had begun and the reactions have been favorable. Currently, Halter's Gulfport facility is constructing a prototype of their 42.5m High Speed Low Wake Pax Ferry which will be debuted in October 1998, at IMTA in New Orleans.

Impact: Their design can carry 300-500 passengers at 40+ knots while producing only a 12 inch wake. Halter believes that the domestic market will most likely develop first because of municipalities that need low wake vessels to prevent property damage. Also they see a significant opportunity in the Chinese market. MARITECH has served as a crucial catalyst to Halter's low wake business. Through this project, Halter has engaged in new vendor alliances as well as new aluminum, light gage construction which requires a different method of welding and fitting.

4. BAA 94-09. Large Fast Ferry Technical Development:

Objective: The goal of this project was to develop a high technology, high capacity, fast passenger/vehicle ferry. Halter wanted to design and build in aluminum to carry a large number of people and cars at a high speed competitively.

Approach and Status: This project got off to an aggressive start, but slowed because of design-specific patent issues. The designer stated that he was not infringing on a Stena patent, but the designs were too similar and Halter could not use the original design. In January 1997, Halter proposed several other hull form variations and concepts to their major team contributor, who was the prospective owner for the original design and was awaiting Title XI approval. Halter has also contacted other potential owners to determine their requirements for replacement or additional fast ferries. In turn, they have diverged from one specific design, the Catamaran, into multiple designs including a Monohull, a Catamaran, and a Sponson-Assisted Monohull. This was done after reviewing new designs for incorporation into the development project. Halter has restructured the program to broaden the designs available in order to encompass a larger group of potential buyers. Halter has developed an agreement in principle to create a Joint Venture with an Australian fast ferry builder to build their designs in Halter facilities. The price of the first of these vessels is not on an even footing with the tenth ferry of the same design being constructed in Australia.

Impact: This project was restructured from a single design into multiple because of the Stena patent issues. Halter believes that there is an excellent prospect for both Car/Passenger and RO/RO Freight building. Halter sees real Navy applicability in this project; contributing to fast sealift capability which will enable rapid transport and deployment of troops and military equipment. Halter would not have entered the fast ferry international market without the MARITECH program. The project has been very beneficial in extending Halter's knowledge and prospects for fast car ferries. In addition, from this project they developed a Fast Cargo Catamaran which they are confident will be built in the future. Without MARITECH, Halter would not have considered this project.

C. Overall Shipyard Goals and Strategies:

1. Expansion and Acquisition: As part of their overall strategy, Halter has focused on increasing its product offerings and facilities through internal expansion and asset acquisitions or business combinations. This overall strategy is complemented by Halter's goal to expand their repair business, as well as through vertical integration.

2. Capitalize on Expanding Offshore Marine Work: Halter believes that they are well positioned to take advantage of the expected upturn in the market for new offshore support vessels. To better compete in the market, Halter acquired Texas Drydock, Inc. in 1997. Now known as TDI-Halter, they specialize in the construction, conversion and repair of mobile offshore drilling units.

3. Vertical Integration: As the demand for offshore workboats and drilling rigs increases, Halter has chosen to take steps to protect itself against possible bottlenecks in the availability of critical equipment by purchasing several companies that manufacture such components. They acquired three companies which design and manufacture cranes, mooring systems, and winches in October 1997, allowing them to manufacture the majority of components for various rig kits. The acquisitions were seen as "consistent with [their] previously announced objective to pursue a vertical integration strategy as it pertains to some of the more critically engineered components used in the production of vessels and rigs." John Dane III, Chairman, President and CEO of Halter Marine Group, noted that "[d]ue to the current expansion of the energy industry in the Gulf of Mexico and elsewhere, limited industry production capacity has extended deliveries and affected pricing for some of these components." All of the companies will be incorporated into the newly formed Engineered Products Group. In December 1997, Halter announced that the Engineered Product Group had acquired McElroy Machine & Manufacturing Company, a leader in the design and manufacture of an extensive line of marine deck equipment for commercial, fishing, government, and military vessels. This strategy will also allow Halter to deliver many of their vessels on an accelerated schedule because components will be fabricated by them.

4. Increase Repair and Conversion Work: Continuing its policies of expansion, Halter announced that it would acquire Bludworth Bond Shipyard, Inc. which operates yards in Houston and Texas City that specialize in ship repair and conversion. Dane called the acquisition "an ideal fit," noting that expanding the groups presence in the repair and conversion market was "one of [their] strategic goals." In addition, they announced in October of 1997, that they would reopen the former Eastern Marine yard in Panama City for new construction, and switch its Gretna Machine & Iron Works, Inc. to repair and maintenance. Halter began a multi-million dollar program to upgrade and increase the ship repair and conversion services of two of its four New Orleans-area shipyards as well as shipyards in Mississippi and Texas. Dane noted that "the increasing activity in the offshore oil and gas industry as well as more maritime business in Gulf Coast ports is creating a need for additional ship repair and conversion as well as increase maintenance." Halter has agreed to purchase Calcasieu Shipyard in Sulphur, LA which represents "another important milestone in accomplishing [their] strategy to expand the repair part of [their] business."

5. Co- Production and Technology Transfer Programs: Halter is active internationally with co-production and technology transfer programs. They have successfully completed a technology transfer program in South America and have another one underway in the Philippines.

D. QUESTIONS

1. Ship Design and Construction Strategies:

a. What ships have been sold, built, are under construction, or have been designed as a result of MARITECH?

See table below

Supporting Data for Ship Design and Construction Strategies:

Status	Description of Vessel	Metric Benefits
Completed (Built)		
Under Construction	42.5m High Speed Low Wake Pax Ferry	Application of IMO HSC, ABS & aluminum, light gage construction, new market, vender alliances
Designed	• 23K DWT Container / Bulk Carrier • Sea Shuttle Container Feeder (with hull extension, flush deck, and hatched versions) Fast Super Feeder (Norasia) Pentamaran Super Feeder (Norasia) 1120 Open Top / 1140 Conventional Container Ship (Mc/J) • High Speed Low Wake Passenger Ferry- 45m (1 and 2 deck versions) 100 Passenger Express Ferry (Zhenghua) 200 Passenger Catamaran Ferry (Zhenghua) Light Weight- 30m (NY Waterway) 117 ft Passenger Ferry (Naviarca) 138 ft Low Profile Passenger Ferry (Potomac River Jet) 45m High Speed Passenger Ferry for Great Lakes (Philip Delahy) • 110 m Fast Car Passenger Ferry HSM150 HSM 280 HSC 330 HSC 525 Pentamaran Fast Car Passenger Ferry HST 630 HST 800 HST 1000 76m Fast Trailer Carrier (Carib Cargo) 82m Gas Turbine Car Passenger Ferry (AFF)	New designs for the international market place
Under Design		

b. What changes in construction strategies have been developed?

Light gage aluminum construction techniques are now being used at Halter, and they have reoriented a production facility to begin aluminum fabrication of ferries. They are also using aluminum extrusions in construction processes.

c. Were any international competitive benefits derived from MARITECH ship designs and construction projects, and if so, what were they?

1) Imported designs and became technologically aware of Large Fast Ferry designs and market opportunity. Halter has made a commitment to go into this market internationally.

2) Determined market competitiveness of smaller container feeder vessels.

3) Realized advantages of Jones Act and MARAD Title XI Loan Guarantee Program.

2. Technologies Developed or Applied to Improve Design, Production/Manufacture, Operation, and/or Repair of Ships:

a. What technologies have been developed or applied to the design, production/manufacture, operation, and/or repair of ships through MARITECH?

1) Extended deck and stiffener use under Large Fast Ferry. Examined application to USN MKV Project.

2) Concurrent design application under Virtual Shipyard Project (subcontracted basis). Process not mature for less complex ships.

Supporting Data for Technologies to Improve Design, Production/Manufacture, Operation, and/or Repair of Ships:

Technologies	Description	Metric Benefits
Extended aluminum deck and stiffeners use	Use extrusion vice panel with stiffener welded	Less distortion, labor saving, lighter weight
Drawing communication	E-Mail drawings via Internet internationally	Time and cost saving

b. Were any international competitive benefits derived from technologies developed or applied under MARITECH projects, and if so, what were they?

1) Two potential customers want Halter to build large fast ferries (one RO/RO Cargo and one Car/Passenger).

2) One Far Eastern customer wants a high speed, low wake passenger ferry.

3) U.S. Joint Venture being considered because of Large Fast Ferry project for U.S. market.

4) A significant number of potential international customer contacts have been developed, due to the MARITECH programs.

3. Facility Expansion or Modernizations and Process Enhancements Made to Improve Design, Production/Manufacture, Operation and/or Repair of Ships:

a. What facility modernizations or expansions or process enhancements (e.g., yard layout) have taken place as a result of MARITECH?

1) Pascagoula facility production flow. Arranged new layout derived from MARITECH projects for ships of this size.

2) Aluminum facility being planned. E-CAT prototype being constructed in one now at the Gulfport yard (9 acres under roof); second larger facility being planned as a result of MARITECH developed opportunity.

Supporting Data for Facility Expansion/Modifications and Process Enhancements to Improve Design, Production/Manufacture, Operation and/or Repair of Ships:

Task	Description	Metric Benefits
Facilities Expansion	Pascagoula Upgrade Gulfport Central enhancement to large aluminum being planned	Deepwater capability to build vessels up to 650' - Approximately $20 million spent Capability to build large aluminum RO/RO ferries, approximately $5million
Facilities Modernization	Gulfport adaptation to light weight aluminum	Additional aluminum shipbuilding capability
Processes Planned	Aluminum extrusion use in lieu of plate and welded stiffener.	Stronger Material/Design
Processes Implemented	Aluminum extrusion use in other DoD programs	Stronger Material/Design

b. Were any international competitive benefits derived from these expansions, modernizations, or enhancements, and if so, what were they?

1) Able to solicit additional ships and ships of larger sizes.

2) Able to solicit large fast aluminum ferry construction, and additional smaller aluminum.

c. Did you examine foreign shipyards as part of a MARITECH project, and if so, how did your findings influence your facility expansion or modernization or the planned enhancement of your processes?

1) Visited Austal shipyard (Henderson, Australia) building large fast ferries.
2) IHI visited three of our shipyards with a view towards building for the 23,000ton Container/Bulk Carrier. Their plan was useful for incorporating other vessels as well. Examined exterior photo

coverage of 250 DWT High Speed car/passenger vessel under construction at Danyard (Aarlbourg, Denmark).

3) Recognized that large aluminum work is not necessarily facilities intensive. Halter plans on covered construction.
4) Conofeeder visit was MARITECH related to examine container ship designs and demand.

4. Commercial Business Practices Developed or Applied for requirement analysis, supplier relations and material procurement, human resource management, customer relations and marketing, and cost estimating and financial management systems (or others applicable to your shipyard):

a. What new commercial business practices have resulted from your MARITECH projects?

E-Mailing drawing internationally via Internet derived from pursuing international designs and technology transfer.

Supporting Data for Commercial Business Practices Developed or Applied:

Commercial Business Practices	Description	Metric Benefits
E-Mail drawings internationally	Correspondence and drawing transfer via Internet (in lieu of direct modem)	Save postage/time responding to customer requirements and questions
Look to Foreign suppliers	Large fast seats are perceived as better offshore, (also gears, jets, engines and electronics)	Halter was perceived as more knowledgeable in the fast ferry market place
Procured commercial database for ships and fast ferries	Procured commercial databases and put on our computer network, to be tasked by multiple users	More knowledgeable in the marketplace. Able to evaluate potential customers better and faster
Video Teleconferencing	Employed Video teleconferencing (on screen data discussion) in lieu of domestic and international travel	Used in other applications for business development (teaming, etc.) Cost of travel

b. What new business markets have been developed or expanded through commercial business practices developed or applied through MARITECH?

1) Technical papers presented and new exhibits attended
2) Fast Ferry markets opportunities were developed
3) Medium size multipurpose ship opportunities developed
4) High Speed / Low Wake requirements recognized along with a market for future potential

c. Were any international competitive benefits derived from business processes developed or applied under MARITECH projects, and if so, what were they?

1) Halter was perceived as having a capability that we actually had to go to the ship designer offshore to obtain. They were viewed as high-tech because of this.
2) They were more knowledgeable of the international marketplace.
3) All U.S. shipbuilders were thought to be too expensive. Now foreign owners are going to Halter, recognizing that they are competitive.

5. Impact on Navy Shipbuilding:

a. What is the impact of the MARITECH projects on Navy shipbuilding?

Large Fast Ferry technology, both aluminum and steel, is applicable to Navy Frigates and to DoD fast Sealift. DoD funds are being budgeted authorized, and appropriated now for Fast Sealift. The designs that they have invested in can be used directly. Very fast container vessel development directly applicable to Navy/DoD shipbuilding.

b. What commercial practices are you now using in Navy contracts?

Applying commercial practices whenever they are allowed. APL first large application of commercial practices. T-AGOS, AGOR, T-AGS, and T-AGOS SWATH are basically commercial.

c. What positive impacts could be manifested if the Navy agreed to adopt commercial business methods identified or used in MARITECH projects?

Costs would go down. There are many DoD procedures, for example the sub-contractor consent clauses in Fixed Price Incentive Fee contracts, contribute nothing to the product and detract substantially of the management attention by the shipbuilder. Usually, the local government oversight activity is the last to recognize the benefits of using “commercial” business methods.

6. MARITECH Program Process:

a. What cultural and process changes have resulted from procedures employed through the MARITECH Program?

1. Consortia **-** *Has forming consortia become a normal approach in your commercial and Navy business practices?*

Halter was a consortia member in two MARITECH projects. Both were seriously hindered by the inability to make timely decisions. They much prefer the prime and sub arrangement.

2. Teaming **-** *Has teaming become a normal approach in your commercial and Navy business practices?*

This is becoming a normal approach to Government business because of the broad expanse of their requirements. Halter tries to team with others who would bring some experience or capability that would complement their capability. The preponderance of commercial business practices is still to contract with a prime for the largest or most significant effort, and the prime will subcontract for the other parts.

3. Were your associations with foreign partners useful, and if so, do you plan to use such associations in future commercial and Navy contracts?

Associations with foreign designers, test facilities, owners, and builders were developed. They will use all of these in future DoD work.

b. What MARITECH Program processes did you particularly like/dislike, and do you have any suggestions for such future programs?

1) Halter viewed the design effort (product development) to be more beneficial than the "process" improvement. Both are necessary, but the product development encompassed the process. The process development and application projects that they saw appeared to concentrate on things that turned into an end product rather than the process intended to decrease shipbuilding cost or time.

2) Halter noted that their AOTR was extremely helpful, especially during the proposal revisions.

3) They also had a good experience with the proposal process in general, particularly with obtaining approval for revisions.

7. Comments on the Global Shipbuilding Market:

As the world "shrinks" due to more expansive communications and population increasing, trading will increase, resulting in more trade volume by ship. As a niche builder of medium to small ships, Halter notes that their market will increase. Speed will be more important in the future, in both a defense and commercial market.

As political pressure for global trading "levels the playing field", U.S. shipbuilders should be more viable in global market competition. Global viability with the U.S. shipbuilders will be dependent on the actions they take individually to determine which markets they want to be in, and the vigor and competence with which they pursue that goal. Halter also noted that the Title XI loan program is currently the most notable draw for foreign buyers, giving the U.S. yards a 10% price advantage.

What must be done for the U.S. to successfully compete in the global market and what should be the role of programs such as MARITECH?

MARITECH should spearhead the high tech development of the processes and products that the shipbuilders collectively determine they should pursue for the collective use. Efforts such as the MARITECH Advanced Shipbuilding Enterprise should be supported.

Maritech Review
Case Summary #9

Administrative Data

Lead Shipyard: **Ingalls Shipbuilding**
P.O. Box 149, Pascagoula, MS 39568-0149

Date of Shipyard Interview: 11 February 1998

Roger Banks - Manager, Contract Administration
Danny Bruhl - Manager, Production Control
Judy Wheat - Program Manager, Cruise Ship Design
Walt Whitehead - Engineer, Composites
Gerry Embry - Engineer, Advanced Technology
George Vogtner - Analyst, CAD/CAM
Peter Presel - Director, Business Development
John Sizemore - Engineer, Robotics

AOTR: Michelle Lingerfelt, MARAD

MARITECH BAA/Projects:

1. BAA 94-09 Cruise Ship Preliminary Design ($2,136,728)

Consortium Members: Ingalls Shipbuilding
Jamestown Metal Marine Sales
Deltamarin and Finnyards (Finland)
Hopeman Brothers

Shipyard POC: Judy Wheat

2. Projects Participated in, but not led by, Ingalls:

a. BAA 94-44 Intergraph MariSTEP

Consortium Members: Intergraph Corporation
Bath Iron Works
General Dynamics/Electric Boat Division
Ingalls Shipbuilding
Newport News Shipbuilding

Shipyard POC: George Vogtner
AOTR: Mr. Ben Kassel, NSWC/CD

b. BAA 94-44. Structural Composites, Composite Ship Superstructures Systems

c. BAA94-44. Cybo Robotic Welding

Researcher: L. Worcester

Case Summary

A. Background

Ingalls Shipbuilding is the nation's leading shipbuilding company for the design, engineering, construction, life cycle and fleet support, repair and modernization of surface combatant ships for the US Navy and international navies and commercial marine structures of all types. Located in Pascagoula, and in continuous operation since 1938, Ingalls is Mississippi's largest private employer, with 10,700 employees. Ingalls seems most efficient when the number of workforce personnel is between 9,000 and 15,000. A need to reach surge capacity such as wartime, the yard has functioned efficiently with 23,000 employees. Shipbuilding for the Navy alone may not be sufficient to maintain the desired workforce level; therefore, Ingalls supplements the Navy work with commercial work. The Navy, however, will remain the key customer to Ingalls. Ingalls invests $25-30M capital on an annual basis. Since 1975, Ingalls has delivered 118 ships, 74 of which were new, major surface warships into the US Navy's fleet. In its history, approximately fifty percent of the vessels that Ingalls has delivered were commercial ships.

Ingalls is also a participant in the offshore commercial market, principally in the areas of drilling rigs and ship construction, repair and overhaul, and in the construction of advanced, deepwater offshore supply vessels. Ingalls is actively participating in a US competition to build two cruise ships with an option for a third ship.

Litton Industries, headquartered in Woodland Hills, CA, has been Ingalls' parent company since 1961, and is involved in worldwide technology markets for advanced defense, electronic and information systems. Litton, founded in 1953 as a small electronics company, has evolved into a $4.2 billion company focused in defense and commercial electronics, information technology, and shipbuilding.

Litton Industries, Ingalls Shipbuilding, and the State of Mississippi joined forces in the late 60s to build a new, modern shipyard. This new shipyard was built across the river from the existing facilities, and was developed around a new modular ship production concept. This process involves extensive engineering, design, and ship production coordination.

Modular ship production begins with hundreds of smaller subassemblies in which piping sections, ventilation ducting, and other shipboard hardware, as well as major machinery items (i.e., main propulsion equipment, generators, and electrical panels), are installed. The preoutfitted subassemblies are then joined with others to form assemblies which are welded together to form complete hull and superstructure modules. (Ingalls does all the installations, even for vendor-supplied systems.) These giant ship modules, each weighing thousands of tons, are joined together on land to form the completed ship hull prior to launch. The result of this early outfitting and modular construction is: a Navy ship is more than 70% complete at launch and a commercial ship is about 80% complete at launch.

Ingalls' ship launch and recovery process works as follows: Completed ship hulls are rolled on a rail transfer system from the construction to Ingalls' floating dry dock for launch. The dry-dock is then positioned over a deep-water pit and ballasted down, allowing the ship to float free. Following launch, each ship is taken to an outfitting pier for christening, final outfitting, dockside and at-sea pre-delivery testing and onboard crew training. This system has been refined and upgraded over the years, and has been applied to the construction of US Navy multi-mission destroyers, amphibious assault ships, and guided missile cruisers. In 1978, Ingalls was selected by the Navy as lead shipbuilder for the Aegis guided missile cruiser program. Over the life of the program, Ingalls was awarded contracts to build 19 of the 27 cruisers. Those 19 cruisers were delivered between 1982 and 1994. In 1987, Ingalls was selected by the Navy to participate in the construction of the Navy's Aegis guided missile destroyer fleet. Ingalls was awarded contracts to build 17 Aegis destroyers, and 10 have already been delivered. Within the last 10 years, Ingalls has been awarded various contracts to build LHD Class ships (amphibious assault ships); there are currently five Ingalls built LHDs in the Navy fleet. Ingalls was the first US shipyard to be certified ISO 9000.

Ingalls uses a 3D CAD system that is linked with an integrated Computer-Aided Manufacturing (CAM) production network of host-based computers and localized minicomputers throughout the shipyard. Ingalls' system produces digital data used by the CAM equipment to electronically direct the operations of numerically-controlled manufacturing equipment, cutting steel plates, bending pipe, and laying out sheet-metal assemblies, and supporting other manufacturing processes. This technology enhances design efficiency and reduces the number of manual steps involved in converting design drawings to ship components, improving productivity and efficiency.

Interview with Peter Presel (Director, Business Development); Ingalls core business is centered on the design, construction and support of US Navy markets . Since US Navy business has decreased, Ingalls has looked to commercial and foreign warship markets. International ship construction is difficult because of subsidies to foreign shipyards. The Koreans sell certain types of ships for less than what the materials cost for an American shipyards. In 1993, 1,625 commercial vessels were under construction worldwide, but none in the U.S.

Ingalls has attempted to target sophisticated Jones Act ships, with a high dollar value. Oil drilling is occurring in deeper Gulf of Mexico. Ingalls central gulf location and long history of supporting the oil patch makes oil rigs and service ships Ingalls business target.

When Ingalls began the design of the cruise ship, they had no customer. After receiving the MARITECH award, Disney announced they wanted to build a cruise ship, so they became a potential customer for the cruise ship design. However, Disney's schedule became too aggressive and Ingalls had to back out of the deal. Ingalls did team with Royal Carribean Cruise Lines (RCCL) as a silent partner to obtain input on the cruise ship design. Current legislation has allowed American Classic Voyages (AMCV) to solicit invitations to participate in the design and construction competition for two cruise ships with options for additional ships. These US built cruise ships will be placed in the Hawaiian trade. Ingalls' current backlog is 39 ships. Included in this backlog is small deepwater supply vessels (190 ft to 240 ft).

B. Summary of MARITECH Projects Managed or Participated in by this Shipyard
1. BAA 94-09. Cruise Ship Preliminary Design

Background: Ingalls teamed with Deltamarin and Finnyards of Finland for the development of the cruise ship design. The target customer was Disney; within a couple of days before signing a contract, Disney announced that the scheduled ship delivery date needed to be moved forward by six months. And, the firm fixed price contract agreement would be required. Ingalls decided that the new schedule would not allow for necessary preliminary design development, so they canceled the deal. (Post MARITECH: Ingalls still had the design that they believed was a good one, and teamed up with Royal Caribbean Cruise Lines to get some direction/guidance on how to improve that design. The American Classic Vessel Hawaiian Islands Cruise Ships project is being competed in 1998 and Ingalls considered using a modified version [needs to be 150 feet shorter] of their design for the competition.)

Objective: Ingalls performed a coordinated research and development program designed to develop the Cruise Ship Preliminary Design, Manufacturing Plan, and Market Analysis. These techniques and/or technologies will assist Ingalls in entering into the cruise ship construction market.

Approach: The design of a cruise ship is specified by the owner/operator and therefore cannot be totally undertaken without a firm order. However, the basic hull form, the propulsion plant, machinery rooms, and other below-deck functional systems can be specified in a Preliminary Design. The design document produced included text describing individual ship systems, general machinery arrangement drawings, a master equipment list, and selected diagrams. Cruise ships generally show a delivery of three years from contract award. Therefore, development of a Manufacturing Plan will require extensive examination and most likely a revision of the fundamental approach used for the development of Navy ships.
Status. Complete. Design and Manufacturing Plan and Market Analysis was delivered.
Impact: This project places Ingalls in a position to enter the competition for new cruise ship construction opportunities. This will allow Ingalls to establish a US presence in a new and expanding market.

2. Projects Participated in, but not led by, Ingalls:

a. BAA 94-44. MariSTEP (Intergraph)
Background: MariSTEP is a MARITECH sponsored project targeting prototype implementations of the emerging STEP shipbuilding application protocols.

Ingalls agrees that this is a good start. This effort needs to be continued after the end of this three year effort. Prototype translators and participants will enhance their systems to enable Product Data Model Exchange. This project will develop prototype translators to exchange information in only a portion of the detail design phase of a product life cycle for piping, arrangements and structure. Early in the project, the participants discovered that because of reduced U.S. Shipbuilding participation between 1993 and 1997, some of their needs were not in the ISO Shipbuilding standards. This is mainly because the main participants were European Regulatory Bodies. Subsequent efforts by U.S. participants in ISO have reinstated these requirements. The concern is that U.S. Shipbuilders must maintain their presence to ensure are requirements are in the standards and that programs like MariSTEP must continue beyond this to add more functionality to these prototype translators.

Another general concern is that some disparities exist between the European ISO STEP protocols and MariSTEP. This is being addressed and some ISO STEP participants are helping with MariSTEP. However, the task funding for coordinating and melding the two efforts was just cut by $250K. Ingalls was emphatic that his effort must go on until the problem of non-connectivity is solved, but added that if MARITECH gets out of the business, who will continue?

Objectives: The objectives are to: enhance the global competitive position of the U.S. shipbuilding industry; enable the virtual shipyard, accelerate the implementation of STEP throughout the U.S. marine industry, assess the ability to implement STEP application protocols; and enable a product model definition and exchange capability to support simulation based design initiatives.

Approach: Use existing technology to develop a data transfer capability utilizing emerging STEP standards, for the use in ship design.

Status: Preliminary phase; the infrastructure is not in place to yet to begin implementing this new process.

Impact: Quick turnaround of data exchanged on product models, problem resolution, etc., for cleaner more mature 3-D product model.

b. BAA 94-44 Structural Composites, Composite Ship Superstructures Systems.

Background: Ingalls superstructure goal is to provide a deckhouse to the Navy using ABS and Coast Guard requirements.[97] Unfortunately, consortia members have moved slowly; there is no "Program Manager" leadership. Each vendor is responsible for their piece of the structure, including the CAD/CAM drawings that will then be put in the "final model" (a geometry based production system) that Ingalls is responsible for. Materials being considered include eglass, vinyl ester resins, and Kevlar (for special applications, such as armor). Special problems include structural repair and fire hazard.

Objective: The purpose of this project is to develop a composite superstructure for commercial vessels, while maintaining reasonable manufacturing costs, reducing assembly cost, and evaluating new technologies and materials that enhance the performance of the superstructure.

Approach: Superstructure system concepts will be developed and evaluated both technically and economically to determine which concepts best meet the goals of this program. Preliminary designs for the individual components of the system will be developed based on the established design loads and the system concepts. The best designs will be selected and specific materials and laminates will be detailed for each component. Manufacturing and superstructure assembly processes will be evaluated and selected. The test program and final certification will be developed and performed. Specifically, the deckhouse structure will be built at Ingalls, and the components will be supplied by consortium members.

Status: Ingalls has performed a trade study for using composites rather than steel in a variety of ships, such as the arsenal ship deckhouse; they established performance criteria and developed a test program for small parts and joints; and they started a preliminary design of components.

Impact: The Navy understands the benefits of composite superstructure (e.g., light weight , reduced RCS, lower maintenance costs). NAVSEA is considering using the composite framing for the top levels of the SeaLift Ship Technology Development Program; Ingalls may use this composite technology as part of the superstructure of their cruise ship design.

Commercial application is a potential future prospect. Ingalls is principally interested in application to the Navy, but they would furnish a composite deckhouse to an interested commercial customer.

c. BAA 94-44 CYBO: Robotic Welding

Background: Ingalls is a beta-site for the portable and the gantry welding systems. Two fixed overhead systems are in place at Ingalls, and is in the testing and development phase for welding collared opens. Currently, 2-5% of welding at Ingalls is robotic; the CYBO welders would increase that to 5-9%. Ingalls believes that the original idea behind the CYBO project is sound; however, they haven't come up with a way to integrate the various hardware pieces together with a system that works. Ingalls stated that it should be relatively easy to fix the software problems since CAD/CAM-to-welder translators are not difficult. This, coupled with the excellent equipment in CYBO's system, is the reason that the shipyards have been patient. However, Ingalls added that CYBO's problems and tardiness are placing the project in jeopardy. A significant problem seems to be systematization.

Objective: The objective is to develop and test a robotic welder for shipyard application.

Approach: Develop the basic hardware/software for a portable welding robot and a gantry welding robot; demonstrate the portable robot at Alabama Shipyard; demonstrate the portable system at Ingalls; develop the gantry robot and install at Ingalls.

Status: CYBO is in the prototype phase; the system integration has not begun. Ingalls intends to continue to participate in the project and serve as a beta site (when everything works), if CYBO agrees to leave the welding machine for one year.

Impact: If successful, the CYBO program could offer robotic welding with automatic programming. As yet, this doesn't exist; if it did, Ingalls would probably buy it.

C. Overall Shipyard Goals and Strategies:

a. *Teaming.*

- Ingalls and Avondale have reached an agreement to work together on certain future commercial and Naval shipbuilding programs. This agreement establishes a framework for Ingalls and

[97] Currently, Ingalls is not interested in composite hull production.

Avondale to pursue shipbuilding programs where their complementary experience, expertise, capacity, and capability will enhance the competitive posture of the team and provide increased value to potential customers.

- Ingalls, Bath Iron Works, and Lockheed Martin will team to compete for the Navy's multi-million dollar program, SC-21.
- Forge international business alliances for the cruise ship market

b. *Facilities Improvements.* Litton Industries plans to invest $25M in a major facilities programs at Ingalls. Ingalls' President, Jerry St. Pe' has been quoted to say that, " this investment will enhance Ingalls' already-extensive capacity for naval ship construction and modernization, and will significantly broaden our shipyard's capability to produce commercial vessels, offshore drilling rigs, and production platforms." The facilities program will involved two major projects: (1) expansion of the company's floating dry dock, used to both launch and retrieve vessels [started in Oct. 97]; and (2) construction of an additional production bay that will be dedicated to the building of drilling rigs, production platforms and other structures for the offshore industry [scheduled to start mid-98].

c. *Navy Projects.* Ingalls plans to compete for SC-21, as well as continue as a lead designer, builder, and support contractor (overhaul/modernization) for US surface combatants.

d. *Commercial Projects.*

- Offshore Industry: In 1997, Ingalls was chosen by Edison Chouest to build as many as 19 deep water offshore supply vessels. The new generation of deepwater supply vessels will support drilling and production operations in the Gulf of Mexico. The order could be worth $40M-$70M for Ingalls. By 2007, it is predicated that Ingalls will have 120 jackup rig installations; 20 drill ship installations; 80 semi-submersibles installations.
- Alaskan Trade Market: Ingalls has its own design for small tankers (oil) which is similar to the Newport News double eagle priced in low $50Ms; plan to enter the British petroleum and sea river (ex-Exxon) tanker markets.
- Container Ships: Ships going to Hawaii, Puerto Rico, and Guam; currently bidding to build four ships with option for four additional ships; potential contract value is $500M.
- Cruise Ships: Ingalls plans to compete for the contract to develop two cruise ships that service the Hawaiian Islands (legislation was passed that the Hawaiian Islands must use US shipyards to build their cruise ships).

D. QUESTIONS

1. Ship Design and Construction Strategies:

a. What ships have been sold, built, are under construction, or have been designed as a result of MARITECH?

Supporting Data for Ship Design and Construction Strategies:

Status	Description of Vessel	Metric Benefits
Completed (Built)		
Under Construction		
Designed	Cruise Ship	There are opportunities to compete for cruise ship construction within the next year.
Under Design		

b. What changes in construction strategies have been developed?

None.

c. Were any international competitive benefits derived from MARITECH ship designs and construction projects, and if so, what were they?

Teaming with Finland for the cruise ship design had Disney interested in being a customer; however, due to unanticipated schedule issues, that project did not succeed

2. Technologies Developed or Applied to Improve Design, Production/Manufacture, Operation, and/or Repair of Ships:

a. What technologies have been developed or applied to the design, production/manufacture, operation, and/or repair of ships through MARITECH?

Supporting Data for Technologies to Improve Design, Production/Manufacture, Operation, and/or Repair of Ships:

Technologies	Description	Metric Benefits
Composite Superstructures	Deckhouses made of various composites, i.e., kevlar, resins, etc.	No corrosion, lighter-weight, decreased radar signatures

b. Were any international competitive benefits derived from technologies developed or applied under MARITECH projects, and if so, what were they?

None.

3. Facility Expansion or Modernizations and Process Enhancements Made to Improve Design, Production/Manufacture, Operation and/or Repair of Ships:

a. What facility modernizations or expansions or process enhancements (e.g., yard layout) have taken place as a result of MARITECH?

N/A

b. Were any international competitive benefits derived from these expansions, modernizations, or enhancements, and if so, what were they?

N/A

c. Did you examine foreign shipyards as part of a MARITECH project, and if so, how did your findings influence your facility expansion or modernization or the planned enhancement of your processes?

N/A

4. Commercial Business Practices Developed or Applied for requirement analysis, supplier relations and material procurement, human resource management, customer relations and marketing, and cost estimating and financial management systems (or others applicable to your shipyard):

a. What new commercial business practices have resulted from your MARITECH projects?

None.

b. What new business markets have been developed or expanded through commercial business practices developed or applied through MARITECH?

Ingalls plans to use the lessons learned from the cruise ship design project, including the cost estimating, for the American Classic Vessels proposal and future cruise ship development programs

c. Were any international competitive benefits derived from business processes developed or applied under MARITECH projects, and if so, what were they?

None.

5. Impact on Navy Shipbuilding:

a. What is the impact of the MARITECH projects on Navy shipbuilding?

If the MariSTEP prototypes are successful, the shipyard communication and infrastructure systems will improve and increase productivity; this will benefit both commercial and Navy shipbuilding efforts.

b. What commercial practices are you now using in Navy contracts?

Ingalls states that the business practices are the same for both commercial and Navy

c. What positive impacts could be manifested if the Navy agreed to adopt commercial business methods identified or used in MARITECH projects?

N/A

6. MARITECH Program Process:

a. What cultural and process changes have resulted from procedures employed through the MARITECH Program?

1. Consortia **-** *Has forming consortia become a normal approach in your commercial and Navy business practices?*

Yes. This is one of the important results of MARITECH; Ingalls was able to meet other industry members that would be potential teammates on other future projects. That was not done prior to MARITECH.

2. Teaming **-** *Has teaming become a normal approach in your commercial and Navy business practices?*

Yes. See answer above. Teaming with domestic yards on technology is not difficult; however, teaming on information sharing issues is impossible due to competitive natures regarding potential profit/cost issues associated with infrastructure.

3. Were your associations with foreign partners useful, and if so, do you plan to use such associations in future commercial and Navy contracts?

Yes. The foreign partnership with Deltamarin and Finnyards led to us coming up with a design for the cruise ships, which will be applicable in future work. Ingalls will pursue foreign teammates for future work.

b. What MARITECH Program processes did you particularly like/dislike, and do you have any suggestions for such future programs?

The follow on should allow for the 50% of shipyard contributed funds to come from IR&D; this will keep the overhead costs down and provide the shipyard more financial flexibility.

7. Comments on the Global Shipbuilding Market:

What must be done for the U.S. to successfully compete in the global market and what should be the role of programs such as MARITECH?

Development of international standards for not only pricing/cost of shipbuilding, but also the standards, requirements, contract management, etc.

Maritech Review
Case Summary #10

Administrative Data

Lead Shipyard: **Marinette Marine Corporation**
1600 Ely Street, Marinette, WI 54143

Date of Interview: March 23, 1998

Shipyard Point of Contact: Pete Anderson, Marketing Director

ATOR: Tom Conroy, MARAD

Date of AOTR Interview: 20 March 1998

MARITECH BAA/Projects:

BAA 96-01, 96-42. Transitioning to A 21st Century Advanced Manufacturing Facility, Phases I & II

Consortium members:

Ship Design & Process Technology:	Pelmatic AB (Sweden) International Market
Shipbuilding Process Technology:	TTS (Norway)
Small tanker market Analysis:	Simonship AB (Sweden)
Process Consultants:	Tim Colton, Lou Chirillo

Researcher: M. Hammon

Case Summary

A. Background

Marinette Marine Corporation (MMC) is located on 57 acres near the N.E. Wisconsin Lake Michigan shoreline, approximately sixty miles north of Green Bay. It is a privately owned shipbuilding company founded in 1942. Since inception, the yard has built nearly 1,300 vessels, including tugs, ferries, buoy tenders, research vessels,. Current employment is approximately 600. Its primary niche vessel is ≤ 300' in length.

Marinette's Federal business base is primarily commercial and the Coast Guard. Currently, Marinette is building six Coast Guard buoy tenders and overhauling a commercial 350 passenger ferry. The company has no Navy contracts, but in the past has built Navy patrol craft, berthing barges, torpedo weapon retrievers, mine-counter measure ships, yard patrol craft, a variety of landing craft and workboats.

The company's focus changed in 1995-96 when MMC's corporate leadership decided to develop the capability to market commercial vessels internationally. It was obvious that the company's design and manufacturing processes were uncompetitive and needed modernization. MARITECH provided a way to do so, but resources for the 50% matching funding were short. When the company won a major Coast Guard buoy tender contract in 1996, its manufacturing shortfalls were exacerbated. Seeing the increasing need to modernize, MMC made the commitment to participate in MARITECH, at that point, using funds from the Coast Guard contract and won the first of two projects aimed at a major business makeover.

B. Summary of MARITECH Projects Managed or Participated in by this Shipyard

BAA 96-01, Transitioning to A 21st Century Advanced Manufacturing Facility, Phase I

The first MARITECH project was designed to modernize the company's processes in small, but global steps. Implementation of the improved processes would be proved by design of a high-speed aluminum ferry and a 11,500 dwt. product tanker (design licensed from Pelmatic). The company believed that such a small tanker would be profitable in the Great Lakes trade. Based upon its experience building twenty 80' x 35' aluminum pontoons for the Coast Guard, MMC believed it could build a 30 meter, 450 aluminum passenger ferry and compete for fast ferry contracts.

Shortly after winning the proposal, however, product tanker prices plummeted, so MMC modified the proposal to design an ethylene tanker, instead. Further analysis of the aluminum fast ferry market showed that market was too soft for MMC to commit major resources, so the project was indefinitely shelved. Recently, the company has provided quotes for ferries, but is not actively pursuing the market.

All three designs (product and chemical tankers, and the aluminum ferry) were completed to varying extents and are marketed in the company's design book. Marketing, manufacturing, pipe fabrication, launch, management, planning, training processes were evaluated.

Marketing: In order to choose appropriate markets and products, Marinette would survey their capabilities and those of their competition. This would also have the benefit of highlighting areas for improvement. Their marketing personnel would gather information and present a presence at trade shows, where they would educate potential customers about Marinette's capabilities. The would develop a price database to determine if an adequate return on investment is possible with various products. Finally, they would identify appropriate products and target markets.

MMC attended domestic and foreign trade shows, educating prospective customers about MMC's capabilities and developed a database of competitors' prices to determine a fair return on investment for their vessels.

Manufacturing: The materials handling process was identified for immediate attention. Materials management affected every other business area, so MMC felt that its improvement would reap company-wide benefits. Particular areas for improvement were inventory control, vendor relations, materials requirements, and re-work. Additionally, robotic welding was evaluated, but found to be uneconomical and too technologically risky for the small vessels MMC builds.

Material Handling: Improved work conditions within blocks was a concern. Sanding, blasting, and coating should be done more efficiently. Once completed, blocks should be moved through the yard to the fabrication facility for assembly more efficiently. Out of this work, MMC improved its re-work tracking process and block transportation crawler.

- Before MARITECH, re-work was tracked as an overall shipyard characteristic. Because of MARITECH, MMC tracked re-work by project and rates fell dramatically. Piping access hole cutting errors, which forced hot re-work, were identified and the cause was fixed immediately. If the error was caused by a design error, the CAD database was changed. If the error was labor-related, the worker was re-trained. On the Coast Guard buoy tender project, the errors on ship #1 were corrected quickly enough to effect work on ships #2 and #3, and re-work rates dropped from 12% to 1%.

Also, engineers redesigned the mover which transported the modules, upgrading its capability from 115 tons to 150 tons. The company plans to market the improved design to other small yards.

Pipe Fabrication: The company felt that its existing system may need modernization, and analyzed new fabrication machines and procedures.

- MMC decided, however, it was efficient enough for its small piping requirements. The company didn't install an automated pipe fabrication facility, but did upgrade some of its fabrication machines to enable three dimensional bending and fabrication of flanges up to two diameters wide.

Manufacturing Facility: The company considered construction of a modern facility for construction of the aluminum fast ferry it had designed.

- Unfortunately, they determined that the domestic and international ferry markets were saturated and didn't build the facility. They did, however, modify the proposal to build a hot work facility to improve material handling.

- Previously, flat plate and modules were finished in separate facilities or in the open. Further, outfitting was done after module construction or on the vessel. Now all hot and cold outfitting is done in this facility head down and as modules are being built.

Improve Launching Systems: Larger, heavier commercial vessels require an enlarged launch area and firm yard grounds. The company would evaluate the expansion of the side-launch area and perform geologic evaluation of the soil content in the yard.

- These analyses were performed and shelved, pending orders for ships that would require such infrastructure upgrades. Plans call for expansion of the launch area from 220 feet to as much as 700 feet, depending on the ship.

Management: New processes mean new ways of managing resources, including the workforce, so MMC leadership wanted to look at resource and personnel processes, including union relations.

- The workforce is represented by one union and has been supportive of process improvement, except regarding outsourcing and increased subcontracting. The company started a wellness program intended to improve worker health and decrease accidents.

- Additionally, the company wanted to manage supplies better. It invested in electronic commerce by developing an electronic supplies catalog and build an international supplier database to support international customers' build lists. That database is complete, though with corporate funding.

Planning: Marinette identified the need to manage workloads to even material flow, improve scheduling, and efficiently assign work packages.

- The company is evaluating software to plan workflow. The goal is to tie the schedule to work packages, which will dictate labor and material requirements.

Training: The company considered the impact new processes would have on the workforce. Even without new technology, process reform would require workers to think differently about how to do their jobs. Sub-contractors and suppliers may need training on new procedures and data requirements.

- The company established welding and electrical schools for workers. Supervisory and staff training courses were begun. Previously, on-the-job training was the primary method. This effort has cut welding and electrical installation defect rates.

Estimating: The company recognized the need for improved cost, engineering, and production man-hour estimation capability, especially as they attempted to build larger, different ships.

- The company compiled data from their previous engineering and manufacturing efforts and performed a regression analysis to derive models for future production. Tests showed that the data was an accurate predictor for ships of the type and size MMC has traditionally built. The model doesn't scale up well for larger vessels, such as the tanker.

- For the future, MMC is adapting a commercially available software estimating package for the construction industry.

Impact: The first project benchmarked Marinette's processes very successfully.

- The hot re-work project showed that significant improvements in accuracy could accrue from relatively minor changes in material handling.
- Electrical and welding defect rates are down because of improved training.
- The company was able to successfully shift from ship construction to process improvement, when market conditions dictated.

BAA, 96-42, Transitioning to A 21st Century Advanced Manufacturing Facility, Phase II

The second project implements the remaining process improvements identified in phase I and integrates the shipyard's work centers and processes using "Advanced Business Practices and Total Process Systems technology". *It is just underway and there are few specific accomplishments.*

Many of the emphasis areas in the first study further attention:

Advanced Business Practices

- Requirements Analysis
- Supplier Relations and Material Procurement
- Customer Relations and Marketing
- Cost Estimating
- Financial Management
- Improved Communications
- Electronic Commerce
- Employee Training Tools
- Advanced Management Systems

Total Process Systems

- Production Planning and Scheduling
- Material Tracking and Control
- Engineering Standards/Processes
- Advanced CAD/CAM/CIM
- Steel Fabrication
- Assembly and Outfitting Processes

Marinette brought an outside consultant, Grant Thornton into the consortium to assist in the process re-design, new product development, and enterprise system development processes. After the strategic vision was established, however, the company decided to perform those project tasks internally and with newly hired specialists.

The project focuses on these tasks:

1. Develop a Project Plan- This is the outcome of the first MARITECH project
2. Develop a Strategic Vision- At a senior management off-site, a vision and strategic plan was developed to describe the future integrated shipyard model, establish goals, and define metrics.
3. Re-design Marinette's Processes- Processes would be linked and re-designed, as dictated by the strategic plan model. Major processes to be examined are production planning and scheduling, materials requirements and planning, engineering, office systems, and existing interfaces.
4. Develop a "New Product Development" methodology- Evaluate Marinette's manufacturing processes for application of new technology and methods. The central method for implementation is integrated design and production, "Design for Manufacture & Assembly" (DFM/A). DFM/A integrates CAD/CAM, material handling and scheduling, and supplier relations. The goal is to simplify design and production, eliminate excess parts, and streamline processes.
5. Develop Enterprise Software Requirements- Marinette will for a team to develop enterprise software requirements for each functional area and business function.

   That team has met and is evaluating two packages. Currently, Marinette uses approximately 40 different software packages in all functions.

6. Software selection and implementation- Planned for later this year.

C. Overall Shipyard Goals and Strategies:

Goal/Strategy 1: Improve commercial competitiveness through construction of a product tanker and fast ferry.

Goal/Strategy 2: Dramatically reduce time frame to manufacture ships by using automobile and aerospace industry enterprise resource planning techniques.

D. Questions

1. Ship Design and Construction Strategies:

a. What ships have been sold, built, are under construction, or have been designed as a result of MARITECH?

Designed: Product and chemical tankers (11,500 dwt.) and a 350 passenger 30 meter aluminum fast ferry.

Sold: None

Supporting Data for Ship Design and Construction Strategies:

Status	Description of Vessel	Metric Benefits
Completed (Built)	None	
Under Construction	None	
Designed	Product and Ethylene Tankers Aluminum Ferry	Upgraded CAD/CAM Improved Estimating Tool Developed vendor database
Under Design	Updating Ferry Design	

b. What changes in construction strategies have been developed?

Modular outfitting now done during module build, instead of on vessel

Built hot work facility

c. Were any international competitive benefits derived from MARITECH ship designs and construction projects, and if so, what were they?

Built an international supplier database

Raised MMC's international profile by attending trade shows

Improved knowledge of international market and processes

2. Technologies Developed or Applied to Improve Design, Production/Manufacture, Operation, and/or Repair of Ships:

a. What technologies have been developed or applied to the design, production/manufacture, operation, and/or repair of ships through MARITECH?

Automated Safety incident data to bring down insurance costs

Improved material handling processes

b. Were any international competitive benefits derived from technologies developed or applied under MARITECH projects, and if so, what were they?

None to date

3. Facility Expansion or Modernizations and Process Enhancements Made to Improve Design, Production/Manufacture, Operation and/or Repair of Ships:

a. What facility modernizations or expansions or process enhancements have taken place as a result of MARITECH?

- Launch way ground bearing survey performed in preparation for future expansion

- Automated tool control system implemented
- Upgraded cutting machines, pipe bending & flushing machines

Supporting Data for Expansion/Modifications and Process Enhancements to Improve Design, Production/Manufacture, Operation and/or Repair of Ships

Task	Description	Metric Benefits
Facilities Expansion		
Facilities Modernization	New Hydraulic Fluid analyzer reduced flushing process while sample was being tested	Saved 10% flushing time, approximately 1-3 days, depending on ship size.
Processes Planned	Planning enterprise IT system for material management, scheduling, CAD/CAM, and business processes by end of 1999.	Reduced manpower, real-time management process improvement
Processes Implemented		

b. Were any international competitive benefits derived from these expansions, modernizations, or enhancements, and if so, what were they?

Enterprise system will reduce inventory management costs, improve estimation accuracy, and work package tracking.

c. Did you examine foreign shipyards as part of a MARITECH project, and if so, how did your findings influence your facility expansion or modernization or the planned enhancement of your processes?

Yes: Sweden (2), Norway (1)

- Modeled outfitting, detail design processes.
- Not much else was useful for Marinette's size yard and business type

4. Commercial Business Practices for requirement analysis, supplier relations and material procurement, human resource management, customer relations and marketing, and cost estimating and financial management systems (or others applicable to your shipyard):

a. What new commercial business practices have resulted from your MARITECH projects?

None to date

b. What new business markets have been developed or expanded through commercial business practices developed or applied through MARITECH?

None to date

c. Were any international competitive benefits derived from business processes developed or applied under MARITECH projects, and if so, what were they?

None to date

5. Impact on Navy Shipbuilding:

a. What is the impact of the MARITECH projects on Navy shipbuilding?

No Navy building. Coast Guard construction was improved by:

- Reduced delivery time for first buoy tenders to 14 months from contract award
- Reduced Coast Guard contract costs and increased MMC profitability on FFP contract

b. What commercial practices are you now using in Navy contracts?

In our Coast Guard work, we use commercial processes, except in berthing command & control, and other areas where there is no commercial analog. Otherwise, MMC uses ABS standards and procedures

c. What positive impacts could be manifested if the Navy agreed to adopt commercial business methods identified or used in MARITECH projects?

N/A

6. MARITECH Program Process:

a. What cultural and process change have resulted from procedures employed in the MARITECH Program?

1. Consortia **-** *Has forming consortia become a normal approach in your commercial and Navy business practices?*

- MMC is more open to consortia and teaming. This has resulted in a reduction in travel, increase in teleconferencing, and better exchange of tech data.
- The company has become more aware of new processes and technologies used by other yards and is eager to leverage that information when possible.

2. Teaming **-** *Has teaming become a normal approach in your commercial and Navy business practices?*

- Teaming is used internally on all programs. Teams from all functional groups exchange ideas in production, planning, and design.
- Customer involvement is encouraged. A potential product tanker customer recently participated in design team meetings.

3. Were your associations with foreign partners useful, and if so, do you plan to use such associations in future commercial and Navy contracts?

Yes

- Pelmatic provided customer referrals, client references, and information on international design standards.
- Simonship helped with international market analysis and sales.
- TTS participated in early module system studies.

b. What MARITECH Program processes did you particularly like/dislike, and do you have any suggestions for such future programs?

Like:

- The process enabled MMC personnel to visit other yards and customers to learn about the market and current technology.
- Relations with Lou Cirrilo provided information about Japanese processes.

Dislike:

- Proposals to DARPA were handed off to MARAD for management, causing confusion about program ownership.
- Modification requests occasionally took a long time for review.

AOTR Relationship:

- AOTRs need training on complexities of cooperative agreements to help inexperienced program participants.

7. Global Shipbuilding Market:

- Product Tanker**-** Not improving because prices are too low on the foreign market
- Ethylene Tanker**-** Better chances because it's a niche product
- Ferry**-** Tends to be a regional market dominated by small builders. The Australians control the foreign capacity

What must be done for the U.S. to successfully compete in the global market and what should be the role of programs such as MARITECH?

- Builders must continue to become more competitive.
- At some point, a reduction in overcapacity is inevitable
- The workforce must be stabilized, because once they leave a shipyard, they're lost to that yard.
    - Retraining is a major cost.

- OECD- should be implemented, because single countries won't stop subsidies on their own.
    - They need political cover that the treaty will provide.
- Navy shipbuilding Competitiveness Program is very bad for small yards, especially those without Navy construction.
    - The Program amounts to a subsidy for the big, Navy yards with commercial construction
    - Will drive smaller yards out of business.

Maritech Review
Case Summary #11

Administrative Data

Lead Shipyard: **NASSCO**
Harbor Dr. & 28th Street, San Diego, CA 92186-5278

Date of Shipyard Interview: 26 February 1998

Steve Clarey - Manager, Advanced Programs
Richard H. Vortmann - CEO, NASSCO
Gary M. Hatherington - Advanced Programs Engineer
Peter Jaquith, Director - Production Engineering
Malcom Bell - Senior Consultant, First Marine International, Ltd.

AOTR: Tom Conroy, MARAD

Date of AOTR Interview: 22 December 1997

MARITECH BAA/Projects:

1. BAA 94-09. Market and Producibility-Driven Shuttle Tanker Design ($1.875M)

Consortium Members:
- Owner/Operators: ARCO Marine (U.S.- Alaskan oil shipping company)
- Propulsion: MAN B&W

2. BAA 94-09. U.S. Built Cruise Ship Design ($4.9375M)

Consortium Members:
- Owner/Operator: American Classic Voyages [Parent company of American Hawaii Cruises]
- Power plant: General Electric Navy and Marine Systems Engineering Group
- Outfitter: Hopeman Brothers Inc. [U.S. marine interior and accommodations]
- Consultant: Mercer Management Consulting [Cruise Industry Experts]
- Financing: Argent Group, Ltd. [Shipping projects investment bankers]

3. BAA 94-09. Vehicle Carrier Design Program ($3.262M)

Consortium Members:
- Design Agent: Designers and Planners
- Marketing Analysis: MRC Marine (UK)
- Owner/Operator: Totem Ocean Trailer Express (TOTE)- operator or three 1970s-era steam RO/ROs in service between Alaska and the CONUS
- Classification Society: American Bureau of Shipping (ABS)

4. BAA 96-42. Ship Factory Transformation ($2.895M)

Consortium Members: [All Consultants]

Phase I (Funded):

- Shipyard Process Re-engineering: First Marine International
- Manufacturing Practices Analysis: W. Miller & Company

Phase II (Unfunded):

- Shipbuilding Software Development: Kockums Computer Systems
- Product Process Software Development: Anderson Consulting
- Information Storage and Management: Computervision Inc.

5. Projects participated in, but not lead by, NASSCO:

a. BAA 94-44. Intergraph - MariSTEP
b. BAA 94-44. CYBO - Automatic Welding of Structural Beam Erection Joints
c. BAA 94-44. UCSD - Advanced Material Technology for Ship Design & Construction
d. BAA 96-05. EB - SHIIP
e. BAA 96-42. NIIIP - NIIIP for SPARS
f. BAA 96-42. UCSD - International Competitive Fast Ferries & Computer Technology

Researcher: Mike Hammon

Case Summary

A. Background: National Steel and Shipbuilding Company (NASSCO), located in San Diego, is the only remaining full service shipyard on the West Coast for the design, repair, conversion, and construction of large, ocean-going ships. It is one of the six major shipyards engaged in new construction work for the U.S. Navy that comprise the industrial base. Over the past thirty years, NASSCO has delivered 97 ships to commercial and government customers. It is a major commercial shipbuilder in the U.S., specializing in tankers and dry cargo carriers. For the Navy, the yard designs and builds complex auxiliaries and naval support ships. Its backlog consists of the fourth of the AOE Fast Combat Support Ships and seven new construction, gas-turbine powered Large Medium Speed RO/ROs (LMSRs) for the Strategic Sealift Program. NASSCO recently delivered three LMSRs which it converted from Maersk Shipping L-Class container ships.

Originally founded as California Iron Works machine shop in 1905, NASSCO ownership has moved through several phases since 1905 including ownership by Henry Kaiser, producer of the Liberty Ship during WWII. Kaiser's shares were acquired in 1979 by the other major owner at the time Morris Knudsen and held until 1989 when the company was acquired by its employees through an ESOP. Today the company employs approximately 4300 people in all trades and occupations.

No commercial new construction contracts are in progress (the LMSRs are government contracts built to commercial standards and specifications), but NASSCO is pursuing a number of commercial contracts, all based on MARITECH design projects: (1) it won a competitive design contract for three 125,000 DWT, twin-screw, double-hull, crude oil tankers (with options for four more) for British Petroleum for movement of crude oil from Alaska to West Coast refineries); (2) a contract for two 1800-passenger cruise ships (with an option for a third) for American Hawaii Cruises under the provisions of the FY 1998 Defense Appropriations Bill; and (3) a contract for two (with an option for a third) large commercial RO/ROs for Totem Ocean Trailer Express' Alaskan service between Tacoma and Anchorage. Last year NASSCO was unable to meet the desired delivery dates for two 125,000 DWT twin-screw, double-hull, crude carriers which it had designed for ARCO due to its strategic sealift program backlog. ARCO awarded the construction contracts to Avondale.

Previous commercial construction includes:

Type	No.	Customer	Tonnage	Delivered
Hawaii II Class Container Ship	1	Matson	21,500	1992
Alaska Class Tanker	2	Exxon	209,000	1986-87
La Jolla Class Tanker	3	American Trading Transportation	44,000	1982-86
Ingram Class Tanker	2	Ingram Corp.	37,500	1982-85
Carlsbad Class Tanker	3	Union Oil Co.	37,500	1981
San Diego Class Tanker	4	Shell Oil Co., ARCO	188,500	1978-80
San Clemente Class Tanker	13	Aeron Marine	89,700	1974-78
Coronado Class Tanker	6	Margate Shipping, Moore-McCormack Lines	38,300	1973-77
Hyak Class Wash. St. Ferries	4	State of Washington	2,493 L. Tons	1967-68
C-3 and C-4 Dry Cargo	13	American Export Lines	16,810 & 23,000	1961-66

NASSCO has three new-building positions, eight full service berths for outfitting and repair, and on-site machinery repair, sheet metal and pipe fabrication shops, and a large steel fabrication capability. All facilities are contained within 147 acres leased from the Port of San Diego, south of the San Diego Bay Bridge and north of the San Diego Naval Station. The biggest cranes in the yard provide for single lifts of 175 tons and multiple lifts of 240 tons. There is a floating dry dock 620 feet x 130 feet with a 25,000 ton lifting capacity which is being lengthened by 200 feet to accommodate dry-docking of the Navy LHA/LHD classes of amphibious assault ships in San Diego. A rail spur serves the yard and its organic steel fabrication facility.

B. Summary of MARITECH Projects Managed or Participated in by this Shipyard

1. BAA 94-09. Market and Producibility-Driven Shuttle Tanker Design

Objectives:

1. Achieve a 10% shuttle tanker construction market share.
2. Establish U.S. shipbuilding as a major player in the world-wide shuttle tanker industry.
3. Take a leading role in development of advanced propulsion, dynamic positioning, connection and loading systems, environmental and safety systems.

Background: NASSCO used this project to examine the opportunities to re-enter the shuttle tanker market it previously occupied in the early 1980's. The intended design would incorporate state-of-the-art technology, be double-hulled, capable of year-round operation in open or coastal waters, and operate in arctic and sub-arctic environments. NASSCO's technical approach consisted of five tasks:

- Market Analysis & Marketing Plan. The company would perform a detailed marketing study and analyze how new oil fields under development in Norway (9), Britain (13), and Canada (3) would creating demand for new shuttle tankers for the next 10-15 years.
- Design Concept. Structural and Systems design are considered central, since they offers the greatest producibility payoffs and challenges. Within that area, engineers will analyze various tank arrangements and sizes, double hull or double skin, repeating structures, and various plate sizes. Other areas for consideration are propulsion, ship configuration, dynamic positioning, cargo loading alternatives, navigation systems (e.g. GPS), and corrosion control.
- Production Approaches (with Kawasaki Heavy Industries - KHI). Using lessons learned from KHI, NASSCO will benchmark processes in other Japanese and European yards.
- Build Strategy. NASSCO will apply technology transfer and lessons learned from its relationship with KHI to improve production processes and productivity. The goal is to improve productivity by the year 2000 by 33% to improve NASSCO's competitive position in the industry. This will still lag international standards in leading world-class shipyards.
- Financing Plan (with First Marine International, Ugland and KHI). Various customer financing options will be explored, including traditional public sources, participation with major suppliers, and government programs.

Impact: Market research conducted prior to the start of the project indicated that the U.S. was not in a position to compete in the international shuttle tanker market due to over-capacity in the international shipbuilding industry, predatory pricing, and continuation of foreign government subsidies. Further, the domestic Jones Act shuttle tanker market was immature.

Project design goals were met by converting the project to the design of a 125,000 DWT double-hull, twin-screw crude carrier for Atlantic Richfield (ARCO Marine) in its Alaskan trade. The design incorporated state-of-the-art environmental protection, safety, and automation features, and was structurally designed for a thirty-year life in the rigorous Gulf of Alaska operating conditions. The ARCO design was subsequently used as the baseline design for the BP crude carrier design project.

NASSCO was unable to meet ARCO's required delivery dates due to its backlog of strategic sealift contracts, and ARCO awarded the construction contract to Avondale. BP is expected to award a contract for three tankers with options for four more by July 1998.

Follow-on tanker projects are all in the domestic market and include additional crude carriers for the Alaskan trade as well as shuttle tankers for increased Gulf of Mexico production. In the long-run, the company hopes to construct 1-2 ships annually, creating 500-600 permanent NASSCO jobs and 1,000-2,000 supplier/support industry jobs.

2. BAA 94-09. U.S. Built Cruise Ship Design

Objectives:

1. Obtain a 10% share of new cruise ship construction [1-2 vessels annually] by 2000
2. Re-establish the U.S. shipbuilding industry as a cruise ship building power

3. Become a leader in developing advanced propulsion, control, environmental, and safety systems for cruise ships

Background: Of the four MARITECH projects NASSCO is involved in, this is the most ambitious. NASSCO has experience building tankers and RO/RO ships such as the LMSRs from which the TOTE vehicle carrier will be adapted, but it has only repaired cruise ships. No U.S. shipyard has built a large ocean-going cruise ship in more than forty years. Smaller vessels for use on the Great Lakes and coastal waters have been built by smaller yards, such as Nichols Brothers of Seattle and Atlantic Marine of Florida.

NASSCO's project duration was set at 24 months, to be completed at the end of 1996. At the end of that time, they wished to have completed their market analysis and contract design, and be on contract with at least one owner, and be in detailed design for their first ship. In early 1995 they assembled an international design team of industry leaders from Finland, Sweden, the U.K., and the U.S. The goal was to develop a new cruise ship conceptual design targeted at the Hawaiian market. At the end of the 1997, they had completed their concept and preliminary designs for American Classic Voyages, the only U.S. cruise ship operator and NASSCO consortium member. NASSCO continued work on design and production technology improvements and long range facilities planning for the construction of modern cruise ships. The State of California awarded NASSCO a $250,000 defense conversion cash grant to assist on the cruise ship project.

No contracts have been signed for new construction, but with the help of Senator Inouye (D-Hawaii), §8097 of the FY 98 Defense authorization provided the legislative authority (and up to $250,000 of MARITECH funds) for a temporary waiver to the Jones Act. The waiver allows a U.S. cruise operator to flag-in to U.S. coastwise service in Hawaii, a foreign-built vessel immediately after signing a construction contract for two U.S. newbuildings. The DoD Appropriation Act was signed by the President in October1997. American Classic Voyages must sign the new construction contract within 18 months and begin operating the ships by the beginning of 2005 and 2008, respectively.

American Classic Voyages has elected to compete the contract and NASSCO intends to bid. Of note, its international MARITECH design team from the project has committed exclusively to NASSCO for the American Classic Voyages project. Although NASSCO will be competing with Avondale and Ingalls, they believe they have a competitive edge, due to their team make-up and their previous MARITECH cruise ship design experience.

The project technical approach was based upon five tasks:

- Market Analysis and Marketing Plan: Mercer and American Classic Voyages would perform detailed marketing studies to describe cruise ship market trends and opportunities for a U.S.-flag vessel, cruise customer preferences, and demand for new technologies.
- Development of Innovative Design Concepts: Develop a design targeted to a specific market segment, which focuses on breakthrough technologies and satisfaction of owner/operator customer needs. NASSCO believed that it brought unique design talents to the project, having designed and built Navy ships with advanced propulsion and outfitting systems and commercial vessels with environmental and safety systems compliant with the latest Coast Guard and EPA requirements.
- Development of Innovative Production Approaches: NASSCO would benchmark leading European cruise ship builders to understand their unique production processes. These would provide an improvement path for these highly engineered and outfit-intensive ships. GE and Hopeman would then identify areas where advanced and processes and technologies could be applied to improve producibility of the design.
- Development of A Build Strategy: NASSCO would create a build strategy and master plan for cruise ship construction drawing based upon its benchmarking visits and on-going improvements in its Navy construction programs. Facility and process improvements would be examined, particularly for processing the light-scantling structural blocks and large number of passenger and crew accommodations.
- Development of a Financing Plan: NASSCO, Mercer, and American Classic Voyages, working with Argent would explore alternative financing opportunities using both Title XI and innovative asset-based financing.

Market Issues:

To say that the international cruise ship industry is a paradox would be a gross understatement. Using 1994 statistics:

- 131 vessels operated world-wide, with only two under a U.S. flag
- Only one of the cruise lines was American [consortium member American Classic Voyages and it owned and operated the only two ocean-going ships referred to above.
- Over 90% of the passengers filling the 5.2 million berths were American.
- The industry is dominated by four foreign lines, Carnival, Princess, Kloster, and Royal Caribbean.
- NASSCO believes that the new construction market will be fueled by several factors:
- Customer demand is forecast to grow to over eight million by the end of the decade
- Fleet replacement. In 1994, fully half of the existing tonnage was more than 20 years old. Ships on order then represented only 50% of those expected to need replacement.
- Construction is largely demand-driven; as soon as new vessels were produced, they were filled. The 1992 industry occupancy rate was 93%, the greatest of any transportation mode.
- Political and legislative mandates by Representatives Gibbons, Clay, Unsold would force foreign owners to modify their vessels to comply with work standards, environmental standards, and allow foreign flagged vessels to be re-flagged as U.S., providing the operator agreed to build a U.S. built vessel.

To establish itself in this market, NASSCO wanted to use this project to improve its design and production processes, thus lowering costs. They believe that their labor rates were 33% below European yards, but needed to invest heavily in process improvement and facilities.

Impact: If objectives were met, 1-2 vessels would be constructed annually creating 1,500 permanent shipyard jobs and at least 3,000 indirect supplier and support jobs nation-wide.

3. BAA 94-09. Vehicle Carrier Design Program

Objectives: Develop a partial car/truck carrier (PC/TC) as a baseline design adaptable to either a commercial pure car carrier (PCC) or a next generation Sealift Ship with only minor modifications.

Background: As long as Americans continue purchasing imported cars and trucks, the need for ships to deliver those vehicles will grow. In this project NASSCO built upon its experience with Navy fast sealift ships to design a carrier for Jones Act traffic. A foreign carrier which delivers cars to a U.S. port must offload all vehicles bound for any U.S. port and an American vessel will re-load them for delivery to other American ports. Using 1994 data, more than 100 such foreign vessels unloaded vehicles in U.S. ports each day.

NASSCO believed that the vehicle carrier could be their ticket to re-entry into the commercial shipbuilding market. Their research showed that an aging PCC fleet and continued demand for foreign vehicles would fuel demand for new vehicle carriers through the end of the century. Further, because this type of ship is relatively complex, they believed that their experience with Navy sealift construction would provide a competitive edge over those foreign yards specializing in less complex tankers and product carriers. In the long run, they also believed that subsidies would decrease, also improving NASSCO's competitiveness.

Like NASSCO's shuttle tanker and cruise ship proposal, this vehicle carrier project had five major tasks:

1. Develop a marketing analysis and plan (NASSCO and K-line)
2. Develop a vehicle carrier design (NASSCO, K-line, KHI) for PCC/PCTC
    - Create a summary of design innovation opportunities, including parametric trade studies
    - Plan for implementing new technologies
    - Finalize the concept design to contract ready stage
    - Drawings, make/buy list, specs, vendor/equipment lists
3. Develop a build strategy for rapid start of construction
4. Develop a vehicle carrier production improvement plan
    - Upgrade shipyard production methods and technology to world-class state
5. Develop a financing plan (All consortium members)
    - Public sources, equipment suppliers

A comprehensive market analysis of the vehicle carrier market was conducted by MRC Marine of the U.K. Their conclusions were: 1) there was little forecast growth in the PCTC and PCC market due to the on-shore establishment of automobile manufacturing facilities in the U.S. and other target markets; 2) the market was dominated by long-term relationships between automobile shippers and foreign shipyards; and 3) U.S. prices were uncompetitive in the international vehicle carrier market. Based upon this analysis, KHI and K-line declined to participate in the project.

The current Jones Act dry cargo fleet numbers about 32 ships. The major operators are Matson, Sea-Land, Crowley, and Totem Ocean Trailer Express (TOTE), the potential customer for this MARITECH project design. TOTE, of Seattle, which operates a fleet of three 1970's-built, steam-powered trailer ships between Tacoma and Anchorage, was eager to participate in the project and in 1995 joined as a consortium member and potential customer.

Drawing on its commercial design and construction experience with Matson container ship conversion and the Navy strategic sealift program, NASSCO completed a concept design in late 1997 for a replacement trailer ship for TOTE's fleet. The new design will be more economical to operate (slow-speed diesel propulsion versus steam), increase existing trailer and automobile capacity by one-third, incorporate the latest in environmental safety and navigation systems, and have the ability to move military equipment in a national emergency.

TOTE plans to complete its detailed review of the concept design in early 1998 and to complete a preliminary design by late-1998. It hopes to sign a construction contract in early 1999 to begin replacement of its ships in the 2002/2003 time frame .

NASSCO believes that its MARITECH vehicle carrier design will have excellent dual-use potential as a replacement for the aging MarAd Ready Reserve Fleet of RO/ROs, as well as additional ships for Alaskan service, should the gas pipeline be built or additional oil exploration begin.

Impact:

1. Construction of 1-2 ships annually,
2. Contract design for next-generation of RRF RO/ROs, and
3. A potential to sell carriers on the open market.

4. BAA 96-42. Ship Factory Transformation

Objectives:

1. Re-engineer existing design and production planning processes and incorporate off-the-shelf hardware and software systems to improve the flow of information (CAD, NC tool instructions, shop orders, work packages, etc.) to production work centers in a more timely and cost-efficient way.

2. Use such these improvements to match world-class pre-production products and processes with NASSCO's recent progress in adapting world-class manufacturing concepts in its production facilities.

Background: This project represents the NASSCO shipyard of the future. The "Factory" concept will create a production-driven design process integrated with a modern information technology (IT) system. The system is designed to reduce the interpretation of data by personnel at each point in the process. It is based upon European and Japanese design factors, but much more integrated and improved over existing systems.

The project hopes to achieve such synergy by targeting five areas:

1. Define ship-factory outfitting pre-production processes, product attributes, i.e. process baselining.
2. Re-engineer workflow tasks to provide products to production work centers which have previously re-engineered their processes.
3. Identify IT requirements for an improved planning and production knowledge base.
4. Develop the IT system configuration design to define pre-production and production engineering materials and processes.
5. Implement the selected IT system design and pilot it on an existing or new product.

At the end of sixteen months, the company hopes that this project will result in a demonstration of system capabilities to enable pre-production functions to support an improved, i.e. "world-class" production process.

NASSCO's long-range facilities plan envisions a $200 million, four-phase facilities and process modernization program to optimize materials flow, dramatically increase throughput (with a resultant reduction of cycle-time, i.e., time from contract award to delivery) and link all design, pre-production, production, and business offices in a state-of-the-art information system. This concept of a world-class manufacturing capability will take 10 years to implement and is dependent upon continuing Navy and commercial business. MARITECH has co-funded the initial design studies.

Impact: Integration of a world-class manufacturing capability with equally capable design and engineering capability would result in huge productivity and quality improvements, and enable the company to realize design-to-build cost and time reduction goals.

C. Overall Shipyard Goals and Strategies:

Process Innovation: Revise and re-engineer pre-production and production processes to cut costs and become more competitive as a commercial ship builder.

Commercialization: Use those improved processes to become a dominant market force in U.S. commercial tanker, RO/RO, and cruise ship construction.

Technology Transfer: While remaining a primary Naval shipbuilder, re-engineer facilities and processes to continue simultaneous commercial construction and naval auxiliaries and support ships.

D. Questions

1. Ship Design and Construction Strategies:

a. What ships have been sold, built, are under construction, or have been designed as a result of MARITECH?

- Shuttle Tankers: ARCO crude carrier contract completed. ARCO design was a baseline for BP design competition. In negotiation with BP for construction contract for 3 larger, NASSCO-designed ships with options for up to 7.
- Cruise Ships: Preparing contract design proposal to American Classic Voyages for 2 ships (option for a 3rd) for Hawaii intra-island operations. Will be active in future bidding for Disney Jones Act ships.
- Vehicle Carriers: Contract design on-going for ships to replace TOTE fleet. Contract award expected in early 1999 for two ships with options for 1 to 3 more.

Supporting Data for Ship Design and Construction Strategies:

Status	Description of Vessel	Metric Benefits
Completed (Built)	None	
Under Construction	None	
Designed	ARCO 125,000 dwt crude carrier	
Under Design	BP crude carrier TOTE trailership AMCV cruise ship	

b. What changes in construction strategies have been developed?

- Marketing surveys indicate opportunity for U.S. yard in cruise ship construction for Hawaii and other Jones Act market, with potential for follow-on construction.
- Continuing market for construction and modification of Alaskan crude carriers due to increasing oil production and OPA-90 requirements phasing out single hull tankers and increased oil production in the Gulf. Recent DOI decision will require that shuttle tankers in the Gulf be Jones Act compliant.

c. Were any international competitive benefits derived from MARITECH ship designs and construction projects, and if so, what were they?

NASSCO is improving productivity and reducing cycle time from contract award to delivery of its new construction. As a result of their efforts and MARITECH experience on the cruise ship project, NASSCO expects to be internationally competitive in large cruise ship design and construction, soon, especially if they win the American Classic Voyages competition.

2. Technologies Developed or Applied to Improve Design, Production/Manufacture, Operation, and/or Repair of Ships:

a. What technologies have been developed or applied to the design, production/manufacture, operation, and/or repair of ships through MARITECH?

- All projects, especially the Ship Factory Transformation project, will institute better pre-production (design, planning and engineering) and production processes to reduce costs and time to build. Those processes include CAD/CAM, NC tool instructions, tracking of shop orders, and work packages.
- Cruise Ship Project: 1) Modular passenger and crew cabin design and production processes will transfer to the TOTE and BP tanker proposals, 2) an integrated electric drive system has been adapted to the BP tanker.

Supporting Data for Technologies to Improve Design, Production/Manufacture, Operation, and/or Repair of Ships

Technologies	Description	Metric Benefits
CAD/CAM	Linked processes for various disciplines and between design and production	Implementation of just in time inventory Reduced time to build

b. Were any international competitive benefits derived from technologies developed or applied under MARITECH projects, and if so, what were they?

- Re-design of steel facility to improve throughput. Reduces cycle time, but still 2.5-3 times longer than Japanese and Koreans for simple ships like tankers.
- Re-engineering pre-production activities to match recent, marked increase in production throughput.

3. Facility Expansion or Modernizations and Process Enhancements Made to Improve Design, Production/Manufacture, Operation and/or Repair of Ships:

a. What facility modernizations or expansions or process enhancements have taken place as a result of MARITECH?

The “Ship Factory Transformation” project is the fundamental process enhancement vehicle for NASSCO. The first phase of a multi-phase yard re-design program developed in that project to optimize material and information flow is being implemented

Supporting Data for Facility Expansion/Modifications and Process Enhancements to Improve Design, Production/Manufacture, Operation and/or Repair of Ships

Task	Description	Metric Benefits
Facilities Expansion	New steel handling facility and yard design	Expected to double steel throughput through steel fabrication and assembly.
Facilities Modernization	Improved material and interim product flow	Expect a 25% improvement in steel cost and cycle time
Processes Planned	Integrated Information Technology (Enterprise) system	Will significantly reduce pre-production design and engineering cycle time
Processes Implemented	Improved block pre-outfitting procedures	Decreased time from launch to delivery from 12 to 8 months on Navy Sealift Ships. Seventh ship will have 35% fewer production man-hours than the first.

b. Were any international competitive benefits derived from these expansions, modernizations, or enhancements, and if so, what were they?

See above.

c. Did you examine foreign shipyards as part of a MARITECH project, and if so, how did your findings influence your facility expansion or modernization or the planned enhancement of your processes?

Yes, visited European yards to benchmark processes and compare costs on both cruise ship and tanker production. The new block assembly and steel fabrication facility was designed based on these visits. The technology transfer agreement and long-term relationship with KHI in Japan continues to be of great benefit in simplifying designs, reducing material content, and improving productivity.

4. Commercial Business Practices for requirement analysis, supplier relations and material procurement, human resource management, customer relations and marketing, and cost estimating and financial management systems (or others applicable to your shipyard):

a. What new commercial business practices have resulted from your MARITECH projects?

None to date

b. What new business markets have been developed or expanded through commercial business practices developed or applied through MARITECH?

New relationships have formed which lead to discussions with BP, TOTE, and American Classic Cruise Lines

c. Were any international competitive benefits derived from business processes developed or applied under MARITECH projects, and if so, what were they?

- Developed a long term strategic development plan for facility modernization
- Design and planning process redesigned to reduce cost and cycle time, provide increased support to integrated outfitting methodology

5. Impact on Navy Shipbuilding:

a. What is the impact of the MARITECH projects on Navy shipbuilding?

- Modular construction of accommodation units
- Increased pre-outfitting of blocks
- Improved teaming with vendors and with skills in the yard

b. What commercial practices are you now using in Navy contracts?

The Navy LMSR ships are being built to modified commercial standards and practices with some shock hardening of the emergency switchboard and diesel generator.

c. What positive impacts could be manifested if the Navy agreed to adopt commercial business methods identified or used in MARITECH projects?

- NASSCO believes that 12 large medium-speed RO/ROs could be delivered for the price of 10, if Navy would allow full commercial practices.
- Ships should be designed around the customers' functional requirements and the shipyards' production capabilities.
- Future sealift requirements could be met using "militarized" commercial ships, instead of new designs.
- Additional savings could accrue if long-term (multi-year procurement) contracts were awarded, thus stabilizing funds.

6. MARITECH Program Process:

a. What cultural and process change have resulted from procedures employed in the MARITECH Program?

1. Consortia - Has forming consortia become a normal approach in your commercial and Navy business practices?

Yes, as the company is doing in the BP project, but with fewer vendors than common in Navy programs

2. Teaming - Has teaming become a normal approach in your commercial and Navy business practices?

Yes, particularly with major vendors and suppliers like GE, Hopeman, etc.

3. Were your associations with foreign partners useful, and if so, do you plan to use such associations in future commercial and Navy contracts?

Yes.

b. What MARITECH Program processes did you particularly like/dislike, and do you have any suggestions for such future programs?

AOTR was particularly useful due to flexible, hands-off attitude and limited contract administration.

7. Global Shipbuilding Market:

- Major markets will remain those protected by Jones Act.
- Cruise ship market could be met by more than one yard, but competition with foreign builders will limit the ability of American yards to compete. Estimated market size is 10-15 ships (5 for the Hawaii trade) over a 10 year period.
- Shuttle tanker and container/trailer ship market is very small, but could grow if uncertainty over Jones Act renewal is resolved.
- Prospects for commercial ships for international trade are negligible due to excess capacity and predatory pricing.
- Re-opening the Philadelphia Naval Yard under the preferential agreement was a significant competitive bonus for Kværner. Funded by local and U.S. governments and not enjoyed by other U.S. builders.

What must be done for the U.S. to successfully compete in the global market and what should be the role of programs such as MARITECH?

- Market must provide volume contracts to enable yards to perfect their processes.
- Jones Act and Passenger Vessel Act must be preserved to maintain stability in the industry.
- Navy should: Take a position advocating Jones Act as a way to preserve industrial base, accept more commercial practices and ship designs, decrease change orders, resist shipyard consolidation in the name of efficiency.

Maritech Review
Case Summary #12

Administrative Data

Lead Shipyard: **Newport News Shipbuilding (NNS)**
4101 Washington Ave., Newport News, VA 23607

Date of Shipyard Interview: 8 January 1998

Michael Powell - Director, Engineering Development, Carrier Innovation Center
Joseph Baumer - Systems Engineer
Mark Reidelbach, P.E. - Project Engineer, Innovation Center
Alan Titcomb - Manager, Research and Concept Development
Dan Wooley - Program Administrator

AOTR: Mike Wade, NSWC

Date of AOTR Interview: 19 December 1998 (Dale Rome, NSWC)

MARITECH BAA/Projects:

1. BAA 94-09. World Class Shipbuilder ($12.4M - total cost)

Shipyard Contact: Alan Titcomb

2. BAA 95-02. Market Driven LNG Carrier Design ($8.2M - total cost)

Consortium Members: IHI Marine International (IHI)
SeaRiver Maritime

Shipyard Contact: Alan Titcomb

3. Projects participated in, but not led by, NNS:

a. BAA 94-44. MariSTEP (Intergraph)
b. BAA 94-44. Auto Weld of Structural Beam Erection Joints (CYBO)
c. BAA 96-05. COMPASS (Intergraph)
d. BAA 96-42. FIRST: A First Principles Approach for Ship Integrated Process and Product (IPP) Development (Intergraph)
e. BAA 96-42. Electronic Data Interchange and Commerce (MMA)

Researcher: S. Tennyson

Case Summary

A. Background

Newport News Shipbuilding (NNS) is the largest privately owned shipyard in the United States, employing over 18,400 people as of December 1997. Since it was founded by railroad magnate Collis P. Huntington in 1886, the company has built nearly 800 ships, ranging from tugboats and passenger liners to aircraft carriers and submarines. Located near Norfolk, VA, NNS operates eight dry docks, two outfitting berths, three outfitting piers, an 11-acre automated steel fabrication center, a foundry complex, test laboratories, machine shops, a computer center and an apprentice school. The yard's largest dry dock was recently lengthened to 662m (with crane lift capacity of 900 metric tons) so that an aircraft carrier and a commercial ship can be built in the dock simultaneously; it is the largest dry dock in the Western Hemisphere. In addition, the 130, 000 square foot Module Outfitting Facility is a fully enclosed ten story high building capable of simultaneous construction of 2 panamax size ships. The range of these facilities allows Newport News to service a wide variety of construction, conversion and repair projects simultaneously. It is the only shipyard in the United States capable of building and servicing a full range of surface and submersible ships, and the only one that builds aircraft carriers. Newport News' current orderbook includes four *Double Eagle* double-hulled product tankers, two Nimitz-Class aircraft carriers and various overhaul jobs.

Tenneco, a packaging and automotive parts conglomerate, owned Newport News until it was spun-off to Tenneco’s shareowners at the end of 1996. During the 28 years they operated under Tenneco, NNS was strengthened, re-entering the market for commercial ships and pursuing the foreign sales of fast frigates.

Tenneco's Chairman and CEO, Dana Mead, noted that NNS had "a seasoned and dynamic management team that has created a world class competitor fully capable of standing on its own and thriving as a public company." In addition, according to the March 1996 press release announcing the spin-off, Newport News "has substantially improved its competitive cost position during the past three years and expect[ed] to be competitive with any foreign shipyards when its $70 million investment in computer-integrated, steel-fabrication equipment [was] completed in 1997."

NNS has also created the Carrier Innovation Center. The Center is a place where engineers and project members identify, develop, and integrate technologies into the next century shipbuilding process. The mission of the Center is to reduce costs of aircraft carriers designed and built at the shipyard. The Commercialization team investigates and studies the use of current and future commercially-produced equipment and components for inclusion into aircraft carriers. The team also explores commercial approaches to design and construction.

On March 16, 1998, Newport News announced changes in its commercial shipbuilding business that will result in a reduction of the number of ships to be built and a withdrawal from this market by June 1999. NNS took a pre-tax charge of approximately $150 million against its 1997 results. The charge includes projected contract cancellation costs and the recognition of higher than expected production costs on commercial ships currently under construction. The $150 million charge is in addition to a $57 million dollar loss reserve that Newport News established in September 1997 for the Double Eagle product tankers, and the extension of construction and delivery schedules for the domestic ships under contract. According to William Fricks, Chairman and CEO, "the existence and the severity of the issues [relating to costs of material and labor productivity] led [NNS] to the difficult but necessary decision to take a substantial earnings charge, truncate this program and exit the market."

Despite NNS' withdrawal from the commercial market, the introduction of commercial practices into the Company's production processes is resulting in improved performance on aircraft carrier construction and overhaul contracts. NNS is beginning to see meaningful productivity gains as a result of commercial practices that have been implemented. According to Fricks, "Newport News' core Navy programs and operations remain solid."

On December 18, 1998, Newport News acquired Continental Maritime Industries of San Diego, CA. Continental Maritime operates as a wholly owned subsidiary of NNS, focusing on repair programs for the Navy's West Coast Fleet. The acquisition is a key component of Newport News' strategy to broaden its base of services to the Navy's nuclear powered aircraft fleet.

Prior to the unanticipated charge, Newport News announced earnings before interest and taxes for 1997 of $131 million, net income of $44 million, and diluted earnings per share of $1.23. The $150 million charge will result in an operating loss of approximately $19 million, and a net loss of $1.36 per share. The net cash impact in 1998 of the increased cost projects and one-time exit expenses is estimated to be approximately $30 million in free cash flow. The cash outlook for 1999 actually improves by approximately $10 million compared to previous internal estimates due to the absence of commercial outflows and higher core business contributions.

B. Summary of MARITECH Projects Managed or Participated in by this Shipyard

1. BAA 94-09. World Class Shipbuilder

Background: In this project NNS set a course to develop the detail design of a class of 46,000 deadweight ton double hull product tankers for the international market. The first phase of the project focused on the pre-contract activities necessary to obtain construction contracts for a series of such ships. The second phase focused on detail design and construction products necessary to cost-effectively build this ship for customers in an acceptable period of time. This project paralleled the goals of the overall MARITECH Program to support the successful marketing, design, and construction of commercial ships. The first phase of this project totaled $6.4 M but the contract was later revised to include Phase II increasing the total cost to $12.4 M.

Objective: The objective of this project was to transition part of NNS to a globally competitive commercial shipbuilding division. This was to be accomplished by developing a design and build strategy for the sale of a 46,000 DWT product carrier on the international market.

Approach and Status: During the 12-month Phase I Period, NNS developed contract design documents to suit vessel performance specifications and classification and regulatory requirements. This effort included

11 contract design drawings as well as purchase documentation for main engines, deckhouses, and structural materials, noise and vibration analyses, and the development of a 3-D product model organized by ship class and geometry files.

Phase II consisted of the completion of the product tanker design and consisted of dynamic load analysis, the development of inspection standard and miscellaneous other standards a paint plan, and the development of construction drawings to support steel fabrication and ship erection.

Impact: The product tanker design created in Phase II served as the basis for Newport News' entering into commercial contracts to build nine product tankers, one of which was delivered in September 1997. Because of a number of issues related to costs of material and productivity, Newport News reached agreements with its customers in March 1998 to complete construction of five of the remaining eight product tankers. Contracts for the last three ships were canceled. The restructuring of Newport News' commercial contracts was announced simultaneously with the announcement of its decision to exit the commercial market in mid-1999.

Despite Newport News's announcement to exist the commercial market, the MARITECH design project can be considered a success as Newport News built the first commercial ship in more than two decades (and the first commercial ship order for an American shipyard from an international customer since 1957). Although, it should be noted that the Eletson Holding, Inc. (Piraeus, Greece) contract was awarded the day after the proposal was submitted to MARITECH. The first of the original nine double-hull petroleum product tankers, American Progress, was delivered to Mobil Corporation on September 27, 1997. The American Progress is the first double-hull vessel built to the standards required by the U.S. Oil Pollution Act of 1990 (which requires that by 2015 all ships carrying petroleum in U.S. coastal waters be double-hull) in a U.S. shipyard.

NNS is currently completing construction on its Double Eagle product tankers. Of the remaining five, work is substantially complete on three which will be delivered in 1998. The remaining two will be delivered by mid-1999. (Initially nine tankers were sold; the remaining three contracts have been canceled.)

The Double Eagle, *American Progress*, has been named one of the "Great Ships of 1997", by Maritime Reporter and Engineering News. Of the 14 ships featured, it is the only ship built in an American Shipyard.

2. BAA 95-02. Market Driven LNG Carrier Design

Background: Seeing a large demand for LNG (liquefied natural gas) carriers in Asia after 2000, Newport News teamed with IHI Marine and SeaRiver International to meet that market need as well as determine other potential markets.

Objective: The first objective of this project was to determine the market needs for LNG carriers, including identifying owners and operators who will be replacing or adding to their fleets. The next objective is to review various concepts and existing designs to develop the concept design(s) that will fit the needs of the target markets. After the concept is determined, NNS will develop it in more detail and eventually define the technical data, the ship test and trial plan, cost and delivery schedule during the contract design phase.

Approach and Status: Newport News will approach this project through four separate tasks: market analysis, concept design, preliminary design, and contract design. During the first task, Market Analysis, NNS will verify the market demand projections they made in their proposal, identify potential customers and shipping routes, and determine the general characteristics of LNG carriers which will be needed 5-20 years in the future.

During the Concept Design task phase, Newport News will develop concept designs and sketches as well as derive ship characteristics from similar ship types and existing hull forms. In addition, they will estimate performance and operating characteristics with reasonable accuracy. Market needs, production costs, and other factors will be evaluated to select the most promising concept design for development.

In the Preliminary Design task, NNS shall develop the selected concept design in more detail by preparing scaled arrangement drawings and a hull body plan, and performing naval architectural calculations. During the Contract Design task, Newport News and its teaming partners will complete the drawings and technical data sufficient to completely define the ship performance, ship equipment, the construction plan, ship size and capacity, the ship test and trial plant, cost and delivery schedule.

Impact: After careful examination of current and future LNG carrier market trends during a lengthened market survey period, Newport News has decided that the Asia market is not that responsive to foreign built ships. Therefore, it is concentrating on the Northern Shore of Alaska as a potential market for small LNG carriers as well as specialized ships that would be able to convert the natural gas flares at oil pockets into liquid. However, given NNS' recent withdrawal from the commercial shipbuilding market this project may be curtailed at the end of the current phase, prior to completion.

3. Projects participated in, but not led by, NNS:

a. BAA 94-44. MariSTEP (Intergraph): MariSTEP is a MARITECH sponsored project targeting prototype implementations of the emerging STEP shipbuilding application protocols. The objectives are to enhance the global competitive position of the U.S. shipbuilding industry, enable the virtual shipyard , accelerate the implementation of STEP throughout the U.S. marine industry, assess the ability to implement STEP application protocols, and enable a product model definition and exchange capability to support simulation based design initiatives.

b. BAA 94-44. Auto Weld of Structural Beam Erection Joints (CYBO): The objective of this project is to deliver a fully integrated prototype system (consisting of a clamping fixture and a robotic head) to each of the three participating shipyards. The lead, CYBO Welding, will then market the systems to other shipyards. Automating the process of welding the 5,000 to 10,000 structural beam erection joints in a normal ship can save as much as $500K per ship.[98] The cost of rework and injury will be substantially reduced. Despite the fact that NNS is an observer, and not a Beta site in this project, they intend to expand robotic welding at their shipyard to their Navy work. They also note that it will reduce costs in the Double Eagle product line. Once in place, automated welding will decrease welding time by 25-50%. Currently, only 4% of the welding on the Double Eagle is done robotically; they intend to expand that to 10%

c. BAA 96-05. COMPASS (Intergraph): The COMPASS Program is an innovative, cost-effective, completely open desktop design and automation solution for the shipbuilding industry. As a comprehensive next-generation design and data management platform/technology foundation, it will serve to integrate shipbuilding products and processes across the entire ship lifecycle. COMPASS leverages the expertise and effort of world-class authorities in computer and shipbuilding technology, incorporates the results of previous and ongoing ship-related DARPA products and integrates state-of-the-art and next-generation computer technologies. It will include stages of the ship lifecycle that have not been comprehensively addressed by computer technology.

d. BAA 96-42. FIRST: A First Principles Approach for Ship Integrated Process and Product (IPP) Development (Intergraph): This project will develop an integrated product and process environment to rapidly conceive, analyze, and estimate alternative ship designs with an emphasis on providing production and lifecycle level of detail information during pre-contract design. The objective is to establish a shipbuilding information infrastructure based on "first principles" levels of information to optimize ship design for production, such as manufacturing constraints (i.e., facilities, personnel and production rates). Rapid development of marketing ship designs or models requiring detailed engineering and production information is critical to international competitiveness, and is currently a barrier to U.S. shipbuilders entering the world market. With interaction between ship design and manufacturing processes, the shipyard production managers will be able to accurately assess how changes in ship design will affect production costs and schedules. In addition, design alternatives can be studied to reduce the time it takes to build a ship or ship series. NNS' role is smaller than in COMPASS, and they are mainly acting as consultants concerning their understanding of COMPASS, upon which platform this project builds.

e. BAA 96-42. Electronic Data Interchange and Commerce (MMA): This project was proposed to establish an electronic business practice between U.S. marine equipment suppliers and shipyards by utilizing "data-on-demand" via the Internet. The major areas of concentration were the establishment of a computer culture in the supplier industry, the establishment of electronic links between suppliers and shipyards, and the development of an open indexing system that displays available data and

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[98] This corresponds to about 27,000 man-hours of effort.

version through which links to all related data are made. The project will also develop digital catalogues for 18 marine suppliers. The intent of the project is to take time and cost out of the purchase and requisition process. It will create a standard for the industry. Besides NNS, the consortium consists of: The Marine Machinery Associations (Arlington, VA), M. Rosenblatt & Sons (Arlington, VA), Kockums Computers Systems (Annapolis, MD), Computervision Corporation (Bedford, MA), Ingalls Shipbuilding, SAIC, and Bath Iron Works.

C. Overall Shipyard Goals and Strategies:

1. Process Innovation: In February 1996, Newport News Shipbuilding launched a major new initiative aimed at cutting the time it takes to design and build a ship by at least 50 percent. The “Full Speed Ahead = 2x” program focuses all the shipyard’s employees on doubling the speed of their processes by redesigning and recreating them. The five major processes that are being emphasized are: design, production planning, material sourcing, steel fabrication, and outfitting. NNS plans to apply this same plan to all their products. CEO Fricks commented that “[they] must look at the total company and how it works. In short, we must redesign and recreate this company in order to achieve a breakthrough improvement.” After having cut its workforce by more that 14,000 since 1990, he notes that increasing speed, increases their throughput, resulting in more work and more jobs.

2. Commercialization: On March 16, 1996, Newport News announced changes in its commercial shipbuilding business that will result in a reduction of the number of ships to be built and a withdrawal from this market by June 1999. Despite its withdrawal from the commercial market, Newport News plans to implement the use of the commercial practices and improved processes that it learned in the commercial business in the production of aircraft carriers as well as other Navy work.

3. Dual Production: The yard's largest dry dock was lengthened to 662m., with crane lift capacity of 900 metric tons, to permit the simultaneous production of an aircraft carrier and a commercial ship at the same dock.

D. Questions

1. Ship Design and Construction Strategies:

a. What ships have been sold, built, are under construction, or have been designed as a result of MARITECH?

NNS has designed and sold six Double Eagle double-hulled product tankers under the MARITECH program.

Supporting Data for Ship Design and Construction Strategies:

Status	Description of Vessel	Metric Benefits
Completed (Built)	1 Double Eagle to Mobil	6 Sales
Under Construction	5 Double Eagles	See above
Designed	2 Double Eagle Designs (MARITECH played a major role), one domestic and one international	Current marketable Double-hull tanker in design book
Under Design	1 LNG Carrier	Currently has no up-to-date model in its design book.

b. What changes in construction strategies have been developed?

Many changes in NNS' construction strategies have been a result of the 2x process improvements implemented throughout the yard. These changes include: just-in-time delivery of materials, more contracted work and procurement, more intense scheduling or demand-based scheduling, expansion of the dry dock to accommodate dual production of ships, and more pre-outfitting of modules that are delivered to the site rather than fabricated on site. MARITECH was at the root of all of this because the shipyard had commercial ships to build.

c. Were any international competitive benefits derived from MARITECH ship designs and construction projects, and if so, what were they?

The benefit from the MARITECH ship design was the sale of a Double Eagle, their first commercial ship in nearly 20 years. In addition, NNS now has an order book design available for the commercial market. They have also learned that in future ventures, if it is possible, they will buy a proven design and make it work for their plant and manufacturing facilities.

2. Technologies Developed or Applied to Improve Design, Production/Manufacture, Operation, and/or Repair of Ships:

a. What technologies have been developed or applied to the design, production/manufacture, operation, and/or repair of ships through MARITECH?

- Yard layout simulation (through shops, docks, etc...) to simulate the flow of materials through the entire shipyard, optimizing every product line. This is a result of commercial work but will be used in the Navy work as well.
- Shared Data Environment is being used to consolidate information and stop bottlenecks before they happen. Its intent is the development of a decision tool to connect individual computer systems throughout the shipyard into an overarching computerized management decision system. It is in the process of being implemented at NNS and will require a huge culture change, going from mainframe to PC based. They are focusing on process rather than technology, which is there to support the process. The goal is a 50% reduction in schedule and costs.
- CYBO welding project - NNS is not a Beta site, but they are an observer in the project, and are planning to expand this technology to Navy work during the next 6-12 months. It will result in a 25-50% reduction, where applicable, in welding time. Their goal is to go from 4% robotic welding to 15-20%.

Supporting Data for Technologies to Improve Design, Production/Manufacture, Operation, and/or Repair of Ships

Technologies	Description	Metric Benefits

Electronic Data Interchange & Commerce	It will be a computer database to market, catalogue and inventory materials by NNS vendors.	Will reduce lead time; but it is not yet under contract although NNS has done work in anticipation.
MariSTEP	It is a MARITECH program that is trying to develop protocols that allow data sharing (product exchange) across different computing environments.	Reduced costs and time.

b. Were any international competitive benefits derived from technologies developed or applied under MARITECH projects, and if so, what were they?

None to date, but with the implementation of these technologies, Newport News' processes will improve, thereby reducing costs and cutting delivery schedules, making them more competitive.

3. Facility Expansion or Modernizations and Process Enhancements Made to Improve Design, Production/Manufacture, Operation and/or Repair of Ships:

a. What facility modernizations or expansions or process enhancements have taken place as a result of MARITECH?

NNS has spent a significant amount of money on capital improvement in the recent years, and purchases it's own equipment enabling it to be used on both Navy and commercial vessels. However, none of the facility expansions/modernizations have been a direct result of the MARITECH program. Process enhancements will result from the implementation of MariSTEP and Electronic Data Interchange and Commerce programs under MARITECH; but these programs are still in development and have not been fully implemented at NNS.

Supporting Data for Facility Expansion/Modifications and Process Enhancements to Improve Design, Production/Manufacture, Operation and/or Repair of Ships

Task	Description	Metric Benefits
Facilities Expansion	Expansion of the dry dock	Dual Production of commercial and military ships
Facilities Modernization	State-of-the-art Automated Steel Cutting and Fabrication Facility	Reduced time and costs
Processes Planned	Shared Data Environments	Reduced time and costs Prevent problems and bottlenecks Integrated Shipyard Processes from the Welder in the yard to the design team in the Carrier Innovation Center
Processes Implemented	Process Lanes More Pre-outfitted modules	Reduced time and costs

b. Were any international competitive benefits derived from these expansions, modernizations, or enhancements, and if so, what were they?

Although no benefits have directly been derived to date, in the long run these expansions and improvements will increase the international competitiveness of NNS.

c. Did you examine foreign shipyards as part of a MARITECH project, and if so, how did your findings influence your facility expansion or modernization or the planned enhancement of your processes?

NNS did examine foreign shipyards and adopted some of the facility and process improvements such as process lanes that were observed; however, the foreign yards were not visited as a direct result of the MARITECH program.

4. Commercial Business Practices for requirement analysis, supplier relations and material procurement, human resource management, customer relations and marketing, and cost estimating and financial management systems (or others applicable to your shipyard):

a. What new commercial business practices have resulted from your MARITECH projects?

See table below.

Supporting Data for Commercial Business Practices Developed or Applied:

Commercial Business Practices	Description	Metric Benefits
Vertical Teaming	NNS has teamed with vendors rather than compete with them to create a more productive situation for both. Also, it better enables them to transfer data between one another.	Cost and Time Savings Improved Relationships
Standards and Requirements Analysis	NNS has determined that standards are critical to their success and have begun to generate them for their shipyard and products. If you have standards, requirements become less interesting. They noted that it was important to put a cost on a ship before the customer knocks on the door, and to inform them that any changes will incur additional costs.	Cost and Time Savings
Human Resource Management	NNS has begun to train its personnel to do multiple tasks or to have multi-skilled trades.	Cost and time savings People are not idol
Benchmarking	NNS has formed relationships with four foreign shipyards and has implemented many of the processes and facility improvements that they observed on their visits to these yards.	Improved Efficiencies Time and Costs savings More competitive
Customer Relations / Marketing	NNS is striving to improve their marketing skills and to create marketable design books.	Increase ship sales
Cost Estimating Improvements	Some of their cost estimating procedures translate from the Double Eagle tankers to the LNGs. This relates to standards.	Cost savings and reduced design change implementation

b. What new business markets have been developed or expanded through commercial business practices developed or applied through MARITECH?

NNS has developed its own Double Eagle product tanker design and has marketed it.

c. Were any international competitive benefits derived from business processes developed or applied under MARITECH projects, and if so, what were they?

To date, no international competitive benefits have resulted from these business processes.

5. Impact on Navy Shipbuilding:

a. What is the impact of the MARITECH projects on Navy shipbuilding?

Currently at NNS, dual production of an aircraft carrier and a Double Eagle tanker is taking place, using the enhancements discussed earlier such as Shared Data Environment and 2x Process Improvements. In addition, it is an integrated production without boundaries between projects, sharing personnel and equipment. They use the same process lanes, data initiatives, etc. and the benefits of planning flows through the shops and yards. It is important to note that time allocation is kept segregated between the projects.

b. What commercial practices are you now using in Navy contracts?

Yard layout simulations and the same process lanes are being used in Navy as well as commercial contracts. Starting with CVN-77, NNS hopes to use MariSTEP. Eventually, NNS would like to see the Navy move to commercial standards, and they are beginning to see that the Navy is coming to the table with specs. and requirements and then leaving the designs to the shipyard.

c. What positive impacts could be manifested if the Navy agreed to adopt commercial business methods identified or used in MARITECH projects?

Reduction in costs and delivery time of vessels.

6. MARITECH Program Process:

a. What cultural and process change have resulted from procedures employed in the MARITECH Program?

1. Consortia **-** *Has forming consortia become a normal approach in your commercial and Navy business practices?*

Forming consortia was a good approach and worked very well. It was difficult to accept, but a major pay-off in the end.

2. Teaming **-** *Has teaming become a normal approach in your commercial and Navy business practices?*

Teaming also worked well. NNS has developed relationships with foreign yards that it never would have otherwise. The concept was not rapidly embraced at first, but worked out well in the end.

3. Were your associations with foreign partners useful, and if so, do you plan to use such associations in future commercial and Navy contracts?

NNS finds such associations very useful, and has formed relationships with four international shipyards. However, due to political situations in their countries they are not at liberty to say publicly who they are.

b. What MARITECH Program processes did you particularly like/dislike, and do you have any suggestions for such future programs?

- NNS stated that Cooperative Agreements have worked well and that they were more flexible than the standard contracts. It was easier to change the scope based on markets and work loads. However, it did take over a year to get it in place and rules were added to make it more like a contract. They feel that the AOTR and his/her backlog of projects has an affect on the contract process and that they have a lot to learn regarding contract transactions. NNS felt negotiations should focus on what is of mutual interest to both parties.
- Also the performance milestones worked well to track management and define deliverables.
- Foreign concerns need to be better addressed. Many foreign yards/entities are apprehensive about terms and conditions in the agreements.
- All in all, they felt that the program was fairly administered, and very respective of patents and technology concerns.
- They also felt that it was important to note that MARITECH is still a successful idea even if the international commercial market doesn't develop immediately. The international benchmarking and the MARITECH program have helped improve their competitiveness, which is demanded should a commercial opportunity arise. The Navy still benefits because of the increased efficiencies.
- NNS also suggested that there be someone in the Navy designated to make decisions and set policy on commercial business practice and standards adoption.

7. Global Shipbuilding Market:

NNS feels that Japan and South Korea will still dominate in the international arena, and that China looms large in the background in the future.

NNS does not feel that the global shipbuilding market will be more viable for U.S. shipbuilders because of factors that are beyond their control. This includes the fact that the foreign countries tend to want to use ships built in their countries just as we do under the Jones Act.

What must be done for the U.S. to successfully compete in the global market and what should be the role of programs such as MARITECH?

- Programs such as MARITECH should play a partner in developing processes and technologies that will be dual use and reduce the disparity between Navy and commercial work.
- U.S. shipyards must adopt commercial business practices and commercial standards to improve efficiencies which in turn, will reduce costs.
- Shipbuilders must be willing to share the work and ideas, which they have not done in the past because of competition for Navy contracts.
- Eliminate direct and indirect subsidies of shipbuilders by foreign governments protectionism practices by some countries, direct and indirect subsidies by major foreign shipbuilding nations, and

the intentional pricing of ships below cost to keep expanded infrastructure busy.

Maritech Review
Case Summary #13

Administrative Data

Lead Shipyard: **Nichols Brothers Boat Builders**
5400 South Cameron Road, Freeland, WA 98249

Date of Shipyard Interview: 24 February 1998

Ron Young - Young Associates Project Services, Ltd.,
8281 South Coho Way, Clinton, WA 98236-8902
Matt Nichols - President, Nichols Brothers Boat Builders

AOTR: Tom Conroy, MARAD

Date of AOTR Interview: 20 March 1998

MARITECH BAA/Projects:

95-02. Commanding Share of the International Fast Ferry Market

Consortium Members:

Gladding-Hearn Shipbuilding
University of California at San Diego (UCSD)

Researcher: M. Hammon

Case Summary

A. Background

Nichols Brothers Boat Builders, headquartered on Whidbey Island in Puget Sound Washington, is a small yard engaged primarily in construction of one-of-a-kind specialty boats. For 33 years Nichols has built ferries, excursion boats, charter vessels, fishing boats, tugs, pilot & patrol boats, and research vessels. It has built more high speed all-aluminum fast catamaran passenger ferries than any other builder in the US and is the fourth oldest fast ferry builder in the world. The firm is family owned and its business base is totally commercial. It has occasionally repaired small Navy vessels, but since there are no small Navy vessel construction programs, Nichols has no plans to enter the Navy construction market.

Nichols Brothers and Gladding-Hearn formed a marketing agreement with INCAT in 1983 for U.S. sales of INCAT high-speed catamaran ferry designs. That association proved fruitful and Nichols has sold 24 such ferries, including some to Fiji, Palau, Marshall Islands (used by the U.S. Army), and Puerto Rico. Nichols engineers and construction workers have traveled to Tasmania for training at the INCAT facility. Nichols has no organic naval architecture capability and licenses ferry designs from INCAT. Design data is shared electronically between INCAT, Nichols, and Gladding-Hearn, if appropriate. Other vessel designs are subcontracted to local architecture firms or previously produced designs are modified by Nichols' engineers.

B. Summary of MARITECH Projects Managed or Participated in by this Shipyard

Objectives:

Project objectives for Nichols Boat Builders are:

1. Develop a low-wake catamaran hull design in the 40m range
2. Implement Zone Outfit Logic Technologies (ZOLT) in their manufacturing processes
3. Enhance computerization in the yard
4. Proactively market internationally
5. Facilities & process improvements

This project is designed to enable Nichols on the West Coast and Gladding-Hearn on the East Coast to enter the world-wide fast ferry market with new and higher technology designs than they otherwise would have been able to without MARITECH. The owner credits Nichols' MARITECH involvement for much of the company's current success in the fast ferry market.

After successfully building catamaran excursion ferries and special purpose boats for use in Alaska, San Francisco, and Catalina, Nichols recognized that though they would like to expand into the international market, they didn't have the experience to compete internationally or the on-site engineering staff to design a competitive boat. Since Gladding-Hearn was interested in much the same objectives, the two companies entered into an agreement with INCAT, an Australian ferry designer to design vessels for sale world-wide. Gladding-Hearn and Nichols would be the U.S. agents for the designs. Each would market to American customers on their respective coasts, but both companies could market globally, as they see fit.

Nichols' focus in this project was on low-wake hull design technology. Low-wake hulls are especially important for use by ferries in locations where the vessels operate in long narrow passages, congested harbors or in other ecologically sensitive areas where generating a low wake while maintaining a high speed is a requirement.. The design goal was for a 40m catamaran hull traveling at 35-40 knots with zero wake at 4 ship lengths. Washington State requires no more than an 11" wake 1000' from the vessel. Nichols current goal is to develop a hull design that totally cancels its own wake.

Nichols Brothers also looked into implementing ISO 9000 quality standards throughout the yard and improving their international marketing presence. Because of their involvement in MARITECH, Nichols has been able to contract with experts in foreign marine transportation as well as execute foreign marketing studies and make contacts with foreign operators and owners,., which have lead to a greater awareness of and presence in the international fast ferry marketplace with a majority of the focus being the Asian fast ferry market. The company has sent engineers and staff to INCAT's Tasmanian facility to study their design, production, and marketing techniques in order to further improve their production processes and advance their international competitive position.

Finally, the company has become heavily involved in the application of Zone Outfit Logic Technology (ZOLT) production processes. ZOLT, a subdivision of the Product-Oriented Work Breakdown Structure (PWBS), consists of the Hull Block Construction Method, and the Zone Outfitting and Painting Methods. Nichols, prior to MARITECH, constructed the hull structure in modules, but did not incorporate outfitting into the construction of those modules. ZOLT emphasizes a thorough advanced planning process that leads to segmenting a vessel into larger, fully outfitted construction modules. Construction planning of the modules is further broken down into component work packages. This "assembly line" type design and production process is safer, more manageable, and yields efficiencies in one of a kind ship construction. For Nichols, application of ZOLT/PWBS across their design and construction processes improved material flow, accuracy, and thus reduced labor hours . Most of the savings have resulted from "zone" piping, electrical outfitting, painting, and installation of components on units and modular structures prior to final assembly.

Impact:

1. Nichols' marketing efforts have generated contacts with the Indonesian and Chinese governments for fast aluminum ferries. Indonesian business is currently on hold due to the current Asian financial crisis, but the company is convinced there is a substantial market there for numerous fast ferries
2. ZOLT application is credited with saving 1 1/2 months of build time on a recent commercial tractor tug order. The customer awarded a follow-on order for six more tractor tugs .

C. Overall Shipyard Goals and Strategies:

Goal/Strategy 1: Double business base in 5 years (currently $20M annually).
Goal/Strategy 2: Successfully compete in international and domestic small vessel/ferry market.
Goal/Strategy 3: Compete for military business, if appropriate.

D. QUESTIONS

1. Ship Design and Construction Strategies:

a. What ships have been sold, built, are under construction, or have been designed as a result of MARITECH?

None. Construction processes are much more efficient, though on vessels under construction. Current company backlog is 6 tractor tugs and 1 catamaran ferry ($45M, 2 years).

Supporting Data for Ship Design and Construction Strategies:

Status	Description of Vessel	Metric Benefits
Completed (Built)		
Under Construction		
Designed	Low wake hull with INCAT. Suitable for 500 passenger ferry	
Under Design	Advanced Low Wake Hull with INCAT	

a. What changes in construction strategies have been developed?

ZOLT has completely changed Nichols' production processes *b. Were any international competitive benefits derived from MARITECH ship designs and construction projects, and if so, what were they?*

Low wake hull design

Volume/productivity increased

Labor costs reduced by 12%

2. Technologies Developed or Applied to Improve Design, Production/Manufacture, Operation, and/or Repair of Ships:

a. What technologies have been developed or applied to the design, production/manufacture, operation, and/or repair of ships through MARITECH?

Zone Outfitting Logic Technology (ZOLT) is the major innovation for Nichols. Its entire design and production process has been rebuilt around ZOLT guidelines.

Improved CAD/CAM

Optimized material flow- changed yard design, begun to kit sub assemblies and assemblies

Made major advances in computerization of the overall shipyard

Supporting Data for Technologies to Improve Design, Production/Manufacture, Operation, and/or Repair of Ships:

Technologies	Description	Metric Benefits
CAD/CAM (AutoCAD 14)	Linked design, production and business departments to decrease repetitive data entry and preclude misinterpretation of data. System still in development, so metrics are vague	

b. Were any international competitive benefits derived from technologies developed or applied under MARITECH projects, and if so, what were they?

See 1.c.

3. Facility Expansion or Modernizations and Process Enhancements Made to Improve Design, Production/Manufacture, Operation and/or Repair of Ships:

a. What facility modernizations or expansions or process enhancements (e.g., yard layout) have taken place as a result of MARITECH?

See 2.a.

Supporting Data for Facility Expansion/Modifications and Process Enhancements to Improve Design, Production/Manufacture, Operation and/or Repair of Ships:

Task	Description	Metric Benefits*
Facilities' Expansion	Will expand yard property 100%	Unknown. All facilities improvements are not finished yet.
Facilities' Modernization	Additional production and warehouse buildings Enclosed final production facilities Re-designed production flow in yard	
ZOLT	Improved material flow, company upgraded CAD/CAM software to build a more producible design, redesigned material flow in the yard, identified need for additional land to optimize material flow and manufacturing process	20%-30% reduction in production time between vessels of the same type
Production material flow	Yard surveys disclosed need to change material flow and add new	Decreased production time and repaint time due to weather

	facilities/land. Enclosed paint, blast, and Catamaran facilities	9 months vs. 12 for tugs 9 months vs. 12 for catamaran

b. Were any international competitive benefits derived from these expansions, modernizations, or enhancements, and if so, what were they?

Implementation of ZOLT and facilities and process improvements enabled Nichols to reduce production costs enough to be competitive in several otherwise inaccessible world ferry markets.

c. Did you examine foreign shipyards as part of a MARITECH project, and if so, how did your findings influence your facility expansion or modernization or the planned enhancement of your processes?

Association with INCAT and visits to Australian shipyards resulted in upgrades to design software, and analysis and improved manufacturing processes.

4. Commercial Business Practices Developed or Applied for requirement analysis, supplier relations and material procurement, human resource management, customer relations and marketing, and cost estimating and financial management systems (or others applicable to your shipyard):

a. What new commercial business practices have resulted from your MARITECH projects?

Supporting Data for Commercial Business Practices Developed or Applied:

Commercial Business Practices	Description	Metric Benefits*
Just in time inventory	Steel and Aluminum deliveries vehicles are left for Nichols employees to unload when efficient to do so, rather than when vendor delivers materials	Workers don't interrupt production flow to unload vendor trucks
Resource Identification	Materials for assemblies and sub-assemblies are barcoded and kitted.	Production time and costs are easier to track and labor has been saved

b. What new business markets have been developed or expanded through commercial business practices developed or applied through MARITECH?

MARITECH involvement enabled Nichols to market internationally to Mexico, Indonesia, Puerto Rico, South America, Greece, India, Vietnam, and China.

c. Were any international competitive benefits derived from business processes developed or applied under MARITECH projects, and if so, what were they?

Improved design and production methods.

Higher profile at international trade shows.

Ability to travel to customer locations to market, instead of waiting for customer calls (pre-MARITECH).

5. Impact on Navy Shipbuilding:

a. What is the impact of the MARITECH projects on Navy shipbuilding?

None, since there is no Navy construction. Occasionally Nichols does Navy repair, and ZOLT would bring savings.

b. What commercial practices are you now using in Navy contracts?

None.

c. What positive impacts could be manifested if the Navy agreed to adopt commercial business methods identified or used in MARITECH projects?

Unknown.

6. MARITECH Program Process:

a. What cultural and process changes have resulted from procedures employed through the MARITECH Program?

1. Consortia - Has forming consortia become a normal approach in your commercial and Navy business practices?

Consortium with Gladding-Hearn and INCAT was a natural outgrowth of pre-MARITECH business relationships.

If appropriate, Nichols would form a business consortium with other partners for specific projects.

2. Teaming - Has teaming become a normal approach in your commercial and Navy business practices?

See 6.1.

3. Were your associations with foreign partners useful, and if so, do you plan to use such associations in future commercial and Navy contracts?

Clearly, the relationship with INCAT has been central to Nichols' business strategy for penetration of the domestic and international fast ferry market. Without MARITECH involvement, though, Nichols wouldn't be able to market INCAT designs internationally.

b. What MARITECH Program processes did you particularly like/dislike, and do you have any suggestions for such future programs?

Positive:

- Program flexibility and "hands-off" method has enabled participation by companies that would never operate under a defense (Navy) contract.
- Technology incorporation like ZOLT has transformed the company's production process and would have been nearly impossible to incorporate without MARITECH help.

Negative:

- MARITECH must allow participants to spend funds for overseas marketing travel and hiring of local experts. Without that, some shipyards such as Nichols, will be unable to market to foreign customers. Thus, they would be incapable of capitalizing on the international competitive advantages achieved through participation in the MARITECH program.

Future:

- Focus on processes. Nichols would like to learn more about fusion welding and possibly become ISO 9000 certified if the market conditions make it advantageous.

7. Comments on the Global Shipbuilding Market:

What must be done for the U.S. to successfully compete in the global market and what should be the role of programs such as MARITECH?

Financial assistance is necessary, as long as foreign competitors have it. Subsidies aren't the only method and probably will never be approved in Congress. Tax credits or deductions would be just as effective.

Australian subsidies have dropped from 27% to 9% for INCAT. Assistance of that magnitude would make Gladding-Hearn and Nichols competitive globally given the significant cost reductions they have attained due to participation in MARITECH.

Possible emerging opportunity is to operate yards overseas. Nichols has been asked to operate yards in the Southeast Asia, but has counter-proposed to produce kits at their yard for assembly in the customer country.

Administrative Data

Lead Shipyard/Date of Interview: **Todd Pacific Shipyards Corporation (TPSC)**
1801 16th Avenue, S.W., Seattle, WA 98124

Date of Shipyard Interview: 25 February 1998

Roland H. Webb - President and CEO
Camilla DiBarra - Program Manager, Process Improvement
Gene Kegley - Assistant General Superintendent
Gene Henley - General Superintendent
Ludwig R. Marz - Director, Human Resources

MARITECH BAA/Projects:

1. Integration of Modern Manufacturing Methods and Modern Information Systems

Consortium Members: Delteck Systems
Elliott Bay Design Group, Ltd.
MARITECH Engineering Japan Co., Ltd.
Total Transportation Systems (TTS)
Richard Storch
L.D. Chirillo
Ernst & Young LLP

Shipyard POC: Robert A. Gilbert

2. Projects participated in, but not led, by TPSC:
   a. Electronic Commerce/Computer Integrated Enterprise: New Shipbuilding Methodology Through the Shipbuilding Information Infrastructure Project (SHIIP)
   b. Electronic Commerce/Computer Integrated Enterprise: NIIIP Shipbuilding Partners And Subcontractors (SPARS)

Researcher: J. Richardson

Case Summary

A. Background

Todd Pacific Shipyards Corporation (TPSC) was founded in 1916. With approximately 700 employees on a 48 acre facility, TPSC houses 11 unions with 13 locals. There are 3 dry docks. TPSC is largely in the repair and service business. They have also built a number of medium size ships. For example, several ships have been constructed for the Navy, including nearly a third of the Fast Frigate Guided Missile Ships (FFG) in service today. They maintain Navy Fast Combat Support Navy Vessels (AOE). In the commercial sector, TPSC has built large (22,500 Ton) self-loading barges as well as a variety of smaller vessels.

TPSC went bankrupt in 1986 because, in their own words, “they had not implemented the kind of operational changes that would have made them commercially competitive in today’s market.” Their Board of Directors has made it clear that they must gain this competitiveness, and successfully address the commercial shipbuilding market or lose stockholder support. Since they are the only Northwest shipyard capable of constructing medium size ships, they feel they represent an important part of the shipbuilding industrial base, and that their recovery should be of vital interest to the government in general, and the Navy in particular. TSPC’s major problems are in their organizational structure, outdated production methodologies, and uncertain future markets. Without significant advancements in all of these areas, they feel that they cannot compete in the global market.

In 1993, under new management, TPSC began fundamental improvements, with plans to move to higher order fixes as it became possible. This meant implementing structural changes that involved more advanced process technologies, gaining productivity, and more certainty in winning new construction contracts. Commitment to these goals wavered from time to time, but in 1996/97, when TPSC lost $21M, they redoubled their efforts to modernize their processes. Since then, the company feels it has made great improvements in their operation through becoming product oriented.

Recently, TPSC won a contract to build 3 Washington State Jumbo Mark II Ferries.[99] They have delivered one and have nearly completed the second. This Ferry contract, awarded on 12 January 1995, was a major vehicle for applying and evaluating the products flowing from MARITECH projects. Unfortunately, the first ferry delivered did not bring them as far along the learning curve as they expected. As a result, they are projecting a $21M loss on the three ferries.[100] On the up side, the ferry is reported to have been well received by Washington State and there will be a fourth ferry up for bid soon. Further, as discussed later in the report, TPSC believes it has improved the efficiency of its processes to the point where they are becoming competitive. This is reflected in the progress metrics on the last two ferries being constructed.

The transformation of the corporation is taking a good deal of re-engineering. TPSC is trying to develop a climate of trust and cooperation with the union, which they believe has had a major payoff by allowing them to re-engineer their structure and operations. The reorganization is being supported by ISO 9000.

The implementation of estimating and design business practices, and computer system integration and improvement is critical. (For example, establishing one platform to integrate the individual department computer systems.)

As much as any other shipyard studied, TPSC has employed MARITECH projects to enhance operations. MARITECH enabled TPSC to hire consultants from MARITECH Engineering Japan (MEJ), composed of former employees of the Japanese firm IHI. This provided an important benchmark for them, as it has for numerous Asian and European shipyards,[101] and invaluable guidance to make the changes warranted in its shipyard operations.

Interview with Mr. Rolland Webb, CEO: In his opinion, this is a shipyard, rather than a shipbuilding program. TPSC has a full facility shipyard, but they only began building ships during the 1950's. Ship repair is still their mainstay. In general, TPSC does not build for the Navy. The last Navy ship construction were the Frigates in 1984; however, they repair quite a few Navy ships. This Navy repair work has been made much more efficient through the MARITECH projects. The Navy has been very supportive of TPSC's MARITECH work, and has become both innovative and open-minded concerning the adoption of commercial practices and new process technologies. This is particularly true of the uniformed Navy. TPSC's goal is to get to the point where a repair job is approached the same way, whether it is a Navy or commercial ship.

One of the results of post-bankruptcy constraints by the TPSC Board of Directors was a restriction on infrastructure capital improvements. Additionally, since the projected loss on the Washington State Ferries, the Board is only allowing them to bid on smaller, simpler (lower risk) contracts.

Mr. Webb remarked that MARITECH has helped them to become much more efficient. They have invested between $12M and $14M of hard fought funds to this end.

Domestic business is robust due to the Jones Act, which Congress may eliminate. If that happens U.S. shipyards will be badly (perhaps mortally) hurt. As it is, many ship owners are putting off needed refurbishments and repairs until the matter is settled.

The "residence" of TPSC, Harbor Island in Seattle, is an EPA Superfund site. Pollution problems have forced TPSC to set aside $17M for clean up, even though they believe that most of the pollution was caused by others. Obviously, this set-aside has not helped their financial situation.

B. Summary of MARITECH Projects Managed by this Shipyard.

Some General Comments. Perhaps no other shipyard has put MARITECH funds to better use in the area of benchmarking. Their relationship with IHI produced superb insights. We were impressed with the willingness of TPSC's staff, at all levels, to follow the lead of the various consultants from MEJ, a Japanese firm composed mostly of IHI veterans. An American consultant to TPSC, Mr. L.D. Chirillo,

[99] This was a welcome contract. TPSC's manning levels were around 400 when they won. At the height of the ferry construction they had about 1,000 people. Interestingly, if out-of-state bids had been accepted, TPSC would probably have been outbid by one of the Gulf Coast shipyards.

[100] TPSC's projections are to lose money on the first ship, break even on the second, and make some profit on the third.

[101] TPSC suggests that the world market has surpassed the U.S. in shipbuilding as it did in building automobiles, because new skills and methods adopted overseas replaced those still being employed in the U.S.

developed some extremely cogent analyses of what must be done to improve TPSC's competitiveness.[102] TPSC has realized the nature of their problem – process inefficiencies in nearly every sector of their operation. These inefficiencies are present in all shipyards we visited and none seem more committed to overcoming them than TPSC.

Evidence of improvements are:

- TPSC's Repair Division supervisors meet every morning at 6 AM, specifically to plan the day and discuss status of ongoing or new jobs. During these sessions, they analyze mistakes and new ideas that developed during the previous day. The MEJ consultant appeared each morning and was almost always able to make suggestions that paid off.
    - One of the major areas of emphasis has been the application of Product Work Breakdown Structure (PWBS), and workflow planning and scheduling. This division adopted MEJ's admonition to plan carefully, and maintain schedule. The Division Chief said, "when a repair job came in we used to go down to the ship and start working on it. Now we sit down and plan the job from start to finish – it pays off." Another comment, this time on maintaining schedule: "Mr. Watasan [the MEJ consultant] forced us to abide by our schedule. We were amazed to find that on the last day of the repair schedule we were actually painting and cleaning up!"
    - The differences with which they approach and conduct jobs are crucial. The shipyard has a long way to go to compete with the Japanese, but it is making progress.
- The Steel Supervisor discussed the results of bringing together fitting and welding operations, and completing all cutting and work on the assembly before beginning to weld.
    - In the Steel Shop, worker's suggested improvements yielded considerable time and effort savings, including a 6 hour T-Bar Slot cutting operation that was reduced to minutes through a simple automation.
    - Another savings resulted from a combination of workflow modifications and changes in table heights.
    - The application of these and other efficiencies resulted in a reduction of time and effort between Ferry 1 and 2 construction jobs of 35 percent, and then an additional 17 percent for Ferry 3.
- A comment heard during one of the interviews: "there have been more changes around here during the past 3 years than in the previous 20."
- Accuracy control reported a reduction of man-hours from 100,000+ hours on Ferry 1 to 50,000 hours for Ferry 2, to a projected 40,000 hours for Ferry 3.
- The Director of Human Resources commented that TPSC is trying to measure by objectives what it takes to successfully meet business goals (from a personnel performance standpoint). Employee/supervisor contracts are now required to include performance metrics.
- Progress in the area of computer systems and information infrastructure was not as obvious. Much work is being expended to move from the old mainframe that used to serve the collective needs of the shipyard to a distributed PC system with some degree of integration. However, it was not clear how they planned to solve the connectivity problems and create an enterprise system, especially one that can be used for outsourcing. For example, they are still using punch cards for some tasks (e.g., time auditing) but, on the other hand, they are integrating barcoding for tool checkout. We decided that, if we were to return to the yard, this is an area where more time should be spent. It should be stated that these are expensive decisions. It is not surprising they are being made with considerable deliberation.

There was, of course, no way for the Review Team to validate these numbers. But even the fact that TPSC is collecting them (and we saw records to indicate they were), plus the fact that they considered them important, is significant. All in all, we were impressed with the way this beleaguered shipyard is

[102] The efficiency of the processes are paramount to success. Although computers are important to these processes, the Japanese have incorporated their Product Work Breakdown Structure (PWBS) and other innovations without significant use of them.

handling their situation, and would reserve special admiration for the hard and skillful work of the program manager, Camilla DiBarra.

1. Integration of Modern Manufacturing Methods and Modern Information Systems

Background: This project began with an original agreement, signed in February of 1995, which underwent two modifications (June 1996 and September 1997). The total government cost share is $3,797,546.00 (with an equal share furnished by TPSC).

This will be discussed in two steps, the original scope of work and the work accomplished under the two modifications.

Objective: To re-engineer TPSC's traditional shipbuilding approach into a modern manufacturing system. TPSC hopes this will lead to success in the international commercial shipbuilding market.

Approach and Status:

A. The original Scope of Work performed under this "Other Transaction" was divided into three task areas:

- Installation of a computer information network to support their manufacturing modernization: This involved substituting a distributed PC computing system for the mainframe currently used at TPSC. Naturally, new integrated software as well as hardware was required, and consultants were to be involved in decision and implementation process. TPSC considered this a vital first step in the enabling PWBS and other aspects of their pursuit of international competitiveness. For connectivity, a Local Area Network (LAN) was to be installed. The first application was to create a material and labor cost database. Some specific goals are to:
    - Integrate standards and modules into the computer system, providing access to information throughout the yard

- Enhance the Material Management System (MMS):
    - Automate the connection between labor collection and payroll
    - Automate the work order system
    - Develop an on-line help function
    - Improve connections between the estimating and planning system and the MMS platform
    - Develop a material allocation function program
- Conduct computer skills training

- Introduction of modern manufacturing fundamental methodology to the shipyard: This task dealt with the cultural changes and understanding that must accompany the operational metamorphosis performed under task 1. Help from outside experts was enlisted to garner support among the workforce for the new ways of doing business and to ensure an understanding regarding the nature of, and the need for, the changes. It included a survey of the shipyard, planned consulting sessions, and distribution of materials throughout the shipyard. Some features of this effort are:
    - MEJ general review of shipyard, with participation of L.D. Chirillo
    - Distribution of educational materials on modern manufacturing methods to all TPSC employees
- Training: Again, outside expertise was employed in this task, including Chirillo and MEJ. Training was conducted in three stages: i) training in scheduling, assembly procedure, accuracy control, and outfitting; ii) training in steel detail planning, design support, accuracy control, and outfitting design support; and iii) training in steel planning and design support, line heating and faring, and outfitting planning and design support. This involved:
    - Intensive training for key production employees
    - An efficiency study by Ernst and Young of administrative departments
    - Formation of labor/management committees to address issues of change that lead to labor disputes and grievances

B. The Modified Scope of Work added definition and expanded on the original proposal. Tasks are organized as described in the 9/16/97 Revised Statement of Goals.

1. Part I. Re-engineer to a product oriented organization. The goal was to move the shipyard from functional orientation to a product orientation. TPSC's approach to this task has been to empower subsections of the company, forming composite crews, and thus decentralizing planning and integrating management positions (such as the repair contracts and repair superintendents). Additionally, TPSC has negotiated a labor contract that allows them to create the composite work crews referenced above. Specific goals have included defining future organization structures. This has been difficult to perform from a macro level. To date, they have worked closely with MEJ to define part of the organization for Engineering; this task is still in progress.

    A second goal is to define the training required to affect this culture change. They have worked with a policy group called the Work and Technology Institute to evaluate the kind of training needed, and are in the process of developing training programs.

2. Part II. Application of ISO 9000. The overall goal of this project was to have an ISO 9000 system. TPSC felt that such a system would have a positive impact on the organization. The first step was to create effective corrective and preventive action procedures. These procedures have just been implemented. The second step will be to add structural and process changes to their procedures, employing ISO 9000 to imbed these changes.

3. Part III. Improving Estimating and Marketing. Two goals associated with this task are to radically decrease time needed for estimating (through changing both "top down" and "bottom up" estimating), and to increase accuracy. Top down (Parametric) estimates are being made faster by collecting and

using market information. Bottom up estimates are used for repair and conversion work where each job may be different, while subsections may remain similar. To expedite this process, TPSC is using a software functionality called Work Packaging. They are developing a mechanism that uses continually updated cost returns to provide automated bottom up estimates.

Their marketing goal is to learn how to effectively market new construction. Through the employment of existing databases, they have developed detailed customer portfolios for trade shows. Next they will work out ways to identify and meet customer requirements.

4. Part IV. Improvements to Design. TPSC is attempting to learn how to maintain the skills and structure needed for an effective design group when work is not steady. Their approach included developing a software interface that requires little training. The software is based on standard parts and assemblies, and has strong controls for drawing format. The codes also feature search mechanisms for items such as materials, parts, and drawings. They are writing a design manual that ties into their ISO 9000 documentation to provide detailed guidelines for drawing content and administrative structure. In addition, they plan to develop generic schedules and reports to allow rapid expansion of the design department or subcontracting design work in a Virtual Corporation environment.

5. Part V. Improvements to Production. Under this part, benchmarking will be performed with IHI to improve production engineering and production planning, as well as production processes (such as line heating and semi-automated welding). TPSC feels this has been their most systematic and successful project. MEJ has been an vital part of this effort, touring their yard, reviewing process, and providing suggestions.

6. Part VI. Improvements to Automation of Integrated Systems. In order to automate repetitive administrative activities, TPSC has identified areas specific to accounting and material tracking that involve double entry of data or which are inefficient. They have then developed software solutions within their existing system.

7. Part VII. Design Production Integration. Training is being provided as a result of a comprehensive engineering effort. They sent a group of their most critical production front line supervisors to Japan for a week to work with MEJ specialists to learn production engineering activities. Next, they plan to use these supervisors in a transition role to assist with the design effort. A training curriculum will be developed to train (and test) others.

8. Part VIII. Improvements to Fabrication and Installation Processes. In order to increase the throughput of their shops, TPSC is teaching the shop workforce the analytical skills to plan their own throughput improvements. (During our visit, we saw some of the suggestions at work.)

9. Part IX. Development and application of performance management metrics, and reporting and incentive system. Operational metrics that allow success monitoring are being developed and applied. A business strategy is being established, with management incentives aligned to it. Next, the metrics will be developed.

10. Part X. Enterprise-wide computer system integration. The updating and integration of software platforms is being accomplished in order to enhance communication among functional areas, without demanding redundant operations (e.g., double entry). Their strategy is to switch to TCP-IP protocols and then to evaluate the best available integration method. They are not committed to a particular methodology, but will choose the best available at implementation.

11. Part XI. Customer relations and marketing. Seamless communications on customer needs will be pursued through the creation of an intranet functionality (called “client profiles”) that will enable the tracking of all information about repair customers at an enterprise level. This information will be available to all personnel in the organization, including all front line supervisors and marketing personnel who interact with these customers.

<u>Impacts:</u>

A. The original Scope of Work: The mainframe computer was replaced and a LAN-integrated distributed computer system installed, with appropriate software. Experts from IHI were hired to help in improving and benchmarking operations. Progress was made in changing the culture and process of the shipyard by forming a Process Change Team with their best people and, beginning with the Steel Shop, rippling the needed changes throughout the shipyard.

B. The Modified Scope of Work added definition, and expanded on the original proposal. The status of experts from IHI, MEJ, was discussed under B.8 above. TPSC's first round of exposure to MEJ suggestions resulted in some changes. The second round included more in-depth discussions, photographic documentation, and specialized training, such as cell manufacturing. Overall, improvements of 30% have been realized during construction of the Ferry Project. An additional 20% was realized between the building of the second and third ferries. TPSC believes there is more improvement to be gained.

During this period, the transition was made from the mainframe computer to the LAN. The LAN has 400 stations located throughout the entire shipyard, and has made a significant difference in the ability to transfer material information.

2. Projects participated in, but not led by, TPSC:

a. Electronic Commerce/Computer Integrated Enterprise: Through the Shipbuilding Information Infrastructure Project (SHIIP), Electric Boat will attempt to deploy National Industrial Information Infrastructure Protocols (NIIIP) throughout the shipbuilding industry. This will allow the sharing of information throughout an enterprise (among separate business areas). This is difficult because of the heterogeneity of computing environments. The approach is to set up a reference deployment at Electric Boat (EB). The principal target is ship construction (assembly and installation), since information infrastructure technologies have been successfully introduced to design, engineering, and manufacturing through standards affecting CAD/CAM (although unlike most CAD/CAM data structures, that adopted for SHIIP must be object-oriented). It is premised that there are numerous data stores and applications within each business area, beyond design, engineering, and manufacturing, that needs to be accessed throughout the shipbuilding enterprise. This is particularly true now that shipyard-wide Integrated Product and Process Teams (IPPT) are beginning to manage the construction of ships. These teams, consisting of shipbuilders, supervisors, engineers, planners and so on, often need access to information that used to exist only within one or two business areas. Furthermore, teams will eventually include vendors and sub-contractors, as well as other shipyards, since more consortia are expected in future shipbuilding. Challenges include scalability, robustness, and the ability to use legacy applications and data stores.

The results of these actions will be a new shipbuilding methodology, with new shipbuilding processes and organizational paradigms, such as a team-based approach to shipbuilding. Validation of these products will be accomplished through testing.

Objective: To develop, deploy, and standardize a new shipbuilding methodology for the U.S. shipbuilding industry, leveraging advanced information infrastructure technologies and the new shipbuilding processes, along with workforce cultural and organizational changes that result. These objectives are to be applied to both commercial and Navy shipbuilding. The delivered system will be production-grade.

Approach and Status: The approach is to deliver enterprise-wide information to the shipbuilding workforce, using advanced object-oriented information infrastructure. The enterprise information structure must be consistent with NIIIP, STEP, NIIIP-TIMA, and HLA/CORBA protocols.

Information modeling (defining properties, behavior, and interaction of data objects) is being developed which can adapt to the changes in processes which the data objects undergo as a result of changes in the shipbuilding business environments. The following steps are being followed:

- Within each business area to be represented in the enterprise-wide information model, teams of modeling and domain experts will be formed. The teams will identify the processes to be incorporated from their business area and build the models by identifying objects, relationships, and constraints from the processes chosen. The model will be reviewed by a quality control group. Some of these business areas are:
    - configuration controlled design,
    - manufacturing resource planning,
    - master production scheduling,
    - procurement, and
    - production control.

- Then the information models from all business areas will be integrated into an enterprise-wide information model.

Impact: If this project is successful, the shipbuilding industry will be able to share information throughout the shipbuilding enterprise, including shipyards, vendors, and subcontractors. This will result in profound changes in organization and workforce culture, and will greatly enhance the ability to assemble complex systems in a coordinated and efficient manner. It is directed particularly toward improving the efficiency of low rate production, a major factor in the high cost of Navy shipbuilding.

According to EB, this project has already reduced construction span time and cost for Navy ships. These efficiencies stem from the following:

- Re-engineered processes (e.g., construction workforce access to 3-D graphics and text information regarding ship design).
- Reducing non-value-added functions (e.g., the elimination of the organizations that currently deliver the information described above to the workforce).
- Greater workforce efficiency (e.g., accessibility of enterprise information allows the workforce access to more cultural change activities, such as leadership training and team building).
- Increased alternatives and timely solutions (e.g., by allowing access to enterprise data, the workforce is able to consult with design data and design personnel, collectively reducing risk in reaching solutions that are less conservative).

b. <u>Electronic Commerce/Computer Integrated Enterprise:</u> NIIIP Shipbuilding Partners And Subcontractors (SPARS): The objective of this project is to establish Virtual Enterprise (VE) technologies for shipbuilding. The VE will represent customers, partners, subcontractors, and suppliers using NIIIP technologies. VE will enable electronic-based business inter-operations that are transparent to the underlying processes and computing environments of the participants. The shipbuilding VE is to accomplish the following:

- Enable implementation of advanced business practices in requirements analysis, supplier relations, material procurement, and resource and financial management through the application of information technologies to the inter-operation of shipyards and their IPTs.
- Enable total process systems by establishing system-wide integrated design and production facilities, thereby reducing total time and cost of ship design and construction.

The approach is to:

- Establish shipyards as VE gateways to provide near-turnkey shipbuilding business processes to their supply chains, thus product teams can cost effectively work together
- Establish inter-operability mechanisms to link heterogeneous computer environments of different companies for rapid communication, accurate monitoring, and responsive control of shipyard activities
- Provide secure, easy-to-use internet-based supplier information
- Provide the ability to share design information
- Manage complex schedules
- Establish proof-of-production feasibility of assembly and disassembly
- Build a robust VE knowledge base

C. Overall Shipyard Goals and Strategies:

An expression of overall TPSC goals and strategies that are affected by MARITECH are taken from publications by the company.

Purpose/Objectives: To provide ship-owners with price-competitive, high-quality production services using appropriate facilities and offering rapid return of ships to service, leading to sufficient profitability of TPSC, in terms of net income, that its owners are willing and able to reinvest in the business.

Strategy 1: To radically transform TSPC's operation into a product oriented system by benchmarking with IHI to create a world class shipyard, and to develop a fully integrated computer system to support that structure.

Strategy 2: To use the Jumbo Mark II Ferry contract to implement and test the needed re-engineering of their organizational structure, operations, and processes.

D. Questions

1. Ship Design and Construction Strategies:

a. What ships have been sold, built, are under construction, or have been designed as a result of MARITECH?

Washington State Jumbo Mark III Ferries

Power Barge

Anchor Handling Tugs

Supporting Data for Ship Design and Construction Strategies:

Status	Description of Vessel	Metric Benefits
Completed (Built)	Washington State Jumbo Mark III Ferries	Reduction in construction time: 30% between first and second ferry and an additional 20% between the second and third ferry (Documentation is available).
Under Construction	Washington State Jumbo Mark III Ferries	2 under construction
Designed		
Under Design	Power Barge Anchor Handling Tugs	Competitive steel prices moved TPSC from first to second tier of bid. TPSC states that it has the most competitive steel rate for repair on the West Coast. This is in part due to application of new construction production methodologies and better planning.

b. What changes in construction strategies have been developed?

Ferry ship 1 employed conventional ship construction processes. Major difficulties resulted in finding people willing to change these processes, but when they did, for ships 2 and 3, the payoff was obvious. Ship 2 was transitional (elementary pre-outfitting), and ship 3 was largely built with integrated outfitting processes. The cultural issues are hard, coupled with the fact that TPSC had done no ship construction for 10 years. As a result of the activities of the Production Engineering Group, combined electrical, pipe, sheet metal, and steel outfitting took place at the earliest stages possible. This was accomplished with one craft for all hot or welded outfitting. Cold or bolted outfitting was accomplished with separate crafts, but in a significantly more coordinated manner.

TPSC had wanted to precede beginning ship 1 with 3 months of training, but they ran out of time and had to begin construction. They paid for this in inefficient procedures.

Coupling the Production and Design Group was particularly difficult. They sent a team to Japan for one week to learn how and why they should do pre-outfitting, and they brought in consultants from IHI. They went through nearly 200 people to find the 80 who could apply the new processes.

c. Were any international competitive benefits derived from MARITECH ship designs and construction projects, and if so, what were they?

TPSC is not yet competitive in the international shipbuilding market. Their approach to gaining that competitiveness is to become more efficient, address the domestic market, and work their way into the global marketplace.

2. Technologies Developed or Applied to Improve Design, Production/Manufacture, Operation, and/or Repair of Ships:

a. What technologies have been developed or applied to the design, production/manufacture, operation, and/or repair of ships through MARITECH?

See table below

Supporting Data for Technologies to Improve Design, Production/Manufacture, Operation, and/or Repair of Ships

Technologies	Description	Metric Benefits*
Group Technology/Cell Manufacturing/Cycle Time Reduction (Shop Level)	In the Pipe Shop, pipe piece family manufacturing was accomplished. In the Sheet Metal Shop, a cell manufacturing/cycle time reduction analysis was accomplished. In the Steel Assembly Shop a lay down, fit and weld rotation was instituted. On the building ways, a set, fit and weld rotation was imbedded on schedule.	Sheet Metal Shop (30% productivity increase), Steel Subassembly Shop (30% productivity increase).
Detailed Planning/ Decentralized Planning.	Division of effort between shop planning and central planning necessary for decentralization has been achieved.	This will improve outfitting rates on the third ferry.
Introduction of Effective Production Metrics	The change of steel weight to steel fit/weld lengths was incorporated.	This has enabled the shops to track their improvements and to plan budgets.
Introduction of Accuracy Control	Significant gains from reducing accuracy tolerances. All workers now accept accuracy measurements as part of their work.	Pushed rework back into an earlier stage of production (but has not eliminated it).
Introduction of Semi-Automated Welding/One Sided Welding	The purchase and use of semi-automated welding machines and ceramic backed tape.	This has enabled the increase of productivity of welding processes, the quality of welds, and the normalization of shrinkage.
Introduction of Design for Production	Techniques for design for production integrated design/production team efforts.	Improved productivity, less rework, and is expected to increase success in bids.
Introduction of Line Heating and Distortion Removal	Reduction of distortion and removal of distortion of steel plates due to handling, welding and cutting.	The ferry construction requires significant amounts of thin plate. Now, unlike pre-training, little distortion remains by the erection stage, saving uncounted man-hours.

b. Were any international competitive benefits derived from technologies developed or applied under MARITECH projects, and if so, what were they?

TPSC is not yet competitive in the international shipbuilding market. Their approach to gaining that competitiveness is to become more efficient, address the domestic market, and work their way into the global marketplace.

3. Facility Expansion or Modernizations and Process Enhancements Made to Improve Design, Production/Manufacture, Operation and/or Repair of Ships:

a. What facility modernizations or expansions or process enhancements have taken place as a result of MARITECH?

Facilities modernization is being done on their own. Wisdom drawn from the MARITECH projects is being employed. TPSC has spent nearly $20M on facility upgrades to: rebuild launchways, relocate departments, purchase new welding equipment, expand LAN, convert the ordinance building to module shop, create a pipe manufacturing facility, level old buildings, create steel shop jigs, convert the Sheet Metal Shop to cell manufacturing, upgrade the paint Shop, and modify layout onboard ships. More facility improvements are planned.

b. Were any international competitive benefits derived from these expansions, modernizations, or enhancements, and if so, what were they?

Not yet; however, initial contacts were made.

c. Did you examine foreign shipyards as part of a MARITECH project, and if so, how did your findings influence your facility expansion or modernization or the planned enhancement of your processes?

Yes, extensively. As stated in the report, it was extremely helpful.

4. Commercial Business Practices for requirement analysis, supplier relations and material procurement, human resource management, customer relations and marketing, and cost estimating and financial management systems (or others applicable to your shipyard):

a. What new commercial business practices have resulted from your MARITECH projects?

Supporting Data for Commercial Business Practices Developed or Applied:

Commercial Business Practices	Description	Metric Benefits
Planning for repair and new construction	See report	
Tightening controls in financial and project management		

b. What new business markets have been developed or expanded through commercial business practices developed or applied through MARITECH?

As stated, MARITECH was very helpful in the ferry construction, repairs, and the power barge design. TPSC states that it has the most competitive steel rate for repair on the West Coast. This is in part due to application of new construction production methodologies and better planning.

c. Were any international competitive benefits derived from business processes developed or applied under MARITECH projects, and if so, what were they?

Not Yet

5. Impact on Navy Shipbuilding

a. What is the impact of the MARITECH projects on Navy shipbuilding

- TPSC has done Navy repair work for 10 years. Navy repair work was 50 percent of the company's business before the ferry contract. Now it is about 30 percent. They apply general commercial practices when possible. A document supplied by TPSC details a number of cost savings to the Navy from the shipyard's adoption of commercial practices. For example they use commercial practices in blasting and painting, which saves the Navy money and allows them to get more work done on the ship within their budget. Navy repair business will probably pick up because the Navy is keeping more ships near home port (which is sometimes Seattle).
- The Navy has also saved on TPSC's productivity enhancements described throughout the case summary.
- TPSC has a phase Maintenance contract on Navy AOEs. This provides TPSC with historical repair databases to track repairs on ships under contract. TPSC has saved the Navy repair money by pointing out items scheduled for replacement that are actually serviceable (in fact, some of these items were new, having already been replaced in a foreign port.
- May also build auxiliary vessels, such as Barracks Barges.

b. What commercial practices are you now using in Navy contracts?

See above

c. What positive impacts could be manifested if the Navy agreed to adopt commercial business methods identified or used in MARITECH projects?

- Activity-based costing should be adopted. The Navy system hides the true cost of Navy business, since it spreads overhead across all jobs instead of concentrating on reducing overhead selectively. The Japanese avoid these overhead costs.

- Phase maintenance is a good deal for the Navy and the shipyard.

6. MARITECH Program Process:

a. What cultural and process change have resulted from procedures employed in the MARITECH Program?

1. Consortia **-** *Has forming consortia become a normal approach in your commercial and Navy business practices?*

TPSC indicated that consultants worked well, but they do not use consortia.

2. Teaming **-** *Has teaming become a normal approach in your commercial and Navy business practices?*

TPSC has developed teaming relationships with several commercial customers, such as Washington State Ferries, Wilderness Cruises, Holland America Lines, and Glacier Seafoods.

Their relationship with IHI produced superb insights. We were impressed with the willingness of TPSC's staff at all levels to follow the lead of the various consultants from MEJ, a Japanese firm composed mostly of IHI veterans. An American consultant to TPSC, Mr. L.D. Chirillo, developed some extremely cogent analyses of what must be done to improve TPSC's competitiveness.

3. Were your associations with foreign partners useful, and if so, do you plan to use such associations in future commercial and Navy contracts?

They did some marketing trips to foreign trade shows and to some potential customers, which yielded repair jobs. For example, a German container ship company just called as a result of meeting TPSC representatives at a trade show. They may bring business. Cruise ships are the biggest foreign repair business.

TPSC indicates that it will continue with their foreign partners and are currently involved in a project to use MEJ consultants on their next Navy contract.

b. What MARITECH Program processes did you particularly like/dislike, and do you have any suggestions for such future programs?

- Cost share is equitable, very happy with it.
- Do not initiate government auditing procedures!
- NSRP consortium worked well.

7. Global Shipbuilding Market:

Japan is not subsidized the way other countries overseas are. The shipbuilding industry is overcapacity, but not sure by how much. Also see interview with Mr. Webb.

What must be done for the U.S. to successfully compete in the global market and what should be the role of programs such as MARITECH?

No response.

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