REPORT TO THE CONGRESS

BY THE COMPTROLLER GENERAL OF THE UNITED STATES

Ways To Increase U.S. Shipbuilding Productivity

Maritime Administration

Department of Defense

At four large U.S. shipyards, management needs to make improvements to increase efficiency and economy in ship construction. GAO endorses the purpose of the Maritime Administration's Shipbuilding Modernization Program, which is designed to increase productivity and efficiency of the shipyards by means of the construction differential subsidy.

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COMPTROLLER GENERAL OF THE UNITED STATES
WASHINGTON, D.C. 20548

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To the President of the Senate and the
Speaker of the House of Representatives

This report identifies ways to increase U.S. shipbuilding productivity.

We reviewed the shipyards because of the Government's financial involvement through its subsidy support for construction of merchant vessels and its direct funding for constructing naval vessels. Because of the nature of this involvement, increased efficiency and economy in shipyard operations should result in direct savings to the Government.

We made our review pursuant to the Budget and Accounting Act, 1921 (31 U.S.C. 53), the Legislative Reorganization Act of 1946 (31 U.S.C. 60) and the Legislative Reorganization Act of 1970 (31 U.S.C. 1154).

We are sending copies of this report to the Secretaries of Defense, the Navy, and Commerce and to the Assistant Secretary of Commerce for Maritime Affairs.

Comptroller General
of the United States

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ABBREVIATIONS

CDS	construction differential subsidy
DOD	Department of Defense
GAO	General Accounting Office
MARAD	Maritime Administration

COMPTROLLER GENERAL'S
REPORT TO THE CONGRESS

WAYS TO INCREASE U.S. SHIPBUILDING PRODUCTIVITY
Maritime Administration
Department of Defense

D I G E S T

Almost $30 billion of Federal funds have been spent in private shipyards during the past 20 years--approximately $28 billion to build Navy ships and $2 billion in construction subsidies for American merchant ships.

At four private shipyards, GAO found ways to improve operations, increase productivity, and reduce costs. Followup visits were made to each to determine whether they acted on GAO's suggestions.

Of 70 GAO suggestions to management, 36 were accepted and 34 were not, as of the time this report went to press. Of the 36 accepted, 7 had not yet been put into practice by management, primarily because they lacked funds to invest in capital equipment and facilities. (See app. I.)

GAO suggests shipyard improvements in

--facilities acquisition and management (see ch. 2);

--production planning and control (see ch. 3);

--labor morale, absenteeism, turnover, efficiency, and productivity (see ch. 4);

--preventive maintenance practices (see ch. 5);

--quality assurance (see ch. 6);

--industrial engineering (see ch. 7); and

--procurement of raw materials and supplies (see ch. 8).

1 The Department of Defense agrees that shipyard management and operations can be improved in these areas and, with minor exceptions, agrees with GAO's suggestions.

2 The Maritime Administration comments that, in general, GAO's suggestions are not new and apply in varying degrees to the industry as a whole. Maritime feels that GAO judged the four shipyards in terms of an optimal set of standards on every issue without sufficient attention to reasons for past decisions and to costs of implementing recommended changes.

GAO did not use or apply an optimal set of standards in evaluating shipyard operations. Each shipyard was evaluated individually with its own advantages or constraints considered. Each shipyard was looked at with one question in mind: What improvements could be made that would result in ships being produced more efficiently and economically? GAO recognizes that some suggestions require additional study. However, in the long run they can be justified economically.

The Navy and the Maritime Administration should evaluate shipbuilders' operations regularly to identify needed improvements, seek maximum efficiency and economy of operations, and determine if Government funds are being effectively spent to provide maximum benefit to the Government.

The Maritime Administration's proposed Shipbuilding Modernization Program includes use of construction differential subsidy funds for modernizing U.S. shipbuilding to achieve production efficiency rates that are comparable to the best foreign facilities. GAO endorses this objective. (See p. 22.)

CHAPTER 1

INTRODUCTION

The efficiency and economy of U.S. shipyard operations greatly interests the Government because it spent about $29.8 billion on this industry during 1954-74. The Department of Defense (DOD) spent $28.2 billion in private shipyards on direct procurement of ships; and, the Maritime Administration (MARAD) furnished $1.6 billion in the form of subsidies for building commercial ships, in accordance with the Merchant Marine Act of 1936, as amended.

The principal congressional objectives for Government support of the shipbuilding industry as expressed in the act are to:

--Create and maintain efficient shipbuilding and repair capability in the United States, with sufficient skilled personnel to provide an adequate mobilization base for the national defense.

--Promote the development of U.S. foreign and domestic commerce.

The efficiency of the private shipbuilding industry is of special importance to the Government in relation to these objectives, both in terms of military readiness and the amount of Federal funds payable in the form of construction subsidies. For more than 20 years, most Navy ships have been built by private shipyards, and since 1968 all Navy ship orders have been placed with private shipyards. In terms of dollars, the Navy is an important source of demand for the shipbuilding industry. In addition, the amount of the construction differential subsidy for building a commercial ship, payable by the Government to the shipyard, is the difference between the U.S. shipyard price and a fair and representative foreign yard price to build the same ship, with a maximum subsidy of 50 percent. Improving the efficiency of shipbuilding operations causes reductions in construction costs at U.S. shipyards, which should result in direct savings to the Government. We made this audit because of these special relationships and the large potential for direct Government savings.

Our approach in this study was to observe and analyze the operations of four selected shipyards, with their cooperation, to identify opportunities for reducing cost and increasing efficiency. We are not implying that any of

the four shipyards were subject to mismanagement. On the contrary, our brief visits with the managers of these shipyards indicates that they are attempting to solve their problems and build ships efficiently, given the market conditions under which they must operate.

In an earlier report, "Government Support of the Shipbuilding Industrial Base," February 12, 1975, (PSAD-75-44), we suggested that the Congress consider authorizing the Maritime Administration to approve, in appropriate circumstances, subsidized construction of ships in U.S. shipyards for non-U.S.-flag operation and the subsidized U.S.-flag (certified under U.S. laws to fly the U.S. flag) operation for foreign-built ships. This authority will provide desirable flexibility in administering merchant marine support programs so that changes can be promptly made to achieve the Nation's changing merchant fleet and shipbuilding capability needs most effectively and economically.

Further, without this additional authority and flexibility in administering the subsidy programs, MARAD is limited in its ability to:

--Provide market stability by leveling temporary peaks and valleys in U.S. shipbuilding activity.

--Promote specialization in constructing ship types which U.S. shipyards can build most efficiently and economically.

--Encourage shipyards to invest in facilities and maintain needed shipbuilding skills.

The approach outlined in the 1975 report is still valid, and the results of our shipyard reviews complement our previous findings and recommendations. This report identified specific shipyard improvements that have been made, identifies others which could or should be made, and provides some of the reasons why shipyard management has not made these changes under the current system.

CHAPTER 2

FACILITIES ACQUISITION AND MANAGEMENT

Shipbuilding requires numerous types of facilities, large level land areas, and various types of production equipment, all of which must be efficiently planned and integrated. Also the shipyards need sufficient storage space, complete with lifting equipment, to move and store various sizes, shapes, and types of steel plate, pipe, and structural shapes. Facilities are also needed to provide protective storage for many items used in outfitting ships. The facilities must be capable of moving, handling, and lifting materials and units ranging in weight from several tons to hundreds of tons. To provide for economical and efficient shipbuilding, the facilities need to be arranged to handle material as little as possible and to promote a smooth and even flow of work through the various stages of shipbuilding.

Our study addressed:

--The adequacy, physical layout, and the effective use of facilities at each shipyard visited.

--Facilities modernization and maintenance.

--How facilities affected in-process inventory, material flow, material handling, and the overall productivity and efficiency of the labor force.

Facilities at each shipyard visited had some constraint which impeded productivity. Management categorized these as due to (1) a lack of capital funds to make improvements that would increase their ability to produce ships more economically and (2) a lack of space within the shipyard.

We offered the four shipyards 30 suggested improvements including:

--Acquiring new capital equipment (usually very expensive and requiring approval before purchase).

--Modifying existing facilities.

--Rearranging the flow of materials.

--Constructing new facilities.

--Making facilities expansion studies.

Management accepted 16, of which 12 were implemented. (See app. I.)

For example, we suggested that one shipyard consider acquiring a new frame bender. A frame bender is a large machine used to roll the steel structure that forms the ribs of a ship's hull. Management said that our suggestion had been adopted--the machine was purchased and was being installed. By having its own frame bender, the company will not be as dependent upon suppliers and will reduce the risk of costly schedule interruption. The shipyard managers estimated a 14-percent return on the investment.

At another shipyard we suggested that an area adjacent to the end of the graving dock (a dock that can be kept dry for use during shipbuilding) be used to construct, assemble, and outfit the deckhouse portion of ships. The deckhouse is being built in the location suggested in two sections and completely outfitted on the ground. Each section is then lifted onto the ship where final installation is completed. This suggestion has reduced the overall construction and outfitting time for the deckhouse and facilitates the planning and use of labor.

CHAPTER 3

PRODUCTION PLANNING AND CONTROL

Production planning and control personnel contribute to efficient ship construction by planning yard operations so that:

--Workers and equipment are fully employed.

--Materials are available in the right quantities when needed.

--Material inventories are not excessive.

--Accurate and timely reports are made and maintained, identifying work in process as well as potential production bottlenecks and problem areas.

Through production planning and control, all related shipyard activities are coordinated and focused on delivering ships on schedule.

At the four shipyards we concentrated on the scope, depth, and coverage of the production activities and on the capability of the people doing the planning.

We made seven suggestions for improving the shipyard production planning and control operations. Five suggestions were partially or totally accepted and adopted; two were not accepted. (See app. I.)

Several production planning and control systems actually being used varied in:

--Depth of detailed planning.

--The planning methods and procedures being applied.

--Organizational structure responsible for the system.

--The number of people employed in the planning function.

--The degree to which the systems were computerized.

--The numbers and types of reports.

Three shipyards fully or partially adopted our suggestion to integrate, centralize, and computerize the production planning and control system. Two shipyards are using a modular approach to change their production control system. With the modular approach, changes are implemented and tested in one group before continuing to implement them throughout the shipyard. This approach gives the people affected time to become familiar with the change and provides time to work out any problems and to insure proper implementation.

At another shipyard, our suggestion to phase in the Department of Defense cost schedule control system criteria, Department of Defense Instruction 7000.2, as a means of improving the existing cost and schedule systems, was adopted. This should improve the schedule control and the discipline of their production planning and control system.

A comparison of production planning in U.S. shipyards with foreign competitors indicates that the latter have more detailed and sophisticated systems. The Kockums shipyard in Sweden has a computer-based planning and control system which is comprised of precalculations, design data, work onhand and in the shops, administration of material, financial data, and detailed planning for the workshops. Japanese shipbuilders use their production control systems to plan operations in such detail that deliveries of steel provide for only a 5- to 15-day supply in their inventories. Perhaps such control contributes to the lower foreign shipbuilding costs.

CHAPTER 4

LABOR RESOURCES

Shipbuilding is a labor intensive industry because of the numbers of workers needed to build ships. It requires many different skilled workers, such as welders, pipe fitters, electricians, mechanics, crane and equipment operators, material handlers and expediters, carpenters, painters, machinists, test technicians, loftsmen, draftsmen, and engineers. Many of these people work outdoors, year round, under adverse weather conditions; and, since few shipyards have a steady flow of ship orders, the work force expands and contracts. Also, other industries pay higher wages. Such conditions contribute greatly to a high turnover of personnel.

At each shipyard, we analyzed the number of workers and associated workspaces that were or were not protected from the weather, the types of personal facilities available to the workers (lockers and restrooms, cafeterias, parking, etc.), and the labor turnover and the reasons for it. We were interested in the noncovered workspaces, because in bad weather the productivity of the outside work force can be reduced to nearly zero. Estimates show that without protection from weather, a 20-percent loss in productivity can occur during winter. A study at one shipyard concluded that adverse weather was causing losses of over $2 million annually. The lack of adequate personal facilities can also contribute to absenteeism, low morale, high labor turnover, production interruptions, overtime, and rework.

Management's attention to labor turnover problems is important. Problems such as increased employment and training costs, efficiency losses, low production, and increased scrap and rework costs adversely affect shipyard operations.

Labor turnover in the four shipyards ranged from about 25 to 60 percent. At the shipyard having a 60-percent rate, the annual costs were about $2.4 million, as shown below.

Cost due to efficiency losses during learning period of newly hired employees	$2,326,000
Personnel department salary and administrative costs directly associated with hiring and terminations	75,000
Added costs of instruction and training supplies directly attributable to the turnover rate	42,000
Total	$2,443,000

According to the Bureau of Labor Statistics, the national average annual turnover rate for the shipbuilding and repairing industry is 15.9 percent. This rate includes: separations--8.6 percent; quits--2.0 percent; and layoffs--5.3 percent. Since this rate is a national industry average, a goal of 16 percent does not appear unrealistic to us. If the shipyard experiencing the rate of 60 percent could reduce that to 16 percent, it would save approximately $1,792,000 annually. Only one shipyard was, however, analyzing the reasons and costs associated with labor turnover.

The Commission on American Shipbuilding reports that a relatively stable work force should yield a 10-percent improvement in labor productivity at shipyards with a high rate of turnover.

We offered three suggestions for covering the outside work areas as a means of increasing productivity, for identifying and measuring labor turnover costs, and for reducing turnover. (See app. I.)

Managers at one shipyard agreed with our suggestions and studied the problem as well as the potential savings. They could not adopt the suggestion, however, because their requests for funding had not been approved by the parent corporation. At another shipyard, although the managers initially said they would not adopt our suggestion, we later found they had covered some, but not all, of the areas suggested. The areas covered included: an extension of the plate fabrication shop, which includes their panel line where flat panels are fitted together and welded; the addition of a new enclosed blast and paint building; and a new building in which steel plates for webs and steel bars forming T-frames are welded together.

One shipyard promptly adopted our suggestion to interview employees as they leave (make exit interviews) to identify the reasons for labor turnover and to initiate actions to reduce these costs. The labor turnover rate later declined. The decline could not be attributed solely to the exit interview, as the shipyard had also initiated more intensive prescreening of prospective employees, had started a foremen evaluation program, and had relaxed its strict policy of automatic discharge for absenteeism.

CHAPTER 5

MAINTENANCE

Ship construction involves expensive facilities and equipment to move, handle, and lift the different materials throughout the shipyard and to fabricate, assemble, erect, and test the various parts as required. Adequate maintenance of these facilities and equipment is important. When breakdowns happen the efficiency and productivity of the shipyard manufacturing and construction processes can be greatly reduced or come to a halt. Maintenance must be performed, therefore, at a level which will insure, and contribute to, continuous and reliable ship construction.

Preventive maintenance is a program of periodically inspecting, servicing, cleaning, and replacing worn parts of equipment and facilities. Some benefits of a preventive maintenance program are lower machine repair costs, reduced production equipment interruptions (downtime), fewer large-scale repairs, less disruption of production schedules, and less overtime. The cost of a good preventive maintenance program can generally be more than economically justified when compared with the money that would be lost when equipment breaks down.

In general, management paid little attention to maintenance of equipment and facilities at all shipyards visited. Only one had a formal preventive maintenance program; and, at the time of our visit, it covered only 37 percent of the systems identified by that shipyard as requiring preventive maintenance. All four shipyards had widely dispersed maintenance facilities which contributed to poor control of maintenance labor and supplies. None had complete documentation of downtime, maintenance costs, or use of machinery and equipment. Maintenance which could have been scheduled on the second or third shift, with less interruption of production, was done at all shipyards during the first shift and on weekends, costing the shipyards more money in overtime pay. A formal preventive maintenance program would have saved about $2,000,000 annually in one shipyard and about $580,000 annually in a second shipyard.

At three shipyards we suggested that a formal preventive maintenance program be developed and implemented. The program should include:

--Records on equipment use and maintenance.

--Manufacturer's maintenance recommendations.

--Cost records of equipment downtime.

--Operator's equipment condition reports.

--Maintenance schedules that would minimize production interruptions.

--Control of maintenance labor and supplies.

Management has begun to implement this suggestion.

Our suggestions at two shipyards to consolidate fragmented maintenance-material storage areas to provide for effective management planning and for control of maintenance personnel and material resources have been agreed to by management at both shipyards. Only one has begun to fully implement it. The second shipyard could not obtain corporate funds to provide a storage facility for consolidating its fragmented maintenance materials. (See app. I.)

CHAPTER 6

QUALITY ASSURANCE

Quality assurance is the responsibility of all shipyard employees. Quality should be infused in the entire shipbuilding system from ship design to production engineering, to construction operations, to inspections and test, and to delivery. To insure that the required quality level is achieved, shipyards often establish quality assurance programs. Quality assurance programs should be designed to provide information for preventing and detecting discrepancies and for initiating timely and positive corrective action.

Managers emphasized different aspects of quality assurance at each of the shipyards. At those shipyards doing work for the Navy, more emphasis was placed on formalized quality assurance policies, procedures, and systems than at those shipyards building commercial ships. We made 11 suggestions intended to strengthen and improve shipyard quality assurance functions. (See app. I.)

The shipyards decided not to adopt any of our suggestions. While the managers did consider our suggestions they:

--Believed their present systems were adequate.

--Could see no advantages to be gained by adopting our suggestions.

--Felt other functional groups could just as well perform the tasks of our suggested quality assurance group.

--Concluded that the costs outweighed the benefits that might be obtained. Furthermore, the managers generally believed that Navy contracts already contain excessive quality assurance requirements that necessitate a large staff of Government administrators to enforce compliance.

Although our quality assurance suggestions were not accepted, they have merit and would benefit each shipyard. Our suggestions were designed to provide managers with a totally coordinated quality program, which is necessary to insure that a quality product is being consistently produced. We believe that shipbuilding, like most other industries, needs a quality assurance program that has total responsibility for quality, coordinates quality objectives throughout the planning and production of the product, and is located fairly high in the organizational structure.

CHAPTER 7

INDUSTRIAL ENGINEERING

Industrial engineering is a discipline concerned with the design, installation, and improvement of integrated systems of men, materials, and equipment. This discipline is needed in the shipbuilding industry because it (1) is highly labor intensive, (2) must handle a range of material from small and light to extremely large and heavy units of steel structures, and (3) involves large investments in facilities and equipment.

Normally, industrial engineering would include but not be limited to:

--Communication with design engineers to insure unit producibility.

--Selection of manufacturing, construction, and assembly processes and methods.

--Selection and design of tools.

--Design of facilities, including layout of buildings and equipment, materials handling equipment, and raw material and finished unit storage facilities.

--Development and application of labor standards and performance measurement techniques.

In the four shipyards, industrial engineering tasks were being done by many groups scattered throughout various organizations within the shipyards. Only one shipyard had a group specifically called Industrial Engineering. Another shipyard had a group primarily concerned with establishing and maintaining labor standards for work covered by an incentive clause in the shipyard's labor union contract. In addition, the shipyard contracted for outside services to fulfill its industrial engineering needs. A third shipyard had one industrial engineering position, but the duties of that position were limited to designing special tooling, jigs, and fixtures in response to problems arising in the operations department of the shipyard. The fourth shipyard had a small group that made methods and procedures improvement studies and did schedule and performance monitoring. We made eight suggestions about industrial engineering. Four were accepted, and four were not. (See app I.)

One shipyard made daily work sampling studies in various areas of the shipyard. These studies had been made for many months, and the calculated productivity level had stabilized at a relatively low level, with little variance over the time period. We suggested that the daily sampling be discontinued and the available industrial engineering resources be used to identify the problems contributing to the low productivity levels. The industrial engineers could then initiate corrective action that would result in increased productivity. Later, the shipyard was divided into 17 areas and the daily sampling studies were reduced to a random selection about once every 17 days. As a result, the industrial engineers were giving problem areas greater attention.

At two other shipyards we suggested that managers examine the existing labor standards to identify opportunities to enhance their reliability and usefulness. One shipyard took steps to increase its use of labor standards and is now applying them to planning, scheduling, estimating, equipment replacement and modernization, and performance measurement. The second shipyard did not agree with our suggestion and has not made any changes in the uses of its labor standards.

CHAPTER 8

PROCUREMENT

In the United States, about 45 to 60 percent of the total cost of commercial vessels is made up of purchased materials--steel, pumps, valves, pipe, wire, motors, paint, etc. Because of this, purchasing and procurement activities warrant attention. If material is not delivered when needed, production may be interrupted, causing schedules to be missed. Excessive material handling and expediting may be required as well as additional labor costs.

Because materials are so expensive, we concentrated on the size of the material inventories being maintained and the inventory management practices being used. The shipyards visited had limited storage space. Warehouse space which must be maintained away from the shipyard adds to ship costs through the additional expenses for items such as rent, material handling, transportation, and security.

Three of the four shipyards were maintaining large, costly inventories of steel in order to minimize production delays and to protect against cost escalation. Such practices should be evaluated in terms of increased materials carrying costs (keeping material in inventory), increased materials handling costs, and impact that the use of the limited available shipyard real estate for material storage purposes has on other operations. Management should, of course, take the steps necessary to protect against material shortages and price escalation. However, managers should compare related costs with benefits. Little evidence shows that such analyses were being made. Some shipyards did not adequately control their inventories, because economical order quantities were not being determined and ordering costs were not balanced against carrying costs. We made two suggestions to help reduce inventory carrying costs. (See app. I.)

Our suggestion that management establish a balance between the costs of ordering material for inventory and the various costs associated with carrying the material in inventory was adopted by one shipyard and rejected by another. One shipyard took action through improved planning to reduce its inventory of steel plates from a 12- to 8-week supply and its quantity of in-process and partially completed subassemblies and assemblies. Due to the steel shortage problem at the time of our study, the other shipyard felt that it

should develop sound relationships with its suppliers. Management felt that this relationship was more effective than performing elaborate analyses of requirements and associated carrying costs. The cost of material in their inventory could be reduced by about $300,000 a year by reducing excessive inventory stocks.

CHAPTER 9

EFFICIENCY AND ECONOMY ISSUES

Two issues, if implemented, should improve the efficiency and economy of shipbuilding operations in the United States.

AUDITS OF SHIPYARD OPERATIONS

Our audits or reviews of the shipyards' operations were designed to identify and measure, where possible, opportunities for reducing construction or management costs, increasing work force efficiency, and increasing productivity. Our approach was to evaluate the shipyard as a total system of interacting operations and functions, recognizing that suggested improvements would have to be implemented considering the shipyard's existing physical boundaries and its constraints. In each shipyard we audited primarily those areas with the greatest potential for improvement in efficiency and economy. Improvement would, hopefully, make those shipyards more competitive with foreign shipbuilders.

The Navy makes production audits at shipyards when the initial staff estimates are being greatly exceeded or when scheduled contract delivery dates are in danger of being missed. These audits include many functions of shipyard operations and may include all of the functions and operations studied and addressed in this report. These audits are jointly conducted with the Maritime Administration when the shipyard being studied has a large amount of military and commercial work. According to the Navy, these audits are not regularly scheduled but are undertaken only when a problem or potential problem arises.

Also, the Navy makes preaward surveys of the shipyards' capabilities in connection with specific procurement requirements. These surveys are usually concerned with the shipyards' overall management, financial and production capabilities, and its ability to perform as required in the contract. Unlike a thorough production audit, such preaward surveys do not concentrate on identifying potential improvements.

MARAD does not audit or study private shipyards to identify inefficiencies or ways in which it feels shipyard productivity can be improved. Since passage of the 1970 Merchant Marine Act, MARAD has been working with the U.S. shipbuilding industry, through the National Shipbuilding

Research Program, to improve industry productivity and to reduce Government subsidy. This program has been carried out by MARAD working and funding projects as perceived by the shipbuilders and carrying these projects through development and demonstration. MARAD does not make followup audits at shipyards implementing the new techniques to determine their effectiveness in reducing construction costs or improving productivity.

Subsection 211(g) of the Merchant Marine Act of 1936, as amended, specifically authorizes and directs the Secretary of Commerce to investigate, determine, and keep current records of the number, location, and efficiency of shipyards. In addition, with respect to a particular ship procurement, MARAD could have those portions of shipyard operations audited which affected procurement by including appropriate provisions in the solicitation for bids and the contract entered into between the Secretary of Commerce and the shipbuilder receiving the construction differential subsidy (CDS). In the construction differential subsidy, MARAD funds the difference between the domestic and foreign price of a given ship.

We made 70 suggestions for improvements to the four shipyards. About 2 years later, 29 suggestions had actually been accepted and adopted by shipyard managers, 7 were accepted but not adopted, and 34 suggestions were not accepted. (See app. I.) Considering the potential that exists for improvement in shipyard operations, MARAD and the Navy, by regularly making similar audits, could possibly produce even greater savings in shipyard operations.

DESIGN/PRODUCTION INTERACTION

Like any other industry, to be efficient and competitive, shipbuilding should be emphasizing producibility during the design phase. Was producibility being addressed? What results were attained? Except for one shipyard, producibility was being formally addressed during the design phase. In most cases, design engineering managers said that the design-engineering staff knew about the shipyard's construction capabilities and that producibility was being reflected in the resultant design. Producibility considerations are most effective when design engineers and production/manufacturing engineers actively and openly exchange ideas during the ship's design and development. Such an interaction serves both as a check on the acceptability of the design and as a commitment from production engineers that the ship can be built economically.

The Navy does not have a producibility requirement that it uses in design contracts. Recent Navy procurement contracts have requested that the contractor respond on the basis of the most economical cost and delivery rate if it differs from the Navy's specified requirements. This assures that producibility will be considered in some way, although not necessarily done. Further, unless a design contract contains a producibility requirement, contractors may not address the subject. Producibility analysis made after the design has been completed is ineffective and costly.

Producibility analyses addressed by design and production manufacturing engineers, conducted as the design evolves, including a review of all specifications and drawings, should

--insure that the design can be produced economically,

--insure the accuracy of specifications and drawings and thereby minimize errors and possible schedule delays,

--minimize internal changes after the design has been released for production,

--provide for advanced assessments of make-vs-buy,

--provide advanced information on tooling requirements,

--identify unnecessary or unwarranted military specification requirements,

--insure the maximum use of in-house production capabilities,

--insure that engineering paper is adequate and most useful for manufacturing purposes.

A Webb Institute of Naval Architecture report in 1969 cited the value of "designing for production" as the first step for improving productivity.

CHAPTER 10

AGENCY VIEWS

We solicited comments on an earlier draft of this report from the Department of Defense and the Maritime Administration. The following paragraphs summarize the major points made by each agency.

DEPARTMENT OF DEFENSE

DOD agreed that shipyard management and operations can be improved in the areas cited. Other areas, such as individual worker productivity, training, safety, etc., not within the scope of this study can also be improved.

DOD noted that close examination is needed when comparing U.S. shipyard production planning and control systems with those used by Japanese and Swedish shipbuilders, because the workload situations are not the same. According to DOD, shipbuilders have orders of a number of similar ships allowing maximum automation of production planning and control. Most American shipbuilders have not, however, been able to obtain similar workloads enabling installation of management systems that will support series production.

We agree that workload is an important factor in implementing effective management systems. However, production planning and control--as a management system--is basic to construction of ships, regardless of the size of the workload. Shipyards should be using systems which:

--Plan for full and effective use of shipyard capacity.

--Control the work in all production operations.

--Plan and control the work-in-process inventory.

--Permit projecting delivery requirements and inventory levels.

We agree with DOD's comment that improved working conditions will not be a panacea for the overall labor problems that beset the industry. Shipbuilding is a labor intensive industry which experiences considerable labor turnover and production interruption. Better working conditions, including covered work areas, can help increase productivity, reduce production interruptions, and reduce costs related to rework, absenteeism, maintenance, and training.

Further, DOD agreed that labor turnover is a major problem and is attempting to resolve it with the Maritime Administration and the Departments of Labor and of Health, Education, and Welfare. DOD agreed with our suggestions about maintenance.

DOD commented that the quality program specification invoked in shipbuilding contracts does not require a standard organization for quality assurance but that personnel working in quality functions have sufficient well defined responsibility, authority, and organizational freedom to identify and evaluate problems and to initiate, recommend, or provide solutions. DOD indicated that shipyards choose to use either centralized or decentralized control to achieve the desired results.

Shipyards should have the option of using either centralized or decentralized management control of their quality program. We do not believe, however, that decentralized quality functions will be effective or objective if their responsibilities and authorities are not well defined and divided among the various departments within the shipyard. To be effective, quality assurance should have the authority and responsibility to accept or reject the product, to evaluate quality problems, and to initiate corrective actions.

DOD generally agreed with our comments on industrial engineering and indicated that such an organization would depend on the particular circumstances and the shipbuilder. Industrial engineering, or its equivalent, should be alined as an individual department to insure that the shipyards' operations are addressed as a total system for overall efficiency and productivity. Industrial engineering is an ongoing essential part of any effective manufacturing organization.

While DOD generally agreed with our suggestions for improving shipyard procurement practices, it expressed reservations about them because of problems caused by changing economic conditions. However, we observed practices which indicated a lack of inventory control and indiscriminate buying of items in ample supply that had not been greatly affected by changing economic conditions. We stressed the need to give proper consideration to the advantages and disadvantages of purchasing materials and supplies in advance of need.

MARITIME ADMINISTRATION

MARAD commented that we apparently judged the shipyards in terms of an optimal set of standards on every issue, without considering the reasons for past decisions and the cost of

implementing the changes. To the contrary, we did not have a set of optimal standards against which we measured the shipyards' operations. We did, in the short time available, observe and evaluate the shipyards' operations using one basic criteria: Could the function, task, activity, operation, etc., be done more economically and efficiently? Based on information at the time of our review, we suggested ways management could reduce costs or increase efficiency at their shipyards. Many suggestions were provided, recognizing that additional study was warranted to further explore the suggestions and to validate the preliminary findings. We did not attempt to determine the feasibility and the impact on profitability of any particular suggestion, because we were limited in time and lacked the necessary information to make such calculations.

MARAD said that we considered shipyard layout "from the point of view of the optimum shipyard, with no consideration of the cost involved in achieving such a layout." Each shipyard layout was evaluated from the standpoint of what could be done to improve operations and material flow and to reduce material handling. The costs to implement our layout suggestions were not developed because many suggestions required further study by the shipyard managers to determine the most feasible approach. Consequently, we could not measure the savings which could result from our suggestions. We believe, however, that the savings would exceed the cost to implement the improvements. Our followup discussions with management indicated that about 53 percent of our suggestions regarding facilities were accepted. To date, 40 percent have been implemented.

MARAD stated that the U.S. shipbuilding industry has spent $514 million on major equipment and facilities improvements since the Merchant Marine Act of 1970 was enacted and plans to spend $291 million in the next few years. Although shipyards are spending substantial sums, particularly for new facilities to build liquified natural gas energy carriers, a great deal more needs to be done. Improving existing facilities will contribute to increasing worker efficiency and reducing actual construction time and costs.

MARAD also noted that the problem areas we observed are being studied by its Shipbuilding Research and Development Program. We are aware of the program and discussed some of the projects with shipyard personnel. For fiscal year 1974, less than 12 percent of the MARAD dollars spent on research and development contracts was for developing innovative technology to increase productivity and reduce manufacturing costs in U.S. shipyards.

The comparison of U.S. shipyard production planning and control systems with the more sophisticated systems in use in Japan and Sweden was provided to show that our competitors in the world market are more advanced in this vital area, placing U.S. shipyards at a disadvantage. Our reference to Japan maintaining a 5- to 15-day steel supply does not mean that the U.S. shipyards should do likewise as was inferred by MARAD. We recognize that steel supply situations may vary among countries and that it may not be possible for U.S. shipyards to efficiently operate with only a 5- to 15-day steel supply. However, such inventory levels do indicate that U.S. shipyards might be able to reduce their inventories. Inventory and work-in-process should be maintained at the most economical level, which will be different for each particular shipyard.

MARAD referred to our use of the 16-percent labor turnover rate as being an optimum or ideal rate. It was not intended to be optimum or ideal but only to show potential savings if the high labor turnover rates could be reduced to the national average. Because shipbuilding is labor intensive, shipyard management should be more concerned with the impact of labor turnover on the shipyard operations.

CONSTRUCTION DIFFERENTIAL SUBSIDY

An earlier draft of this report suggested that MARAD consider revising its subsidy program to provide for improved shipyard operations and increased efficiency, productivity, and competitiveness which would reduce the subsidy rate or eventually eliminate it. The desired goals were to reduce ship construction costs, make the U.S. shipyards more competitive with foreign shipyards, and reduce the need for the present levels of Federal ship construction subsidies. MARAD is now proposing the Shipbuilding Modernization Program that is directed toward modernizing U.S. shipbuilding to achieve production efficiency rates comparable to the best foreign facilities. Part of this program includes the use of CDS funds to implement plans that would result in construction savings and productivity gains.

In view of MARAD's efforts to implement such a program (using CDS funds) to reduce costs of constructing vessels and to improve productivity, we have no further recommendation at this time. We endorse the use of CDS funds, and consider this important to the benefit of the U.S. shipbuilding industry.

FLUCTUATING WORKLOAD

Both the Navy and MARAD commented that they are cooperating with one another to determine whether the industry can accept shipbuilding programs. The Navy points to annual congressional budgets as a difficulty in long-range workload forecasts, while MARAD indicates that it has no control over the decisions to build a ship and at which yard since contracts are negotiated between the owner and the shipbuilder. The Navy agrees that the lack of firm and continuous planning has been a major cause of cost increases in the naval shipbuilding program. Hopefully, the Navy's 5-year plan, as required by the Congress, will help in balancing shipyard workloads.

Because MARAD and Navy rely upon the same shipyards for the construction, repair, conversions, and alterations of their ships, close cooperation between them should be maintained when awarding subsidies or contracts. Such cooperation could help insure the effective use of the industry's available capabilities.

Additional factors that should be considered when developing a balanced shipbuilding workload are:

--Planning for and justifying capital expenditures.

--Cost and productivity of the labor force.

--Impact on local economies.

--Mobilization requirements.

--National defense.

--The needs of foreign and domestic commerce.

We concluded in our report, "Government Support of the Shipbuilding Industrial Base," that national goals for the shipbuilding industry could be achieved more effectively and economically if MARAD had the authority and flexibility to approve subsidized ship construction in U.S. shipyards for foreign-flag operation. With this flexibility and authority MARAD could provide stability for U.S. shipyards by leveling temporary peaks and valleys in U.S. shipbuilding activity.

AUDITS OF SHIPYARD OPERATIONS

MARAD did not agree with the suggestion in our earlier draft that it and the Navy jointly audit shipyard operations because (1) it would require large expenditures of funds and resources, (2) legislative authority does not exist, and (3) the audits would unnecessarily involve the Government in the operations of private shipyards. The Navy did not comment on this, although it is already auditing some areas suggested.

Additional audits of this nature need to be made. Because our audits at each shipyard were limited to 3 weeks, we had to be selective in choosing areas for audit and the depth to which each area could be evaluated. A great deal more needs to be done about this. Such reviews can provide:

--A basis for improving shipyard operations, thus contributing to more effective and realistic contractor pricing proposals.

--Information useful for evaluating make-vs-buy decisions.

--MARAD with an assessment of the shipyard's detailed facility modernization plans, as required by the proposed Shipbuilding Modernization Program.

Our suggested audits would keep both MARAD and the Navy apprised of how well the shipyards are functioning and provide a means of identifying potential improvements. Simply stated, if the Government is going to spend money to build ships, it should also have some means for determining if these funds are being effectively used for the greatest benefit of both the Government and industry.

In view of the potential opportunities for improvements in the facilities and operations that exist and the amount of Government funds spent on ship construction under the CDS program and Navy contracts, greater attention should be given by MARAD and Navy to the efficiency of the shipbuilders' operations. Our limited audits produced 70 suggestions for improvements, thus indicating the effectiveness of such reviews.

To minimize the impact that these audits can have on the day-to-day operations of the shipyard, they can be scheduled to accommodate the shipyard management with a minimum of disruption in their operations. Further, to the

extent possible, the Government should use existing evaluation approaches, such as preaward surveys, modernization program reviews, mobilization readiness studies, and resident contract administration service reviews, wherever possible to minimize and reduce any further intrusions into the shipyard's operations.

DESIGN/PRODUCTION INTERACTION

Ship designers have a dual role in designing new ships: they must meet the requirements of the customer and at the same time be concerned with the producibility aspects of their design. Design engineers and production engineers should be constantly working together while the design of the ship is evolving, and both should be concerned with how the ship will be built. If design and production can work together on producibility, the ship will probably be constructed in less time and at a lower cost, because:

--Materials will not have to be scrapped due to design changes necessary to accommodate production.

--Easier and less time-consuming construction and assembly procedures can be identified, thereby, minimizing rework.

--Unnecessary operations and problems can be identified and corrected in advance.

The Navy and MARAD both supported the suggestion in our earlier draft that greater emphasis be given to producibility during the design phase. The Navy indicated that it is using this concept on the Guided Missile Frigate program. MARAD is addressing the matter with industry through a cooperative 5-year, $5 million research and development effort.

CHAPTER 11

SCOPE OF REVIEW

Our initial review was limited to 3 weeks of onsite work at each of four major U.S. shipyards during September 1973 to March 1974. Two of the shipyards were on the east coast, one on the gulf coast, and one on the west coast. The shipyards were selected to provide a variety of (1) locations and (2) type of work. Two shipyards were building both subsidized commercial vessels and naval vessels. A third built only subsidized commercial ships, and the fourth built naval vessels only.

At each shipyard we concentrated on the areas of operations and management that we considered had the greatest potential for improving the shipyard's efficiency and production capability. These areas were selected on the basis of preliminary investigations, the results of prior Government reviews in these shipyards, and literature research of the shipbuilding industry which preceded our field visits.

We reviewed a great many reports, papers, articles, and studies made by Government agencies, private consultants, technical societies, and the shipyards themselves. Study techniques included interviewing shipyard management personnel, collecting and analyzing data on yard operations, and observing procedures and practices in most of the functional areas of management and operations. We also interviewed officials at the Maritime Administration, the Navy, the Coast Guard, and the American Bureau of Shipping.

After we had identified those areas where we thought the shipyards could improve the efficiency and economy of their operations, we submitted our suggestions in separate letters to the managers of each shipyard. In March and April 1976, we made followup visits to each shipyard to discuss with management the status of implementation of our earlier suggestions and, if not accepted, to identify the reasons why. Their comments, reasons, and rationale regarding our suggestions are included in this report, along with Navy and MARAD comments.

We recognized, at the time of our initial visits, that time and money would be required to implement some of our suggestions. We also recognized that shipbuilders must make a profit to survive in the everchanging world market and

that, therefore, many of our suggestions would require further study by shipyard management, to determine the most feasible approach if a change were justified. For these reasons, we did not attempt to measure the potential savings.

OUR SUGGESTIONS FOR IMPROVEMENTS AND THE SHIPYARDS' IMPLEMENTATION AND/OR COMMENTS

Summary

	Our suggestions		
	Accepted		Not accepted
	Adopted	Not adopted	
Facilities acquisition and management	12	4	14
Production planning and control	5	0	2
Labor resources	1	1	1
Maintenance	6	1	1
Quality assurance	0	0	11
Industrial engineering	4	0	4
Procurement	1	1	1
Total	29	7	34

Our suggestions (note a)	Accepted (note b) Adopted	Accepted (note b) Not adopted	Not accepted (note b)	Shipyard actions and/or comments on our suggestions
Facilities acquisition and management:				
1. Acquire 40-foot plate rolls to roll larger and thicker steel plates and reduce amount of butt welding.	1	-	-	Company purchased a used set of 40-foot rolls for approximately $275,000. Information was not available to calculate actual savings.
2. Acquire a 600 to 700 ton frame bender to reduce cost of present operations and to reduce the risk of schedule interruptions by relying upon various suppliers.	1	-	-	Company acquired a 700 ton frame bender for approximately $282,000. Because the equipment is being installed, actual savings data is not available.
3. Provide area at end of graving dock for assembling and pre-outfitting deckhouse to facilitate construction.	1	-	-	The area identified is being used to construct and outfit the deckhouse in two sections. Each section is lifted onto the ship where final installation is completed.
4. Provide an area on the corner of the graving dock for rudder assembly to facilitate handling and construction.	1	-	-	A corner of the graving dock is being used to assemble the ships' rudders. This area has been provided with a movable shelter.
5. Upgrade crane lifting capacity to provide for heavier lifts and to reduce construction costs through fewer lifts.	2	-	-	One shipyard increased the lifting capacity of two of the four cranes as we suggested, for approximately $150,000. Upgrading the other two cranes was estimated at $750,000, as structural changes to the buildings were required. However, this improvement could not be economically justified. The second shipyard increased its crane-lifting capacity and was upgrading the track foundations during our followup visit.
6. Improve pipe storage methods to facilitate pipe selection, minimize errors, reduce present storing space, and reduce damage from handling and storage.	1	-	-	A new pipe storage area is being planned that will provide for centralized in-yard pipe storage and should reduce the amount of material handling. Also, the amount of fabricated pipe to be stored should be reduced through better planning.

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Our suggestions (note a)	Accepted (note b) Adopted	Accepted (note b) Not adopted	Not accepted (note b)	Shipyard actions and/or comments on our suggestions
7. Level all shipways and pave area to be used for ground assembly and buffer storage.	1	-	-	Five of the nine shipways were leveled and the area paved. The remaining four are being used as a panel assembly and subassembly area. The leveled area is primarily being used for storage of units from the panel shop. Management has studied leveling the remaining ways and has determined that, for the current and future workload and the investment required, the present ground assembly area is adequate.
8. Extend craneways from both sides of graving dock to the blast and paint buildings to provide a heavy lift capability and to minimize the need to move units using the transporter.	1	-	-	The managers agreed with our suggestion and submitted a proposal to the corporate level for approval. It was not accepted because they lacked funds to purchase capital equipment and facilities. A revised proposal of about $750,000 was submitted to extend only the craneway on the south side of the dock to the ground assembly platen where the heavy lift units were being assembled. This revised proposal was approved at the corporate level but not yet funded. This same suggestion was made by private consulting firms.
9. Construct a new blast and paint facility to provide flexibility of operation and to comply with environmental regulations.	1	-	-	The company initiated studies to determine location, size, and cost of a facility to be used to blast and paint shaped units. The need has been discussed at the corporate level. Local environmental requirements are that the blast and paint operations be done inside or under cover.
10. Increase the size of the proposed graving dock to permit construction of a whole ship and the stern section of a second ship at the same time or to construct vessels up to 300,000 deadweight tons.	1	-	-	The graving dock was widened by 11 feet but not lengthened as suggested. Widening the dock permits constructing larger ships with wider beams. Instead of lengthening the dock to provide for building one complete ship and the aft section of another ship at the same time, as suggested, the company intends to to build the center tank section of

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Our suggestions (note a)	Accepted (note b) Adopted	Accepted (note b) Not adopted	Not accepted (note b)	Shipyard actions and/or comments on our suggestions
				another ship on an adjacent buildingway. When the completed ship is launched, the center tank section of the next ship will be floated into the graving dock, thereby, accomplishing the same objective.
11. Conduct cost-effectiveness studies of the two alternative sites for the proposed shipyard expansion.	1	-	-	The company did conduct a cost-benefit analysis of the two alternative sites being considered for expansion. One site, owned by the company, was not selected because of high development costs and because the terrain was not suitable for ship construction. The alternate site was selected because of cost factors, labor availability, the ease of converting existing facilities to support shipbuilding fabrication, and the short time in which the changes could be made.
12. Construct a new graving dock with two 200-ton cranes to provide for workload leveling and the capability to increase ship output.	-	1	-	Management agreed with our suggestion and included it as a part of its overall facilities improvement program. However, the current and projected levels of business would not justify the expenditure involved. Also, test borings at the suggested location indicated poor subsoil conditions.
13. Install inverted skate wheel conveyor between the panel shop and the blast and paint shop to provide for easier movement and less handling of panels and to eliminate the need for the panel transporter.	-	1	-	This suggestion was agreed with but not adopted because of lack of funds to purchase capital equipment and facilities as well as a reduction in the number of ships being produced and the corresponding reduction in the number of panels to be handled in this manner.
14. Provide the employees with a parking area closer to where they work to reduce the time to and from their vehicles and to improve management-employee relations.	-	1	-	Several parking sites along with various parking arrangements were considered but none adopted because enough space could not be provided to accommodate all employees. The company has provided new

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Our suggestions (note a)	Accepted (note b) Adopted	Accepted (note b) Not adopted	Not accepted (note b)	Shipyard actions and/or comments on our suggestions
				eating, locker, and shower facilities, considered higher priority than parking.
15. Relocate pipe shop, welding school, gear alinement, and outside machinists in an existing building. These changes are necessary because other suggestions have affected the facilities in which these activities are located.	-	1	-	The company agreed that this was a good suggestion; however, the building that was suggested to be used, while being located on the shipyard's property, is being used by another division of the corporation. The shipyard would have to pay to relocate the present tenant. Therefore, the shipyard elected not to pursue the matter.
16. Relocate machining operations in another facility so the building can be used for ground assembly to support the efficient construction of ships. The contractor's decision to transfer fabrication operations to another site negates this suggestion.	-	-	1	This suggestion was not accepted because the company considered the costs and time involved and the disruptive aspects to be too great. Also the decision to have fabrication done at another facility releases additional ground assembly area that was not available at the time of our initial visit.
17. Relocate mockups closer to engineering and use the vacated area for pre-erection staging to provide additional space and improve flow of work. The contractor's decision to transfer fabrication operations to another site negates this suggestion.	-	-	1	This suggestion was not accepted because (1) moving the mockups would preclude their being available at a critical time in the design phase and would be time consuming and expensive and (2) the present location makes them readily available for use by the design and the shipyard trades.
18. Relocate and consolidate a cluster of buildings--carpenter shop, wire room, paint storage room, hydrogen trailer, cylinder bank, storehouses, and central tool house--to make available about 1 acre of space at the head of the slipways to facilitate ground assembly. The contractor's decision to transfer fabrication operations to another site negates this suggestion.	-	-	1	This suggestion was not accepted because the support services are needed for various aspects of the shipbuilding process. Relocating them would create additional problems without appreciably increasing ship construction.

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Our suggestions (note a)	Accepted (note b) Adopted	Accepted (note b) Not adopted	Not accepted (note b)	Shipyard actions and/or comments on our suggestions
19. Construct two new shipways to relieve the congestion in the shipway area, to improve working conditions, and to provide for increased productivity.	-	-	1	The contractor believes that this suggestion would not provide a capability to build larger ships if future plans shift in that direction. Since our review, the contractor made extensive facility additions and changes which provide for additional construction capabilities. This eliminates the need for additional shipways.
20. Use a floating drydock to launch ships, because it would be less expensive, allow for some construction and outfitting while in the dock, and allow for continued construction on the land shipways.	-	-	1	Shipyard managers studied the use of the drydock for launching and find it less suitable because (1) it requires a grounding mat and crane capacity equal to a graving dock and would involve an expenditure comparable to the construction of a graving dock, (2) lacks the flexibility of being used in the future as an overhaul/refit basin, and (3) the extended use of the dock for required outfitting may result in a need for a second drydock to maintain adequate schedule protection.
21. Relocate the proposed graving dock with additional landfill to provide more ground area, increase usable outfitting dock space, make available two new outfitting piers, and provide for a pre-erection staging area.	-	-	1	This suggestion was not accepted by the shipyard because (1) the company had already obtained the necessary approvals and building permits (considerable change and delays would be caused if an alternate location were selected), (2) schedules for completing the dock became a factor since the contracts for the ships to be built in the dock were completed and contained severe penalties for late delivery, (3) no assurance existed that the needed approvals could be gotten to change the location, and (4) relocation would have disrupted yard operations and may have affected delivery schedules.

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Our suggestions (note a)	Accepted (note b) Adopted	Accepted (note b) Not adopted	Not accepted (note b)	Shipyard actions and/or comments on our suggestions
22. Relocate the pipe shop, foundry, and galvanizing shop to improve material flow.	-	-	1	The shipyard managers disagreed with the proposed material flow and the related facilities changes that were necessary to implement it. Management indicated that this suggestion was not feasible to implement, would be very costly, and would disrupt their operations.
23. Extend the fabrication area, adjacent parallel ground assembly platens, and the collocator system to improve material flow, especially of heavier assemblies; reduce material handling; and increase plate storage and reduce plate handling.	-	-	1	This suggestion was not accepted because its implementation depends upon relocating the pipe shop, foundry, and galvanizing shop. However, management is adding to its fabrication area in the direction opposite that suggested by us by installing a panel line at an estimated cost of $1.1 million.
24. Install free roller conveyor lines with side power grabs in paved ground assembly area to facilitate movement of assemblies and improve material flow.	-	-	1	Free roller conveyor lines suggestion was not accepted because the workload would not justify the expenditure.
25. Install a Goliath crane on the existing graving dock to provide for heavier lifts and the yard's growth potential.	-	-	1	Installation of a Goliath crane had been considered originally when the dock was built but was not adopted because of economic reasons and because two 200-ton cranes could provide greater flexibility and utilization.
26. Provide 100- and 200-ton cranes to handle the assemblies in the new ground assembly area to facilitate handling and reduce the need for the unit transporter.	-	-	1	These suggestions were not accepted because their implementation depended upon the installation of the conveyor lines and the new graving dock which were not adopted.
27. Modify existing warehouse to be used for blasting and preparing units for painting, to comply with environmental regulations and to minimize rework.	-	-	1	The present system of using steel shot outdoors to prepare units for paint meets environmental requirements. Our suggestion was, therefore, not accepted. The shipyard is planning to install a shot recovery system that will reduce the cost of recycling the shot and is estimated to cost approximately $600,000.

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Our suggestions (note a)	Accepted (note b) Adopted	Accepted (note b) Not adopted	Not accepted (note b)	Shipyard actions and/or comments on our suggestions
28. Enlarge and use existing warehouse for painting units, to comply with environmental regulations and to minimize rework.	-	-	1	The present ways of doing all painting outside do not violate any local environmental regulations; therefore, implementing the suggestion is unwarranted. Until local conditions or regulations that would be affected by the outside painting change, the company does not plan to make any changes.
29. Provide a system of rollers for feeding the assemblies into and through the blast shop and directly into and through the paint shop.	-	-	1	This suggestion was not acted upon, as it relates directly to suggestions in numbers 27 and 28, which were not implemented.
Total	12	4	14	
Production planning and control:				
1. Integrate, centralize, and computerize production planning and control functions to provide for the preparation of detailed plans, schedules, and budget of all production operations.	3	-	-	One shipyard that totally agreed with the suggestion has taken several implementing actions: planning has been combined and centralized in one organization, and in-process storage quantities have been reduced; all structural schedules are now computerized with plans to convert the manually prepared outfitting schedules to the computer; and greater use is made of the available labor standards for planning purposes. The shipyard hired a consulting firm to evaluate its production planning and control system, and their recommendations were basically the same as ours. The second shipyard also began to integrate its production planning and scheduling system. The computerized planning and control system now includes all fabrication, pipe, and sheet metal operations and it is planned to be extended to all shipyard operations. Another shipyard improved and upgraded its system

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Our suggestions (note a)	Accepted (note b) Adopted	Accepted (note b) Not adopted	Not accepted (note b)	Shipyard actions and/or comments on our suggestions
				since our initial visit. This shipyard relies considerably on the experience of its production engineering staff for planning decisions and for developing detailed estimates for each trade involved in the construction of the ship. The production control system is computerized to provide current schedule status as well as performance measurement indexes.
2. Expand an existing data information system to include all shipyard operations and to integrate with it an automated material information system to provide planning details, timely and realistic schedules, and a means for evaluating the impact of proposed changes to both plans and schedules.	1	-	-	These two systems are being integrated by a new employee. However, it was stressed that this may take some time because the necessary changes will be made gradually, to disrupt the operations in the yard as little as possible. The system will be expanded to include some areas not included in the existing data information system.
3. Implementation of DODI 7000.2 should be phased in immediately to demonstrate its value for improving "the discipline of the existing cost and schedule systems."	1	-	-	Various management subsystems are being implemented before complete acceptance by the Government. The various systems being developed will be applied to all new construction work accepted by the shipyard. Implementation has provided a greater degree of attention to the principle of marrying the budget and the scheduling processes. Also, implementation of DODI 7000.2 has forced attention to both the time and dollar aspects of the program.
4. Develop and apply detailed manhour budgets or standards to all shipyard operations, to provide for realistic scheduling and accurate worker performance measurements.	-	-	1	Managers believed that detailed labor standards were not practical for shipbuilding and that they would not be used. Measurements are developed using historical data which forms the basis for planning and estimating. If actual data can support the various needs for

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Our suggestions (note a)	Accepted (note b) Adopted	Accepted (note b) Not adopted	Not accepted (note b)	Shipyard actions and/or comments on our suggestions
				production planning, estimating, scheduling, measuring productivity, etc., management will continue to use it.
5. Consolidate the production control, planning, and material departments into one organization called Production Planning and Control, reporting to the vice president, Yard Operations, to insure integration of all work and to provide management greater assurance that work is being accomplished efficiently and economically.	-	-	1	Management did not agree that the suggested consolidation would be beneficial or produce any greater assurance that the work would be done more efficiently or economically. Some organizational changes have taken place with the production planning staff, but these changes do not match our suggestion.
Total	5	0	2	
Labor resources:				
1. Conduct exit interviews to identify specific reasons for labor turnover and develop measurements of labor turnover costs and initiate actions to reduce these costs as appropriate.	1	-	-	The company promptly adopted this suggestion and its labor turnover rate declined dramatically. Much of the reduction was attributed to: more intensive prescreening of employees, revisions to company policy as identified by the exit interview, and a foremen evaluation program designed to reduce absenteeism.

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Our suggestions (note a)	Accepted (note b) Adopted	Accepted (note b) Not adopted	Not accepted (note b)	Shipyard actions and/or comments on our suggestions
2. Provide cover for open work areas.	-	1	1	One shipyard, even though not adopting our suggestion, agreed that covering the outside work areas would increase productivity and minimize schedule disruptions. The primary reason given for not covering work areas was lack of funds to invest in capital equipment. A shipyard official indicated that covering the work areas would be included in the company's long-range facilities planning. The second shipyard did not accept our suggestion because it did not feel that covering the shipyard as suggested with the material specified was practical.
Total	1	1	1	
Maintenance:				
1. Develop and implement a fully documented preventive maintenance program to reduce schedule delays and equipment downtime, minimize worker idle time, and reduce maintenance costs.	3	-	-	Each shipyard initiated formal preventive maintenance programs. At one, manufacturing engineers are implementing the program. They do not have enough experience yet to identify the savings associated with the program. The second shipyard, with a full-time staff of about 15 people working on various aspects of preventive maintenance, implemented about 75 percent of its formal program. The bulk of the remaining work involves completing maintenance specifications. At the third shipyard, a limited preventive maintenance program was implemented. The primary areas of coverage include cranes, panel shop, blast and paint shops, roto-blast, and all rolling stock. This yard is also installing its maintenance work order system.
2. Consolidate fragmented maintenance material storage areas, to maintain minimum cost levels of				One shipyard took actions to consolidate and reduce its maintenance storage areas. This was accomplished on a trade-by-trade basis

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Our suggestions (note a)	Accepted (note b) Adopted	Accepted (note b) Not adopted	Not accepted (note b)	Shipyard actions and/or comments on our suggestions
maintenance materials and to provide for more effective management, planning, and control of maintenance resources.	1	1	-	and based upon a study of where and how much maintenance should be done throughout the shipyard. The second shipyard agreed with the concept but had not yet adopted it because of higher priority work. Present plans are for maintenance to work with facilities planning in determining its maintenance material storage areas.
3. Organizationally aline all maintenance functions to be the responsibility of a single manager or department, to create better management and to provide for planning of resources and tasks.	1	-	-	All maintenance functions were grouped together and are responsible to the Manufacturing Engineering Manager. Additional staff were hired to oversee and plan the maintenance activities.
4. Use the third shift for maintenance operations, to minimize machine downtime and reduce the cost of doing maintenance.	1	-	-	About 90 percent of the maintenance is being done primarily on the second shift, rather than the third shift as suggested, because it was found to be more effective. Maintenance on cranes, however, is usually done on the third shift or is scheduled at the same time the cranes are down for normal inspections and tests. Since starting the preventive maintenance program, maintenance overtime has been reduced about 80 percent with no regular maintenance being scheduled for the weekend.
5. Establish closer control over the issuance and accountability of handtools to the workers, to reduce the dollars being lost annually.	-	-	1	Control procedures on the issuance and accountability of handtools have not changed. Management indicated that this was a relatively minor cost area and that projects with higher priority had not permitted time to study the situation or to determine if anything should be done.
Total	6	1	1	

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Our suggestions (note a)	Accepted (note b) Adopted	Accepted (note b) Not adopted	Not accepted (note b)	Shipyard actions and/or comments on our suggestion
Quality assurance:				
1. Assign to the Quality Assurance Department the analysis of problems related to quality, to pinpoint the cause and recommend corrective action.	-	-	2	One shipyard did not see any benefit to be gained by adopting our suggestion, because their current practices of dealing with problems were adequate. The second shipyard indicated that problems which occur during manufacturing are evaluated for cause and corrective action and that the same applies for vendor items. These problems are not normally handled by quality control but by various trades or functions involved. To assign this responsibility to quality would not mean that the problem would be solved by the best qualified person.
2. Have quality assurance (1) organizationally equal to other functions like engineering and production and (2) report directly to the next higher level of management, to insure its objectivity.	-	-	2	One shipyard did not believe that establishing a separate Quality Assurance Department would be beneficial, as it was satisfied with its present organization and the way in which problems of quality were being handled by the various groups within the shipyard. Managers of the second shipyard did not agree with this suggestion. Their experience indicated that following our suggestion would increase management's problems. Also, they thought that, if the Quality Department were in the suggested position, there would be more finger pointing (in trying to set the blame for problems) than attempts to resolve those problems.
3. Assign receiving inspection to quality assurance, to insure that all materials received conform to ordered specifications, that proper tests have been performed, and that the necessary documentation was provided.	-	-	3	The shipyards disagreed with this suggestion. Each commented that receiving inspection was being adequately done by the organizations to which it was assigned and that to change that assignment would not be beneficial or result in any improvements. They felt that to merely change the name of the responsible organizations was not necessary and that the quality of receiving inspection would not be improved.

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Our suggestions (note a)	Accepted (note b) Adopted	Accepted (note b) Not adopted	Not accepted (note b)	Shipyard actions and/or comments on our suggestions
4. Have the Quality Assurance Department participate in reviewing drawings, plans, test memos, and supplier test specifications or requirements to insure that they contain adequate and sufficient quality requirements and provisions.	-	-	3	Each shipyard disagreed with this suggestion. In responding, management indicated that their present practices were sufficient for assuring that their drawings, specifications, and other documentation adequately covered the necessary quality requirements. According to one shipyard, it had problems that could be traced to or identified with not having its quality control staff review drawings or specifications.
5. Have the Quality Assurance Department improve its inspection documentation relating to commercial work-in-process, to identify construction problem areas, causes of production delays, and excessive rework.	-	-	1	This suggestion was not agreed to, because management considered its present inspection processes and amounts of documentation adequate for identifying problem areas, including people responsible for generating rework costs. Management considered any additional documentation to be excessive for its needs and, therefore, an unnecessary expense.
Total	0	0	11	
Industrial engineering:				
1. Reduce the daily work sampling to less frequent random sampling with more industrial engineering attention directed to identifying and resolving the basic conditions and problems that are causing people to work inefficiently.	1	-	-	Work sampling has been reduced, as suggested, except for the shipyard roadways which are still being studied each day. The shipyard was divided into 17 work sampling areas, and studies are being made in these areas, on a random basis, once every 17 days. In addition, specific industrial engineering groups have been tasked to identify and resolve problems.
2. Examine the use of labor standards to identify opportunities to enhance their reliability and usefulness to management.	1	-	1	This suggestion was accepted by one shipyard and rejected by the second. The shipyard that accepted this suggestion expanded the use of its labor standards to such areas as planning, estimating, scheduling, performance measurement, and budgeting.

APPENDIX I

Our suggestions (note a)	Accepted (note b) Adopted	Accepted (note b) Not adopted	Not accepted (note b)	Shipyard actions and/or comments on our suggestions
				Examples of how the labor standards are being used are: production control uses the standards to plan construction of the ship in the graving dock, the estimating group uses the standards in its pricing of change orders, standards are used to justify acquiring new capital equipment, and standards are used for measuring employee labor efficiency.
				Managers at the second shipyard do not rely upon labor standards. They rely more on measuring worker performance to a historical standard than to an engineered standard. Also, being a nonunion shipyard they are reluctant to institute engineered time standards. They feel such standards would have an effect on their labor-management relations.
3. Develop a formally structured, methods-improvement program for improving operations and increasing worker efficiency.	-	-	1	The company responded that its present practice of improving its methods was adequate. It did not see any benefit to be derived from changing just to satisfy our suggestion. The industrial engineering staff that works daily with first-line supervision and observes ongoing operations identifies the need for methods improvement and works with the design and tool engineers to get improvements implemented. Also, weekly meetings are held with area supervisors to review problems and the need for methods improvement.
4. Establish procedures that will insure communication between industrial engineering and design engineering that addresses the producibility of design.	1	-	-	The shipyard adopted a procedure where the industrial engineers review the design with the design engineers as it evolves and before the drawings and plans are finalized. This is done informally, which management finds effective. Producibility is further verified by use of a check-list which is completed by the industrial engineer as the new design is reviewed.

APPENDIX I

Our suggestions (note a)	Accepted (note b) Adopted	Accepted (note b) Not adopted	Not accepted (note b)	Shipyard actions and/or comments on our suggestions
5. Combine existing industrial engineering functions, being performed by separate departments, into a single Industrial Engineering Department to provide for coordinated management of resources when considering methods improvement, equipment modernization and utilization, plant layout, tooling, cost reduction, and performance measurement.	1	-	1	Managers at one shipyard accepted our suggestion and assigned the Manufacturing Engineering Department responsibility for performing the various indicated engineering functions. The second shipyard did not accept our suggestion, because it was not convinced of the benefits to be gained. This shipyard will continue to function with four separate departments doing related industrial engineering activities, because it believes this organization to be more effective.
6. Prepare a producibility handbook to assist design engineers by identifying production capabilities, limitations, and capacities.	-	-	1	This suggestion was discussed by the Manager, Production Engineering, with the Director of Engineering and not accepted because it was not considered cost effective. The constant communication between the production engineers and the design engineers was very effective, and the producibility handbook probably would not be needed.
Total	4	0	4	
Procurement:				
1. Establish a balance between the costs to order inventory and the costs associated with carrying items in inventory.	1	-	1	One shipyard took the necessary steps to implement our suggestion by reducing the 12-week inventory of steel to about an 8-week supply. This reduction resulted from management's attention to the costs involved and from improved production planning, which permits the shipyard to operate with a smaller inventory of material. The second shipyard, while recognizing the basic principle of the suggestion, felt that it should develop sound relationships with its suppliers to enhance its position in obtaining the materials needed, when needed, as opposed to an analysis of carrying costs.

APPENDIX I

Our suggestions (note a)	Accepted (note b) Adopted	Accepted (note b) Not adopted	Not accepted (note b)	Shipyard actions and/or comments on our suggestions
2. Consider reviewing the advanced purchasing program to insure that proper weight is given to the advantages and disadvantages of purchasing items in advance of need, so that only items in short supply or items where the resultant carrying cost is warranted will be purchased.	-	1	-	The availability of materials has changed since this suggestion was made and the company has altered its purchasing practices. Currently, the company's procurement practice includes analyzing costs based on specific conditions and situations, types of contracts involved, rate of progress payments, escalation provisions, material shortage forecasts, etc., before company funds are committed. Management indicated that given the same conditions that we observed they would probably revert to the same procurement practices.
Total	1	1	1	

a/Each suggestion was not made to each shipyard visited.

b/Number of shipyards to which the suggestion(s) apply.

APPENDIX I

APPENDIX II

PRINCIPAL OFFICIALS RESPONSIBLE FOR ADMINISTERING ACTIVITIES DISCUSSED IN THIS REPORT

	Tenure of office	
	From	To
DEPARTMENT OF COMMERCE		
SECRETARY OF COMMERCE:		
Elliot L. Richardson	Feb. 1976	Present
Rogers C. B. Morton	May 1975	Feb. 1976
John K. Tabor (Acting)	Mar. 1975	Apr. 1975
Frederick B. Dent	Feb. 1973	Mar. 1975
ASSISTANT SECRETARY FOR MARITIME AFFAIRS-MARITIME ADMINISTRATOR:		
Robert J. Blackwell	July 1972	Present
Andrew E. Gibson	Mar. 1969	July 1972
DEPARTMENT OF DEFENSE		
SECRETARY OF DEFENSE:		
Donald H. Rumsfeld	Nov. 1975	Present
James H. Schlesinger	June 1973	Nov. 1975
DEPUTY SECRETARY OF DEFENSE:		
Willaim P. Clements	Jan. 1973	Present
Kenneth Rush	Feb. 1972	Jan. 1973
ASSISTANT SECRETARY OF DEFENSE (INSTALLATIONS AND LOGISTICS):		
Frank A. Shrontz	Feb. 1976	Present
John J. Bennett (acting)	Apr. 1975	Jan. 1976
Arthur I. Mendolia	June 1973	Mar. 1975
SECRETARY OF THE NAVY:		
William Middendorf II	Apr. 1974	Present
John W. Warner	Apr. 1972	Apr. 1974