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Infrastructure Study in Shipbuilding: A Systems Analysis of U.S. Commercial Shipbuilding Practices

VA-1

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ABSTRACT

This report documents the results of the first phase of the Infrastructure Study in Shipbuilding (ISIS). The purpose for the first phase was to accurately document the current processes used to build commercial ships in the United States. These results have provided an increased understanding of the commercial shipbuilding process and have also provided a strategic planning tool capable of determining the length of time required to market, design, build and deliver a typical merchant ship in the united states.

The methodology used to document the shipbuilding process was IDEF,. The resulting product was an IDEF,, function model composed of 272 interrelated activities. A subset of seventy of these functions were analyzed with critical path methodology to produce a Gantt chart representing an atypical merchant ship acquisition program. Data was taken from a recently completed merchant ship program and used to establish an overall process duration for these seventy functions.

INTRODUCTION

The Maritime Administration (MARAD) and the Navy realize the importance of providing direction for existing maritime policy and R&D programs if the industry is to become globally competitive. The Infrastructure Study in Shipbuilding (ISIS) was conceived out of a mutually perceived need to create a strategic planning tool that could aid all sectors of the shipbuilding industrial base. ISIS represents a first step towards identifying actions required to help the United States shipbuilding industry become competitive in world markets. It is difficult, however, to formulate such an industrial strategy without a firm understanding of the processes by which commercial ships are marketed, designed, built, and sold in the United States. The objective, therefore, for this initial phase of the project was to develop this understanding and to document it.

This study used a systems approach for analyzing and documenting the current U.S. shipbuilding process. While in the past two decades there have been a multitude of studies aimed at improving and modernizing individual shipbuilding functions, many of which have made significant contributions towards improving productivity, it is not clear that they have improved the industry's ability to produce a ship in a competitive time frame. The individual components have been dissected, analyzed, and improved, but the U.S. shipbuilding industry is still not actively competing in the global market.

The intent of this study is to explore an alternative approach for improving the competitive stance of the industry. This approach is centered on identifying those activities that drive the ship acquisition process from the standpoint of time. The key to reducing costs and gaining market share may lie in shortening or optimizing the overall process duration required to develop, market and manufacture merchant ships.

OVERVIEW OF THE SHIPBUILDING INDUSTRY

The ISIS study chose to define the industry as those shipyards, and the elements of the infrastructure that support them, that are currently capable of constructing large ocean-going ships (400 feet or longer). This definition is a subset of the one employed by the 1982 MARAD-sponsored shipyard mobilization base survey (SYMBA)[1][3][2]. This sector of the industry currently consists of 20 shipyards which is approximately 50% of the number that were in existence in 1982[3]. Employment in this sector has declined from approximately 124,000 shipyard workers in 1982 to under 95,000 in 1990[3]. This segment of the industry currently accounts for 95 % of the industry's total work force[3]. Five of these twenty shipyards account for 95% of the dollar value of all existing naval ship construction contracts[3].

[1] U.S. Dept. of Transportation, Maritime Administration, Washington, D.C.
[2] David Taylor Research Center, Dept. of the Navy, Bethesda, Maryland.
[3] Numbers in brackets designate References at end of paper.

The business base of the remaining shipyards, identified by the SYMBA survey, is shifting towards repair work. The 140 shipyards identified in 1982 by the survey were categorized as follows; 37 were classified as new construction, 49 were full repair, and 54 were limited repair facilities[3]. Repair yards represented 73 % of the shipbuilding industrial base in 1982. There were 116 facilities remaining in 1990 which were categorized as follows; 20 new construction yards and 96 repair yards[3]. Repair yards represented 83 % of the shipbuilding industrial base in 1990. These figures not only represent a 17% decrease in the total number of facilities between 1982 and 1990, but also highlight a demographic shift in the percentage of repair yards within the industrial base.

The industry, as defined by the 116 facilities currently in existence, employs a work force of approximately 100,000 people, of which 90% are directly supported by Navyprograms[3]. This represents aloss of approximately 40,000 shipyard jobs since 1982[3]. Furthermore, it has been estimated that this shipyard work force reduction has resulted in the loss of approximately 100,000 jobs in the industrial sectors of the economy that support shipbuilding[3]. Even under the most optimistic naval ship procurement plan, the Navy has forecast that the industry will suffer additional work force reductions of approximately 20,000 shipyard workers by the end of the decade (reference Figure #1)[3].

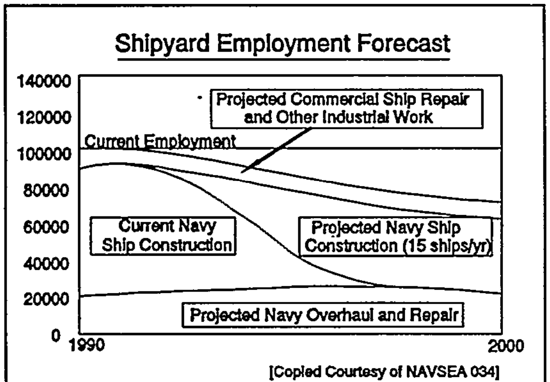

Figure #1 - **NAVSEA Shipyard Employment Forecast**

Industry Role in National Economy

The contribution of shipbuilding to the U.S. economy is relatively minor when compared to the contributions of other manufacturing industries. However, certain industries view shipyards as an important market for their goods and services, and consequently, for employment opportunities. In an economic input-output (I-O) analysis of shipbuilding prepared in 1982 for the Shipbuilders Council of America (SCA) and MARAD by Data Resources Inc., it was projected that by 1987 the industry's impact on the gross national product would be 0.50%[4]. This report went on to describe that out of the 100 industries used by the I-O analysis to represent the national economy, only seven depended upon the shipbuilding market for more than 2% of their total production.

Nevertheless, a revitalized commercial sector of the shipbuilding industry, participating in sales to foreign buyers, could make a substantial contribution to the balance of trade. ISIS estimates show that by capturing 3% of the global shipbuilding market, or an average of 29 merchant ships per year (reference Figure #2), the U.S. industry would generate $18.9 billion in new business (reference Figure #3) by the end of the decade[5][6] This new business could sustain approximately 60,000 jobs within shipyards and their supporting industries (reference Figure #4)[5][6].

AWES* Forecast Calculations

AWES DWT forecast - 378,009,009 dwt by the year 2000.

3% of AWES DWT-11,340,000 DWT-1,134.000DWT/year

Average ship DWT in U.S. flag - Foreign Trade fleet:

143 vessels involved in foreign trade.

Total deadweight - 5,712,OOO.

Average deadweight - 39,944.

Number of ships per year - 1,X34,900 / 39,944 - 29 ships

(* -Association of West European Shlpbuilders)

Figure #2 - ISIS **Analysis of AWES Forecast**

Dollar Value Calculations

The foreign competition is capable of selling a cargo ship with a 36,000 ton displacement for $40,00,000. U.S.

36,000 t = △ - LWT + DWT where: LWT - 1/3 △ - 12,000 t

DWT - 2/3 △ - 24,000 t

$40,000,000. U.S./24,000. DWT-S 1,866.67/DWT

Estimated dollar value of 3% market share over 10 years:

1,134,OOO DWT/yearx$1,667/DWTx 10 years - $18.9 Billion

igure #3 - ISIS Dollar Value Calculations

Job Calculations

The foreign competition Is capable of buikiing a cargo ship with 36,000 ton displacement with 700,000 manhours (MH)*.

36.000t= △ = LWT+ DWT where: LWT - 1/3 △ - 12,000 t

DWT = 2/3 △ = 24,000 t

700,000 MH /24,000 DWT - approx. 30 MH/DWT

Shipyard jobs sustained by 3% of the world market:

30 MH/DWT x 1,134,000 DWT/year - 34,020,000 MH/year

(34,020,000 MH/year) I(1788 MH/manyear**) = 19,242 men

Shipyard labor is approx. I/3 of total labor required":

Total jobs sustained by 3% market share - 3 x 19,242

- approx. 66,060 jobs

• Ref.[6] ** D.0.L Standard *** Ref.[4]

Figure #4 - **ISIS Job Calculations**

Industry Role in National Security

As the Cold War ends, it will be more necessary than ever to maintain a high level of reliable seagoing logistics capability. Until recently, mobilization planning and the requirements for U.S. ships followed some traditional Post-World War II scenarios. These scenarios primarily focused on a conflict between NATO and Warsaw Pact forces being fought on the European continent. They assumed that substantial material would be stockpiled close to the combat zones and that ports and bases would be fully secured prior to the commencement of resupply operations. The duration of any conflict was assumed to be short and attrition of merchant ships, whether from combat casualties or mechanical failures, was treated as a minimal concern. In the framework of this scenario, there was little requirement for shipbuilding within national mobilization plans.

In contrast, current events involving the erosion of the Warsaw Pact as a credible threat, and the anticipated reduction in deployed U.S. forces overseas, have radically changed the logistics picture, particularly with regard to sealift. A Congressional Budget Office (CBO) study in 1984 highlighted the importance of sealift in any extended engagement (reference Figure #5)[7].

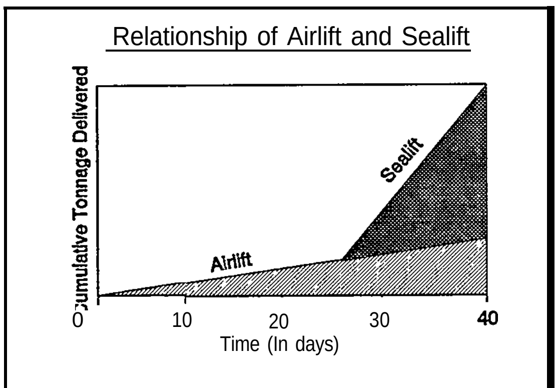

Figure #5 - Congressional Budge Office (CBO) Strategic Lift Assessment (1984

The lessons from operations "Desert Shield" and "Desert Storm", and Great Britain's experience in the Falkland Islands War, suggest that current U.S. sealift assets may not be capable of sustaining forward-deployed forces in the existing threat environment[8][9]. In this new environment, the U.S. is not assured of vast supply stockpiles, nor pre-positioned assets, as was the case in Europe. The U.S. finds itself in a situation of extended and vulnerable supply lines, and its forces completely dependent upon airlift and sealift for re-supply. At a minimum, it is expected that our sealift capabilities including the Military Sealift Command (MSC), Ready Reserve Force (RRF), National Defense Reserve Fleet (NDRF), U.S. Flag merchant fleet, Effective U.S. Control (EUSC) ships and other available tonnage will be re-examined.

Global Market Trends

The shipbuilding industry currently faces major market changes that will have an impact on its future, well into the 21st century. Action is being taken to drastically reduce the government's expenditures for military hardware. A clear result of this will be that the U.S. Navy budget for ship construction will decrease dramatically over the next ten years. Even under the current budget scenario, 95 % of the dollar value of naval ship construction contracts resides in only five shipyards[3]. The budgetary forecast indicates that in the future the Navy will not be able to sustain the industry at its current levels, let alone be the vehicle by which the industry becomes globally competitive. Coupled to this is the fact that the potential for the reemergence of previous forms of government subsidy has been virtually eliminated due to the recent Shipbuilders Council of America trade petition filed with the U.S. International Trade Commission. These factors indicate that the prospects are bleak for government support throughout the 1990s.

The shipbuilding industry can not depend upon the domestic commercial market to fill the void that will be vacated by the Navy. It has been forecast that the domestic market, even with the passage of the 1990 oil spill legislation requiring double-hulled tankers, would at best produce orders for only five to ten ships per year[10]. With the projected naval budget cuts, it will require orders for twenty-five to thirty-five merchant ships per year, by the end of the decade, just to maintain the industrial base at its current level[3]. This means that orders for fifteen to twenty-five ships per year must come from outside the domestic market.

An upswing in global merchant ship construction has been forecast for the 1990s. The number of ships that will be required to maintain the domestic shipbuilding infrastructure translates to three percent of the predicted world market. The definition of the world market used by this study was taken from a forecast prepared by the Association of Western European Shipbuilders (AWES) (reference Figure #6)[5].

Global Trends in Technology

Throughout recent history, most enhancements in shipbuilding and shipping technology have been fairly insignificant. However, there are several events, of revolutionary proportions, that are worth noting:

1) The development and construction of very-large and ultra-large crude oil carriers (VLCCs & ULCCs). This development was in direct response to changes in the distribution patterns of crude petroleum products. This market-driven innovation represented a major shipbuilding accomplishment, and led to a massive restructuring of the global industry. This restructuring was required because of the need to develop new facilities for the construction of these new ships which were much larger than their predecessors.

2) Similarly, although on a much smaller scale, the growing movement of liquified natural gas (LNG) by

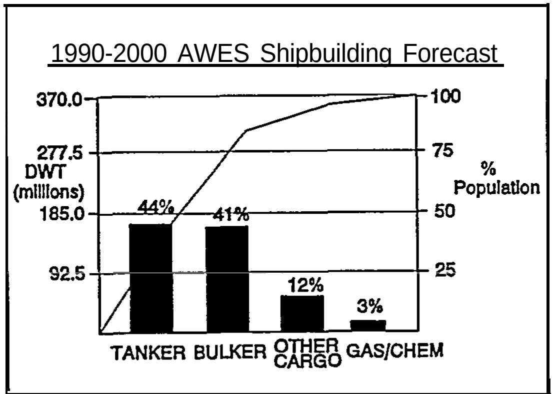

Figure #6 - Product Breakdown of AWES Forecast

ship required the application of complex technology by participating shipyards and precipitated the development of highly-specialized construction facilities.

3) The containerization of liner cargoes had tremendous impact upon the global shipping industry. The effect of this innovation is still being felt today in that it continues to be responsible for the development of cargo handling systems that are evermore intermodal in nature. However, containerization has not had a significant impact on ship construction technology.

At present, new hull forms for improved seakeeping are being developed for application to the passenger market. Other market innovations relate to advanced forms of cargo handling, packaging of goods and ship operations. International awareness of maritime issues concerned with ship safety and environmental protection will be steadily increasing throughout the 1990s. This new emphasis will most likely require technological innovation regarding ship structures and internal arrangements. However, the true extent of these market-driven requirements is, as of yet, unknown.

It should be stated that ship design innovation, however revolutionary, is largely irrelevant to shipbuildiig competitiveness unless it has direct impact upon shipbuilding technology. A case in point, is that the development of VLCCs had tremendous impact upon shipbuilding technology, whereas, containerization had very little effect. Current trends in ship design technology appear to be emphasizing areas that will have little impact upon shipbuilding technology, e.g. smaller crew sizes, increased use of electronics and automation, and improved cargo handling methods. One notable exception is the modularization of passenger and crew accommodation spaces.

The evidence stated above suggests that the solution to the current lack of competitiveness of the U.S. industry lies outside of the realm of new technological breakroughs. The technology trends noted here, although not significant with regards to how the ships of the future will be constructed, will nevertheless, impact heavily upon how these ships are designed and marketed. The process of addressing the market's needs in an economical and timely fashion will become increasingly important. Lessons learned from each of these cases suggests that the industry must become evermore mindful of the future, and what it holds for ships and shipbuilding markets.

ISIS PROJECT DESCRIPTION

The first step in this study was to define the scope. To do that it was first necessary to describe the product, then identify who should be asked to participate in its development, and finally describe analytically all of the activities, and their interrelationships, that contribute to the development of the product. This process led to a definition of the shipbuilding infrastructure that was much broader than that of other recent studies. This expanded view of the industry was necessary to support the study's hypothesis that many of the recognizable problems in U.S. shipyards today originate at an early stage of the ship acquisition process. The ISIS effort has included in its examination industrial segments that heretofore have resided outside the boundaries of studies concerned with analyzing shipyard performance.

For the purpose of this study the shipbuilding infrastructure was defined to include all the participants that are either directly or indirectly involved in the current commercial shipbuilding process. Accordingly, ISIS has defined these participants to include: customer organizations, including shipowner, operator and leasing companies; ship design and systems engineering organizations; classification societies; financial institutions; vendors and subcontractors; government agencies; labor organizations; and education and training institutions. These participants are additional to the shipbuilding facilities and production-oriented engineering organizations traditionally used to define the shipbuilding industry.

This definition was more comprehensive than that found in existing references, but it was necessary in order to accurately model the entire shipbuilding process. Specifically, this definition of the shipbuilding infrastructure includes the customer, i.e. ship owner/operator, not just in his role as a consumer, but as a major player with the capacity to control and dictate the product's development.

This expanded definition also allowed for the examination of activities that precede the actual construction of a commercial ship, such as, the definition of the ship operating requirements, the evolutionary design process, and the development of the business relationship between the buyer (the shipowner) and the seller (the shipbuilder) as defined by the contract document. The contributions of the shipowner in the role of the customer are significant, and were taken into account in our description and modelling of the shipbuilding infrastructure.

The model of the industry's current capability, known as the "As-Is" model, focused on identifying through put inhibitors that encumber the aquisition process.

An analysis of non-subsidized commercial shipbuilding contracts established that the customer's primary objectives are a competitive price and a short construction duration. The customer's concern with quick delivery is primarily financial in nature. The money required to finance the construction of the ship must usually be borrowed on the open market.

Due to intense competition for available capital and the perception of risk on the part of the lender, ship financing packages usually have interest rates and terms that place a considerable burden upon the borrower. Every month that a ship remains under construction in a shipyard is another month that the owner must make the loan payment out of his own financial reserves. As a result, owners are under considerable financial pressure to get their ships operating and earning revenue as quickly as possible. This circumstance places a great deal of emphasis upon the length of time required to construct the ship. This study has attempted to address this concern via the creation and examination of a ship construction timeline. This timeline was based upon a recently completed U.S. merchant shipbuilding contract and utiliied the ship acquisition functions identified by the IDEF, model.

Analysis of the shipbuilding infrastructure required a systems approach that could capture the complex logic and interrelationships among the various process activities, and also identify the influences of constraints that reside outside of the process flow. The method that was selected to accomplish this task was the ICAM Definition language, or IDEF. The origin of this methodology can be traced backed to the Structured Analysis and Design Technique (SADT) developed during the 196Os[ll]. These initial roots evolved into IDEF during the 1970s as a result of the Integrated Computer Aided Manufacturing (ICAM) program sponsored by the United States Air Force[12]. The purpose of this new approach was to create a series of process models that would determine where changes, within a particular manufacturing process, would result in improved productivity.

IDEF methodology is used to gain an understanding of the present condition of the system being scrutinized ("As-Is"). This understanding is achieved through the creation of a structured functional model that identifies activities and how they relate to one another. IDEF comprises three modelling methodologies which characterize the manufacturing process:

1) $IDEF_0$ is used to produce a "functional model", which is a structured representation of the functions of a system and of the information and objects which interrelate those functions.

2) $IDEF_1$ is used to produce an "information model" which represents the structure and semantics of information within the system.

3) $IDEF_2$ is used to produce a dynamic model which represents the time varying behavior of the process being analyzed.

IDEF consists of techniques for performing a systematic analysis of a process or series of integrated processes, and a graphical language for applying these techniques to produce function diagrams. IDEF diagrams are accompanied by text diagrams, which explain unique features of each individual graphic diagram, and a glossary which defines every term used in generating the graphical diagrams. The glossary acts as a project dictionary.

Only $IDEF_0$ was used during the course of the ISIS project. $IDEF_0$ models use as their building blocks individual functions, which are actions that have at least one input and one output. Functions transform their inputs into outputs by employing mechanisms (resources unchanged by the performance of the function), that are subject to certain constraints (rules, laws and basic business practices unchanged by the performance of the function) known as controls (reference Figure #7).

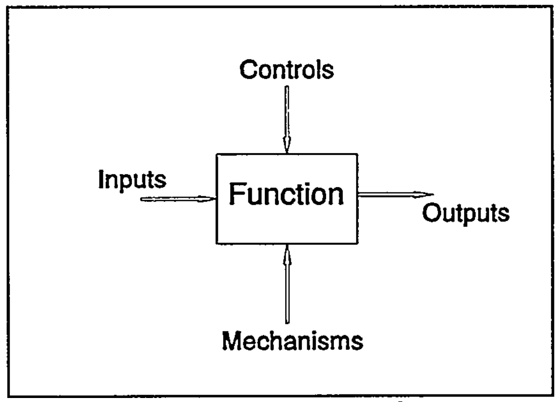

Figure #7 - Basic IDEF Mechanics

In parallel with the IDEF, modelling effort, the ISIS team conducted a series of structured interviews with industry representatives. These interviews were intended to validate the analytic results of the IDEF modelling work, and provide expert testimony on the current state of the industry. A representative cross section of the shipbuilding infrastructure was contacted by letter to verify their willingness to participate in the project. Out of the respondents to this letter twenty-five candidates were selected. These candidates consisted of: ship designers (4); government agencies (4); equipment vendors (4); shipowners (4); shipbuilders (3); universities (3); regulatory agencies (2); and trade organizations (1). Information generated by these interviews was factored directly into the IDEF process model wherever possible. Financial institutions, maritime lawyers and organized labor unions were not included in this initial batch of interviews due to a lack of project resources. However, their input will be sought in the future.

Validation of the IDEF model was an important element of the project. An independent review of the entire model was made by each ISIS team member. After the review was completed, the model was applied to a recently completed ship construction project. The chosen vessel was the lead-ship of a series of products carriers built in the United States. Information and compliance were sought and provided by both the owner and the builder of this ship. The functional breakdown of the ship construction process identified by the IDEF model was used to develop an acquisition timeline for this products carrier. This timeline was analyzed by Critical Path Methodology (CPM). A series of network diagrams and a Gantt chart were constructed for this products carrier using activities identified by the IDEF, model. The final step in the validation process was the review of the text report, IDEF model documentation, and the process timeline by the twenty-five industrial constituents interviewed by the project team.

IDEF models are hierarchial, and constructed from the top down, with each activity at one level decomposed in more detail at the next subsequent level. This process allows for each activity to be analyzed in progressively greater detail until some appropriate limit is reached. The limit which was arbitrarily set by the ISIS team at the onset of the modelling effort was to break the ship acquisition process down into approximately two hundred functions. This level of decomposition was seen as giving the project team a good initial understanding of the entire process, and allowed the team to plan for termination of the project within the recognized time constraint of nine months.

At the highest summary level of the model, the ISIS team examined the function entitled, "Produce a Merchant Ship" (reference Figure #8).

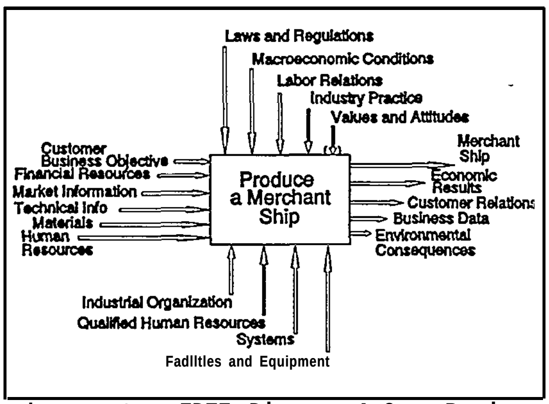

Figure #8 - IDEF Diagram A-O - Produce a Merchant Ship

This top level function was decomposed into three distinct sub-functions:

1) "Develop a Ship Concept" - the activities associated with market analysis, customer requirements, concept design and preliminary design.

2) "Secure a Contract" - the development of a contract package, including contract plans and specifications, acquisition of capital financing, and the selection of a shipyard.

3) "Build and Deliver a Ship" - the detail design, material procurement, construction, testing, trials, and delivery of a merchant ship.

Each function together with its inputs, outputs, mechanisms and controls were documented in standard IDEF format down to a fourth level of decomposition. This fourth level of decomposition resulted in the identification of two-hundred and seventy-two total functions. The following section of the report discusses fifteen of the highest level functions. These functions are used to describe the entire ship acquisition process as defined by ISIS.

CURRENT SHIPBUILDING PRACTICE

This section of the report describes those functions identified in the $IDEF_0$ "As-Is" model, at the first and second levels of decomposition. These levels of decomposition define the ship acquisition process in terms of fifteen distinct functions. Each function is discussed in some detail and commentary supporting the existence and structure of each function has been provided.

Develop a Ship Concept

The "Develop a Ship Concept" portion of the model describes the processes that are used to perform an analysis of shipping transportation markets and translate this information into a set of ship requirements (reference Figure #9).

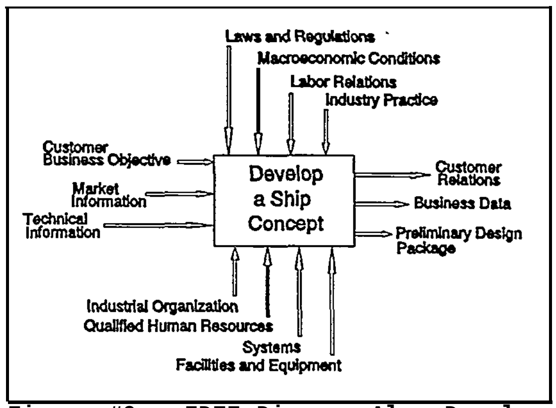

Figure #9 - IDEF Diagram Al - Develop a Ship concept

These requirements are then used as a basis for the performance of both a conceptual and preliminary ship design, that establish the physical characteristics of a ship.

The process described here involves three distinct activities: 1) the identification of shipping opportunities; 2) the execution of a concept design that establishes the technical feasibility for developing a ship system that responds to the identified market opportunities; and 3) the preparation of a preliminary design that establishes the basic ship characteristics and the economic viability of different ship system alternatives.

The purpose of the "Determine Shipping Opportunities" function is to establish the need for new commercial merchant ships (reference Figure #10).

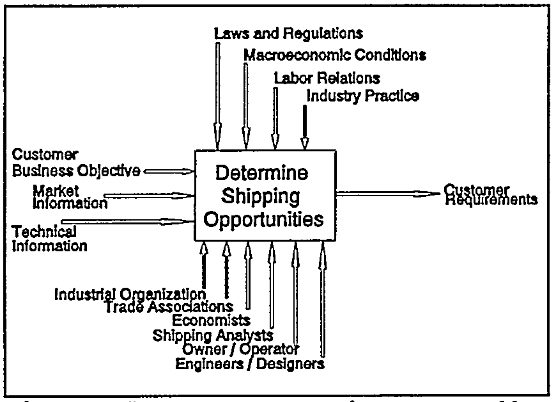

Figure #10 - IDEF Diagram All - Determine **Shipping Opportunities**

The first step is to analyze global transportation markets by studying forecasts of global waterborne cargo movements, existing merchant fleet capacity, fleet demographics and fleet economics. Market sectors are identified where the need for either new tonnage or replacement tonnage can be justified. The need for new tonnage is shown by a clear cut differential between the cargo hauling forecast and the fleet's available capacity. However, this same approach can also be used to justify whether existing tonnage should be replaced. This determination is generally supported by some form of market analysis, focused on a specific business opportunity. The requirement for replacement tonnage can usually be justified on a basis of either improved economics (lower operating costs, improved cargo hauling efficiency), or improved service to the customer (better intermodal connections, improved schedule performance, shorter shipping times).

The potential shipowner will compare his ship system concept against alternative transportation systems to determine if a ship will be preferable to either existing or planned forms of alternative service. The customer then determines how much he can afford to invest to address the market sector he has identified. The shipowner finally encapsulates this information into a set of customer requirements.

Market analysis at present is usually performed within a customer organization, and the results are not normally revealed to other participants in the ship acquisition process. Similarly, initial product development is usually performed by a team consisting of members from the customer's staff and contracted engineering firms. Shipyards, by not being involved in the market analysis or product development, cannot be proactive in executing aggressive marketing strategies or influencing aspects of the product's design that control its producibility[l3]. U.S. shipyards have historically been excluded from the very activities that would allow them to develop the means for analyzing world markets and developing products that could be marketed directly to potential customers. As a result of this, U.S. shipyards, in many cases, find themselves waiting for customers to initiate the process.

The second function under the "Develop a Ship Concept" heading is "Perform Concept Design". Concept design is the first step in the design process; its purpose is to translate a set of mission requirements into the approximate physical characteristics of a ship (reference Figure #l 1).

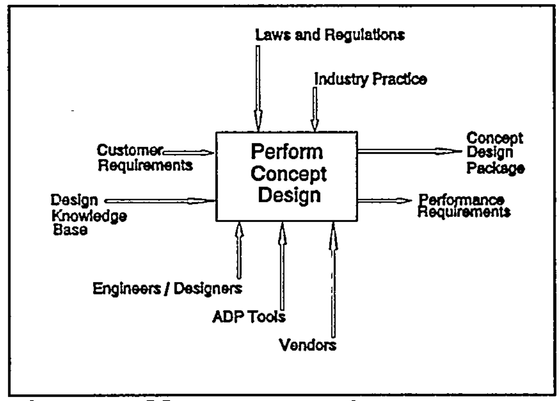

Figure #ll - IDEF Diagram A12 - Perform Concept Design

Concept design constitutes technical feasibility studies to establish one or more sets of ship characteristics, all of which meet the required speed, range, cargo cubic, and deadweight requirements defined by the customer. The concept design process also includes preliminary lightship weight estimates derived from empirical formulas, curves or experience. Variations in design configuration are generally analyzed in parametric studies during this phase to determine the most economical design solution. The selected concept design is then used for obtaining approximate construction costs, which often determine whether or not to initiate the next level of development, preliminary design.

The process of concept design encompasses several distinct activities: 1) empirical studies provide a quick and reliable starting point for the ensuing ship design. These studies generate an initial set of ship characteristics from existing curves, tables, algorithms, ship hull design series and technical databases; 2) parametric studies, include systematic analyses that are used to derive a set of optimum ship parameters that describe the ship's principal dimensions; 3) an approximate estimate of the ship construction cost consists of material, labor and overhead components; and 4) the finalization of the customer's requirements. Throughout this entire process, the results are compared against the customer's requirements and may call for changes to the existing requirements. However, if the proposed changes to the requirements are deemed as being too great it may be necessary to reiterate portions of the concept design process.

Any design process, particularly ship design, is a complex activity trying to satisfy many technical and economic requirements that are quite often conflicting in nature. At the initial stage of design, certain assumptions must be made regarding the behavior of the ship. These assumptions must be confirmed later as the design matures. Ship design is, therefore, an iterative process, proceeding from the early conceptual design through successively more detailed steps. The free and unencumbered flow of information throughout this process is vital to achieving the desired result.

The final function under this heading is "Perform Preliminary Design". Preliminary design involves the development and refinement of the principal characteristics of a ship with greater precision than that required during the concept design stage (reference Figure #12).

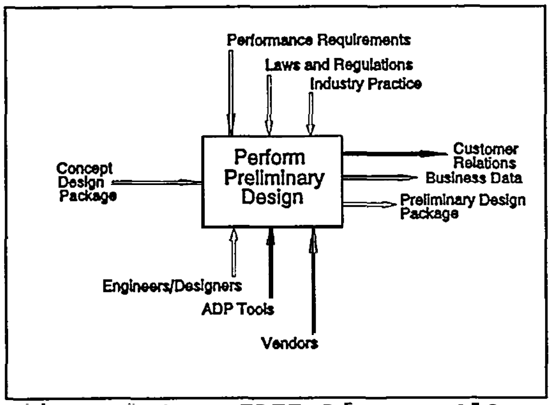

Figure #12 - IDEF Diagram A13
Perform Preliminary Design

These characteristics include principal ship dimensions, selection of hull form parameters, determination of the size and type of propulsion plant, development of a general arrangement and the hull's structural configuration. This design solution must *continue to* satisfy customer requirements such as deadweight, service speed, etc. In some cases, model testing may be required to substantiate the preliminary design results.

The process of preliminary design contains several individual steps: 1) a review of the concept design package, to verify that the owner's requirements have been properly translated into a ship definition that will serve as a starting point for the preliminary design; 2) a definition of ship geometry that involves the development of ship lines, capacity plans, hydrostatics, and trim and stability characteristics; 3) a definition of ship structure that involves the determination of preliminary scanding plans, computation of weights, and corresponding structural loads, 4) an estimate of the power requirements for the selected hull form; 5) the development of the general arrangement; and 6) the preparation of the preliminary design package.

This entire process is iterative. The preliminary design package should reflect the economic viabiity of the design, as well as the necessary technical considerations. The customer's concurrence with the preliminary design package is implied. The preliminary design process is generally self-contained and is not a highly visible component of the overall design process. The results of not having this early design work disseminated to all potential participants in the ship acquisition process have never been quantified. However, it is felt that this early lack of communication can only have a negative affect on the subsequent tasks within the process.

Secure a Contract

This second portion of the model describes the processes that translate the preliminary design package, which identifies a potentially profitable ship system, into a contract design from which a contract can be created and executed for the construction of a merchant ship (reference Figure #13).

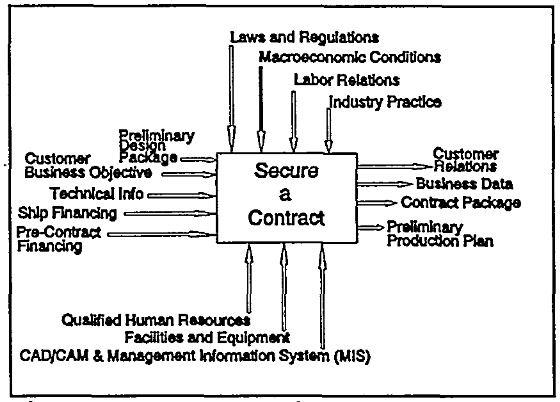

Figure #13 - IDEF Diagram A2 - Secure a Contract

The process of securing a contract involves rive separate activities: 1) contract design, which defines the ship to be built in sufficient detail to allow the award of a construction contract; 2) the preparation of a solicitation package by the customer; 3) the arrangement of financing in support of the ship construction program; 4) the response of the shipyard(s) to the customer's solicitation; and 5) the selection of a shipyard and award of a contract.

The first function under this heading is "Perform Contract Design" (reference Figure #14).

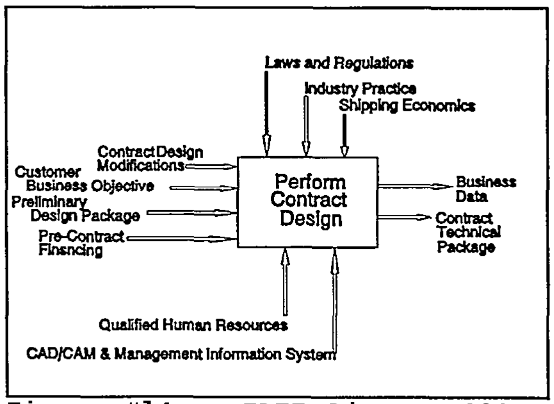

Figure #14 - IDEF Diagram A21 - Perform Contract Design

The contract design, i.e., the design of a ship in sufficient detail to support the award of a construction contract, is customarily performed in the U.S. by an independent naval architectural firm, that has been retained by the customer. This arrangement has made contract design, along with its related deliverables, relatively independent and self-contained. The contract design process is comprised of four major activities: 1) performance of system studies; 2) the preparation of a contract technical package; 3) the obtainment of preliminary regulatory approvals; and 4) a management activity which involves the planning, resource allocation, performance measurement and reporting steps that are generally associated with managing a ship design effort.

A naval architectural firm is normally used to develop the contract design in accordance with the requirements of the customer. As a result, shipyard contributions with respect to producibility or sources of supply are not, in most cases, solicited or incorporated into the design at this stage. This omission tends to make the resulting ship design more expensive, and less widely applicable to the needs of other domestic or international customers.

The second function under this heading is "Prepare Solicitation Package". This function represents the process that the customer uses to initiate communications with one or more shipyards, and their suppliers, for the purpose of eliciting proposals based upon the completed contract design (reference Figure #15).

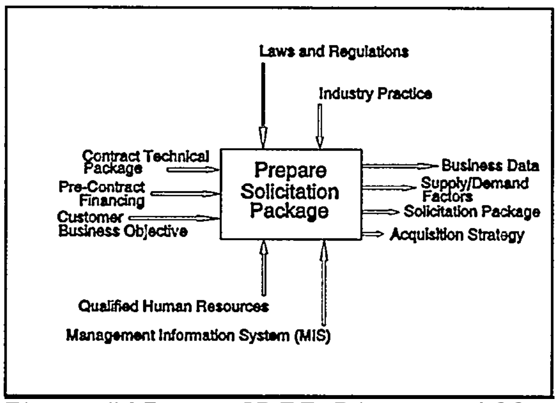

Figure #15 - IDEF Diagram A22 - Prepare Solicitation Package

It is, therefore, necessary to include in the solicitation a technical description of the ship that is as complete as possible at the time the solicitation is let. The following activities are performed by this function: 1) an assessment by the customer of the shipbuilding market resulting in the creation of a set of terms and conditions to be incorporated into the construction contract; 2) the assembly of a solicitation package; 3) the preparation of a bidders list; 4) the distribution of the solicitation among those organizations identified on the bidders list; and 5) the management of the solicitation process.

It is customary for the shipowner's staff to be heavily involved in this function. Shipowners have in the recent past exhibited very little confidence in the level of understanding that U.S. shipbuilding organizations have with regards to ship operations. As a fail-safe measure some of these organizations maintain sizeable technical staffs to insure that this knowledge is incorporated into the acquisition process. The existence of a solicitation package, and the implication that bids are solicited by a customer from more than one shipyard, is indicative of the problem that U.S. shipyards face regarding their product development and marketing strategies. Elsewhere in the world, shipyards have become far more active in defining markets and products; in comparison, U.S. yards have come to employ a more reactive approach.

"Arrange Financing" is the third function under this heading. This function involves the process of obtaining the necessary financing to enter into a construction contract with a shipyard (reference Figure #16.

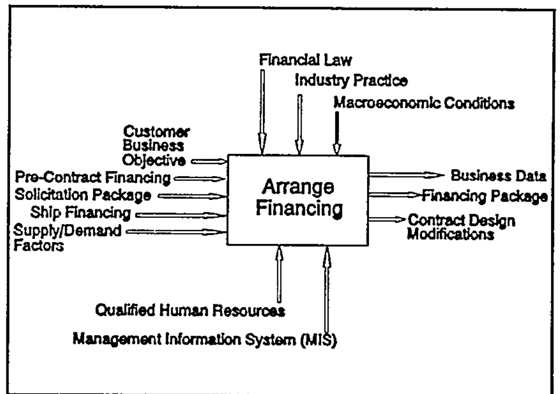

Figure #16 - IDEF Diagram A23 - Arrange Financing

The need for this activity arises from the fact that customers, in general, do not have the financial resources available to invest in a major asset such as a ship, and must rely on existing forms of debt financing. The use of highly-leveraged debt financing is most attractive to operators and their creditors, especially when government loan guarantees are available. This series of circumstances has created a relatively aggressive market for the creation of new financing instruments for ships within both the financial and ship operations communities.

The principal activities accomplished by this function are: 1) an independent assessment of the financial viability of the project; 2) an identification of potential sources of capital; 3) the creation of a capital-borrowing structure; and 4) the attainment of firm commitments from each source of capital. Financing as perceived in this model involves a set of negotiations between the shipowner and the financial institution of his choice.

This is the point within the acquisition process where the economics of shipbuilding intersect with those of the global financial community. U.S. shipyards have not recently been involved, to any great extent, in the financial arrangements supporting the sale of their products. This is in direct contrast to their foreign competitors, who are accustomed to arranging financing for their customers[14]. Obviously, government policies, particularly those involving taxation, supports, and subsidies have a signiticant impact[15]. Much work needs to be done in determining a sound methodology for creating financial packages for merchant ships in the United States. Once the process is understood and clarified the government could be used to help facilitate the policy changes that would be required to make the process attractive to potential customers.

The fourth function in this progression is “Prepare Shipyard Response”. This function describes the process by which a shipyard will respond to the solicitation distributed by the customer (reference Figure #17).

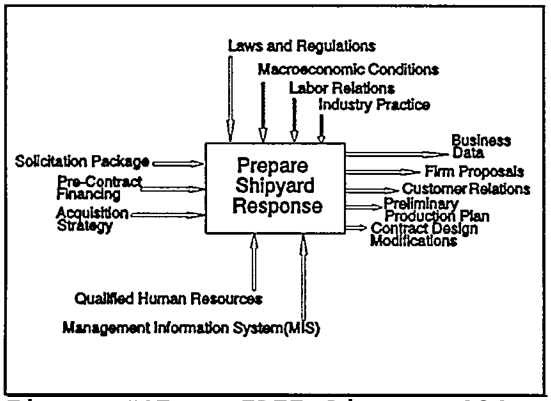

Figure #17 - IDEF Diagram A24 - Prepare Shipyard Response

The following activities are included under this function: 1) a shipyard analysis of the solicitation requirements; 2) the preparation of a cost estimate; 3) the preparation of a formal response to the solicitation; 4) preliminary discussions between the customer and each responding shipyard; and 5) an overall proposal management activity.

The process described here is less formal than that employed by the Government, but is nonetheless competitive. Customers develop preferences for shipyards over time (hence the importance of customer relations). But as in any profit-driven enterprise, customers always seek to lower both investment and operating costs wherever possible.

The fifth and final function under this heading is “Select a Shipyard’. This function involves the steps taken by the customer to select a shipyard, once preliminary discussions with one or more of these yards have yielded a set of firm offers (reference Figure #18).

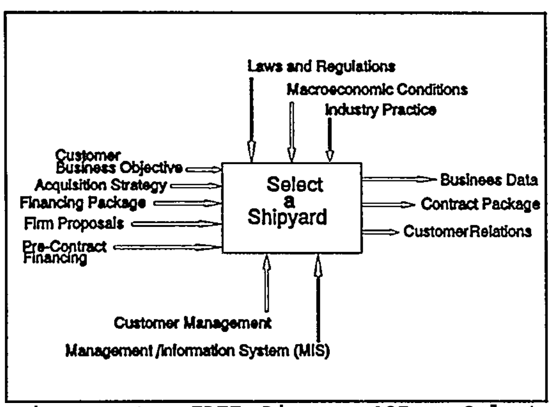

Figure #18 - IDEF Diagram A25 - Select a shipyard

These steps include: 1) the establishment of selection criteria; 2) the evaluation and ranking of each shipyard proposal; 3) final negotiations with the highest ranking shipyard; and 4) the management of the selection process by the shipowner in accordance with his own cost and schedule requirements.

This task assumes some flexibility in the evaluation process. Where shipyards are offering to construct the ship as described in the original solicitation, the selection criteria will involve primarily price and delivery, with some consideration of quality, prior performance, customer relations, etc. However, the process as described allows for each offerer to submit a modified design or approach that they feel is superior to the one that was described in the solicitation package. This added degree of freedom in the proposal process will require the customer to evaluate the benefits of each design variation on a separate and perhaps unique basis.

Build and Deliver a Ship

This third and final group of functions describes the process whereby a shipyard and its suppliers construct and deliver a ship (reference Figure #19).

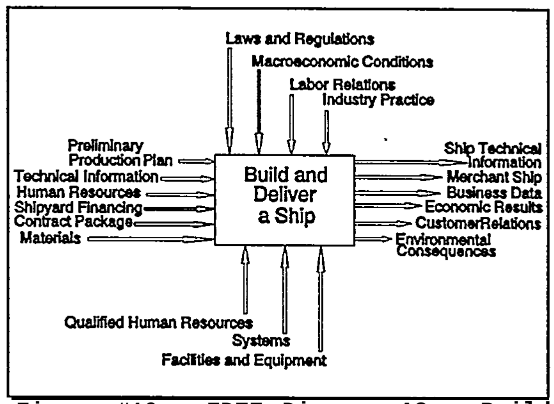

Figure #19 - IDEF Diagram A3 - Build and Deliver a ship

This portion of the procurement process starts with the execution of the construction contract and concludes with the delivery of the ship to the customer. In contrast to the preceding activities, the shipyard is primarily in control of this stage of the acquisition process. In addition, considerable contributions to this portion of the process emanate from supplier and vendor organizations. Construction and delivery of a ship involves four major functions: 1) management of the overall shipyard operation; 2) preparation of a detail design; 3) the procurement of all material and equipment that will be consumed or installed on the ship; and 4) the fabrication, assembly and testing of the ship.

Even though vendors and suppliers are usually subcontracted by the shipyard, and are therefore subject to the shipyard’s project management, they must still be given ample representation within the process model. This is justified due to the critical impact that material availability has on the entire construction process. In some situations, the supply of outside components and labor is so significant that it shifts the shipbuilding emphasis from that of being a fabricator to that of being an assembler.

The first function under this group is “Manage Construction Operations”. This function describes the management process associated with the execution of a shipbuilding contract, and reflects the observation that program planning is a relatively centraliied process within the shipyard (reference Figure #20).

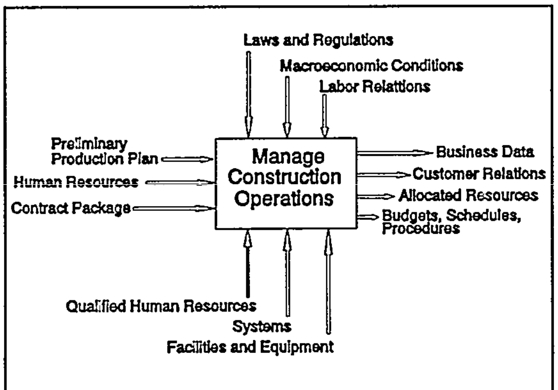

Figure #20 - IDEF Diagram A31 - Manage Construction operations

The following management activities are performed under this function: 1) contract administration, which includes three separate sub-functions: a) the overall process of management control implied through the adherence to the shipbuilding contract; b) the definition of specific requirements placed upon the shipyard organization by the contract; c) the maintenance of customer relationships throughout the contract period and beyond; 2) the identification of resource requirements; 3) preparation and maintenance of Program schedules; and 4) preparation and implementation of required procedures.

The shipyard management and planning activities for a specific contract are relatively centralized, although shop planning activities do introduce some decentralized planning functions. This series **of** tasks also describes the way in which human resources are employed within the industry. Specifically, there exists a small management cadre, and a large blue-collar construction work force. The blue-collar work force’s strength lies in its job experience. In recent years, it has been increasingly difficult to retain, find, or replace highly-skilled workers who are leaving the industry through all of the normal channels of attrition. Training programs within the industry have not kept pace with the recent demographic changes within the work force [16]. There is a need for innovative human resource development strategies that will improve both white-collar and blue-collar productivity [16].

The second function under this heading is “Develop Detail Design”. Detail design is intended to accomplish a number of goals including precise definition of the ship configuration, definition of all material requirements, and the preparation of manufacturing-support information. In addition, specific information derived during the detail design is provided to the customer for his use in connection with the operation and maintenance of the ship (reference Figure #21).

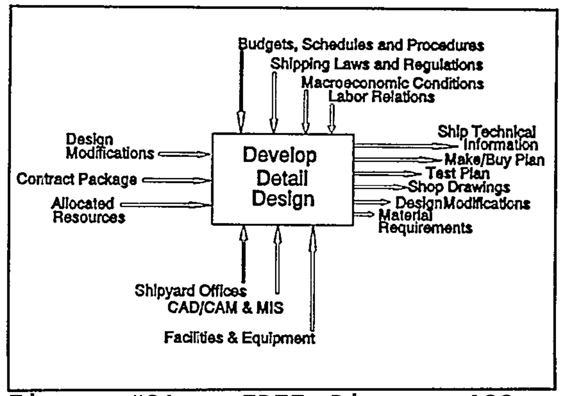

Figure #21 - IDEF Diagram A32 - Develop Detail Design

These goals are reflected in the following activities that comprise detail design: 1) final definition of the ship as a system; 2) design of ship systems and components; 3) approval of the design; 4) development of a production approach; and 5) Preparation of shop drawings.

While the detail design process is important to a successful shipbuildmg program, it has a serious defect: it is effectively isolated from the earlier design efforts. As a result of this isolation, the detail design is executed without access to earlier design products, which can result in additional, and sometimes redundant, design effort. In addition, the detail design tends to be conservative, since innovation is not encouraged at this advanced stage of the design process. If the detail design is performed by an engineering firm outside of the shipyard, another problem can emerge. In this situation, the detail design can proceed independent of the shipyard’s production approach, thereby resulting in a lack of integration into the design of producibility considerations unique to the shipyard and its manufacturing processes. This can severely effect the yard’s ability to deliver the vessel on-time.

The third function under this heading is “Procure Material”. This function describes the process of acquiring all of the material and equipment required to construct and outfit the ship (reference Figure #22).

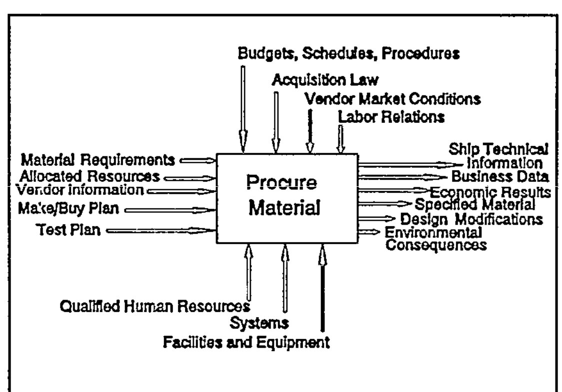

Figure #22 - IDEF Diagram **A33 - Procure Material**

This is a broad-ranging definition, in that the production work performed by supplier organizations has also been included within the process model structure. There are four parts to this function: 1) the definition of procurement requirements; 2) the preparation and issuance of purchase orders; 3) the execution of the purchase orders by the suppliers; and 4) the inspection and storage of the received material within the shipyard, and its release to production.

The U.S. shipbuilding industry's approach to the selection of vendors and subcontractors is constrained by two competing forces. On the one hand, politics encourage shipyards to buy material and components locally, and normally they are happy to do this, except for major cost items. On the other hand, the industry has been forced by the government, in certain cases, to select only domestic sources of equipment on a cost competitive basis. These two concepts of "Buy American" and lowest "qualified" bidder have severely inhibited the industry's ability to develop long-term sources of supply. Vendor-related delays that can result from inconsistent use of vendors have the potential to severely affect the construction duration. However, it would require considerable further study to substantiate this hypothesis.

The decline in world shipbuilding output over the past ten years has been accompanied by a related decline in the number of suppliers capable of furnishing marine equipment and material. This market-driven reality has made it more difficult to acquire needed material in a timely and economic fashion. However, this problem is not solely an American problem, as it is currently shared among all of the major shipbuilding nations. Lessons can be learned from our foreign competition regarding the development of efficient supplier networks. In an environment of reduced availability, it will become increasingly important to take a global approach towards the problems associated with material procurement[17]

The fourth and final function under this heading is "Produce Ship" (reference Figure #23).

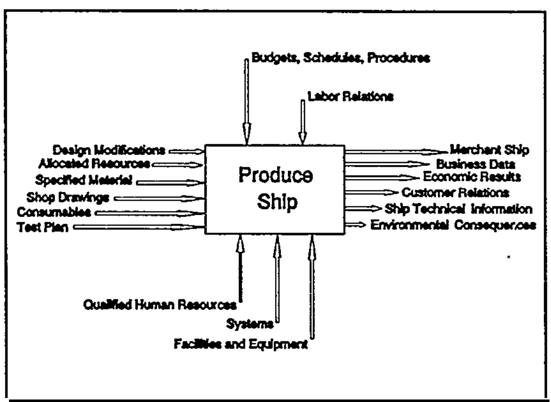

Figure #23 - **IDEF Diagram A34 - Produce Ship**

The following steps have been included under this function: 1) shop planning; 2) fabrication of parts; 3) hull erection; and 4) final outfit installation and testing. This includes all post-launch outfitting and testing activities. These tasks terminate with the delivery of the completed ship to the customer.

The process described here assumes that all production work, including fabrication, installation and testing is performed by a single shipyard. This is an approach that has been customarily employed by the U.S. shipbuilding industry. However, the benefits of large-scale subcontracting among shipyards offers an opportunity to achieve significant reductions in contract duration. There is a subsequent requirement for an increased planning and control effort to facilitate an increased level of off-site manufacturing. The trade-offs and merits of expanding current shipbuilding subcontracting practices need to be examined in greater detail. In addition, the degree of integration between material specification, material procurement, shop drawing preparation, and shop planning activities is worthy of further examination.

TIMELINE DEVELOPMENT & CRITICAL PATH ANALYSIS

There were several project-related reasons for developing a timeline. The IDEF methodology does not establish predecessor or successor relationships between activities. Its main purpose is to identify activities and the critical information, resources and constraints necessary to perform these activities. However, project-related reasons made it necessary to interrelate these activities on the basis of time so an analysis of the overall process duration could be made.

The project team needed a medium that could communicate the results of the project to an audience that did not necessarily possess a working knowledge of the IDEF methodology. Since most ship construction projects in the U.S. employ some form of Critical Path Methodology (CPM) when developing their engineering and production schedules it was decided that the timeline should be constructed using this methodology[18]. The Gantt chart resulting from the critical path method analysis (reference Figure #24) is supported by CPM network diagrams showing the interdependencies between the activities (reference Figures #25-#27)[19]. Analysis of these activities has identified several areas where the consumption of time appears to be a problem.

The "As-Is" model's third level of decomposition was selected for analysis. This was the level of detail selected for representation in the Gantt chart referenced above. This level of detail represented seventy activities. There was a desire to have a compact mechanism for presenting the initial results of the ISIS project. This desire became the overriding consideration in the selection of the number of activities to include in the process timeline. A quantity of seventy activities seemed realistic when based upon the available ship production information. Secondly, for purposes of comparison with foreign shipbuilders and other domestic manufacturers this number of functions was viewed as being supportable.

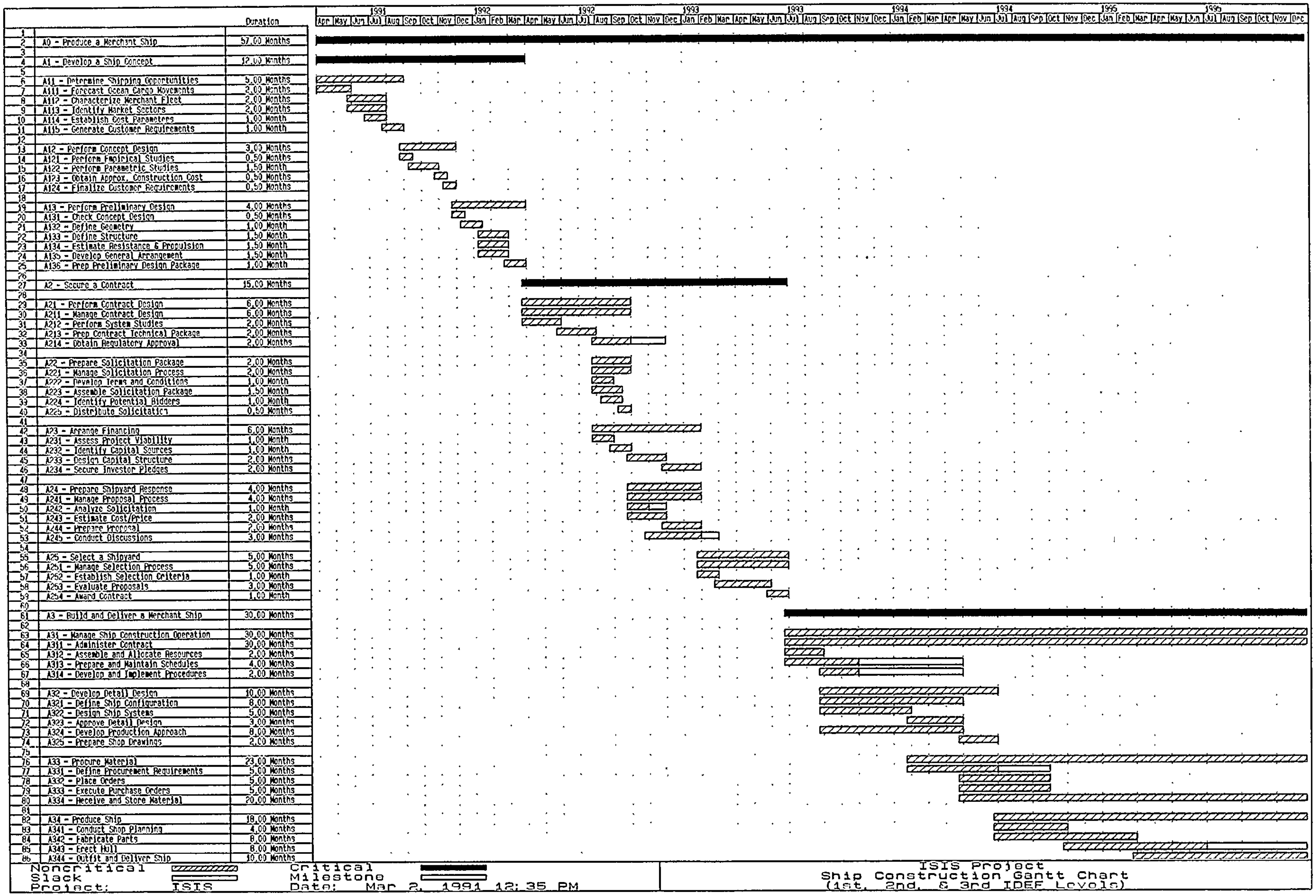

Figure #24 - Gantt Chart (1st. 2nd. & 3rd IDEF Levels)

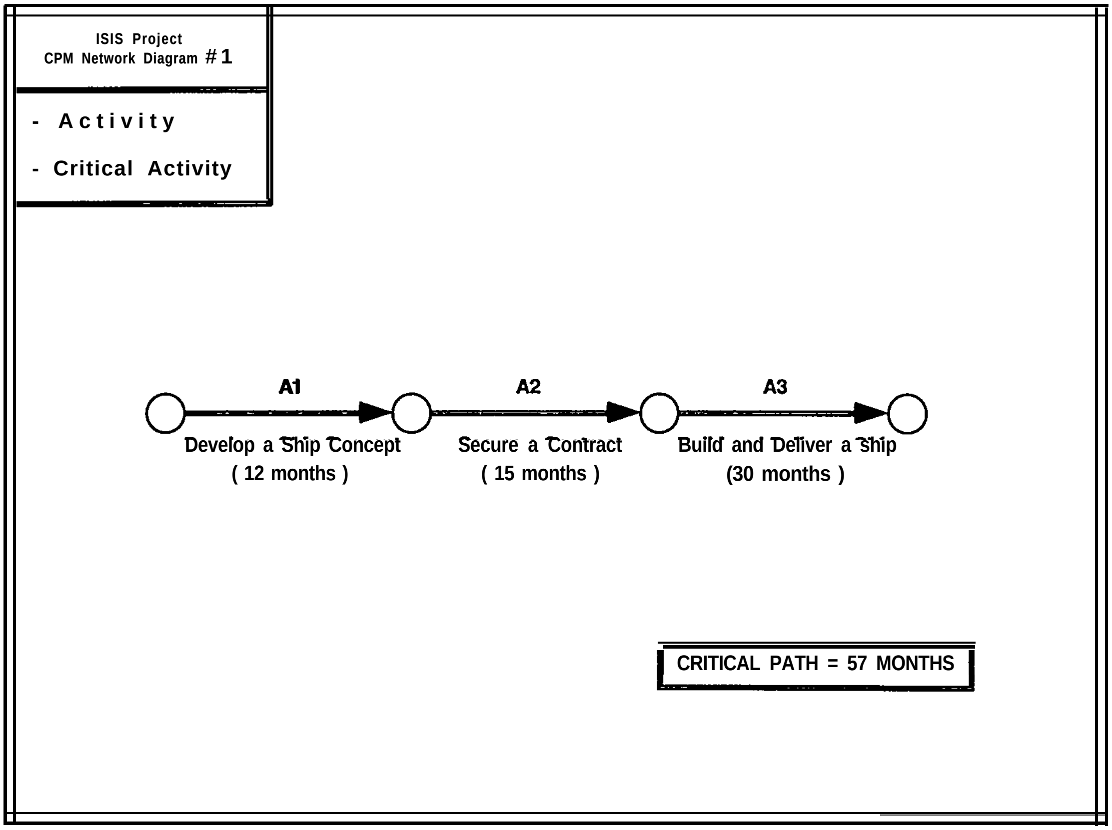

Figure #25 - CPM Network Diagram #1 (1st IDEF Level)

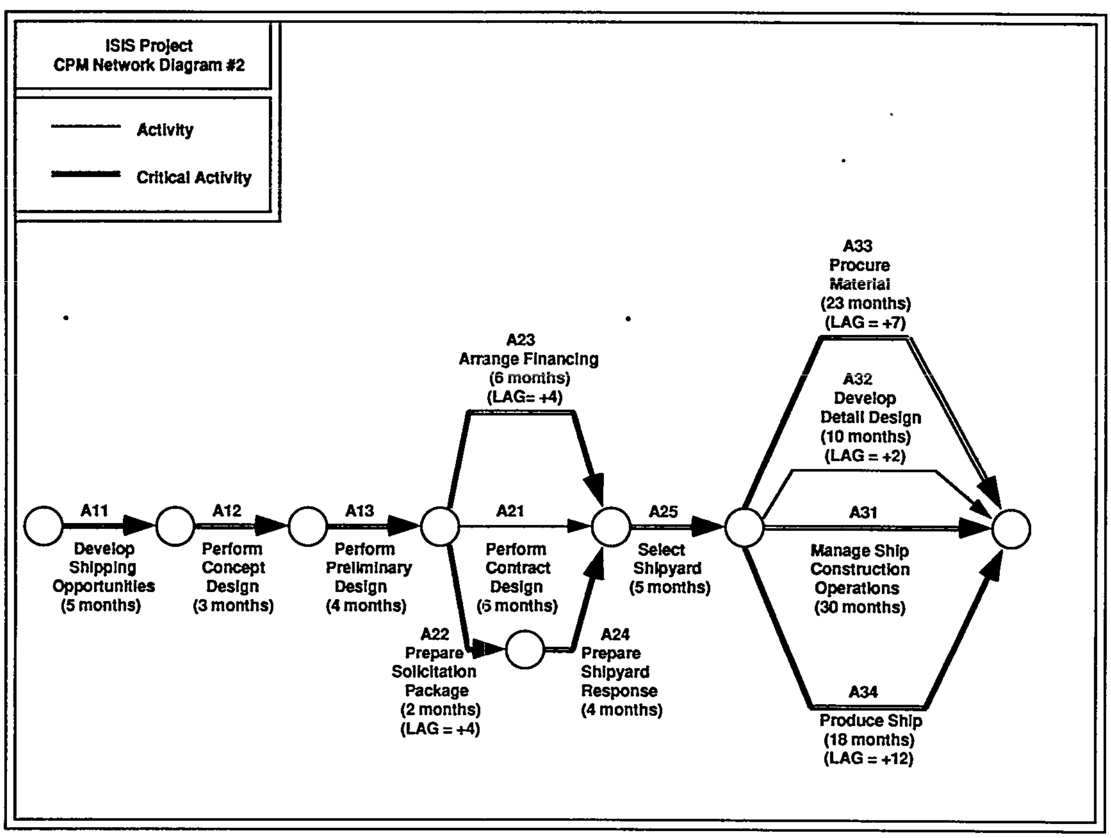

Figure #26 - CPM Network Diagram #2 (2nd IDEF Level)

ISIS Project
CPM Network Diagram #3

- Activity
----- Dummy Activity
- Critical Activity
MAC - Months After Contract
N/S - Not Shown

A111 Forecast Ocean Cargo Movements
A112 Chacterize Merchant Fleet
A113 Identify Market Sectors
A114 Estsbllsh Cost Parameters
A115 Generate Customer Requirements
A121 Perform Empirical Studies
A122 Perform Parametrlc Studies
A123 Obtain Approximate Construction Cost
A124 Finalize Customer Requirements
A131 Check Concept Design
A132 Define Geometry
A133 Define Structure
A134 Estimate Resistance & Propulsion
A135 Develop General Arrangement
A136 Prepare Preliminary Design Package

A211 Manage Contract Deslgn (N/S)
A212 Perform System Studies
A213 Prepare Contract Technical Package
A214 Obtain Regulatory Approval
A221 Manage Solicitatlon Process (N/S)
A222 Develop Terms and Conditions
A223 Assemble Sollcitation Package
A224 Identify Patential Bidders
A225 Distribute Solicitation
A231 Assess Project Viability
A232 Identify Capital Sources
A233 Design Capital Structure
A234 Secure Investor Pledges
A241 Manage Proposal Process (N/S)
A242 Analyze Solicitation
A243 Estimate Cost/Price
A244 Prepare Proposal
A245 Conduct Discussions
A251 Manage Selection Process (N/S)
A252 Establish Selectlon Criteria
A253 Evaluate Proposals
A254 Award Contract

A311 Administer Contract (N/S)
A312 Assemble and Allocate Resources
A313 Prepare and Maintain Schedules
A314 Develop and Implement Procedures
A321 Define Ship Configuration
A322 Deslgn Ship Systems
A323 Approve Detail Design
A324 Develop Production Approach
A325 Prepare Shop Drawings
A331 Deflne Procurement Requirements
A332 Place Orders
A333 Execute Purchase Orders
A334 Receive and Store Material
A341 Conduct Shop Planning
A342 Fabricate Parts
A343 Erect Hull
A344 Outflt and Deliver Ship

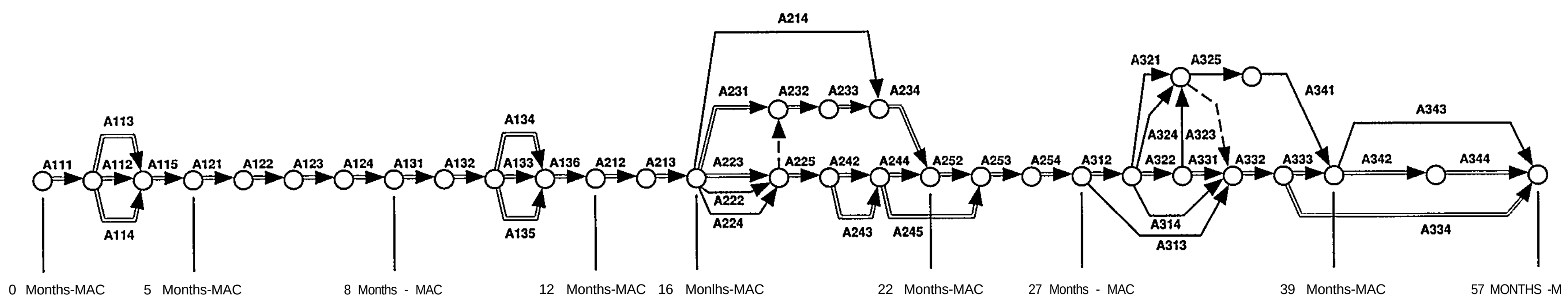

Figure #27 - CPM Network Diagram #3 (3rd IDEF Level)

The validation of the IDEF model required a recently completed ship construction project. This project had to satisfy some basic criteria. The ship had to have been constructed in the United States. The project had to have been completed within the last ten years. The ship was to have been built for a private customer, and financed with a minimum of government involvement. Finally, if possible, the ship should have been constructed for international trade.

The project team was able to obtain information about a ship construction program that met all of the above criteria, except for the international trading requirement. Information was obtained directly from the shipowner. This information was made available only after the approval of the shipbuilder had been given. The selected ship is a products carrier (42,000 DWT) built for a U.S. flag operator. The physical dimensions of the ship are approx. 194 m (640 ft.) long X 32.3 m (105 ft.) wide X 11.6 m (38 ft.) draft. The ship is single screw with a 17,000 bhp low speed diesel power plant and a required service speed of 16 knots. The ship was competitively bid among six domestic shipyards. The construction contract for this ship was awarded to a major U.S. shipbuilder. The ship was privately financed and received no form of government subsidy or loan guarantee.

It was determined that this ship had a critical path duration of 57 months. The three major components of this ship's acquisition timeline, are identified by the 1st level of the IDEF model:

Develop a Ship Concept	12 months
Secure a Contract	15 months
Build and Deliver a Ship	30 months
Total Ship Acquisition Duration	57 months

It should be understood that in this case the shipowner performed the "Develop a Ship Concept" portion of the process. It could therefore be argued that there was no market-driven time constraint on the performance of this front-end acquisition task. This raises the possibility that the 12-month duration is an overestimate of what the task would take if it was performed by either a shipyard or a design firm. Since the ISIS project team had access to information pertaining to only this shipbuilding project there are no grounds for a counter argument against this claim.

However, several questions must be asked. Why is the manufacturer, in this case the shipbuilder, not involved in the early stages of product development? Would the shipbuilders' active participation in product development reduce the time required to not only develop a ship concept design, but also shorten the subsequent phases of the ship acquisition process? What can be done on the part of government, industry and academia to facilitate and implement changes that would enhance the product development cycle for ships?

It was determined that the second portion of the acquisition process, "Secure a Contract", took 15 months to accomplish. In this particular case the capital resources required to fund the ship acquisition were made available by the shipowner. The fact that the shipowner, or shipyard, did not have to locate and acquire sources of capital on the open financial market suggests that the estimate of duration for this portion of the process may be somewhat optimistic. However, any estimate as to the impact on duration of procuring financing on the open market would be purely speculative at this time.

Questions must be raised regarding the contracting process and its identified participants. Is a contract design stage necessary if a standard product development cycle is developed and implemented for ships? Why is the customer responsible for soliciting bids for his own ship? Why is the customer responsible for securing capital financing for his purchase of a ship? Why is the shipyard not seeking out potential customers far in advance of this contracting stage, thereby, eliminating the need for a formal solicitation, proposal, and shipyard selection process?

The third and final portion of the acquisition process, "Build and Deliver a Ship", was determined to take 30 months to complete. There were no customer-related anomalies to this portion of the process as there were with the two previous portions. .There is, however, one striking observation to be made. Out of the 30 months required to complete the ship acquisition, after the award of the construction contract, only 18 months are required to actually construct the ship.

This observation suggests that it takes 12 months for the shipyard to plan, identify, and procure the material required to support the start of construction. Should not a basic build strategy, with an accompanying material requirements plan, be developed prior to contract award? Would the adoption of standard components, materials and interim products expedite the detail design process? Would a more aggressive approach to "make/buy" decisions allow the shipyard to retain the higher value-added work while helping to shorten the construction duration? Should more emphasis be placed on material lead times, and on a vendor's ability to deliver material as required by the production schedule, rather than on material costs?

These questions have been raised in hope that the industry will recognize where problems exist within the current ship acquisition process and start addressing these problems by rallying existing maritime research and development assets. It is important for all members of the shipbuilding infrastructure to be made aware of these weaknesses. Action taken by any one member of the infrastructure without the direct involvement and support of the other members will, at best, lead only to parochial and marginally effective solutions for the industry's problems. Only through knowledge can strategies be developed that will strengthen the existing infrastructure. Unless government, industry, and academia work together to analyze these problems, there will be no consensus as to the action required to solve them. The ISIS team has attempted, through this report, to raise the awareness of where new emphasis for policy, product, and process improvements should be placed in the immediate future.

CONCLUSIONS & RECOMMENDATIONS

The U.S. shipbuilding industry is currently in the midst of a quiet revolution; slowly moving away from traditional shipbuilding methods towards a more modem approach that could be termed ship manufacturing. However, many hurdles still exist, and the effort to date in the U.S. has been limited to piece-meal approaches by individual organizations catering to their own in-house requirements. Sharing of information among members of the shipbuilding infrastructure has been a problem that can be attributed to the strong competitive nature of the existing marketplace. The National Shipbuilding Research Program (NSRP) has improved the accessibility of information dramatically during its life span; however, there still remains a need for a comprehensive "battle plan" for the industry as a whole.

The ISIS team has identified several areas of the existing ship acquisition process that require immediate attention. The first area involves the infrastructure's ability to create and implement a methodology that will develop commercial products on the basis of sound market analysis. The next area concerns the infrastructure's knowledge of how to structure a capital financing package on behalf of a customer. The final area addresses the need for new approaches towards the identification and procurement of material and equipment.

Within the "Develop a Ship Concept" portion of the process there are several relevant observations. There appears to be no obvious reason as to why the industry cannot immediately begin to cultivate commercial market analysis and product development expertise within its own ranks. Product development strategies for the U.S. shipbuilding industry can be developed by analyzing strategies that have been successfully executed by both domestic and international manufacturing concerns. It is postulated that this expertise should reside within the manufacturing sector of the infrastructure. This would guarantee a strong alignment between each manufacturing firm's capabilities and potential markets. Motivation and innovation on the part of market analysts and product developers can best be instilled when they have a direct stake in the outcome of their efforts. The continuous nature of this task also supports the need for the manufacturer to develop a cadre of in-house talent to address this challenging aspect of the ship acquisition process.

This observation is based upon the $IDEF_0$ modelling of the front-end acquisition functions. The $IDEF_0$ functions All - "Determine Shipping Opportunities", A12 - "Perform Concept Design" and Al3 -"Perform Preliminary Design", are currently performed by different mechanisms. In Al 1, there appears to be no domestic organization, either public or private, that currently has resources capable of monitoring the global shipbuilding market and matching U.S. shipbuilding talent with identified market niches throughout the world. This activity is currently performed by market consultants for individual clients on an "as-needed" basis.

In $IDEF_0$ functions Al2 and Al3 there is no single mechanism that can take either an internally, or externally, generated market analysis and use it to develop a commercial ship, and, once developed, openly pursue potential customers. The dysfunctional aspect of these activities appears to be that there are too many participants involved and that each of them has little responsibility or authority to control the overall product development process. It is proposed that there be a central repository established within the infrastructure where such information and analysis could be generated and maintained. This repository could be supported via a form of governmental and industrial cost-sharing.

The "Secure a Contract" portion of the process has become an important contributor to the total process duration. The reason for this may be that the customer has been responsible for all the activities under this heading, by acting as a "general contractor" in order to ensure a satisfactory outcome to the acquisition process. This not only takes a great deal of time and effort on the part of the shipowner but also lengthens the time required for post-contract award activities. The customer clearly does not belong in this position.

The complexity and length of the ship acquisition process affords an opportunity for many individuals within the infrastructure to participate. However, no one participant appears to dominate the overall process. The lack of a central figure for controlling, monitoring and documenting the acquisition process has created a situation where the customer tends to direct the entire process. The customer attempts to direct by exercising the only instrument available, namely, the contract document.

The unconscious result of this action on the part of the customer, however well intended, further denigrates an already complicated and lengthy process. Many of the activities under this heading could be shortened or eliminated entirely if a normal product development cycle were to be adopted by the industry. Reassigning responsibilities seems to be the first step needed to improving this portion of the ship acquisition process. Only after this is accomplished would a re-assessment of the sequence of events have any chance of improving the overall process duration.

The structuring and execution of capital finance packages may also be part of the problem within the "Secure a Contract" portion of the model. It is obviously an area where the industry must make a strong commitment towards becoming self-reliant.

Current trade negotiations between the U.S. and its trading partners portend a future where government subsidies will not be allowed. This will eliminate, or, at a minimum, severely restrict government programs currently used to provide funds or guarantee loans for new ship construction. It is imperative that the industry develop working relationships with private sources of capital as soon as possible. The industry must attempt to identify members of the financial community that will help them to understand the financing process.

The problems that arise during the last portion of the process, "Build and Deliver a Ship," can be accurately predicted by a careful assessment of all the activities preceding the contract award. The shipbuilder has been isolated from the market assessment and product development activities and may therefore have the contract package as his only source of information. In most cases this results in work required to support manufacturing not starting until the contract has been awarded. Since the ship has most likely been designed by someone other than the shipyard, there is little opportunity or incentive for the shipyard at this late date, to influence aspects of the design that might improve its producibility.

The fact that, up to this point, the shipyard has had limited exposure to the ship design forces it into a "cold start" regarding numerous activities such as detail design, scheduling, planning, and material procurement. The result of this can be shown by referencing Figure #24 where it takes twelve months from contract award until the start of fabrication. The lack of industrial standards, regarding engineering design and materials, simply compounds this problem.

This situation leads to a massive engineering and purchasing effort on the part of the manufacturer. This effort is made more difficult by the customized nature of the product, and by the fact that the manufacturer has had little opportunity to analyze the design prior to contract award. Added to this are the constraints placed upon the shipyard by the construction contract and the inherent weaknesses that have been designed into the product from its inception. These weaknesses may severely effect the producibility of the ship and further reduce the productivity that is witnessed in the shipyard.

Some of the responsibiity for the existing situation lies with the shipbuilders. As has been discussed previously U.S. shipyards have had as much opportunity as their foreign counterparts to manage, develop, and market commercial ship designs. However, for various reasons, the industry has not openly embraced this market sector and currently finds itself lagging the world market in this regard. It may be worthwhile to explore why the domestic shipbuilding industry has not made a solid commitment towards diversifying its market base with commercial products.

The third area of the ship acquisition process that requires immediate attention is that of material identification and procurement. The application of various types of standards could have broad implications when applied to this problem. Standard design modules, whose inherent characteristics would allow them to be used in various ship types, would allow for immediate material identification. These pre-designed interim products would not only shorten the design process but could also shorten the time required to obtain material. The concept of standards can also be applied to the sources of supply. A vendor should be qualified on the basis of product quality, on-time delivery, and cost. Once qualified, a vendor should be used as often as possible. This strategy, over time, will breed strong long-term relationships between suppliers and shipyards. Finally, the portions of the ship that must be custom designed and fabricated should be manufactured from standard shapes and sizes of raw materials. All of these areas require an immediate increase in research and development, and front-end planning and engineering.

There is no guarantee that implementing changes to these areas will result in new work. These changes will require the expenditure of risk capital on the part of the shipbuilding infrastructure. So what incentives are there for the industry to change? Where is the risk capital going to come from to pay for these changes? Should these funds be supplied from within the infrastructure or from outside sources? Could changes in government policy encourage and stimulate these types of expenditures? Could consortiums be formed within the industry to address any of these concerns? Are joint ventures with overseas companies the answer? These are questions that need to be answered by the shipbuilding infrastructure as a whole.

One way to help answer some of these questions is to find out how the competition currently accomplishes these activities. However, the development of a shipbuilding strategy for the future cannot be based solely on copying the competition. Information uncovered about the competition must be used to rationalize a strategy whose objective is to outperform the competition. Then, and only then, will the U.S. industry be capable of gaining a foothold in the global market. ISIS intends to support this rationale by analyzing how the competition is performing the ship acquisition process, and developing a future infrastructure option that will define the parameters for a competitive shipbuilding industry in the United States. These steps will follow closely upon the work already accomplished by ISIS.

Lessons learned during the development of the "As-Is" model will be used to further refine this $IDEF_0$ model. Constructive criticisms will continue to be incorporated into the existing model. Areas of the model where more detail is required will be further decomposed. This revised version of the "As-Is" model will serve as the foundation for all subsequent work.

The following step of the ISIS project will focus on analyzing competitive domestic industries and foreign shipbuilding industries that are at the leading edge of the global market. The current plan calls for the establishment of direct contact with at least two maritime research organizations within the European Community and Japan. The purpose for establishing these research ties will be to facilitate the direct comparison of the competitions' approach to the ship acquisition process with established U.S. practice. The focus during this step will be on the time-drivers identified from the "As-Is" model. It will be determined if similar situations have been encountered by other domestic and foreign industries. Opportunities for improvement uncovered in the initial investigation will be specifically addressed by the input received from participants in this stage. The primary goal of this stage will be to develop a comparative basis by which the initial findings can be assessed.

The final stage of the ISIS study will develop a future ship acquisition process, referred to as the "To-Be" model. The "To-Be" model will demonstrate how the United States could be globally competitive on the basis of overall process duration. This model, or "future vision", will merely be an option that can be used as a target by the research and development communities within government, industry, and academia. Upon completion of this project stage, the industry would assume ownership of the model and use it to develop individual corporate business strategies and research and development initiatives. Both the "As-Is" and "To-Be" models would need to be housed and maintained by the industry so that they could be kept current in the ever-changing economic, political, and legal climate.

As the United States enters the 199Os, an issue of national proportions has emerged. The United States, as a maritime nation, is clearly at risk of losing its ability to build commercial ships competitively. The United States must either find the means to facilitate a rebirth of its shipbuilding industry, or, within the next decade, face the consequences of being completely dependent upon foreign sources for its marine transportation assets. It is clear that other seagoing nations have decided to take strong measures to ensure their shipbuilding competitiveness well into the 21st century. The United States should do nothing short of the same.

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