NAVAL SHIPBUILDING IN THE UNITED STATES OF AMERICA

by

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SYNOPSIS

After a brief historical outline of principal developments in the U.S. Navy since 1794, the present composition of the shipbuilding industry is described, and the predominance of naval work highlighted. Naval procurement practices, and some advantages of U.S. procedures are mentioned. New procedures of concept formulation, contract definition and total package procurement are explained, with a description of the effects these procedures have had on the composition and the practices of the industry. The paper concludes with a brief look at some design trends for U.S. Naval destroyers.

NOTE

Statements of fact and opinions expressed in this paper are the responsibility of the author, and do not necessarily reflect the views and policies of the Department of the Navy or the Department of Defence.

AN HISTORICAL OUTLINE

Early Days

In 1794 the first ships of the Navy of the United States were authorised in an Act of Congress to provide a Naval Armament. One of these ships, the USS CONSTITUTION, a 44 gun frigate displacing 2250 tons, still floats today as a commissioned ship of the United States Navy. She lies alongside a Boston pier just across from the berth at which the Royal Australian Navy's third U.S. built destroyer commissioned eighteen months ago.

In the one hundred and seventy years since CONSTITUTION was completed the United States Navy has often been at the forefront of warship building and development. In 1814 the first steam powered warship, Robert Fulton's DEMALOGUS was completed. She carried 20 guns and displaced 2475 tons. The Civil War of the 1860's saw the first naval battle between ironclads; Ericson's MONITOR and the Confederate MERRIMAC. The ease with which they sunk wooden ships, and their inability to sink each other demonstrated the necessity of armour.

The same Civil War saw the first sinking of a surface ship by a submarine, the HL HUNLEY. After being lost and salved twice this manual propelled ship eventually sank the HOUSATONIC, and sank herself in the wash of the sinking. Another submarine of the period, INTELLIGENT WHALE, is preserved today at the Washington Navy Yard.

The reconstruction period after the Civil War saw little naval shipbuilding until the expansion programme of the 1890's. The battleship KEARSAGE built in 1899 was the first vessel of the U.S. Navy to make extensive use of electricity for power and light. Ships were now built of steel and after the turn of the century turbines started to replace reciprocating engines, in small ships. In 1906 three

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cruisers were built powered variously by Parsons turbine, Curtis turbine, and reciprocating engine; each of 16000 horsepower. It was concluded from comparative trials that the reciprocating engine was more economical at low speeds but had less overload capacity and less reliability.

WORLD WAR I

In the period from 1898 to 1912, 166 naval ships were built in the U.S., with an aggregate displacement of 848,000 tons. The next ten years from 1913 to 1922 saw 472 ships built aggregating 1,165,000 tons. In 1916 a 'Big Navy Act' was passed through Congress approving a 10 year building programme intended to make the U.S. Navy the largest in the world. Production reached its peak at about the time of the Armistice and it was several years before deliveries were completed. In 1919, 104 destroyers were delivered and in 1920 another 79. About 20% of naval construction was completed in West Coast yards, with most naval work still concentrated in the North East. About one fifth of the tonnage was built in Navy Yards.

1923-39

The years between the wars became a building race constrained by armament limitation agreements. The U.S. Navy's "second to none" policy was taken as a challenge by the Royal Navy who were also intent on being second to none. The Washington conference of 1922 set a U.S.-British-Japanese ratio of 5:5:3 and imposed a ten year holiday in the building of capital ships. The U.S. scrapped eleven capital ships building, but completed two as the aircraft carriers LEXINGTON and SARATOGA. These ships were to play an important part in stemming the Japanese advance in 1942.

In 1934 Congress passed the Vinson-Trammell Act that authorised a continued building programme, to be shared between private and navy yards, to maintain a Navy of modern warships larger than any other. Three aircraft carriers, 7 battleships, 11 cruisers and 108 destroyers were authorised in the next two years.

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1940-45

In 1940 expenditure on Naval construction reached an all-time high of $326 million. By 1942 this had increased tenfold, and in the three years 1943-45 expenditure totalled more than 23,000 million dollars. In these three years ships delivered included 4 battleships, 28 aircraft carriers, 39 cruisers, 280 destroyers, 171 submarines and over 700 escort ships. Three out of four ships were built in private yards. There were thirteen private yards and six Navy yards building ships of destroyer size. Ships were built fast and Beth Steel, Quincy completed the aircraft carrier HANCOCK in 15 months.

1946-55

The years after World War II saw for the first few years the normal postwar decline in building activity. Few new vessels were ordered until the Korean War when in 1952 SARATOGA and FORRESTAL were the first large ships laid down since World War II. The same year the first FORREST SHERMAN class destroyers were laid down, and NAUTILUS ushered in the era of the nuclear submarine. In 1955 the installation of Terrier in BOSTON made her the first ship to carry supersonic missiles.

1956-65

The decade after the Korean War saw the foundation of todays United States Navy of ships and 650,000 men. 70 nuclear submarines and ENTERPRISE, LONGBEACH, and BAINBRIDGE all joined the fleets. 23 DDG's and 19DLG's were commissioned. Integrated tactical data systems were first installed.

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There was a tremendous growth in the extent and complexity of sensor and weapons systems and of ship's demands for power.

1966-69

Apart from large orders for destroyer escorts there has been some reduction in new orders in the last few years. There has however been a revolution in methods of ship acquisition, with consideration of the life time costs of ships and weapon systems assuming a new importance. The actual number of ships on order in private shipyards has risen fairly steadily since 1951, and reflects the generally lengthening building times of all ships. There are currently over 120 ships building or on order. A $3.8 billion authorisation bill for 31 new naval vessels was submitted to Congress this year.

THE SHIPBUILDING INDUSTRY IN THE U.S.A.

General

Although the subject of this paper is naval shipbuilding, to discuss naval shipbuilding in the U.S.A. is to discuss the shipbuilding industry. The navy of the United States spends $3,000 million a year on shipbuilding, and that is about as much as the rest of the Western World spends on all its ships, military and merchant. The navy buys 80% of the output of American Industry, and the Coastguard and Maritime Administration buy another 15%.

The Composition of the industry.

A large part of manufacturing industry in the United States contributes to the end product that is a naval ship. There are the ship designers, the engine-builders, the manufacturers of radars, computers, guns and missiles, the thousand and one commercial firms that make machinery and

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components that go into naval construction. And of course, there are the shipbuilders who put all these things together and bring to life a modern ship of war.

It may seem superfluous to remind a group of naval architects that the boundaries of ship construction extend beyond the shipyard. You all know that. But I am referring to an entirely different order of things than that you will be used to from British or Australian experience. In the United States the builders of ships reach out and tap not just a marine-oriented, military oriented segment of industry but draw on the industry as a whole. Let me elaborate this point by illustration of the ship procurement process, and comparison of American and British practices. There have been substantial changes in U.S.N. procurement in the last few years and I will go into these in more detail later. In general the practices I describe have been in existence for some years.

Naval Ship Design.

In Britain the design of naval ships has been largely carried out by the Admiralty in conjunction with the lead-builder. Builders were found to lack adequate design staff and increasing use has been made of Yarrow Admiralty Research Department as Admiralty design agent. In the United States, the part played by profit-making consulting designers has been significant for many years. J.J. McMullen, George Sharp, J. J. Henry, Rosenblatts, and Gibbs and Cox have all undertaken substantial design work for the Navy. The contract guidance plans for the DDG's were the work of Gibbs and Cox, while Rosenblatts played a large part in the design of LONGBEACH. Each of these two latter firms has a design staff numbering about 800. The consultants are employed not only as designers to the Navy, but as detailed design agents for the shipyards. In recent years they have become part of the

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contract definition teams being set up for new designs. I would stress that these teams are responsible for systems designs within the ship, such as the propulsion system, in addition to their responsibility for structure and arrangements.

Propulsion Machinery Manufacture and Design

In Britain, turbines for naval ships are designed by Pametrada, AEI, or English Electric. Turbines for merchant ships are designed by PAMETRADA, a marine builders association that includes no land turbine builders in its membership. PAMETRADA designs are build by seventeen different builders, as a subsidiary operation to their shipbuilding activities. The results of this arrangement have not been particularly impressive. In the United States turbines for ships are designed and built not by shipbuilders, not by specialist marine firms, but by the principal turbine builders of the United States. Westinghouse, de Laval and General Electric compete energentically to supply power stations and [illegible] shipbuilders. Similarly the manufacture and design of marine boilers by Foster Wheeler, Babcock and Wilcox or Combustion Engineering is an integral part of their general industrial activity.

Radars, Computers, Weapons

I am not well engough acquainted with the procurement of military electronics and weapons in the United Kingdom to compare the process in detail with that of the United States. I have the impression though that much of what is carried out "in house" in Britain, or by sole suppliers, is in the U.S. thrown open to commercial competition. There are reasons for the difference in approach of course, and a most important reason is the comparative size of the market for Defence Equipment in the two countries. In 1968 DOD payments to the three largest defence contractors in the U.S. totalled 5,598 million dollars.

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Shipbuilders Supply Equipment

It is not however in the very high cost areas that the involvement of U.S. industry generally is most evident, and the differences in practice most marked. The most surprising difference in approach, is in matters of shipbuilders choice of equipment of non-specialised nature to build into the ship. It may not be generally appreciated that in the DDG's for example, the USN does not decide what boilers go in the ship, or what main engines, or pumps, or steering gear, or telephones, or refrigerators, but leaves this choice to the individual shipbuilder. Thus the Australian destroyers are the only ones of 30 ships of the class with the combination of Foster Wheeler-General Electric for main propulsion plant. The variety of equipment that is introduced to the USN in this matter brings with it significant problems of support. Some of these problems are being reduced by current policy to order all ships of a class from a single builder, but in general terms there will be no reduction in the proportion of a ship the builder is required to supply. In fact the proportion may well increase until the builder supplies everything except the crew. In June last year, Admiral Jamie Adair, in charge of ship Acquisition said:-

> " Private design agents and private shipyards design and build most of the ships for the U.S. Navy. We also try to get them to provide much of the material. This simplifies programme co-ordination and keeps changes to a minimum" (1)

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Shipbuilders in the United States

There are seventy-eight private shipyards in the U.S. with capacity for building ships longer than 400 feet and 10 government owned yards. (Nine Navy yards and 1 Coastguard) Average employment in 1968 was "slightly more than 230,000 workers of which some 92,000 are employed in the government owned yards " (2) Not all the shipyards are currently engaged in building ships. Appendix A contains brief descriptions of the activities of the principal private building yards, and of the naval shipyards.

Shipyard Labour

The 92,000 men working in the 9 naval shipyards are divided fairly evently between the yards. The 138,000 in private industry are concentrated in the larger yards. Newport News employes about 14,000 men, General Dynamics Quincy, Avondale, and Ingalls each employ about 10,000 men at the moment and the other yards generally employ less than 5,000 men in each yard. From my three years with Defoe Shipbuilding Company, a yard I assume to be fairly typical of the smaller yards, I found the following aspects of labour practices noteworthy.

a. All shipyard workers belonged to the one industry union.
b. Contracts were renegotiated every three years and marked by hard bargaining. There was industrial peace during the term of the contract.
c. There were wide graduations within any particular craft in degrees of skill and experience, and corresponding graduations in wages.
d. There is no apprenticeship system in operation. Qualification is by trade test on recruitment, and after training whose duration depends on rate of progress.

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e. There is a very high level of job education amongst the workmen who are generally able to discuss both practical and theoretical aspects of their job with some fluency.

f. There are few demarcation problems.

g. Despite some appalling conditions in which to work, aggravated by a temperature range of over 100°, a high standard of effort and quality was maintained.

Wages are generally good, and at the end of 1967 gross hourly earnings of production workers averaged $3.55 with average weekly earnings $144.49 (3).

Shipyard Capital Investment.

Capital investment in shipbuilding in the United States has been low for many years, particularly in comparison with the capital investment in U.S. manufacturing generally. In an address to the American Society of Naval Engineers in 1967 the following figures were quoted by Rear Admiral Sonenshei · (4)

New Capital Investment per $100 Wages

	1958	1964
U.S. Manufacturing	$19	$20
U.S. Shipbuilding	$ 7	$ 5

Value Added Per Production Worker

	1958	1964
U.S. Manufacturing	$12,100	$16,600
U.S. Shipbuilding	$ 9,000	$10,900

The reasons for this are fairly straight forward:

a. Government capital investment during World War II provided many yards with excess post war capacity, and reduced pressures for new equipment.

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b. The jobbing nature of shipbuilding work does not lend itself to intensive capital investment.

c. Better investment opportunities were available elsewhare.

Lack of capital investment tends to lead to low efficiencies that in turn lead to high costs, low profits, and lack of capital for investment. It was with regard to this self perpetuating cycle, and in an endeavour to get better value for its money, that the Department of Defence decided a few years ago to introduce changes in its procurement policies. Reminding you that the Defence Department is a monopsonist buying 80% of the industry's output, it is clear that these changes would result in changes to the industry. I will describe both the procurement changes and their effects on industry.

THE PROCUREMENT OF SHIPS FOR THE U.S. NAVY

The Bureau of Ships.

Before discussion of new processes of procurement it is useful to first review these that have existed for some years past. For this reason I have used the title Bureau of Ships, the organisation for so many years responsible for the procurement of ships for the U.S. Navy, and now translated to the Naval Ship Systems Command. I would like to stress it is the Bureau that has had ships designed, contracted and built to meet the requirement of the Chief of Naval Operations, and not the U.S. Navy as a whole. The autonomy granted to the Bureau and the separation of powers from the other naval departments contributes a good deal I believe to the result attained. In the words of British naval historian Captain Stephen Roskill, R.N:

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> "The strength of the American organisation lay in the quality and technical experience of the officers appointed to the higher posts of the Bureaux, and in the influence they wielded - especially in the fields of technology. The superiority of so much American equipment when compared to its British counterparts undoubtedly owes a great deal to the Bureau System". (5)

The organisation of the Bureau, and in particular the financial authority of its engineering managers, appears to lend itself to a particularly effective management of shipbuilding programmes.

Shipbuilding Contracts.

Contracts for U.S. Naval Ships are competitively bid to a fixed price. Bids are opened and announced together, and contracts awarded, usually to the low bidder, soon after. Escalation clauses provide for changing wage levels in the area (but not in the contractors own firm) and changing material costs. A schedule to the contract states what the U.S. Navy will supply; the builder is required to supply everything else. As mentioned earlier the shipbuilder may choose engine builders or boiler manufacturers as he likes and the Bureau of Ships in Washington is not even cognisant of what has been bought. From the date of award of contract all contract administration becomes the responsibility of the local Supervisor of Shipbuilding.

The Supervisor of Shipbuilding U.S.N.

The area Supervisor of Shipbuilding is responsible to the Bureau of Ships for the satisfactory fulfilment of the contract. In implementation of this he:-

a. Approves plans.

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b. Advises on interpretations of the specification.
c. Approves changes reducing costs or costing up to $5,000.
d. Negotiates cost changes with the contractor.
e. Ensures contractor has a satisfactory inspection system.
f. Approves trial schedules, and
g. Hires and employs staff to perform his function.

If the contractor proposes specification changes resulting in cost saving, half of the saving goes to the contractor and the other half is a saving to the Bureau.

The Supervisor of Shipbuilding is in general left to get on with the job and when it has been completed, and set to work, report it ready for the inspection of the Board of Inspection and Survey.

INSURV

The Board of Inspection and Survey are responsible not to the Bureau of Ships but to CNO, the Secretary of the Navy, and Congress. When a ship is completed their team of experts looks it over in harbour and at sea, and recommends for or against its preliminary acceptance into the U.S.N. For a period of six months after handover to the Navy the ship and all its systems remain under warranty and a final acceptance trial is held by INSURV just before the end of this period. Any defects that have shown up in this time are then rectified at the builders expense.

NEW PROCUREMENT PRACTICES FOR U.S. NAVAL SHIPS

General

The initiative for change in defence procurement practices came from the office of Defence Secretary McNamara,

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as part of his endeavours to rationalise defence planning and to increase the effectiveness of defence expenditure. Today in the words of the Assistant Secretary for Systems Analysis, Alan Enthoven:

> "Force and financial planning are done on a long-range multiyear basis, choices among weapons systems are made only after requirements, capabilities and cost are projected 8-10 years in the future, and decisions are reflected in long-range plans" (6).

These precepts have been translated into a number of new procurement techniques and I would ask you to note that when I talk of procurement I include the processes of design, selection, contracing, building, putting into service, and supporting in the intended role. It is this broad concept of procurement that is fundamental to the approach. Contributing to this embracing approach there are various separable techniques and various new terms. The first of these to be introduced was 'Multi-Year Procurement':

Multi-Year Procurement

Until recently the United States Navy ordered its ships on the basis of annual appropriations. This meant that a class of ships would be ordered a few at a time, year by year, and with changes brought into the contract so each ship differed from its predecessor. Thus the class of 23 DDG's was divided between 6 builders and 7 AKA's were built under seven different contracts. A study of the building costs of 23 DDG's (7) drew the following conclusions:

6 contracts 6 yards (as built)	$420 million
1 contract	Save $55 million
1 contract 1 yard	Save $88 million
1 Shipyard updated	Save $109 million
Build in Sweden	Save $140 million
Build in Japan	Save $264 million

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The innovation is that the NSSC will now call tenders for the construction of the entire class of ships spread over a series of years procurement. Congressional approval has been obtained to adopt this scheme.with its provision for cancellation changes should the continued appropriations not be forthcoming. Whereas in previous years the NSSC encouraged bidders to bid for a small group of ships now each is bidding for the lot.

20 DE's of a single class were awarded to Avondale Shipyard in pursuance of this policy and with a saving over two builders of approximately $16 million. In similar fashion 17 LST's were awarded to National Ship in San Diego at a saving of $19.5 million. The assurance of continued work flow in a programme of this nature has encouraged introduction of new equipment and techniques. Avondale have spent $6-10 million recently on shipyard extension and introduction of computer controlled plate cutting National Steel have introduced fully automated plate handling. This does not help the smaller yards no longer getting business but it is apparently thought preferable to encourage and support the few, rather than to sustain the many.

Concept Formulation

This is now the first step of the new approach to procurement and is a radical departure from previous practice. In the past the Navy worked out a sketch design, and in conjunction with design agents produced a ship design that was sent out for tender. Today the Navy develops broad performance specifications setting out the missions to be performed, the payloads to be carried, and the reliability required. It is then open to design competition to produce a concept for size, number and type of ships that will perform these functions. For each system the life cycle cost is estimated including design, building, spares, operation and maintenance over the designed life. Crew salaries and scrap value all enter this life-cycle cost analysis. The concept formulation period states the requirement and selects the most appropriate general solution to it, or the appropriate method of approach to resolution of the problem.

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Department of Defence approval of the concept is necessary before proceeding to the next stage.

Contract Definition

It is here that industry is first brought in to active participation in design. It can be conveniently divided into three phases:-

A. The Preliminary Proposal Phase
In response to requests for proposals sent to prospective bidders, each bidder puts forward a case to support his being paid by the government to enter a design competition. This period occupies each bidder for several weeks.

B. The Contract Definition Phase
In this stage two or more of the most promising tenderers are selected and awarded a fixed price contract to carry their designs further to the stage where they can guarantee performance specifications and establish firm schedules and cost estimates for the total project. Typically three competitors are selected at this stage and are paid about $5-10 million each for six months detailed design work.

C. The Source Selection Phase
Having received the large submissions of each competitor in contract definition it is now up to the Naval Ship Systems Command to evaluate them. In accordance with predetermined and prepublished criteria the proposals are then evaluated as to:-

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Technical Factors,
Life - Cycle costs Factors, and
Cost - Effectiveness Factors.

Cost Effectiveness rankings are calculated by considering the operational objectives to be met, and for each objective computing a Figure of Merit. This Figure of Merit will usually be a ratio of $\frac{\text{Effectiveness Parameter}}{\text{Lifetime Cost}}$

For example in the case of ships required to deliver a load it would be

$$\frac{\text{Carrying Capacity x Speed}}{\text{Lifetime Cost}}$$

In addition computer analysis of effectiveness is carried out by exercising each proposed ship in a variety of operational scenarios.

D. Contract Award

Having regard to the evaluations of the source selection phase, and where appropriate incorporating the best ideas of various submissions, a contract is negotiated on the basis of the performance and cost figures of the submission. Procurement at this stage will normally be Total Package Procurement with one firm awarded the contract to complete design and build all the ships of the class. As a single order could run to $1000 million or more it is unlikely that firms are likely to accept the risk involved in a straight fixed price contract; or that the Navy is willing to pay the premium in price required to cover the risk.

The type of contract likely to be used is a fixed price - incentive contract allowing for variations up or down as the

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builder gets into the contract, with advantages to both buyer and seller if costs are reduced, and diminishing profit and eventual loss if prices exceed a predetermined level. A target price is agreed, a ceiling price, and variations in cost above and below the target price are shared according to an agreed ratio, commonly 80% government 20% contractor. The contract will provide for an agreed profit commonly 8%. Various incentives and liquidated damages clauses may be included to cover performance figures, delivery times, any other factors meriting special attention.

The contract may extend beyond initial supply and may include maintenance costs for the first few years or perhaps the lifetime of the equipment.

RECENT PROCUREMENTS AND CHANGES IN THE INDUSTRY

General

The Concept-Formulation, Contract Definition process has now been applied to three classes of ship, although none of the projects have yet proceeded to the stage of Total Package Procurement. To provide competitors in these design competitions there have been substantial changes in the industry.

The FDL

The first use of the procedure was in the Fast Deployment Logistic Ship Project (FDL). The concept of these ships was to provide a mobile force that could be quickly deployed to any trouble spot and unload rapidly an army detachment with associated equipment. The preliminary design of a ship to meet this role was carried out by Navy "in house" but it was then decided to apply the Contract Definition concept.

It was soon clear that the majority of builders did not have the strong design teams required to participate

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in a competition of this nature and the initial applicants were reduced to three selected for the contract definiti phase. Each of these three contenders had formed a team that included designers of ships and shipyard facilities, as well as systems analysts and shipbuilders. The three engineering teams were:-

General Dynamics/G. Sharp/C.J. Foster/Arthur D. Little
Litton/J.J. Henry/Ralph M. Parsons/TRW Systems.
Lockheed/Gibbs & Cox/Bechtel Corp.

It will be noted that in each case the prime contractor was a firm with aero-space associations that had recently moved into the shipbuilding industry.

In July, 1967 the source selection phase of the Contract was completed and Litton were announced as selected for submitting the best technical proposed for design and construction of FDL ships. The next stage would normally have been a contract for total package procurement, but this proved impracticable as Congress deleted all funds for this project. It is now hoped that funds may be available to start on 4 ships this coming year.

Although the FDL's have not been build the U.S.N. consider the worth of the approach well established. The Litton FDL turns out to be a substantially different ship to the "in house" design FDL(X).

DESIGN COMPARISON

	FDL(X)	FDL
LOA	675'	855'
BEAM	104'	104'
DRAFT	28'	28'
DISPLACEMENT	28,000 T	40,500
SPEED	22 KNOTS	25 KNOTS
CARGO	6,200 S/T	10850 S/T
COMPLEMENT	52	37
PROPULSION	Gas Turbine	Steam

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"For equal payload capacity the 25 year lifetime cost for the FDL ship system is at least 400 million dollars less than for the FDL(X) ship system, and this takes into account the amortisation charges associated with shipyard upgrading" (8). This is high potential return on the investment of some $15 million for contract definition.

The LHA

A similar exercise in contract definition was carried out for the LHA ships with in this case contracts being awarded to:

General Dynamics	$5,400,000
Litton Industries	$6,400,000
Newport News	$8,200,000

The discrepancies in cost were due to previously contracted studies that GD and Litton had been paid for on the FDL project. The successful contestant was once more Litton.

DX-DXG-DXGN

As the Title suggests these are programmes for escort vessels; conventional, with guided missiles, and with nuclear propulsion. DX is the first type to go to Contract Definition. Proposals were requested from six builders but Avondale, Todd and Newport News were eliminated. CD contracts were then let to the three remaining:-

General Dynamics - Honeywell	$9,000,000
Litton-Rosenblatt-Honeywell	$9,000,000
Bath-Gibbs & Cox-Hughes	$10,500,000

Following evaluation of proposals by the Navy it is expected a production contract will be awarded in August 1969.

Changes in the Industry - Design Teams

The engineering teams formed to take part in Contract Definition assemble far more talent than is generally brought to bear in ship design. Each of the major competitors must employ teams of several hundred engineers to

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produce their designs. These large assemblies of talent, and integration of many disciplines are expected to bring big improvements in design standards. Optimisation studies are being greatly assisted by extensive use of computers and there is increasing usage of computer-aided ship design.

Changes in the Industry - Shipyards

All major shipyards are now embarking on some form of modernisation and it appears this has been stimulated by the new procurment practices. Newport News has a five year updating programme in hand leading off with new plate and storage yards and fabrication shops. Avondale build inverted and rotate their DE sections in special jigs. Tape programmed cutting is in use. National Steel have installed a large automatic plate handling equipment (9). The largest of the shipyard innovations are those planned by Litton industries who have started building an entire new shipyard across from Ingalls on the Pascagoula River. The shipyard is being financed by a $134 million bond issue of the State of Mississippi. The state will own the yard, and Litton run it. The new shipyard is planned for automatic handling and assembly line flow. Complete outfitting of sub-assemblies is intended so that when joined together they form a structurally complete and outfitted ship. Each ship is then moved across for side launching into the river, ready for test and trials. I believe it to be worthy of note that this most modern shipyard in the world utilises a side launching process, enabling ships to be launched much heavier and with lower stresses than in a conventional end launch.

TRENDS IN DESTROYER DESIGN

General

Before concluding this description of naval shipbuilding in the United States it is interesting to review some modern trends in U.S. destroyer design and in doing so I

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will rely largely on a recent paper by Owen H. Oakley of the Naval Ship Engineering Centre (10). The trend in general is one towards increasing displacement, increasing complexity, increasing power demands and increased cost. The reasons for this are principally a substantial increase in the volumetric needs of the electronics weapons payload, and of the crew. The ships size is now volume-determined rather than as before by load carrying capability.

Machinery Developments

There has been little change in the weight and space requirements of propulsion machinery. A pressure combustion boiler was introduced into the DE 1040 class, in attempts to save weight and space. An exhaust gas driven turbo-changer provides combustion chamber pressures of about 5 atmospheres. The boiler is compact but difficult to maintain, and a high incidence of breakdowns has led to its discontinuance. The growing challenge to steam propulsion is that of the marinised aircraft type gas turbine. Units of up to 25,000 s.h.p. per gas generator are available from Pratt and Whitney and General Electric. The Pratt and Whitney FT4 engine is at sea in the MSTS ship ADMIRAL CALLAGHAN, the HAMILTON class Coastguard cutters, and is being installed in the Canadian Navy's new DDH.

In the Concept Definition contests for the FDL tenderers proposed alternate propulsion systems but it was steam that won the day for the FDL. In the current DX competition the protagonists of gas turbines are confident that units will show to advantage in the smaller ships. Steam systems are by no means surrendering the field, and General Electric are proposing a simplified system of one large boiler per shaft set that they are confident will be preferred to gas turbines on all counts. It is interesting that 1200 psi and 950° F remain the preferred steam conditions, with electronic solid state control devices and

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bridge control of engine state and speed. The propulsion system is designed for minimum watchkeeping and maintenance effort.

Hull developments

Changes in hull design and layout generally take the form of provision of increased space for increased requirements of electronics and personnel. The use of all aluminium superstructure to provide added volume, and of bulbous bows to house sonars, has become established practice. There are significant improvements in habitability standards, and new ships have walk-in ships stores and more spacious and better furnished accommodation. In an endeavour to keep pace with the shortening life of weapons systems a close examination is being made of the "modular-podular" concept. This will require a particular sensor or weapons system to be built within a defined envelope fed by specified power supplies. For initial installation, modification, or replacement of the pods, all that will be necessary is for the complete unit to be removed, and a new unit installed and connected. In existing ships there have been marked improvements in arrangements for receipt, stowage and use of stores.

Nuclear Ships

There are two nuclear destroyers in commission and contracts have been awarded for two more. They are ships of more than 8000 tons displacement and it is probably that ships of this size and larger will all be nuclear powered. There does not appear to be any early prospect of neclear power in the smaller ships.

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CONCLUSION

On first arrival at the headquarters of the Naval Ships Systems Command, in Constitution Avenue, Washington DC, one enters a large lobby in an undistinguished building of several storeys. At the foot of the stairs leading to the office of the Chief is a brass plate inscribed with words of Secretary of the Navy, Frank Knox. It reads:

> "We must be intolerant of delay, we must tear our way through red tape, we must pillory bureaucrats who stupidly sacrifice time in pursuit of an impossible perfection."

These words of 1940 go far to express the attitude of the U.S. Navy today and to sum up succinctly the American approach.

The Americans get on with the job. The senior naval officers who are the programme managers, make decisions, and have the control of resources to carry them out. Their shipbuilders are craftsmen who are eager to give of their best. The keen competition in the engineering industry adds to its strength. The man on the spot is left to get on with the work to be done.

All the Americans I met building naval ships gave their best to the job. When they were building ships for the Royal Australian Navy somehow they did even better. I am grateful to them, and salute them, as fine men building fine ships.

APPENDIX A

PRINCIPAL SHIPYARDS OF THE UNITED STATES 1969

The shipyards of the United States of America can generally be considered as in four regional groups: The East; The Gulf; The Lakes; and the Pacific Coast. Naval Shipyards are listed below, with the private yards, in these groupings.

A. THE EAST

The North East coast of the United States was the cradle of American shipbuilding and with the great industrial hinterland remains the strongest area of shipbuilding capacity today.

1. Bath Ironworks, Bath, Maine
   "From the beginning, Bath built the destroyer and the destroyer built Bath". So runs the slogan of this yard that received its first Naval contract in 1890. Currently building 3 DDG's for the German Navy; LUTYENS, MOLDERS and ROMMEL; and modernising 6 DLG's for the USN.

2. Portsmouth Naval Shipyard, Kittery, Maine
   Portsmouth built the CONGRESS, one of the U.S. Navy's first six frigates, in 1794 on hired land, and moved to the site of the present Navy Yard in 1800. Since 1914 Portsmouth has been one of the U.S. Navy's principal builders of submarines, and is currently completing SSN646, SSN660 and AGSS555. As part of a Defence cost reduction programme Portsmouth is to close by 1974.

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3. Boston Naval Shipyard, Charleston, Mass.
Established in 1800, builder of ships in wartime. BNSY is now engaged in conversion and repair work.

4. General Dynamics, Quincy, Mass.
The Quincy yard of the Bethlehem Steel Co., was acquired in 1964 by General Dynamics. The yard was founded in 1884 and in the 1920's built LEXINGTON as well as the Matson liners LURLINE, MARIPOSA, and MONTEREY. Over 10,000 men employed today building 2 SSN, 6 AOR, 2 AE and 4 LSD's.

5. General Dynamics, Groton, Connecticut
This yard since World War I has been the home of the Electric Boat Company, leading builder of submarines for the U.S. Navy. Seven nuclear submarines are now building.

6. New York Ship, Camden, New Jersey
This shipyard closed down last year after 66 years trading. The last ship completed was the nuclear powered frigate TRUXTON.

7. Philadelphia Naval Shipyard, Phil., Pa.
Established 1799. In World War II principal builder of battleships and heavy cruisers. Recently modernised her wartime-built NEW JERSEY for service in Vietnam. Current contracts include 2 AGC, 1 LPH, LST's.

8. Sun Shipbuilding Co., Baltimore, Md.
Principally a builder of commercial ships. Recently completed the MSTS RORO ship ADMIRAL CALLAGHAN, the first all gas-turbine powered merchantman.

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9. Bethlehem Steel, Sparrows Point, Md.
Another commercial yard currently building tankers.

10. Washington Navy Yard, Washington DC.
Naval repair.

11. Newport News Shipbuilding and DD Co., Newport News, Md.
Established in 1886, and privately owned until 1940, Newport News is now the largest shipyard in the United States. The company was purchased last year by Tenneco Inc., a gas pipeline firm, for $123 million. The yard is currently building the aircraft carriers KENNEDY and NIMITZ and expects to build two more nuclear super-carriers. Also building two nuclear submarines, two DLGN, 5 AKA and 1 AGC.

12. Norfolk Naval Shipyard, Portsmouth, Md.
Norfolk is the oldest shipyard in the United States being established in 1767 under the British flag. CHESAPEAKE, one of the first six frigates was built here. No. 1 Drydock, the oldest in the United States, was first used in 1833. In 1862 the MERRIMAC was converted to the iron-clad VIRGINIA before her battle with the MONITOR. TEXAS the USN's first battleship was built here, and LANGLEY the first aircraft carrier completed in 1922. The yard today is used only for naval conversions and repair.

13. Charleston Naval Shipyard, Charleston, S.C.
Established in 1901 this yard built destroyers in World War II but is now principally a small ship repair yard specialising in nuclear submarines.

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14. Savannah Machine and Foundry Co., Savannah, Ga.
Engaged in commercial ship conversion and repair.

15. Jacksonville Shipyards, Jacksonville, Fla.
A small yard currently building a survey ship for the Coast and Geodetic Survey. Has undertaken some naval repair.

B. THE GULF

Despite its low level of industrialisation, the Gulf Coast is rapidly increasing in importance in ship production.

16. Ingalls Shipbuilding Corp., Pascagoula, Miss.
In 1961 the Ingalls Shipbuilding Corporation was acquired by Litton Industries. The Ingalls yard on the Pascagoula river employs about 10,000 men and has the capability of building nuclear ships. Currently 3 SSN, one LPH and 1 AE are on order. Litton are building a new $134 million shipyard just across the river that is expected to commence ship construction this year with the yard to be completed in 1972. Already the largest indistrial employer in Mississippi numbers are expected to rise to about 12,500.

17. Avondale Shipyards Inc. New Orleans, La.
The most rapidly growing shipyard in the United States, Avondale has an order book exceeding $500 million. Ships building include the balance of 10 gas turbine powered HAMILTON class cutters for the U.S. Coastguard and a run of 27 destroyer escorts to be delivered at the rate of one a month. The shipyard is on the Mississippi

and confined by the river levee banks. The destroyer escorts are built in inverted sections and moved about half a mile over the levee to the building ways. There they are joined together, racked sideways as progressed, moved in to a launching cradle and side launched into the river. Employment would now be approaching 10,000 men.

18. Alabama Dry Dock and Shipbuilding Co., Mobile, Ala.
This small yard is building two submarine rescue ships for the U.S.N.

19. Todd Shipyards Galveston and Houston, Texas
The Todd Gulf yards are engaged in commercial ship conversions and repairs.

C. THE GREAT LAKES

Until the St. Lawrence Seaway opened the way to the Atlantic, ships built in the Great Lakes were confined to these fresh water seas unless they were small enough to get down the Chicago River into the Mississippi. However both submarines and destroyer escorts were delivered this way in World War II.

20. American Shipbuilding Co. Toledo and Lorain, Ohio
Principally builders of lake steamers, these yards have carried out "Jumbo" conversions of naval tankers.

21. Defoe Shipbuilding Co. Bay City, Mich.
A yacht builder before World War II, Defoe developed roll-over launching for destroyer escorts completing one every two weeks in peak production. Builder of 7 DDG's including PERTH, HOBART and BRISBANE

for the Royal Australian Navy. Currently completing two oceanographic ships and a number of land ships.

22. Litton, Erie
A new yard to build ships for the Great Lake trade.

D. THE PACIFIC COAST

The West Coast, home of rapidly expanding aerospace engineering, is playing an increasing part in shipbuilding although labour problems have beset the industry in the last decade.

23. Lockheed Shipbuilding Co., Seattle, Washington.
A small but well established firm, the Puget Sound Bridge and Dry Dock Company was taken over by Lockheed in 1959. Substantial Navy orders were obtained and employment increased from 700 to nearly 5,000 men. However various problems led to substantial trading losses for several years ($8 million 1964). Currently completing 5 DE, 7 LPD, 6 rescue submarines and the hydrofoil research ship PLAINVIEW.

24. Puget Sound Naval Shipyard, Bremerton, Washington
Established in 1891. Primarily a large ship repair yard but currently building 2 AOE and 1 AD.

25. San Francisco Bay Naval Shipyard. California
The administration of the two separate Yards of Hunters Point in San Francisco, and Mare Island near Vallejo, was combined in 1966. Hunters Point is principally a repair yard while Mare Island builds nuclear submarines, five now in hand.

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26. Todd Shipyards San Francisco and San Pedro, Calif.
Todds naval building is shared between these two West Coast yards with seven DE's currently under construction at each yard.

27. Long Beach Naval Shipyard, Long Beach Calif.
This newest naval yard was built during World War II and is engaged in ship repair work.

28. National Steel and Shipbuilding Co., San Diego. Calif.
This expanding yard has orders for merchantmen , and a run of 17 LST's. Automatic plate handling equipment has recently been installed.

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THE ROYAL INSTITUTION OF NAVAL ARCHITECTS

AUSTRALIAN BRANCH

NAVAL SHIPBUILDING IN THE UNITED STATES OF AMERICA

BY

A/CAPTAIN W.J.ROURKE, R.A.N.

WEDNESDAY 21ST MAY 1969

DISCUSSION

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DISCUSSION

Mr. E.S. CLARKE, AUSTRALIAN SHIPBUILDING BOARD:

I note with interest Mr. Chairman the large bilge keels shown in the photographs of the D.D.G's. If stabilisation for habitability or operational requirements is the objective would not flume stabilisers be preferable, thereby reducing skin friction? Alternatively if you are going to have extra skin friction would not fins be preferable as a more efficient means of stabilisation?

Author: Until recently the Americans have not given the attention to stabilisation that other navies have as they did not regard it as significant. They considered that bilge keels were adequate for ships like D.D.G.s. In spite of the adverse comments by early crews I do not consider that the movement of the DDGs does in any way significantly reduce its operational capabilities. There is strong support in North America at present for flumes, and perhaps particularly so in Canada. In the slow moving ship it is obviously better than the active fins and these are being used extensively on oceanographic research vessels, ice breakers and similar vessels. The Canadian group seem stronger on this than the Americans but in the new destroyer escorts, like the one shown tonight, the Americans are now fitting Denny-Brown type active stabilisers.

Cdr. P.T. Edwards: No mention was made of cathodic protection. It is fitted, if so what type and how effective is it?

Author: Having been engaged in this field for some time before I left Australia I was a bit disappointed to find that the USN did not cathodically protect the DDG's except for sacrificial zinc anodes around the stern of the ship. Of course in the Great Lakes it did not matter, as you had fresh water there during building. In fact it is one of the fringe benefits of building a ship in the middle of a great continent, that parts could be left all over the place and they did not rust very much.

Mr. N. Holland, Garden Island Dockyard: It appears that payment is made to all contractors asked to produce a design project. If this is so it seems to me that this amounts to restrictive tendering. How are the contractors selected and would this not restrict competition and a possible lower price?

Author: Yes it does restrict competition. This is an implied aim of the whole programme because before the introduction of this scheme there were a very large number of shipyards and it was considered that concentration of the industry would improve its efficiency. They would not want to concentrate it to such an extent that they removed the competitive aspect. It is generally regarded in the United States that you need at least three people, if you can, as real competitors. To be that they have to be about the same size with the same capabilities and it is the policy of defence procurement in the United States to encourage a weaker member, to some extent, to maintain that number of competitors.

In this design competition they have invited all the industry to bid and obviously a little shipbuilder, like Defoe for example, is not going to have the capacity to charge $6,000,000 for one years design work as you need about 1000 engineers for this type of approach. The various groups have joined together to form consortia. A typical group has been one computor manufacturer, one shipbuilder, one naval architect, etc.

In the first stage about eight or ten firms sketch out what is their capability. These initial proposals are reviewed and selection made of the most promising three competitors. These competitors have been selected on a basis of capability and the three of them are paid to go into the design competition. One fact I did not mention in my summary was that at the end of the design competition the Navy owns the product of all of it. If one has produced some marvellous system of ship control, and another a marvellous system of general hull design they can be matched, and then negotiated into the final contract. Another aspect developed quite recently with procurement is the "fixed price incentive contract."

No firm will bid a fixed price on a $2,000 Million contract, because if there is an overrun of 10 or 20% it is so great a loss. The government hates "Cost plus" contracts so they try and mix the two systems. They set an agreed target price and if prices exceed that, the contractor will take an increasing share of the extra cost until he reaches a ceiling price; above that he takes the full loss.

Mr. N. Holland Garden Island Dockyard: This is much the same as the bans clause contract with De Hefferlans. The same sort of thing as any scheme with the employer as well as the employees, this worked very well. Has this just been introduced into America or is this something that has been going on for a long time.

Author: As far as I know cost plus incentive has really only been going, in any scale, for the last three or four years. From a purchasing point of view there is nothing better than having your ship delivered on a six months guarantee basis. This worked effectively as all the defects we found in the ships in the first six months were set right at Long Beach Naval Shipyard and we recovered about 30% of the cost. We did not recover the full amount but we were covered sufficiently to make it a reasonable deal between the builder and us for those things found wrong.

Mr. N. Holland Garden Island Dockyard: This is only possible if there is both an incentive to the employer and to the employee. If you have not achieved an employer/employee incentive it is hard to achieve the other.

Author: To the purchaser there is nothing better than fixed price.

Mr. N. Holland Garden Island Dockyard: A fixed price can be an incentive to the contractor but the contractor himself must have an employee incentive in order to be able to achieve his objective of obtaining a lower price than his competitor.

Author: Yes, there were attempts made to obtain employee incentives, bonus awards, etc. One incentive which I thought was a very useful device was the Value Engineering Clause they have in their contracts. A builder can propose any way of saving money, which if acceptable to the buyer, you share the saving half each. One such example is that the pre-wetting system in the DDG's proved cheaper made out of metal than it was out of plastic, so the builder received $2000 and the Navy a $2000 cheaper ship.

Mr. E. T. Bell GOSIEAA: From your experience in the U.S.A. what would you do to improve Naval shipbuilding in Australia from the point of view of design and procurement?

Author: Different people make up their minds in different ways and I hope, after I say this I can have at least one discussion from another viewpoint on what we have learnt.

It is the individual initiative and delegation to the man on the spot that I would like to see encouraged. The thing that impressed me most in the whole of the United States was not the tremendous technology, not the tremendous capacity but the organisation that allowed a man to get on with the job in hand. We are comparatively bureaucratic. We have a great

reluctance to rely on some builder to do the job without our guidance. We should lean more towards giving much more responsibility to the shipbuilder. Much more responsibility for procurement of the things that go into the ship, more design responsibility of the way the ship is built and this is the greatest lesson I learnt from Defoe Shipbuilding Co.

It is a very small independant company, worked in this way, and it offers more lessons to us in that regard than some of these bigger, more complex organisations.

Mr. E.T. Bell GOSIEAA: Do you think this prevails in the big yards where they are building 20 or 30 destroyers?

Author: Yes. Lake Avondale which is one of the biggest developing shipyards building 27 destroyers. They built ten of the gas turbine cutters for the Coastguard and this was completely up to them except that the Coastguard specified the machinery in the first place. For the first ship the Coastguard specified the way it was to be, then they contracted these people to build ten of them. Avondale changed the ship, they redesigned the control system, became licensees for a different type of controllable pitch propellor, all of this themselves. They were growing to be a reasonably big firm but even then their capacity was not radically different from our yards in Australia. Perhaps that is an overstatement but even so they were able to do this re-design themselves and thought it worthwhile incorporating these innovations at their own risk on a fixed price contract. The spirit of innovation and local decision seemed to be there. Only a few drawings for a naval ship went back to the Bureau for approval. Once the lead yard did the first drawings they were approved by the local supervisor and the lead yard sent the drawings to the follow-on yards who either adopted them or if they wanted to, produced a new drawing that the local supervisor had to approve. The ship was never inspected during construction other than by the resident USN Supervisor. This made a big difference to the builder as they did not have different people with different ideas coming and changing things around. The builder was left to build the ship his way and if it was not right at the end he suffered. He had a specification to meet in performance and various other ways and then right at the end the ship was taken and put through rigorous trials.

I was horrified at some of the things they did to some of those ships. The destroyer escorts were a single shaft ship with a twin cylinder steam machine plant. It is a requirement of the contract to be able to bypass one turbine by emergency change of steam piping. The very first time that ship was under way she sailed with the high pressure stage by passed and steam throttled through a simple valve straight into the low pressure turbine, making a screaming noise you could hear a mile away. About two miles away from the wharf a large steam pipe burst and the engine room filled with steam. The United States Navy people said "that was a worthwhile trial as we showed that design was no good." General Electric who had designed this cross over pipe had to very quickly re-design as it was going to cost them money. Until it was right it was their problem and it is a good way to get ahead.

Mr. K.W. Fisher University of Sydney: If costs are disregarded are Australian shipyards capable of constructing such ships as the HOBART with of course the provision that the special electronic equipment be supplied from external sources. If so, why have these ships not been constructed here? What are the expected cost differences between basic construction of ships such as the HOBART between a small shipyard such as Defoe and a yard of comparable size here in Australia.

Author: Australian shipyards are capable of building ships such as the HOBART. The principal difference between our own shipyards and the American is that American yards have a massive industrial complex at their elbow. This is what made a tremendous difference and your proviso that the special electronic equipment be supplied externally would have to include the main engines, the missile system, the guns and a number of other parts of the ship. Yes, we could have built the ship here but to get the ship built in the time scale that we wanted we would have had to bring in most of the equipment, bringing with it the problems of not being able to quickly turn to an alternative source of supply. Over there the shipbuilder could if he ran into difficulties, readily change his supplier.

As far as the cost differences I do not know if any estimates have been made. The basic labour cost was higher in the United States. There are various figures put forth to show that shipbuilding productivity in the United States is 50% higher than in Britain and about half that in Sweden and Japan.

Mr. E.S. Clarke Australian Shipbuilding Board: It was very interesting to me Mr. Chairman, to see compared Naval and Merchant shipbuilding in the United States. As you know the merchant shipbuilding in the United States is in a sorry flight and the United States Government is extremely worried at the very high cost of subsidising the industry. I can not understand, especially when you see the lack of facilities, for example the photograph of HOBART fitting out without a single crane on the wharfside, how was it managed? Why is it that they can do Naval shipbuilding effectively when their merchant shipbuilding is so expensive. Regarding your comments about the attitude of the men on the job; are they going to achieve better productivity on the tremendous capital structure Ingolls is building at Pascagoula compared with the basic methods that you saw at Defoe? In spite of Ingolls having huge orders, such as twenty destroyers to build, it is a mystery to me.

Author: The ship assembly cost is really only a small proportion (about 20%) of the total ship cost. The United States are the world's largest producer and exporter of advanced electrical and electronic equipment. About 60% of the worlds exports are from the United States and this is in competition with the rest of the world. So much of the military ship is dependant on the supply of such equipment and this is the reason why they can compete in the military shipbuilding role. In effect the highly competitive nature of the payload of the ship more than compensates for the less competitive aspects of the building. I do not know whether the average worker, given those updated facilities you mentioned will be more productive than the average worker here in Australia. It may have been more expensive building there but the production rate and everything that was achieved in the way they went about it is what impressed me so much. My enquiries into the relative costs of building warships in Australia and overseas have not turned up any direct comparisons, and some work seems desirable in this field. Although there are many difficulties in establishing a valid comparison man-hour figures suggest that U.S. yards can build a destroyer at lower cost than Australia, and with less than half the labour.

Mr. R. Bywater, Department of the Navy: I am quite categorical in stating that we could not have built these ships in Australia for the price or in the time and the only reason for this is that I consider Defoe as not necessarily a building yard. The hull of the ship is not the entire shipbuilding project but includes all of the equipment that goes into the ship as being just as important. They were backed by a vast industrial complex. Referring to the Author's statement, it is no different in this nation of ours that the majority of the equipment in a military ship is

military type equipment. This is not only the weapons, electronics or the newer combat equipments fitted in such ships, but also the basic nuts and bolts such as we have been currently discussing with the Australian Shipbuilding Board. This includes for example, light fittings, electric motors, circuit breakers, etc. People in our Design Section have spent weeks trying to obtain suitable contractors for circuit breakers in Australia without success, so we have to import them from either the United Kingdom or the United States. This is the factor that lets local shipbuilding down from the Navy's point of view. This must continue with our modest naval shipbuilding programme, modest in comparison with that of the United Kingdom which we have traditionally followed for the last 20 years or more. We sincerely hope, that with pressure from the Supply and Defence Departments, we will manufacture locally and that we will give the incentive to local industry to build the equipment up to our standards. It is likely to cost us more initially, but if the Government think this is a worthwhile asset in the national technology then possibly in ten to 20 years time we could compete in naval shipbuilding with England or the United States, but right now we can not.

Mr. J. Jeremy Cockatoo Docks & Engineering Co.Pty.Ltd.: Some of the major frustrations to naval shipbuilders in this country are the supply of equipments from both local and overseas sources. In fact we are building ships at the same time as they are being designed. Considerable quantities of equipment which we are putting into TORRENS, building at present, comes from overseas and in this respect we have two particular problems. First, is the apparent late decision which is made by the owners of the ship as to exactly what is required and second, in many instances the notoriously bad delivery records of the overseas suppliers themselves. I know there are a great number of problems to be solved in this regard and if we could find a solution either in a ready and rapid source overseas, or an alternative source in this country, it would greatly assist us.

We have local problems on the subject of design change and I would like to know what the procedure is in the United States for changes in design of ships during the construction period.

Author: My main aim in delegation to the shipbuilder would not eliminate the frustrations and difficulties but would let the shipbuilder have them; they would still exist. It is best to give the shipbuilder the problem of scheduling and organising adequate supply. One important difference between U.S. and Australian practice is that in the U.S. you could not have the shipbuilder do anything at all in the ship unless there was a formal written change to the contract. There was a rapid procedure for having a change order typed up considered and a price adjudicated. Defoe were easier than most, in that once the change was written, they often went ahead with the work before the price was agreed. Irrespective of the price involved there generally had to be a formal amendment to the contract. This is a good practice as the formality improves things for both sides. Another thing that we attempted to do, which was easier because the design was well established there, was to avoid changes in the last twelve months. The U.S. Navy generally tried to do this, but I must correct one possible misapprehension in peoples minds. The U.S. Navy's average delivery time of ships was about one or two years late. Our ships were delivered fairly well on time and my thanks to them for it. They disrupted their own programme often, in order to provide urgent pieces that were needed for our ships. They too have problems in design changes delaying completion, but we should consider this procedure of formalising even the small changes.

Mr. J. Jeremy, Cockatoo Docks & Engineering Co.Pty.Ltd.: Is there a specific date by which major changes must be completed; for instance when the general arrangement and equipment for the ship must be frozen.

Author: Not that I know of, but the responsibility in the United States Naval System is solely that of the Project Manager. He has the job to have the ship delivered and he controls all the resources. If he considers that something else should be done he can tell the shipyard and accept the delay which he will have to justify. In general he has considerable discretion in what to do. There have been some extremely large design changes made in their ships. Some of the D.E's shown tonight were to carry a dome helicopter and then they decided that they would not carry it. They changed the size of the Asroc missile magazine and these changes set the ships back considerably. On the other hand they finished the DLG's which were a new class of ship and commissioned them generally on time. After they were a year old they were given what I can only describe as a complete re-build, to install the integrated Naval Tactical Data System.

WRITTEN CONTRIBUTIONS TO THE DISCUSSION

Mr. J.D. Lee, Department of the Navy: While as Naval Architects we are ready to admit contract definition and contract administration are very much part and parcel of a ship procurement programme and consequently have a large influence on the construction of a ship, particularly from the time scale angle; the paper is disappointing in that it does not contain some of the construction methods enabling complex ships such as aircraft carriers to be built in the short time of 15 months. This is what we associate with U.S. production methods.

American shipyards varied so much that I do not think any one shipyard would represent a typical American Shipyard. Costs at Defoe were very competitive but a comparison between Defoe and for example Boston Naval Shipyard could vary as much as 1200%.

It is interesting to note that the three Contract Definition Construction Formulation projects none has yet been approved in its original form. I do not consider that Australia for example has the big firms capable of entering this kind of competition. Even in the USA there was considerable poaching of staff for such projects. However the concept is good.

The fact that Defoe has gone to this Contract Definition Construction Formulation seems to me to indicate that they have, despite the huge numbers of technical officers at their disposal both in Buships and Naval Shipyards, been unable to produce the right result at the ship and this hardly substantiates the statement on Page 12 of Captain Stephen Roskill. Further New York Ship Co. New Jersey which was predominantly managed by ex Bureau officers was closed down in the middle of a contract for a nuclear submarine, the only such occasion.

It is interesting to note of Petersens, Sturgeon Bay that no employee belonged to a union, they however received incentive payments, had a retirement scheme and were among the highest paid U.S. shipyard workers. Contracts were mostly for United States Navy and Coastguard. They employed 550 men and built ships to large minesweeper size and 165 foot all aluminium gun boats. Equipment was modern and complete. A comparison between the average production worker at Defoe on an annual earning of $7500 and a janitor at Chu Plant Bay City of $8600 is interesting.

Author: Mr. Lee regrets my neglect of construction methods. In wartime the USA introduced many innovations to simplify processes and to speed construction. One such technique was the inverted building and roll-over launching pioneered by the Defoe Shipbuilding Company. But in general I found that apart from highly developed skills in the welding of aluminium structures, there was not that much difference between american construction methods and our own. I believe the major divergences from British and Australian practice lie in design, procurement and management philosophies, and so have concentrated on these areas.

Some of the major design differences evident in the DDG's were:

a) the continuous upper deck sweeping through from stem to stem providing strength and a good seakeeping hull.

b) the use of light alloy for all structure above the upper deck adding significantly to permissible superstructure volume.

c) The spacious two-level layout of main machinery spaces providing good operation and maintenance access to machinery.

All these factors, and the substantial load carrying capacity of the hull, contributes to the high effectiveness of these ships.

I cannot accept that the move towards new design and procurement practices is a measure of failure of previous methods. Rather a philosophy of innovation and experiment ensures that progress is maintained.

Mr. Lester Rosenblatt
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It is with great pleasure that I offer this comment on Captain Rourke's very fine paper, "Naval Shipbuilding in the United States." He has done an admirable job of covering in a very comprehensive way this most complex process.

The principal purpose of my comment is to amplify his description of the role of the consulting naval architects in naval shipbuilding, as well as to describe the type and scope of contract normally provided for naval architectural services.

Historical

Private naval architectural firms have existed in the United States for many years. As a matter of fact, the earliest Naval Constructors were originally civilian naval architects brought into the naval service. Over the years, the position of the Naval Constructor was transformed until today we have in our Navy, Naval Engineering Duty Officers, many of whom are well qualified naval architects in uniform.

Most private naval architectural firms in the United States remained relatively small well into this century. It was not until new shipbuilding programmes began in earnest in the 1930's that several large commercial naval architectural firms were developed. The number of such firms increased greatly during World War II and immediately after, in response to the needs of the nation for ship design services.

For many years the larger shipyards have maintained an in-house capability for preparation of working drawings. All of the Navy Yards are in this category, as well as the larger shipyards such as Newport News, Electric Boat, General Dynamics (formerly Bethlehem Steel) Quincy, New York Shipbuilding (no longer in business), and the Ingalls Shipbuilding Corporation. The smaller shipyards usually depended, to a varying extent, on the private naval architect to provide engineering support as required for their work.

Post World War II Developments

During and immediately following the Korean emergency, the Navy experienced a greatly expanded shipbuilding program. As a result, this period saw a tremendous peace time expansion in the development of private naval architectural firms. In tracing this expansion of private firms, it is interesting to note the changes in procedures followed by the Bureau of Ships. Commencing with its establishment in 1941 and continuing through its disestablishment in 1966, the Bureau of Ships was responsible for the preparation of preliminary design, contract design and working drawings for all ships constructed by the Navy. Initially the Bureau of Ships conducted all preliminary design and contract design work in house and all working drawings were prepared by naval shipyards, the design divisions of the large commercial shipyards, or by private naval architects. During the Korean crisis the Navy found that it could not complete all contract design work within the Bureau of Ships and farm out of contract designs for non-warships was commenced. Similarly, beginning in 1953, the Bureau of Ships began to farm out isolated non-warship type preliminary design projects. By the end of the 1950's, the workload in the Bureau was such that private naval architects were being used for the preparation of contract designs for all types of ships, and in recent years the procedure has been expanded to cover preliminary design of all types of ships. As a result the capabilities and capacities of private

naval architects have grown in response to this need, so that there are now several firms of private naval architects who can handle preliminary design and contract design, as well as working plans, for practically all types of naval and commercial ships.

The advent of Total Package Procurement (TPP) has introduced additional changes. With this modification to contracting procedures, the Naval Ship Systems Command (the successor to the Bureau of Ships) has concentrated its talents more and more on the Concept Formulation phase of ship design development, and has left to private contractors during Contract Definition phase the development of the design in the detail normally covered in the preliminary design and contract design phases. Although working drawings have not yet been developed for a TPP ship, their completion will be by the design division of the successful contractor, with the probable assistance of a private naval architect.

Contracting Basis

The normal type contract under which naval architectural services are provided is a cost reimbursement contract where the naval architect is paid for his actual cost plus a fee which is fixed as a percentage of costs estimated to complete the work defined by the contract (CPFF, i.e., cost-plus-fixed-fee). In some cases, where the scope of the work cannot be well defined initially, the naval architectural contract is a "time and material" contract under which the contractor is reinbursed at a fixed hourly rate. In isolated cases, where the scope of the job can be very clearly defined and where development is limited, design services are procured on a fixed price basis. By far the vast majority of all ship design work is performed under cost reinbursement contracts of the cost-plus-fixed-fee type.

Contracts for the preparation of a naval ship Preliminary Design or Contract Design are normally drawn up on a CPFF basis and are contracts directly between the Government and the Naval Architect. On the other hand, contracts for preparation of working drawings are drawn up between the Shipbuilder and the Naval Architect. These latter contracts are usually on a CPFF basis even though the basic contract to deliver the ship is normally a fixed price contract between the Government and the Builder.

General Comments Regarding Total Package Procurement.

The total package procurement concept, and the purchase of large numbers of identical ships at one time from one builder without competitive contract Definition, are processes not universally accepted as improvements over ship procurement policies of the past.

The total package procurement procedure which the United States Department of Defense has caused to be adopted is highly logical, but it is also exceedingly complex, at least to the extent that large numbers of highly skilled men are required to make it work -- numbers which some believe are beyond those available. In short, it may be that these procurement procedures are too complicated and accordingly consume too many man hours, dollars and, most importantly, too much elapsed time.

Total package procurement procedures seem to many to be best attuned to procurement of large numbers of medium size items. Differences in size have great effect upon the utility of the system. Ships are among the largest and most expensive items procured by the Department of Defense and prototypes are almost non-existent -- unlike aircraft programs. Many persons question the validity of total package procurement for items as large and costly as ships which are always purchased in comparatively small number.

During and immediately after World War II and the Korean War, strenuous efforts were made in the United States to broaden the procurement base. Total package procurement is generally a negation of that principle. It is believed that either of these policies carried to an extreme is wrong and that there is a prudent, really cost effective, mean for construction and design of ships.

It is by no means true that purchase of a large number of ships at one time, whether by total package procedures or not, is a cure-all. Many problems do arise.

For example, and referring to the second paragraph of Page 14 of the paper and the reference to the award of 20 DE's of a single class to a single shipyard at a saving over two builders of approximately $16. million, it is interesting to note a recent contract claim settlement affecting the first 14 ships of the same class. These 14 ships were awarded to Todd at a price of approximately $145 million. A single claim under this contract has just been adjudicated for approximately $95 million! The problems underlying this claim would have been resolved for less expensively if a smaller number of vessels had been involved - - obviously.

In his conclusion, Captain Rourke quotes former United States Secretary of the Navy, Frank Knox.

> "We must be intolerant of dalay, we must tear our way through red tape, we must pillory bureaucrats who stupidly sacrifice time in pursuit of an impossible perfection."

These words do sum up succinctly the way we Americans try to approach the problems; however, this discusser feels that application of Secretary Knox's dictum is more urgently needed today by the United States Department of Defense than when the statement was first made.

Conclusion

It is hoped that the above comments and brief description of the increasingly important role played by the private naval architect in shipbuilding in the United States will amplify this most interesting paper by Captain Rourke.

Author: The amplification of the changing role of consulting naval architects is a valuable addition to this account of naval shipbuilding in the USA. It is particularly welcome from one who has played a significant part in the developments he describes.

Mr. Rosenblatt provides a useful counter balance to my enthusiasm for the new total package procurement practices. I can but agree that competitive design may be uneconomic in manpower, and an over concentrated industry would provide an inadequate procurement base. A balance must be struck and it may well be found that current practices lean too far towards creation of a monopolistic industry. The startling figures for contract claims in a fourteen ship buy, certainly indicate that changes after contract date could invalidate the results of the initial contract competition. Perhaps more than one contract is needed so that some element of competition remains throughout the construction process.

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I would like to congratulate Captain Bourke on his presentation of a most interesting and readable paper.

The main purpose of my comment is to clear up a few apparent discrepancies regarding warship design and procurement in the United Kingdom.

NAVAL SHIP DESIGN (PAGE 5)

It would be a mistake to imagine that the design of warships in Britain rests solely in the hands of the marine-oriented and military-oriented segments of industry. For the Royal Navy, what one might call the Concept-Formulation and Contract Definition stages are completed under the control of Director General of ships using as required the manpower of the Navy Technical branches and:-

Navy-oriented Government organisations such as:-

Royal Corps of Naval Constructors
Royal Naval Scientific Service
Admiralty Materials Laboratory
Admiralty Oils Laboratory
Admiralty Experimental Works
Admiralty Underwater Weapons Establishment.

Other Government organisations such as:-

National Engineering Laboratory
National Physical Laboratory
British Ship Research Asscciation.

Warshipbuilders such as:-

Vickers
Vosper-Thornycroft
Yarrow.

Universities and Technical Colletes
Consultants such as Y-ARD
Industry in general, marine, power generation, petrol/chemical, aerospace, electronics, etc.

When the Contract Definition package is complete, the warshipbuilders compete for fixed price tenders both for building services and for lead-yard services which generally include the preparation of working drawings and bulk ordering of equipment for the class. When the dust has settled, all shipyards selected build to the drawings produced by the lead-yard and fit equipment ordered by the lead-yard thus ensuring similarity amongst all ships of a given class. By this method the shipbuilders are left free to concentrate on building and leave the basic design and selection of equipment to organisations created for the purpose. The final word in all matters rests with Director General of Ships who has in the end to live with and maintain the ships for the next twenty years or so.

The Type 12 Frigate is a good example of the above method of design and procurement. Type 12 Frigates have been built in significant numbers in the United Kingdom for the Royal Navy, the Royal New Zealand Navy and the South African Navy. It has also been built in various modified forms in Canada for the R.C.N., in Australia for the R.A.N., in the Netherlands for the R.Nl.N. and is currently being built in India for the Indian Navy.

A further development in the area of equipment selection is the establishment of a Systematic Machinery and Equipment Selection Policy for the Royal Navy which has been in force for some time (SYMES). The aim of the SYMES policy is to reduce the diversity of mechanical and electrical machinery equipment in the Fleet so as to make the best use of resources in terms of ships, naval manpower, design effort and money: and in consequence to reduce maintenance, logistic and training problems in the Royal Navy. The SYMES policy applies with equal force to propulsion machinery, whether mechanical or electrical, to auxiliary and domestic machinery, both mechanical and electrical and to deck machinery such as capstans and winches. In the case of a composite plant or machine, the policy applies to each of the separate units or parts of which it is comprised.

Apart from the Royal Navy, there still remain certain shipbuilders such as Vickers, Vosper-Thornycroft and Yarrow who have a capability to design and build warships as a commercial venture. Such warships have found favour with certain foreign navies such as Iran, Malaysia and Argentina.

PROPULSION MACHINERY MANUFACTURE AND DESIGN (PAGE 6)

Since the end of World War 2, steam turbines for the Royal Navy have indeed been designed by Parsons, A.E.I. and English Electric, generally on the basis of funded competitive design studies managed by Y-ARD on behalf of the Royal Navy. It will come as no surprise perhaps that in every instance the award went either to English Electric or to A.E.I. who are not specialist marine firms but the principal turbine builders in the United Kingdom. Merchant ship turbines have been following the R.N. lead and with the recent demise of Parsons future competition will be provided from turbine builders in the United Kingdom who manufacture under licence designs of European or U.S. origin.

Turbine designs selected as a result of competitive design studies have been manufactured in the U.K. both by the designer and by other turbine builders who have been licensed for the purpose. In the case of English Electric Y.100 turbine design, arrangements for manufacture have also been made in Canada, Australia and India.

By the same funded competitive design study method boiler designs have been selected from proposals put forward by Foster Wheeler and Babcock and Wilcox and gearing designs from studies by A.E.I., David Brown and Vickers.

The same technique has been applied in the selection of other major components such as turbo-generators, feed pumps, forced draft blowers, etc and is often applied (but seldom funded) in the selection of smaller components.

As a result of this method of selection the whole of British industry's capabilities are brought to bear on the Royal Navy's requirements and ships of a given class are invariably fitted with identical machinery.

In the case of gas turbines for the Royal Navy the situation is entirely different. In this field units have been and are being developed from existing aero engines; the cost of developing custom-designed units of this type being quite unsupportable. In this category are the Proteus, Olympus and Tyne. The A.E.I. G.6. gas turbine currently fitted in the COUNTY and TRIBAL classes is the only custom-designed naval propulsion unit and is based on an industrial engine. Being an unsophisticated and relatively lowly rated deisgn, the development costs by aero engine standards were almost insignificant.

NEW PROCUREMENT PRACTICES FOR U.S. NAVAL SHIPS

The Concept-Formulation, Contract Definition process as applied to the FDL is indeed quite fascinating and the quotation on Page 19 must bring tears of joy to Treasury Departments. Could Captain Rourke tell us if the 400 million dollars relate to the production of a 30 ship system within a closely defined time scale? One has the feeling that a 15 million dollar investment applied to say 4 ships (Page 18) built some years after the oroginal terms of reference had been laid down may not necessarily appear too satisfactory particularly if the ground rules have changed. In the FDL exercise the basic rule appears to be a 25-year lifetime cost but this rule could well be changed at quite short notice for political and economic reasons and a new rule selected from the whole spectrum with initial capital cost at one end and 25-year lifetime cost at the other end.

I would not like to close this comment without a passing reference to the quotation on page 11 from Roskill's book "Naval Policy Between the Wars". It was the recognition of certain shortcomings in R.N. equipment during World War 2 that led to the formation of organisations such as Y-ARD and new methods of design, equipment selection and procurement for post war British warships. These methods may differ from U.S.A. techniques but it would be very wrong to assume that Roskill's views on the inter-war years had any relevance to the present.

Author: I am grateful to Mr. Rimmer for providing an up-to-date statement of British practices in design and procurement of warships. Each side of the Atlantic retains basic differences in approach. The Royal Navy aims at reducing diversity in the equipment of its ships, while the US Navy allows it and encourages it. I believe the latter policy provides more operating headaches, but encourages faster development.

The projected savings on the FDL programme refer to the full production programme and are unlikely to be realised if less ships are built in a longer time. If no ships at all are built, as now appears likely, there will be no savings and the $15 million dollar investment in design will show no direct returns. Lack of Congressional approval for a controversial programme does not invalidate the design process, although it may point a need to have missions approved before spending too much on means of carrying them out. A contract for $1,012,500,000 has recently been awarded to Litten Industries for construction of nine LHA's. This is the largest single shipbuilding contract ever let, and the first naval implementation of the contract definition process.

CAPTAIN W.H. GARRETT, USN (RET.)

It was my privilege to be associated with Captain Rourke and others of the RAN (both Naval officers and civilians) during the construction period of the three guided missile destroyers PERTH, HOBART and BRISBANE. If Captain Rourke's concluding paragraphs are representative of the impression created by this country's naval shipbuilding community on those who came here from Australia to oversee the construction and man these destroyers, then I can only be proud to have had a hand in that effort. In nearly 25 years of experience with naval shipbuilding and repair I have observed that the best results have come about when the ship's company has been knowledgeable, interested and motivated. Captain Rourke and his associates, both in Washington and at the building site in Bay City, Michigan, certainly met these criteria.

It is difficult indeed to contribute to the broad coverage of this paper without becoming engrossed in detailed discussion of specific points. The author has been tremendously successful in condensing a comprehensive overview of a vast subject. It is a tribute to his personal dedication that he was able to accumulate such a diversity of information without detriment to his primary assignment, first on the Washington Naval Staff and then as Engineering Officer of the third ship. Hopefully, the few comments which follow may serve to enlarge upon or clarify certain points without becoming querulously involved in trivial details.

An historical event of great significance which was omitted from mention was the shift from coal to oil as the primary shipboard energy source. This transition occurred largely in the years following World War I, and of course as a by-product of this technological advance came an improvement in living conditions aboard ships as the days of stoking and coal dust disappeared. The advant of radio (wireless) communications, modern fire control techniques for laying naval guns on target and the advent of radar (with due credit to the British) in the 1930's were all significant in the advancement of Navy shipbuilding technology. Captain Rourke nearly sums these and other developments in his allusion to a "tremendous growth in the extent and complexity of sensor and weapons systems and ship's demands for power" which were vastly accelerated in the late 50's and early 60's. For anyone unfamiliar with the progressive "state of the art" in Naval shipbuilding to use a popular current day phrase, his is a masterpiece of understatement.

A development of particular and far reaching significance to the U.S. Navy which should not go unmentioned in any historical survey, however brief, took place at the end of the first decade of this century. On November 14, 1910 Eugene Ely made the first successful aircraft take-off from the USS BIRMINGHAM at anchor in harbor. Some two months later he made an arrested landing on a jury rigged platform aboard the armored cruiser USS PENNSYLVANIA (it was <u>not</u> a continuous flight!). This, of course, was the precursor of the aircraft carrier and naval aviation which was born in LEXINGTON and SARATOGA and came of age in World War II.

Drawing largely on the latest published information of the Shipbuilders Council of America, I will cite a few data which could well be indicative of what Council President E.M. Hood has termed "a renaissance in U.S. shipbuilding which began about five years ago and has been rapidly moving forward. It holds great promise for the future....." During 1968, the final figures showed that total employment in private shipyards amounted to 144,000 and in Naval shipyards 95,200, up slightly from the numbers given by Captain Rourke which were presumably based on preliminary data. The average hourly wage in December of 1968 had also increased to $3.70 for production workers and the corresponding weekly earnings to $153.55 due in part to a small increase in average hours worked

per week. Of greater import, however, is the apparent healthy growth in capital improvement investments by the shipbuilding industry. Again, as reported by the Council, $53 million was spent in 1966 for plant improvements as compared to less than half that figure in 1962. Furthermore, the indications are that nearly double the 1966 figure was spent in 1967 and 1968. Although each yard seems to be tailoring its modernization to its own peculiar situations, the trend appears to be directed toward more automation and "the improvements of material flow and fabrication techniques" (3). The handling and movement of large (sub-) assemblies in an attempt to bring the job materials to the worker is generally favored as a means of increasing individual productivity. The Navy has also developed a comprehensive long range improvement plan for its facilities.

Two of Captain Bourke's observations at Defoe, a very fine, relatively small yard, are not extrapolative across the industry. In many yards, as he states, labor is represented by a single union or an amalgamation of trade unions in some form such as the Metal Trades Council. Other yards, however, are faced with a plethora of union organizations and there is a wide variation in the course of labor-management relations throughout the industry. Newport News Shipbuilding and Drydock Company, for example, endured the first strike in their long history last year. Fortunately it was of short duration.

The second observation which could be misleading is in regard to the apprenticeship system. Both the Naval shipyards and many of the private yards have active and productive apprentice programs of high caliber. Technical and academic subjects are taught in the classroom as well as trade skills in on-the-job training. Graduates of these programs are generally much sought after in industry and frequently have moved rapidly upward in the ranks of production management.

In regard to the listing of shipyards in Appendix A to the paper, it is obviously not intended to be comprehensive in scope, but the inclusion of the recently defunct, privately owned New York Shipyard at Camden, New Jersey, brings to mind the New York Naval Shipyard at Brooklyn, New York which closed its gates on 30 June 1966. This formerly great public yard employed tens of thousands during World War II and was justly famed for its building of battleships, including the renowned USS MISSOURI, on whose decks peace in the Pacific was signed in 1945. Among the yard's post war accomplishments was construction of the supercarriers SARATOGA (CVA60), INDEPENDENCE (CVA62) and CONSTELLATION (CVA64). Current speculation is that this facility may soon be re-opened under commercial auspices, possibly for the purpose of building super-tankers, a job uniquely matched to its past history of building the big ones.

It seems only fair, also, to mention that the Washington Navy Yard has never played a significant role in either the construction or repair of ships in modern times. Perhaps its greatest fame lies in the manufacture of large caliber naval guns, now relegated to the past by the guided missile. Two other Eastern yards worthy of mention even in a summary are the Maryland Shipbuilding and Drydock Company of Baltimore, Maryland and the Norfolk Shipbuilding and Drydock Corporation of Virginia. Both are primarily repair yards, although the Maryland Yard has done a moderate amount of merchant type construction. Bethlehem Steel, of course, has plants at other locations than Sparrows Point, including the Gulf and West Coasts. In the Pacific Coast area, it is Todd's Seattle, Washington yard which has 7 of their 14 DE's under construction, along with the San Pedro division.

It is the procurement area, both old and new, that I think Captain Rourke has done an exceptionally good job of condensation. It is a large area of many facets, any one of which could be pursued profitably at length. I will emulate his example by confining my comments to a few salient points.

The author's opening assessment of the old Bureau (now NavShips) system is of particular interest at this time. In the face of recent adverse criticism of the status of the Navy's shipbuilding program in the press and in testimony before Congress, it appears that steps are being contemplated to strengthen even further the authority of the Ship Acquisition Project Managers. At the same time, no lessening of their responsibility to the customer, the Chief of Naval Operations and the operating Fleets, is to be anticipated. In fact, much attention is being given to ways and means of strengthening the dialogue between those setting the operational requirements (the CNO) and those executing the engineering and financial management functions necessary to the fulfillment of those performance requirements. That this will be accomplished within the broad framework of what the paper describes as "New Procurement Practices" seems to be self evident. That the details of these procedures will be modified as experience is gained is only logical. The art of project management as currently being applied by the Navy (and the Department of Defense) is an evolving one, and in the field of shipbuilding the U.S. Navy has yet to see a completed project. A further step in this direction was taken on 1 May, however, when the Navy and Litton Industries signed the LHA shipbuilding contract calling for the construction of 9 ships in a package deal, at a total price of slightly over $1 billion dollars. This is probably the largest ship contract ever awarded to one company. The DX (now designated DD963) is currently scheduled for contract award in November following Navy evaluation of contractor proposals submitted the first of April.

With regard to the description of the Concept Formulation - Contract Definition process, an erroneous impression may be inferred in respect to the depth of design detail available at various stages, at least in terms traditionally familiar to the naval architect and marine engineer. Concept Formulation may produce no ship "design" as such. In the base line language of the configuration management discipline, the object of C. F. is to translate the Operational Requirements Baseline into a Functional (Characteristics) Baseline. In plainer language, the mission objectives are turned into functions to be accomplished by the proposed system. Prior to proceeding into Contract Definition formal approval must be obtained from the Office of the Secretary of Defense. To obtain this approval, six prerequisites must be established as follows: (1) the mission and performance envelopes be defined; (2) the best technical approaches must have been selected; (3) engineering rather than experimental effort is required; (4) trade-off analyses vis-a-vis other systems must have been made; (5) the cost effectiveness analysis must be favorable; and (6) the cost and schedule estimates must be credible and acceptable. None of this requires a detailed design in the commonly accepted usage of that term. Estimates can, and usually are, made on a parametric basis. Analytical models are employed rather than precise designs.

Subsequently, during what is commonly the competitive phase of Contract Definition, the Functional Baseline is transformed into performance type specifications sometimes referred to as the Allocated Baseline. Functions are defined at the system, subsystem and component level. Although performance type specifications are the required output of C.D., the further requirements for firm schedules and cost data frequently force the competitors rather more deeply into detailed design than would otherwise be the case. The point being made is that a detailed ship design sufficient for even the start of construction is not normally available at the end of Contract Definition.

The concept of basing source selection, at least in part, on a calculated Figure of Merit is deceptively simple. The difficulty lies in deriving an appropriate F.O.M. This is particularly true for a system having a multi-mission objective. It is frequently easier to determine the cost of a system attribute than it is to determine the value of that same attribute, or in terms of the F.O.M. model suggested by Captain Rourke, it is generally easier to quantify costs (even lifetime) than effectiveness. It is suggested that the example cited has limited utility in the complex environment of a warship. Nevertheless, effectiveness must be evaluated and requires a considerable effort on the part of the evaluation team.

A final comment in this procurement area - the industry teams formed to compete in the ship projects thus far have been most impressive. It is hoped that the integrative effect of having this kind of talent arrayed under a single prime contractor with near total responsibility, will result in a whole system approach which will pay large dividends. The shipbuilder of the past, skilled in steel erection and assembly of subsystems, now finds he has a much larger role to play. Responsible for product performance, and given freedom of design, he will be forced to greater engineering effort and broader system management exertion.

Although "Trends in Destroyer Design" could well be the theme of a whole new paper, I will content myself with two comments. First, with respect to the so-called "modular-podular" concept, I have very grave doubts as to its practicality as generally depicted in artistic conceptual sketches showing whole, major subsystems being neatly hoisted off-ship by a giant crane. Generally a replacement subsystem is hanging by another hook just waiting to be dropped in place. Undoubtedly this is feasible for something like a unit air conditioner, or probably somewhat more complex but still self-contained subsystems. For a major subsystem like a missile launching and guidance system, however, I have extreme difficulty envisioning the necessary matching of all interfaces. Perhaps it can be done, but I have not yet seen the detailed engineering required to prove it out.

My second point is related to the volume determination of ship size and has to do with topside arrangements. If we have not already reached it, we soon will be at the point where requirements for antenna space, freedom from electronic interference and radhaz considerations may dictate the above water length of our destroyer designs. A system approach to this subject is currently being given serious attention in the U.S. Navy.

Re-reading my comments, I conclude that Captain Rourke is better than I in the matter of covering his subject in a few words. I congratulate him on a well done job.

Author: Until recently Captain Garrett was Project Manager of the US Navy DX/DXG programme, and before that was responsible for destroyer procurement including that of our DDG's. He has been a great help to me in the past, and is so again. His explanation of the contract definition process is particularly interesting and he introduced some important warnings against over-simplification of the cost-effectiveness model.

The problem of making valid assessments of cost, and the more intractable problem of making valid assessments of effectiveness, are ones that deserve a great deal of attention by those engaged in design or design assessment. There has been, in the past, too little intercourse between those establishing mission requirements, and those devising means of their solution. As Captain Garrett points out a single figure of merit has little meaning when applied to a complex, multi-mission ship. A variety of

operational scenarios must be devised that provide realistic models of probable employment of the vessel. The performance in various roles must be examined and results of studies subjected to the critical scrutiny of those with military experience. Weighting factors must be established that give subsidiary roles the right emphasis. All this is easier said than done, but it has to be done before it will become any easier.

Captain Garrett's remarks on specialist unions and apprentice training show that some of the characteristics I notes as particular to US ship building, were really particular only to a few firms, and that over the industry our practices are more alike. In the same way, I may have given undue emphasis to the separation of powers of the resident Supervisor of Shipbuilding and the Bureau of Ships in Washington. In practice the Washington head office and local supervisor work very closely together and the Bureau of Ships keeps well aware of what is happening in the yards. I did find however that the administrative framework allowed most problems to be locally resolved.

CONCLUSION TO DISCUSSION

To describe Naval Shipbuilding in the USA is a task that is hardly practicable to accomplish in the twenty pages of my paper. I feel now with the aid of the discussion, and particularly the written discussion from the USA, that we have got a little closer to it.

Much of my paper and a great deal of the discussion, was devoted to recent procurement practices. These practices came in for some criticism, and since the paper was prepared there has been increasing dissatisfaction with the escalation of prices in massive total package procurement buys. Already there has been a change in the American aircraft industry towards a "lead production" concept to establish a defined cost on a limited scale. I do not uphold any particular procurement method as the one best way, and would certainly not contend that a method that is right in the USA is necessarily right for Australia. I am certain however that a spirit of enquiry and innovation in design, construction, and procurement is a desirable state of affairs in any industry and in any country.