THE ROYAL INSTITUTION OF NAVAL ARCHITECTS

(AUSTRALIAN DIVISION)

NAVAL SHIPBUILDING – SOME AUSTRALIAN EXPERIENCE

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SUMMARY

Throughout much of the Western World, the high cost of modern Naval ships has resulted in a new relationship between Naval shipbuilders and their customers. The need for tight control of costs has changed the emphasis in contracts from technical criteria to project management and cost effective production in a competitive environment.

This change has also occurred in Australia, where a small shipbuilding industry has built a wide range of ships for the RAN since the Second World War. Often these ships have been built to designs originally intended for other Navies.

This paper examines two major Australian Naval construction projects completed during this period of change. They illustrate the problems and challenges which can arise with the adaptation of foreign Naval ship designs for local construction, and show how the present approach to the management of major new construction projects has evolved.

1. INTRODUCTION

In December 1987 the Australian Government approved the second phase of a project to build, in Australia, eight new frigates for the Royal Australian Navy. With the possibility of four additional ships for the Royal New Zealand Navy, the Anzac Frigate Project will be the largest Naval construction programme ever undertaken in Australia.

It is planned that the twelve ships will be built over a period of about fifteen years, to a design of either Dutch or German origin modified to suit Australian and New Zealand requirements.

In preparing for the ambitious Anzac ship project, great care is being taken by the Department of Defence to ensure that both the shipbuilder and the customer have a clearly defined understanding of the scope and basis of the contract to provide a sound foundation for successful project management.

This has not always been the case in Australia, as is illustrated by the two major Australian Naval construction projects examined in this paper, which together spanned 37 years.

The first project involved the construction of six anti - submarine frigates (now classified as Destroyer Escorts). It began in 1950 and completed in 1971 when the last ship, HMAS Torrens joined the Fleet. Based upon a very successful British design, the ships were extensively modified over the 21 years of the programme. The last two ships were probably the most "Australian" warships yet built. Most are still in service, with the youngest to be replaced in the mid to late 1990's by the RAN Anzac Frigates.

The second project, to provide the RAN with a new replenishment ship, began in 1964 and ended 23 years later with the Acceptance into service of HMAS **Success** in 1987. This complex non-combat ship was the first ship of French design to be built for the RAN, and is the largest Naval vessel ever built in Australia.

Both these major projects provide excellent examples of the problems and challenges which arise with the adaptation of ship designs intended for different operational environments and for construction in different shipyards. They were completed over a period of developing shipbuilding and project management techniques. The lessons of both are worth heeding to the benefit of future projects.

2. HISTORICAL BACKGROUND.

Ships have been built in Australia for the Royal Australian Navy since the first decade of this century. With the close links between the Royal Navy and the Royal Australian Navy it is not surprising that most of these ships have been of British design origin - either existing designs modified for RAN service or ships designed by the British Admiralty specifically the for RAN, like the Seaplane Carrier HMAS Albatross, completed in Sydney in 1928.

Reference 1 provides an outline of the history of Naval construction in Australia.

By the end of the Second World War, a revived Australian shipbuilding industry had built 3 Tribal Class destroyers, 12 River Class frigates, 60 Bathurst class minesweepers and numerous smaller vessels for the RAN. Whilst many yards had participated in this programme, the principal Naval construction yard in Australia was Cockatoo Dockyard in Sydney. This island dockyard was owned by the Navy and leased to a private company, Cockatoo Docks and Engineering Company Pty Limited (later Vickers Cockatoo Dockyard Pty Limited (1972) and Cockatoo Dockyard Pty Limited (1984)). During the War, the Navy had purchased the Williamstown Dockyard in Victoria from the Melbourne Harbor Trust, which it then operated as a Naval Dockyard for the construction and repair of Naval vessels.

These two yards were to undertake most of the Naval ship construction in Australia for three decades after the War, and in particular were responsible for the construction of combat ships.

The Williamstown Naval Dockyard (Wildock) was managed directly by the Department of the Navy. Whilst Cockatoo Dockyard (Codock) was run by a private company, the relationship between the company and the Navy was particularly close. The trading arrangements between the parties were defined in a Wartime Agreement which took effect in March 1940 and was to apply, essentially unchanged, until 1972. Under the terms of this Agreement the company undertook such work as the Navy required on an "at cost" basis, being paid a management fee based on turnover. The private operation of the dockyard enabled it to compete in the commercial market, with the profits or losses from this work being shared between the company and the Commonwealth.

Towards the end of the Second World War, in October 1944, the Navy ordered two Battle class destroyers, one each to be built by Codock and Wildock. Construction of these ships began in 1946.

After the War, the Government recognized the value of maintaining a Naval shipbuilding capacity in Australia for

defence purposes and in late 1946 the Government approved the order for four Daring class destroyers (two each from Codock and Wildock).

It had been intended that the Daring class destroyers should all be completed by 1952. Delays resulted from the lack of technical information, late material and equipment deliveries, a heavy dockyard workload coupled with a shortage of skilled labour, and limitations imposed by Government on the rate of expenditure. The last ship was not completed until 1959. Despite the delay the RAN acquired some fine ships and the shipyards gained valuable experience in a new shipbuilding technology - all welded ships constructed in three dimensional prefabricated units. The design of the ships was progressively modified during construction, with the design work being undertaken in Australia.

It was in this environment that the first of the projects reviewed in this paper began. As it completed in the late sixties, the approach to Naval construction in Australia was under extensive review and a period of change began which continued ever since.

3. THE ANTI-SUBMARINE FRIGATE PROJECT

In August 1950, the Australian Government approved the construction of six Anti-Submarine Frigates, three at Codock and three at Wildock. Preliminary information was given to the shipbuilders in October 1950. This information was somewhat limited, as the design of the ships was not then complete. Although designed to current British Naval Standards, they were intended to be relatively simple ships which could readily be built in quantity.

By the time orders were placed, the number had been reduced to four. Contracts for the construction in each yard of two Anti-Submarine Frigates, First Rate, Type 12 were signed in February 1952, with a planned completion date of 1957.

3.1 DESIGN ORIGIN

The advent of submarines with high underwater speeds towards the end of the Second World War led to the evolution of the specialised Type 12 Anti - Submarine frigate.

Wartime experience indicated the need for frigate designs which could be rapidly produced from prefabricated sections constructed away from the shipyards. Design concepts developed in 1945 anticipated a common hull design which could be adapted for different roles. The need for high speed in the anti-

submarine version dictated steam turbine propulsion. As the design proceeded after the War, likely problems with the rapid production of steam turbines in an emergency resulted in the concept of a common hull and machinery being limited to those ships with an anti - aircraft or aircraft direction role, which eventually became the Type 41 and Type 61 frigates.

The design of the specialised Type 12 anti-submarine frigate was completed by late 1950, and the first British ship was ordered in February 1951. Six ships of the Whitby class were built for the Royal Navy, and the lead ship was completed in May 1956.

The Type 12 frigate was designed to be fully welded and longitudinally framed. It was intended to be built in prefabricated units of about 10 tons weight, which could be pre-outfitted with equipment to a maximum weight of about 15 tons, permitting easy transport of completed sections. Modular construction of operational compartments was also planned. To enable construction in this way, the outfit drawings to be much more detailed than previous practice with large scale arrangement drawings incorporating details of all piping, ventilation and cable ways.

These ambitious aims for modular construction were not achieved, but the design was to prove very successful.

In 1955, the Type 12 design was updated to improve habitability and to make provision for the fitting of the Seacat short range anti-aircraft guided missile. This modified design became the Rothesay class, of which nine ships were built for the Royal Navy.

In 1958, further development of the design began, to incorporate those features needed for the ship to fulfil a general purpose role. This work resulted in the extremely successful Leander class.

References 2 and 3 describe the development of the Type 12 frigate in some detail. Seventy ships of this type were ultimately completed for seven Navies between 1956 and 1981.

3.2 DEVELOPMENT OF THE AUSTRALIAN TYPE 12.

The six RAN Type 12 ships are frequently referred to as Rothesay class. Whilst there were similarities between the first two RAN ships and the RN Rothesay class, there were also many differences. As the design of the RAN ships developed, features of the evolving RN design were incorporated together with purely Australian changes. The resulting six ships are effectively three distinct classes.

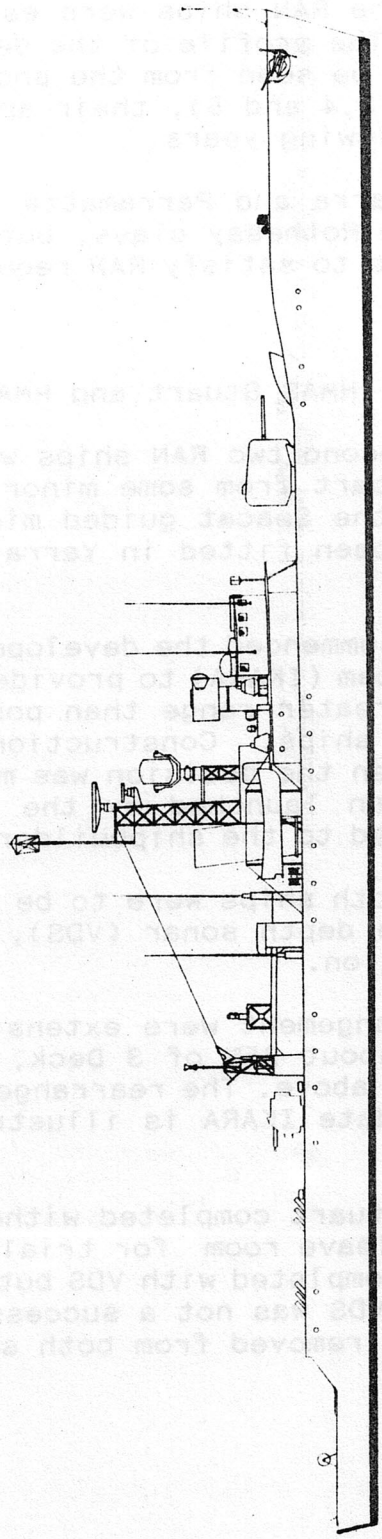


Figure 1 - TYPE 12 FRIGATES, 1950

3.2.1 The First Two Ships - HMAS Yarra and HMAS Parramatta.

As ordered, in 1952, the RAN ships were essentially to be copies of the Whitby class. The profile of the design as ordered is shown in Figure 1. As can be seen from the photographs of the ships as completed (Figures 3,4 and 5), their appearance was to change substantially in following years.

The first RAN ships, Yarra and Parramatta were similar in general configuration to the Rothesay class, but incorporated a number of significant changes to satisfy RAN requirements, which are outlined in Appendix 1.

3.2.2 The Second Two Ships - HMAS Stuart and HMAS Derwent.

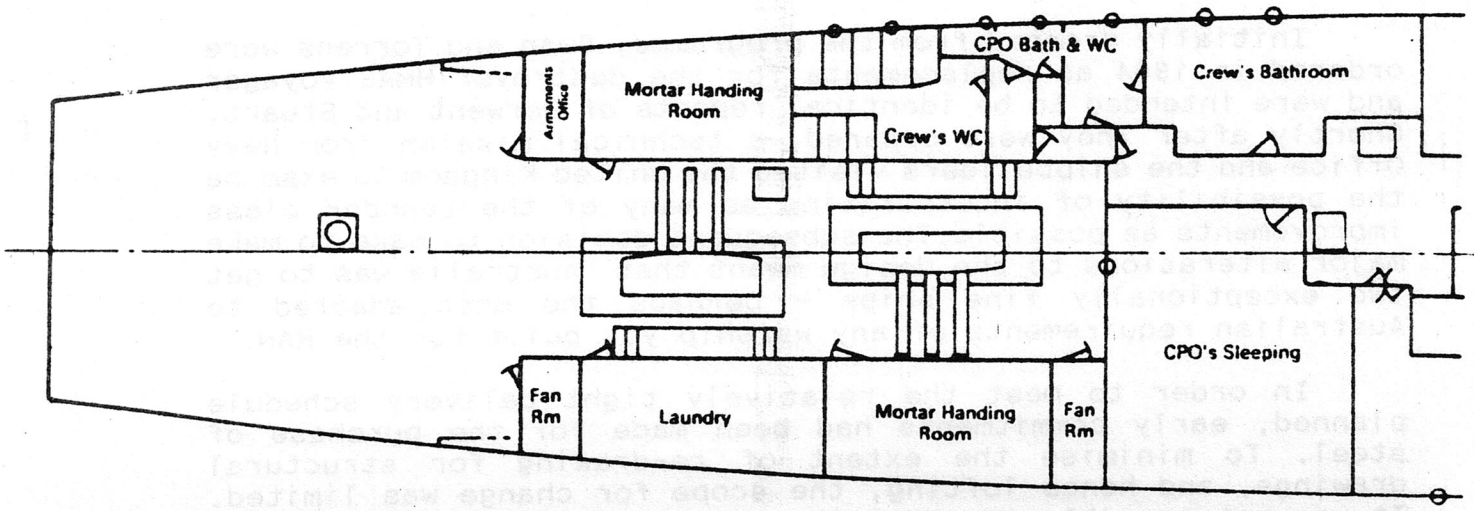
Until late 1960, the second two RAN ships were intended to be the same as the first, apart from some minor modifications. Both were to complete with the Seacat guided missile system, a twin 40 mm mounting having been fitted in Yarra and Parramatta as an interim arrangement.

In 1958, Australia had commenced the development of an anti-submarine guided missile system (IKARA) to provide the capability to engage submarines at a greater range than possible with the mortars then fitted to most ships. Construction of Stuart and Derwent was well advanced when the decision was made to fit them with IKARA and both had been launched by the time their new General Arrangement was issued to the shipbuilders in July 1961.

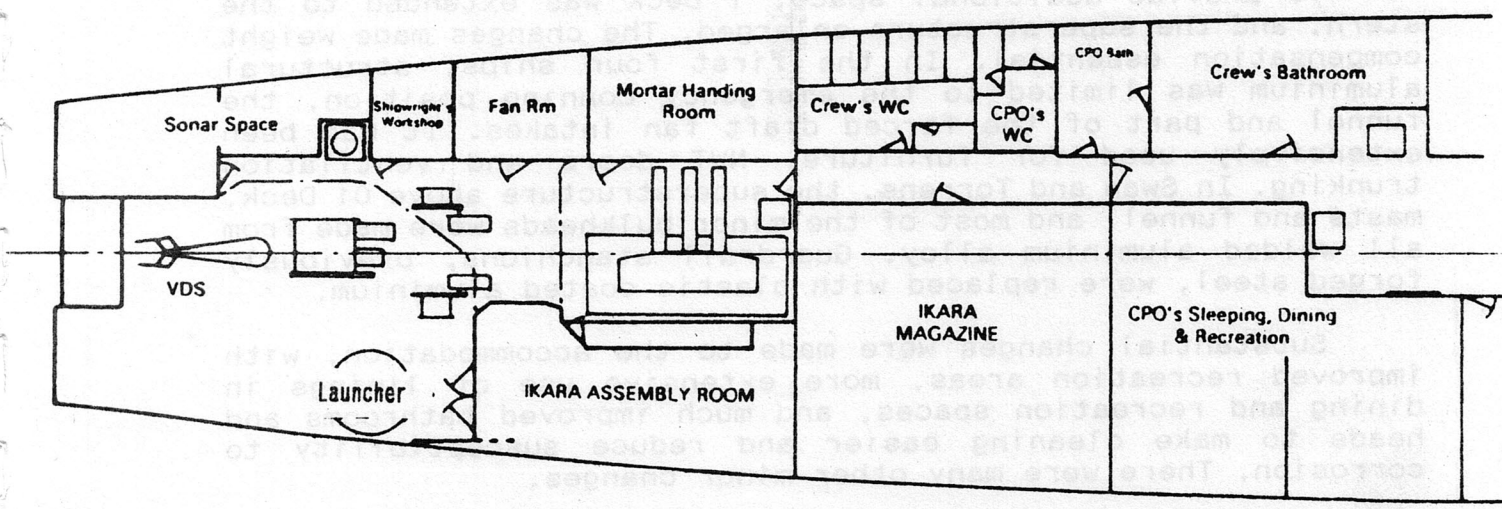
In addition to IKARA, both ships were to be fitted with the Canadian AN/SQS 504 variable depth sonar (VDS), and a modified electronic warfare installation.

The changes to the arrangement were extensive. Internally the rearrangement affected about 25% of 3 Deck, 70% of 2 Deck, and almost 100% of 1 Deck and above. The rearrangement of the aft end of the ships to accommodate IKARA is illustrated in Figure 2.

As IKARA trials ship, Stuart completed without VDS, Seacat and some other equipment to leave room for trials personnel and test equipment. Derwent was completed with VDS but without IKARA, which was fitted later. The VDS was not a success in Australian service and was subsequently removed from both ships.



Yarra and Parramatta - No 2 Deck Aft



Stuart and Derwent - No 2 Deck Aft

Figure 2 - HMA Ships DERWENT and STUART - IKARA Modification

3.2.3 The Third Two Ships - HMAS Swan and HMAS Torrens.

Initially dropped from the programme, Swan and Torrens were ordered in 1964 as replacements for the destroyer HMAS Voyager and were intended to be identical repeats of Derwent and Stuart. Shortly after they were ordered, a technical mission from Navy Office and the shipbuilders visited the United Kingdom to examine the possibility of incorporating as many of the Leander class improvements as possible.The subsequent decision to make to make major alterations to the design meant that Australia was to get two exceptionally fine ships - perhaps the most adapted to Australian requirements of any warship yet built for the RAN.

In order to meet the relatively tight delivery schedule planned, early commitments had been made for the purchase of steel. To minimise the extent of re-drawing for structural drawings, and hence lofting, the scope for change was limited. It was not possible to adopt the wide - beam Leander hull form and other features like the rivetted crack arrestors in the shell and 1 Deck were retained.

Nevertheless the modifications were extensive and are outlined in Appendix 1.

To provide additional space, 1 Deck was extended to the stern, and the superstructure enlarged. The changes made weight compensation essential. In the first four ships, structural aluminium was limited to the emergency conning position, the funnel and part of the forced draft fan intakes. It had been extensively used for furniture, NWT doors and ventilation trunking. In Swan and Torrens, the superstructure above 01 Deck, masts and funnel, and most of the minor bulkheads were made from all welded aluminium alloy. Guardrail stanchions, previously forged steel, were replaced with plastic coated aluminium.

Substantial changes were made to the accommodation, with improved recreation areas, more extensive use of linings in dining and recreation spaces, and much improved bathrooms and heads to make cleaning easier and reduce susceptibility to corrosion. There were many other minor changes.

Swan and Torrens were substantially a new design. The development of the design and preparation of working drawings was carried out in Australia and proceeded in parallel with the construction of the ships. The task was led by Navy Office and shared with the two shipyards. Assistance was provided by a Navy Office Annex established in Sydney and some specialised subcontractors, for tasks such as the air conditioning system.

The changing appearance of Australia's Type 12's can be seen in Figures 3,4 and 5. The general particulars of the ships are given in Table 1.

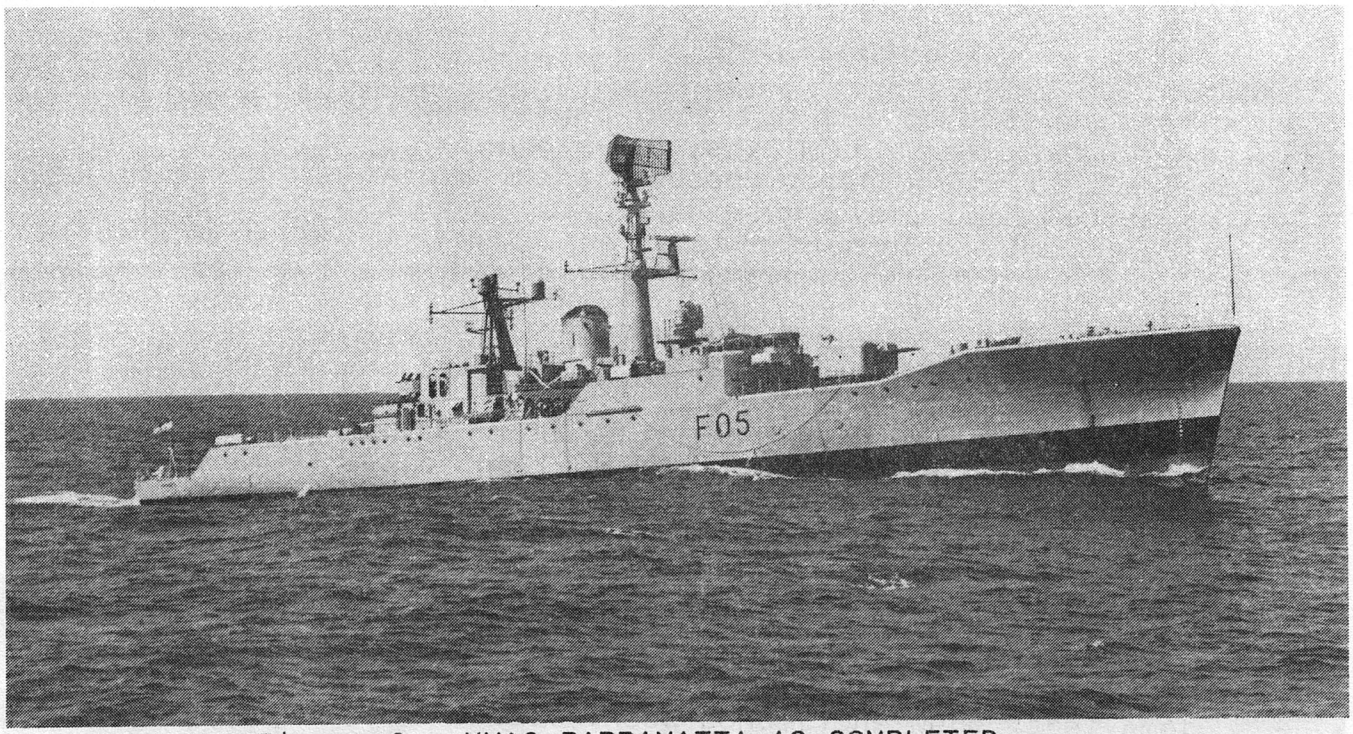


Figure 3 - HMAS PARRAMATTA AS COMPLETED

Figure 4 - HMAS STUART AS COMPLETED

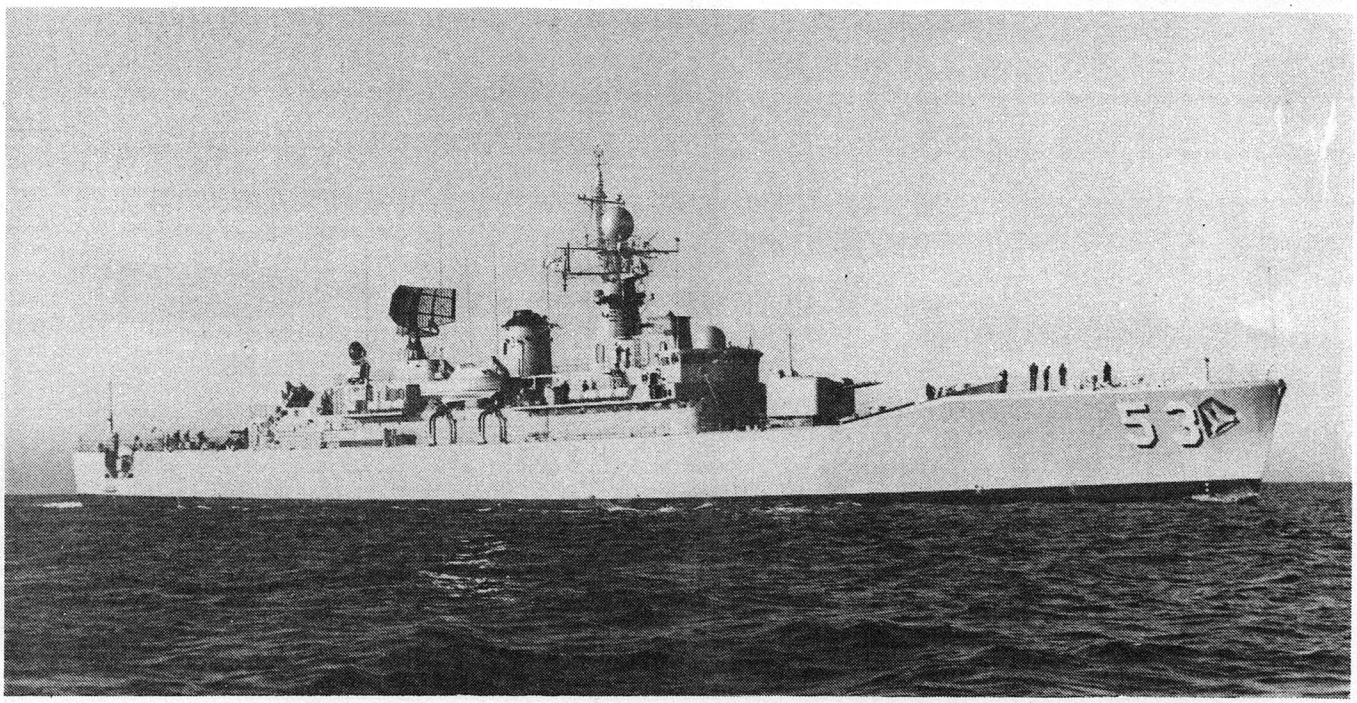


Figure 5 - HMAS TORRENS AS COMPLETED

TABLE 1

RAN TYPE 12 DESTROYER ESCORTS

GENERAL PARTICULARS

	1950 DESIGN	01 & 04 AS BUILT	02 & 05 AS BUILT	03 & 06 AS BUILT
Length, OA	370' 0"	370' 0"	370' 0"	372' 0"
Length, BP	360' 0"	360' 0"	360' 0"	360' 0"
Breadth, Ext.	41' 0"	41' 0"	41' 0"	41' 0"
Depth, Mld.	28' 3"	28' 3"	28' 3"	28' 3"
Displ. Std.*	2,000	2,000	2,100	2,100
Displ. Full Ld*	2,490	2,500	2,700	2,700
Guns, Main	2 - 4.5" Mk 6	2 - 4.5" Mk 6 Mod 1	2 - 4.5" Mk 6 Mod 1	2 - 4.5" Mk6 Mod 3
Guns, Secondary	2 - 40mm STAAG Mk 3	2 - 40mm Mk 5	--	--
Fire Control	Mk VI	MRS 3 CRBF	MRS 3	M 22
Missiles	--	--	Seacat	Seacat
Fire Control	--	--	GWS 20	M 44
A/S Weapons	2 - Mk10 Mortar	2 - Mk10 Mortar	1 - Mk10 Mortar IKARA	1 - Mk10 Mortar IKARA
Radars	277,293 HDWS	LWO2,293 978	LWO2,293 978	LWO2 8GR301
Sonars	162,170	162,170 176,177 182	162,170 176,177 182,SQS504	162,170 176,177 182
Propulsion	Y100	Y100	Y100	Y136
Accommodation:				
Captain	1	1	1	1
Unit Commdr.	-	-	-	1
Officers	20	16	16	18
Snr. Sailors	49	52	52	52
Sailors	215	184	184	184
Total	285	253	253	257

* Tons, approximately.

3.3 THE CONSTRUCTION PROGRAMME.

When the original target date for the completion of the first four Type 12's was set, very little information was available to the shipbuilders. Indeed, construction of the lead ship in Britain had only just begun. Moreover, both Codock and Wildock were very busy with the construction of the Daring class destroyers, and a modernisation programme which included the modernisation of HMAS **Arunta** at Codock and the Q class Type 15 conversions of **Quadrant** and **Quickmatch** (Wildock) and **Queenborough** and **Quiberon** (Codock).

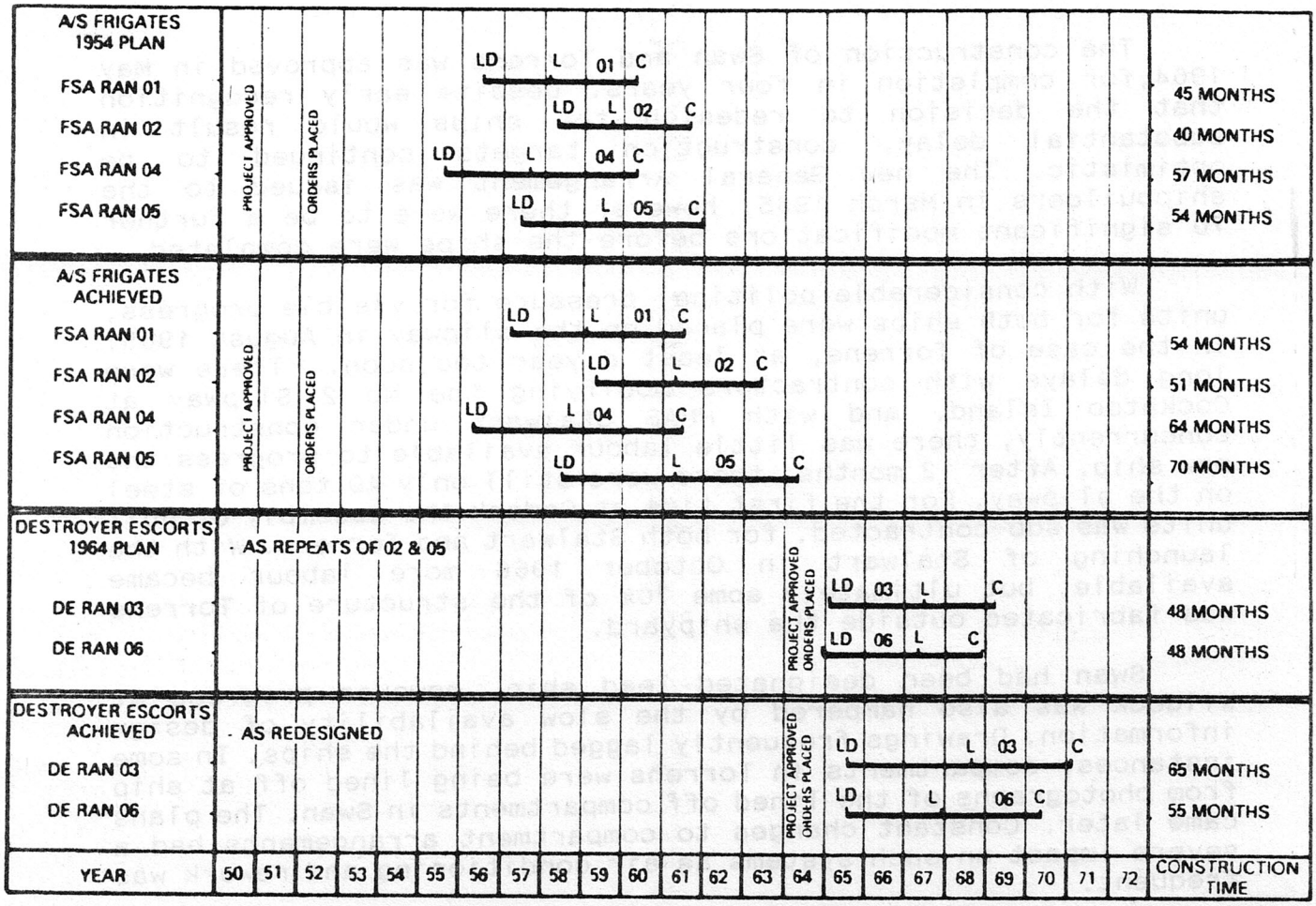
The target completion date of 1957 was clearly unrealistic. Both yards were suffering from a shortage of labour, and early progress on the frigate project was very slow. Furthermore, limits on annual expenditure were set.

During the 1950's many revised targets were set. Each forecast was qualified by the need for the supply of technical information and equipment to suit the construction programme. It was generally assumed that suitable labour would be available to suit shipyard requirements. These conditions were rarely met.

By 1954, the projected programme for the completion of the Daring class destroyers was close to that actually achieved. At Codock, the labour situation had been eased by the transfer of **Quiberon** to Garden Island Dockyard for completion. The programme then proposed for the Type 12's was much more realistic and it is that plan which is shown in Figure 6.

Figure 6 also indicates the programme actually achieved. Whilst the 1954 target was still based upon questionable assumptions on information, equipment and labour availability, the programme was also to be greatly influenced by the extent of modification of the ships during construction. The principal changes have already been mentioned, however the ships were subject to constant modification. For example, between launching and completion there were over 80 modifications to **Yarra** and **Parramatta** which affected the General Arrangement. There were many more changes to detail.

The introduction of IKARA into **Stuart** and **Derwent** considerably delayed their completion. **Stuart** spent some time at sea in February/March 1963, before completion, for test firings of the missile. Installation of the IKARA handling equipment was not complete on commissioning and the ship returned to Codock on several occasions in the following year to complete that work and subsequently to complete systems not installed for her trial ship role.



SHIP	NAME	LAID DOWN	LAUNCHED	COMPLETED
01	PARRAMATTA (Codock)	3-1-57	31-1-59	4-7-61
02	STUART (Codock)	20-3-59	8-4-61	28-6-63
04	YARRA (Wildock)	30-4-56	30-9-58	25-7-61
05	DERWENT (Wildock)	16-6-58	17-4-61	30-4-64
03	TORRENS (Codock)	18-8-65	28-9-68	18-1-71
06	SWAN (Wildock)	18-8-65	16-12-67	17-4-70

Figure 6 - Australian Type 12 Frigate Construction Programme

The construction of Swan and Torrens was approved in May 1964,for completion in four years. Despite early recognition that the decision to redesign the ships would result in substantial delay, construction targets continued to be optimistic. The new General Arrangement was issued to the shipbuilders in March 1965, however there were to be a further 70 significant modifications before the ships were completed.

With considerable political pressure for visible progress, units for both ships were placed on the slipway in August 1965; in the case of Torrens, at least a year too soon. There were long delays with contractors modifying the No 2 Slipway at Cockatoo Island, and with HMAS Stalwart under construction concurrently, there was little labour available to progress the new ship. After 12 months, there were still only 40 tons of steel on the slipway. For the first time at Codock the assembly of hull units was sub-contracted, for both Stalwart and Torrens. With the launching of Stalwart in October 1966 more labour became available, but ultimately some 70% of the structure of Torrens was fabricated outside the shipyard.

Swan had been designated lead ship, however progress at Wildock was also hampered by the slow availability of design information. Drawings frequently lagged behind the ships. In some instances, compartments in Torrens were being lined off at ship from photographs of the lined off compartments in Swan. The plans came later. Constant changes to compartment arrangements had a severe impact on such systems as air conditioning and rework was frequent.

Swan commissioned in January 1970, but was not accepted from the builders until April, and did not leave the yard until June. Even then some incomplete work was deferred until first refit. This situation was not permitted with Torrens and the ship was handed over in a much more complete state in January 1971.

Swan and Torrens performed very well. The achievement in redesigning and building these ships in six and a half years was considerable, and a reflection on the skills and experience which had been developed in Navy Office and the shipyards over the previous 25 years. Unfortunately, much of this experience was to be lost during the 1970's as Australian naval shipbuilding languished.

3.3.1 Equipment and Material Supply.

For all the Type 12's, most of the equipment and some of the material was supplied by the Naval Board "in aid" to the shipbuilders. Whilst a significant proportion was imported, mainly electrical and weapons electrical equipment, some major items were manufactured in Australia under licence.

Major suppliers included the Ordnance Factory, Bendigo (Gun mountings, mortars and gearboxes), Codock (turbines, boilers, condensers and shafts), Commonwealth Aircraft Corporation (IKARA handling equipment) and Federated British Engineers (NSW) Pty Ltd (auxiliary machinery).

The shipbuilders were responsible for the manufacture of furniture and fittings, with a wide range of items including bed berths, kit lockers, furniture, WT and NWT doors, deck lockers, bollards, fairleads, piping system valves, ventilation valves, pipe flanges, minor hull castings and forgings being made in the shipyards. Many of these items were made by Codock for all ships.

A similar approach was taken for **Swan** and **Torrens**. However, a number of items previously made in Australia, including the 4.5" gun mountings, boilers and gearboxes, were imported because of the planned early delivery of the ships and a shortage of resources in Australia.

During the early 1960's, shortages of labour in the shipyards prompted a much higher proportion of sub-contract by the shipyards than had previously been the practice, and many items were supplied by other industries for the first time.

The high level of "in aid" supply was to present the shipyards, and the Navy, with many frustrations. The Government procurement system could not be relied on to supply equipment when required, and promised delivery dates were frequently missed. This made the planning of fitting out very difficult and demanded a high degree of adaptability from production supervision. For example, in January 1970, Codock assessed the number of Naval Board Supply items overdue for **Torrens**, within twelve months of hand over, at over 3,000.

For the last two ships in particular, many of the delays could be attributed to the extensive changes which introduced advanced technology into equipment design, and a much higher degree of participation by Australian industry unused to the demanding standards involved. Most of the delays resulted, however, from an inadequate procurement system.

3.3.2 Contractual and Project Management Aspects.

During the 1950's, responsibility for Naval construction rested with the Third Naval Member (of the Naval Board) as Chief of Construction. Orders for ship construction were placed directly by Navy Office and the Chief of Construction was able to exercise considerable direct control. By the 1960's, the structure within Navy Office had been expanded, with the management of new construction projects becoming the responsibility of the Director General, Naval Production (DGNP) who reported to the Third Naval Member. A Director, Naval Ship

Production and Director, Naval Equipment Procurement reported to DGNP. Ship design was the responsibility of the Director General, Naval Design, also reporting to the Third Naval Member.

With Wildock managed directly by the Department of the Navy, a formal contract did not exist for construction the of the Type 12's in that yard. The arrangements which applied at Codock were more formal, and provide a more appropriate comparison with the procedures of the 1980's.

The Schedule of Conditions signed with Codock in February 1952 for the construction of **Parramatta** and **Stuart** was a very straight forward document. The ships were to be built in accordance with specifications and plans supplied by the Naval Board. Whilst there was a specification for the Type 12 frigates, it was a relatively superficial document and the General Hull Specification, General marine Engineering Specification and Standard Electrical Specification were the principal documents. The Ship Specification was not kept up to date, and did not exist at all for **Swan** and **Torrens**. During the construction of these ships the RAN's own Naval Construction Manual (NCM) superseded the RN General Hull Specification, and incorporated many of the practices and standards developed for **Swan** and **Torrens**. The latest revision or issue of any specification or drawing was the applicable document for construction.

The construction programme was funded by the Government on a three year basis, based upon estimates provided by the shipbuilders. Whilst they were paid cost actually incurred, annual allocations were not to be exceeded. Estimates were subject, initially, to review every six months. The interval was later changed to four monthly and the estimate reviews were coupled with a review of the programme for construction and delivery of the ships. Costs were accumulated and reported against a Standard Navy Cost List introduced during the 1950's. This list was system based, but not as comprehensive as the US Ship Work Breakdown Structure which was to be modified as the RAN Technical Subject Code and adopted for costing purposes in later years.

By the standards of the 1980's, project management of the Type 12 programme was non-existent. There were no formal requirements for planning or progress monitoring, and whilst the shipbuilders submitted regular progress reports they were mainly narrative supported by statements of requirements for delivery of information and equipment.

In the early 1960's the shipbuilders came under pressure to introduce proper planning procedures. In the somewhat conservative environment of the time this was a difficult process. However, for the construction of Torrens Codock introduced network analysis techniques and adopted systems largely based on the requirements applicable to equivalent Naval construction in the United Kingdom (Reference 4).

Whilst these improved methods undoubtedly assisted progress monitoring, their effectiveness in controlling production was limited, as the assumptions of information and equipment availability on which the programmes were based were of necessity somewhat speculative.

During the later stages of construction the principal control document was the Programme of Inspections, Tests, Trials and Completion. It was prepared in accordance with the RN standard specification for the conduct of Inspections, Tests and Trials which applied until superseded by an Australian equivalent in 1964 (Reference 5). Whilst the shipbuilder was responsible for carrying out some of the 230 items, the conduct of most was the responsibility of various Naval authorities. For **Swan** and **Torrens** the main trials authority was the RAN Trials and Assessing Unit (RANTAU), however eight other authorities were involved at various times.

Not only did this complex web of responsibility present problems of trials coordination, the standards to be applied to a particular inspection or trial occasionally came as a surprise to the shipbuilder, who was not necessarily in possession of the latest applicable documentation. This was particularly prevalent with Weapons systems. In order to minimise the problems created in this way, Codock prepared individual specifications for inspections and tests which defined the limits and applicable standards well in advance of the due date. This system was to become a formal joint Navy/Dockyard procedure in a fully recognised manner with the introduction of the Dockyard Test Organisation for the refit of the RAN Oberon Class Submarines at Codock during the 1970's (Reference 6).

Procedures for the conduct of Contractor's Sea Trials were better defined, and indeed this subject occupied 30% of the Schedule of Conditions. Nevertheless, the detailed arrangements were relatively informal. The RAN provided a Naval party (usually based on the Stand-by Ship's Company) for the navigation of the ship and the operation of the machinery and boilers. This did not however relieve the shipbuilder of his responsibility for the conduct of the trials or for the safety of the ship. The shipbuilder was required to indemnify the Commonwealth of Australia against any claims arising out of the trials, yet officers of the Naval Board were entitled to intervene at any time if they felt it necessary.

The shipbuilder was provided with a "Builder's Risk" indemnity by the Naval Board and was not required to insure the ships during construction or trials. Noting that trials of one ship included three firings of a guided missile still under development, it is perhaps fortunate that serious incidents never arose.

There were no requirements for the shipbuilder to institute a formal Quality Control programme. The construction of the ships at Codock was under the oversight of the Principal Naval Overseer and his professional and technical staff.

Other features of the Type 12 contract included a requirement for weight recording rather than weight control. This function, together with those which soon would be known as Configuration Management and Integrated Logistic Support, was the responsibility of Navy Office.

3.3.3 Project Outcome.

Swan and Torrens were particularly successful ships. Consideration was given to the construction of two further ships, however suitable equipment was no longer in regular production and the long lead time for procurement or the further modification of the design to incorporate more modern equipment would have delayed completion to such an extent that there would have been little improvement on the then proposed delivery dates for the new Light Destroyers (DDL). The plan did not proceed.

The growth in Australian design capability during the 1950's enabled the RAN to build a number of non combatant ships in Australia during the 1960's. These included the survey vessel HMAS Moresby, the Destroyer Tender HMAS Stalwart, and Twenty Patrol Boats of the Attack class. This successful experience supported the decision to design in Australia (albeit with overseas help) a new class of destroyer (the DDL) and several support and survey ships. (A summary of Australian Naval construction since 1950 is given in Appendix 2).

The problems associated with the redesign of Swan and Torrens in parallel with their construction, and the cost increases and delays to completion which had occurred with most Australian Naval construction since the Second World War, prompted a major review of the way in which major Naval construction contracts were placed in Australia.

Following Cabinet approval of a new shipbuilding programme in July 1969, a report on Naval Shipbuilding prepared in December 1969 by a Defence committee recognised that previous cost increases and delays had often resulted from projects being started before designs were sufficiently advanced. Cost and delivery estimates were therefore inaccurate. Continuous design modification during construction contributed to further delay and cost increase.

This approach was no longer to be acceptable. Future contracts were to be placed on fixed prices with firm delivery dates. The Department of Defence was keen to see greater competition for Naval shipbuilding contracts, however the Navy

was concerned that considerable additional time would be required to prepare detailed specifications for commercial shipbuilders unused to Naval standards and the delay would have resulted in the loss of experienced people at Codock and Wildock as the Type 12 programme drew to a close. Nevertheless, a move to more commercial contracting had begun and the Navy accepted the need to complete essential design and specification work much earlier than had previously been the practice.

The RAN's relationship with Wildock was not to change significantly for many years, however the Trading arrangements at Codock were no longer regarded by either the Company or the Commonwealth as appropriate and a much more commercial relationship was negotiated which took effect with the renewal of the Company's lease of Cockatoo Island in 1972.

The new agreement provided for Navy work to be undertaken as far as possible at fixed or firm prices. Where fixed prices could not be negotiated, orders were to be placed on an incentive price or cost plus profit basis. Whilst the role of the Dockyard continued to be primarily to undertake work for the Navy, the Company ceased to be simply a manager and became an independent contractor, subject to certain constraints regarding priority for Navy work. The Company assumed full responsibility for any profits or losses arising out of the operation of Cockatoo Dockyard.

4. THE REPLENISHMENT SHIP PROJECT.

4.1 THE FAST COMBAT SUPPORT SHIP (AOE).

In a Naval Staff Requirement of 2 June 1964, the RAN set out its plans for a major replenishment ship capable of supplying all logistic items needed by RAN combatant fleet units at sea. Cabinet approval to proceed with the acquisition of a Fleet Replenishment Ship (AOE) was given in November 1964, however due to the needs of higher priority projects the ship was removed from the programme in October 1965.

The RAN again sought approval for the construction of a Fast Combat Support Ship in May 1969. Two ships were then planned, one for delivery by 1977, and a second ship to replace the existing Tide class fleet oiler HMAS Supply after 1980, when it was expected to have reached end of life. Cabinet approval to proceed with the first ship was given on 22 July 1969.

4.1.1. The Design Development of the AOE.

The design of the AOE was developed in Navy Office, with contract assistance. At first, the ship was intended to be similar in size to HMAS **Stalwart**, the Destroyer Tender designed by Navy Office and built by Codock between 1963 and 1968. As the design developed, the ship was lengthened, principally to accommodate three replenishment stations each side, and space for two large helicopters.

4.1.2. Description of the Ship.

Originally intended to be to commercial standards, like HMAS **Stalwart**, the final AOE design was largely to full Naval standards, although Lloyds Rules were to apply to ship structure and some equipment. Shock protection was to be provided for Main Engines, Diesel Alternators, electrical power distribution systems, communications, radar and armament. NBCD measures were to be provided including a gas citadel and pre-wetting (washdown) system.

The AOE was to have weight and space provision for future fitting of two 30mm gun mounts, a guided weapon system and a Chaff decoy. A Nixie torpedo decoy was to be fitted from the outset.

The ship was to supply stores, spares, food, guided missiles and ammunition, diesel oil, avcat and fresh water. Six stations for underway replenishment (CONREP) were to be provided for both liquids and solids. The replenishment system was to be a ram tensioned high line system with solid state pre-programmed control and electro-hydraulic winches. Remote control of the cargo system was to be provided from a centralised CONREP Control centre, with local control of inhaul and outhaul winches.

Replenishment stations 1,2,3 and 4 were to be fitted with a dual hose arrangement for the supply of diesel oil and avcat. Stations 5 and 6 were to be triple hose stations for diesel oil, avcat and fresh water.

VERTREP capability was to be provided by two helicopters of Sea King size, operating from a flight deck capable a maximum take off weight of 50,000 lbs. Movement of cargo from stowages to transfer stations was to be by fork lift truck. Four cargo lifts were to be provided to cargo spaces with a fifth lift between the main cargo handling deck (1 Deck) and the flight deck on 01 Deck.

Electrical power at 440 volts 60 Hz 3 phase was to be supplied by seven 1 megawatt alternators driven by Paxman Ventura diesels, three of which would be directly connected to the CONREP

distribution switchboard when in the CONREP mode. Six alternators were sited in the Auxiliary Machinery Room forward of the Main Machinery Room, with the seventh forward on 5 Deck as an emergency generator.

The ship was to be propelled by four Ruston and Hornsby 12 AO M diesels, two per shaft, driving controllable pitch propellers. For noise reduction, each shaft set of main engines was to be mounted on a common sub-frame, mounted in turn on a hydraulic constant position mounting system. The non-reversing gearboxes were to be solid mounted. The propellers were to be of noise reduced design and all rotating auxiliaries were to be rubber mounted.

Accommodation was to be provided for a crew of 335, fully air-conditioned and fitted out to Naval standards.

The General Particulars of the AOE are given in Table 2, and the Profile of the ship is shown in Figure 7.

TABLE 2

FAST COMBAT SUPPORT SHIP

GENERAL PARTICULARS

Dimensions:	
Length O.A.	593 ft (179.9M)
Length B.P.	534 ft (161.8M)
Beam Mld.	72 ft (21.82M)
Deep Draught	26.33ft (7.98M)
Displacement:	
Full Load	19,600 tons (19,992 tonnes)
Ballast	16,300 tons (16,626 tonnes)
Cargo Capacity:	
Diesel Oil	7,588 tons
AVCAT	556 tons
Fresh Water	190 tons
Naval Stores	443 tons
Ammunition	468 tons
Victuals	456 tons
Total	9,701 tons (9,877 tonnes)
Propulsion:	
Max. Power per shaft	12,000 BHP
Maximum Speed	20.6 Knots
Complement:	
Captain	1
Officers	29
Chief Petty Officers	27
Petty Officers	44
Sailors	234
Total	335

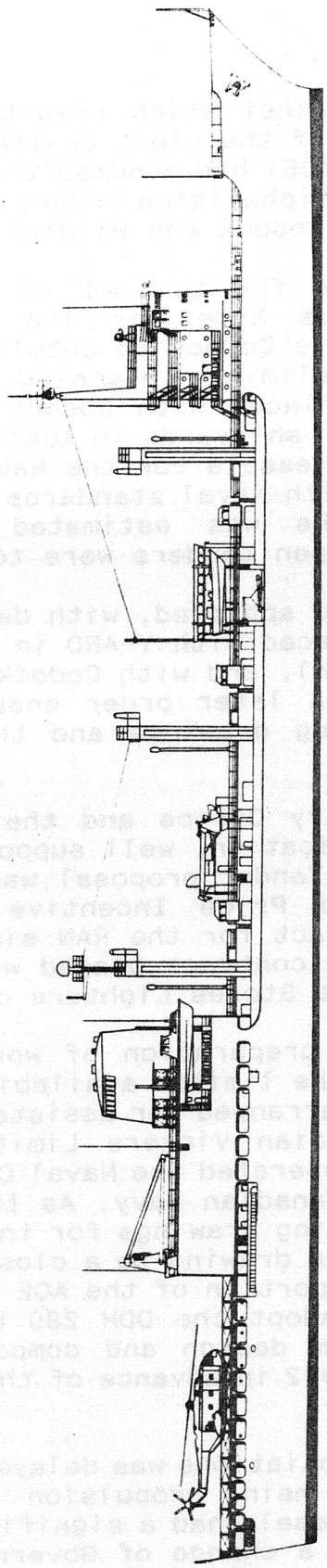


Figure 7 - Fast Combat Support Ship (AOE) HMAS Protector

4.1.3. Contractual Aspects.

The RAN submission to Cabinet which resulted in the 1969 approval for the construction of the Light Destroyers (DDL) and the Fast Combat Support Ship (AOE) had assumed that the previous procedures for the placing of shipbuilding orders would continue, with the work being shared by Codock and Wildock.

A delay in the programme for the AOE of two years was accepted in order to provide time for the completion of sufficient design work to enable Codock to submit a tender on a commercial basis. Orders for preliminary planning, drawing office and lofting work were to be placed with Codock in advance of Tender submission. Whilst other shipyards in Australia had built non-combatant and other minor vessels for the Navy, only Codock and Wildock were experienced with Naval standards, and a further delay of six to nine months was estimated for detailed specification preparation if open tenders were to be called.

Construction by Codock was approved, with delivery planned for late 1976. Orders were placed with Y-ARD in late 1969 (for the propulsion machinery design), and with Codock in early 1970 (for the structural design). A later order enabled Codock to proceed with structural working drawings and the ordering of steel.

The work done by Navy Office and their contractors resulted in a good ship specification, well supported by design drawings, and a comprehensive Tender proposal was submitted by Codock in May 1972. A Fixed Price Incentive contract was proposed, the first such contract for the RAN since before the Second World War, apart from a contract placed with Codock for the construction of three Crane Stores Lighters during 1972.

Contract negotiation and preparation of working drawings continued during 1972. Due to the limited availability of design staff in Australia, Codock had arranged for assistance from their then associated Company, Canadian Vickers Limited, Montreal, Canada, who had for many years operated the Naval Central Drawing Office under contract to the Canadian Navy. As the preparation of the detailed design and working drawings for the Canadian DDH 280 Destroyer programme was then drawing to a close, it had been planned to undertake a high proportion of the AOE outfit working drawings in Montreal, and to adopt the DDH 280 Weight Control procedures. Work on AOE system design and composite services drawings began in Montreal in 1972 in advance of the shipbuilding contract.

Completion of contract negotiations was delayed by technical problems with the selected main propulsion diesels. The incorporation of alternative diesels had a significant impact on the ship design, and following a change of Government in 1972, both the DDL and AOE projects were reviewed. The new Government

decided that the cost of the AOE was unacceptable (then estimated to be $62 million compared with the 1969 approved figure of $42 million) and the project was cancelled in August 1973 along with the DDL.

This cancellation resulted in a dramatic change in attitude to Naval construction in Australia which had profound effect, particularly on the technical resources available within Australia to support Naval design and construction. It introduced a period of reliance on overseas design in the interest of minimal technical risk, with the loss of the significant design capability developed since the Second World War.

Had the AOE not been cancelled, it is unlikely that the project would have proceeded as planned. Despite the much reduced Naval construction programme, Australian ship design capacity proved inadequate during the 1970's as shown during the construction of HMAS Cook, an Australian designed Oceanographic ship ordered from Wildock after the DDL cancellation (Reference 7).

Cook was also delayed by problems with the supply of Government Furnished Equipment (GFE). Whilst the Navy had been able to order GFE as Naval Board Supply Items directly during the Type 12 project, changes to Commonwealth purchasing procedures required GFE to be purchased by a separate Commonwealth Department, following open tender. The procedures of the early 1970's were complex and slow. As a high proportion of the equipment for the AOE was to have been GFE, it is probable that long delays in supply would have resulted, with a very adverse effect on the shipbuilding programme and cost. Coupled with the limited availability of suitably qualified and experienced technical people, this would have made completion of the AOE, to have been named HMAS Protector, unlikely much before 1980.

4.2 THE FLEET UNDERWAY REPLENISHMENT SHIP (AOR).

After the cancellation of the AOE, a further RAN study of replenishment at sea requirements lead to a June 1974 proposal to acquire a fleet underway replenishment ship of lesser capability. Following Departmental approval in November 1974, Ministerial approval was given for the release of an Invitation to Register Interest in early 1975.

The AOR project approval was given on the condition that an existing design was selected which had recently entered service, or was about to enter service, in order to reduce technical risk. Four Australian and twenty seven overseas shipbuilders were invited to register interest.

The project was then planned to proceed in two Phases. Phase 1, Project Definition, was to begin in mid 1976. Phase 2, ship construction, was to start in mid 1977 for completion in 1980.

4.2.1 Design Selection.

Four organisations were selected to tender for the Project Definition: Direction Techniques des Construction Navales (DTCN - France), Rijn Schelde Verolme (RSV - Netherlands), Codock and Evans Deakin Industries Ltd (Australia). Tenders were received from DTCN and RSV on 24 November 1975. The requirement for an existing design meeting the RAN's specified ship characteristics effectively ruled out any Australian offers. Evans Deakin withdrew, however Codock expressed interest in tendering to build the the design ultimately chosen.

The DTCN proposal was accepted and a Project Definition Contract signed on 4 February 1977.

DTCN had proposed an export version of the Durance class Petrolier Ravitailleur (PR) then under construction for the French Navy. Designated PR EXP 1 it was slightly different from the French Navy ships. During the Project Definition, DTCN were to assess the practicability of incorporating a number of RAN design changes, prepare proposals for the incorporation of Australian supplied materials and equipment to the maximum practicable extent, prepare a Shipbuilder's Estimating Package to enable the Australian Government to call tenders for the construction of the ship in Australia, and to develop a priced proposal for the construction of the ship in France.

DTCN placed an order with Codock for assistance with the development of the Australian industry participation and support package.

Following the completion of the Project Definition, Cabinet approval for the construction of a Fleet Underway Replenishment Ship (AOR 01) to the French design was given in August 1977.

4.2.2 Shipbuilder Selection.

In September 1977, the Department of Defence decided that no further consideration should be given to building the AOR in Australia. Negotiations proceeded with DTCN for the construction in France.

Codock pressed the Government in December 1977 to permit it to submit a tender in competition with the French offer. Ministerial approval was announced on 14 April 1978, provided a tender from Codock was received by the end of 1978.

With the move towards construction in France, a Shipbuilder's Estimating Package had not been completed. The SEP was prepared by Navy Office with assistance from DTCN and issued to Codock on 29 September 1978 with a formal invitation to tender by 15 December 1978. Following the submission of the Tender, the decision to place the order with Codock was announced on 23 August 1979, and a contract for the Construction of AOR 01 was signed on 26 October 1979. The contract included an option for the Commonwealth to order another ship (AOR 02) within five years on the same terms.

4.2.3 The Contract.

Unlike previous contracts at Codock, the contract for the construction of AOR 01 was placed by the Department of Administrative Services, through its Purchasing Division, Major Contracts Branch, rather than the Department of Defence.

The fixed price contract was subject to variation due to changes in the cost of labour, materials and equipment in accordance with agreed procedures. The shipbuilder was required to build the ship as defined in the Specification, and to provide Integrated Logistic Support deliverables. Payment was to be in instalments as agreed percentages of the contract price on the achievement of defined milestones.

The Shipbuilder was to be provided by the Commonwealth with a Production Package, including the specifications, drawings, shipyard standards, and requirements for inspections, tests, and trials used for the second French ship of the class, **Meuse**, then under construction. The contract recognised the possibility of differences between the Production Package and the Design Baseline described in the specification and it provided for equitable adjustment to the contract price, through the Change Control procedure, in the event that any unsuitable items of the Production Package demonstrably varied the cost of performance of the contract. In the event that information in the Production Package was at variance with that used as a basis for the contract, the Commonwealth reserved the right to accept the tendered offer.

The shipbuilder was responsible for the purchase of all materials and equipment for the ship with the exception of most spares and a small list of items nominated as GFE. Under the terms of a Memorandum of Understanding between the Governments of France and Australia, signed in May 1978, DTCN provided a performance guarantee conditional upon the inclusion in AOR 01 of certain equipments identical to those in the French ships. Such equipment was to be supplied by the original supplier in France or manufactured under licence in Australia.

Equipment and material was to be bought from Australian suppliers to the maximum practicable extent.

The shipbuilder was responsible for undertaking all required inspections, tests and trials. The RAN agreed to provide an adequate crew for sea trials, however the shipbuilder was responsible for compliance with all State and Commonwealth Merchant Shipping laws. The Commonwealth provided the shipbuilder with a "Builder's Risk" indemnity.

Delivery was subject to excusable delay and liquidated damages were to be payable in the event of late delivery.

The shipbuilder was required to implement a quality control programme in accordance with Australian Standard 1822 - a Level 2 Quality System (equivalent to AQAP 4), and a weight control programme was to be instituted.

Project management requirements were more clearly defined than in earlier contracts. The shipbuilder was required to prepare management plans for Quality Control, Project Management, Ship Construction, Configuration Management, Inspections Tests and Trials, Design Management and Integrated Logistic Support Management.

4.2.4 The Definition of the Ship.

The Australian Type 12's were never comprehensively defined in terms which might be regarded as a contractual specification. Designed from the outset for the RAN, the AOE specification was clear in intent, however the situation for the AOR was quite different. The Design Baseline Ship (PR EXP 1) which formed the basis for the shipbuilder's tender was a variant which had not previously been built, and the selected design changes and the material configuration proposed by the tender were set out in a Baseline Variation/Design Specification.

AOR 01 was defined as an amalgamation of:

- The Design Baseline Vessel, PR EXP 1, defined in the Hull, Mechanical and Electrical Specifications, to be constructed in accordance with the configuration detail of the Design Baseline Vessel as embodied in the Production Package.

- RAN and French design changes selected for incorporation in AOR 01.

- Local variations to the Production Package detail of the Design Baseline to incorporate alternative standards, materials and equipment.

The Commonwealth purchased the Production Package from France, and supplied it to the shipbuilder in a partially translated state. The Production Package represented the arrangement, function and configuration detail of the second French ship of the class, **Meuse**. PR EXP 1, the Design Baseline Ship, differed from **Meuse** in a number of ways. The differences included, for example:

- **Meuse** had an astern refuelling capability, PR EXP 1 did not.

- **Meuse** CONREP alternators were 3,300 volt, in PR EXP 1 they were to be 440 volt.

- The accommodation arrangements were different.

- **Meuse** carried cargo furnace fuel oil, PR EXP 1 did not.

In addition there had been some 51 design changes incorporated in **Meuse** since the definition of PR EXP 1, only 15 of which were to be incorporated in AOR 01.

Accordingly, the Production Package was applicable to AOR 01 only to the extent that it reflected the Design Baseline Vessel. Documents which related to areas of difference were not applicable.

In addition to the 15 French design changes, AOR 01 was to incorporate 40 RAN design changes. These included:

- Changes to accommodation and lifesaving arrangements to satisfy RAN requirements.

- Air conditioning and ventilation to RAN design standards.

- Increased cargo ammunition stowage and modified refrigerated and dry provision cargo arrangements.

- Provision for stowage of cargo missiles and torpedoes.

- An enlarged and strengthened flight deck to handle a helicopter of Sea King size and weight, and an enlarged hangar to accommodate a Wessex utility helicopter (**Meuse** had been designed to carry a WG 13 Lynx).

- The installation of a permanent degaussing system.

- The installation of an emergency diesel generator, switchboard and distribution system.

- Extensive changes to the external communications fit.

- Changed Radar, echo sounder, gyro compass, auto pilot and rearrangement of bridge and chart room.

- Modifications to galley and cafeteria arrangements.

- The installation of an 8 tonne crane in place of two 10 tonne derricks, and a rearrangement of ships boats.

- Modified internal communications.

The French ships of the class were being built in a French Naval Dockyard (DCAN Brest) and complied with the General and Technical Instructions and Specifications then in force in the French Navy, in addition to the structural design standard of Bureau Veritas. The RAN comprised mainly ships of either British or United States design origin. Previous Australian built Naval ships had tended to follow British Naval or commercial standards and there was a developing set of Australian Naval Standards. In the interests of maximising Australian content and providing some degree of commonality with the rest of the Fleet, the Baseline Variation/Design Specification for AOR 01 introduced a wide range of variations to equipment and material specifications, and construction codes and practices.

The impact of these changes on the detail of the Production Package was considerable. Despite examination during Project Definition, the full impact of some of the design changes did not become evident until detailed design was well advanced, and in some instances, after production had begun in affected areas. The local variations were expected to need extensive work for their incorporation; for example the changes in pipe and valve standards were to require new design calculations for all affected systems. Others were less immediately obvious, for example the slight differences in the outside diameter of the Australian made electric cables affected cable gland sizes throughout the ship and its equipment. This introduced changes into equipment otherwise expected to be identical in all engineering respects to that fitted in the French ships.

The General Particulars of HMAS Success (AOR 01), Durance, Meuse, and PR EXP 1 are given in Table 3. The milestones in the evolution of the detailed design of HMAS Success are indicated in Figure 8. Figure 9 shows HMAS Success as completed, and a description of the ship is given in Appendix 3.

4.2.5 Project Management.

Defence project management responsibilities changed with the extensive reorganisation of the Defence Departments which occurred between 1973 and 1975, when the separate Departments of Navy, Army and Air were abolished. Further changes were to occur during the course of the AOR project.

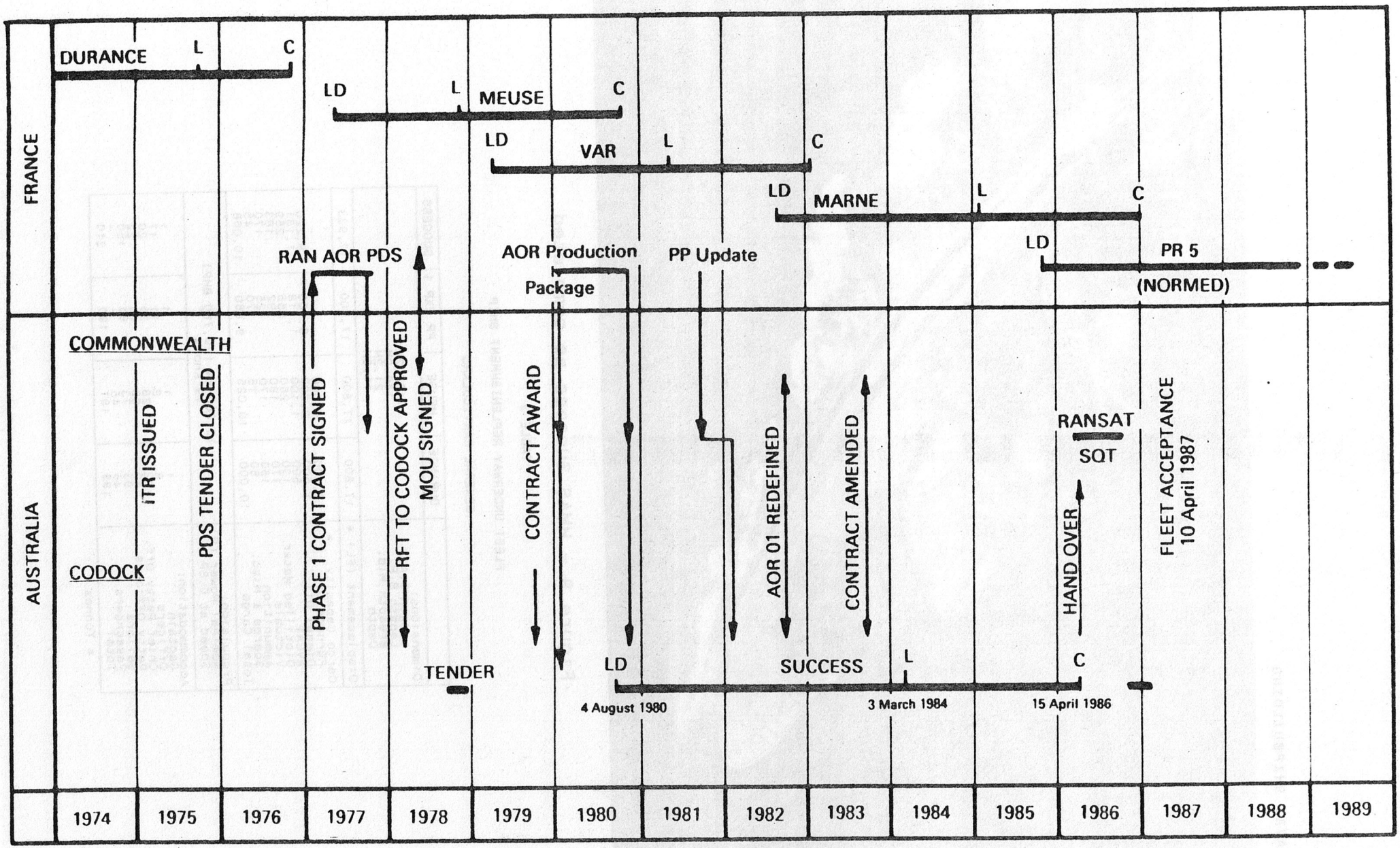


Figure 8 - HMAS Success Construction Programme

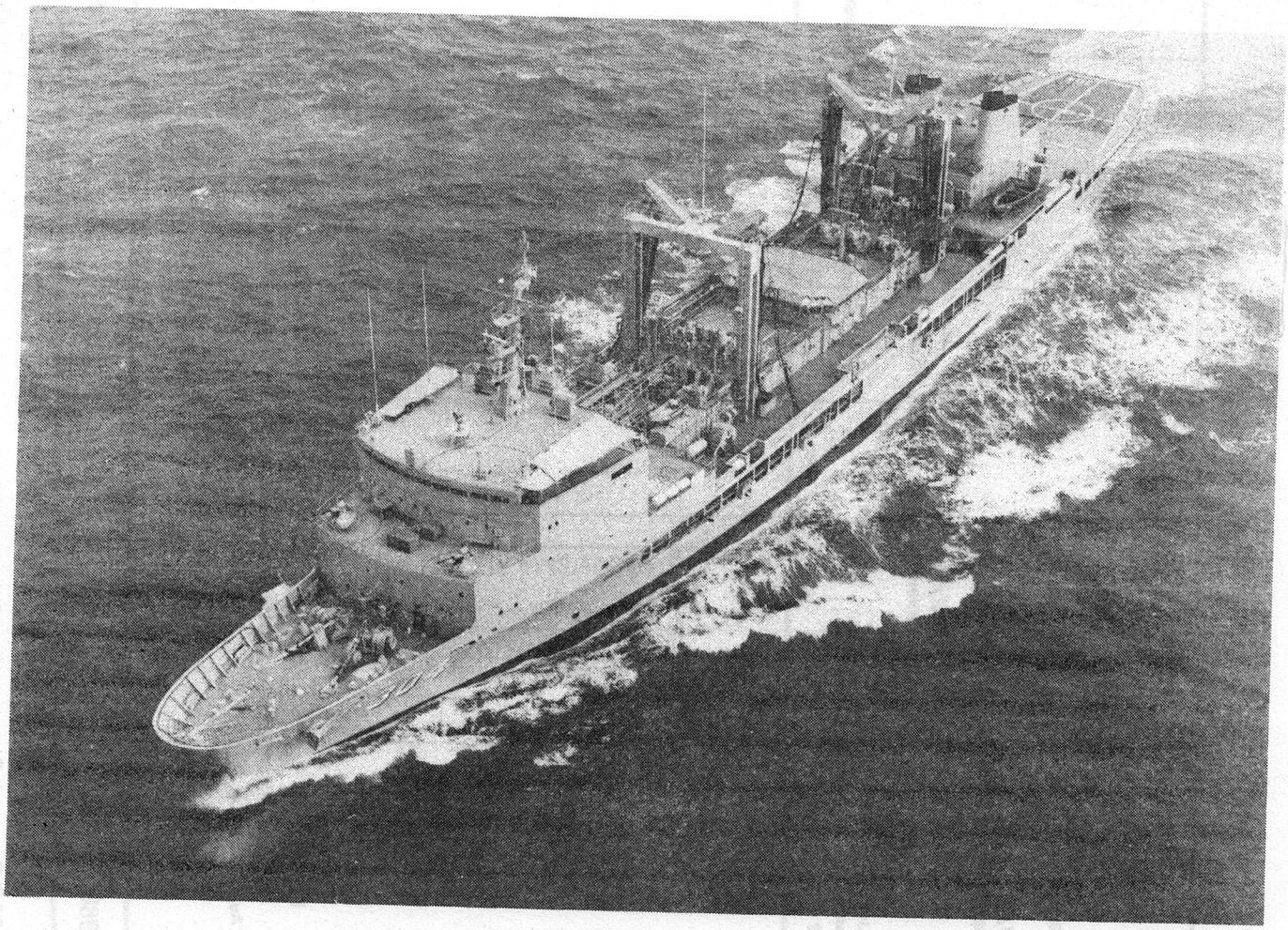


Figure 9 - HMAS Success as completed

TABLE 3

FLEET UNDERWAY REPLENISHMENT SHIP

GENERAL PARTICULARS

	DURANCE	MEUSE	PR EXP 1	SUCCESS
Dimensions:				
Length O.A.	157.2M			
Length B.P.	149.0M			
Breadth Mld.	21.2M			
Depth	11.2M			
Displacement (FL) *	17,800	17,800	17,800	17,933
Cargo Capacity: *				
Furnace Oil	7,500	5,000	-	-
Diesel Oil	1,500	3,300	8,100	8,220
AVCAT	500	1,100	1,118	1,131
Distilled Water	130	260	255	259
Victuals	170	180	192	183
Ammunition	150	170	125	170
Spares & Misc.	50	15	70	45
Total Cargo	10,000	10,025	9,860	10,008
Propulsion:				
Nominal Power (P)	15,280 kW (20,760 BHP)			
Speed at 0.8P	19 Knots			
Accommodation:				
Captain	1	1	1	1
Officers	8	8	11	17
Chief Petty Off.	22	28	36	20
Petty Officers	30	35	46	22
Sailors	93	73	96	150
Passengers	45	45	-	-
Total	199	181	190	210

* Tonnes

Before 1975, it was usual for the Director General, Naval Production to fill the role of Project Director, supported by specialists from within other departments within Navy Office. For the AOR, a separate Project Director was appointed, supported by an ILS Manager and clerical staff. Design, Production and Financial support was provided by functional departments. In 1975 the AOR PD also assumed responsibility for the RAN Patrol Craft project (which in due course resulted in the Fremantle class Patrol Boats).

After 1975, the AOR/PC PD reported to the Chief of Navy Materiel in the central Defence organisation for the coordinative management of both projects. He had no direct authority over functional areas in Navy Office.

In 1979, before the AOR contract was signed, the Patrol Craft responsibility was taken from the AOR PD and in 1982 he became responsible to CNM through DGNP who, in Navy Office, was the Production Authority for the ship.

The Contract Authority throughout the project was the Major Contracts Branch of the Department of Administrative Services (later of the Department of Defence Support).

In the shipyard, the Production Authority was represented by a Production Authority Representative, Contract Built Ships (PARCBS), with (initially) a staff of three. A separate Quality Assurance Representative (QAR) was appointed who reported to the Director Naval Quality Assurance (DNQA) through the General Overseer and Superintendent of Inspection, East Australia Area (GOSIEAA). The QAR was provided with an assistant, and operated quite separately from the Principal Naval Overseer (Codock) and his staff of about 35 who remained with a QA responsibility for Naval refits and other Naval work.

This organisation resulted in a somewhat complex communication and approval chain. As the complexities and problems with the project began to emerge, this Commonwealth organisation proved inadequate.

In 1983, a significant increase in AOR project staff was approved and the structure was modified. The AOR PD gained some elements of direct responsibility. Later, in 1984, the QAR became responsible to PARCBS. PARCBS was also given some authority for local approval of minor changes. These changes greatly improved the effectiveness of the Commonwealth structure in the final years of the project.

Codock had been used to building and modernising ships for the RAN without any resident representation from the ship designers, apart from the RAN. Accordingly, DTCN representation

in Australia had not been considered necessary. As the project progressed, it became clear that a French Technical Assistance Group (TAG) would be of great assistance, particularly with the interpretation of French design philosophy.

The TAG was established in February 1982. Led by a senior engineer from DTCN, the TAG became a closely integrated part of the project team, making a major contribution to the task as a whole.

At Codock, a Program Management organisation was established from the outset with a Program Manager and a small staff responsible for the coordinative management of all aspects of the project and to be the Company's main point of contact with the customer.

As experience with the project grew, the Program Manager's staff was increased and he was given greater authority for project matters. Codock's main job was the refit and support of the RAN Oberon class submarines, which at that time were undergoing a major modernisation as part of the Submarine Weapons Update Programme (SWUP), which completed in 1985 (Reference 6). Under the terms of the Trading Agreement between Codock and the Department of Defence, the submarine refits had priority at all times. In view of this obligation, and the wide use of common resources, a change from a contract management structure overlayed on a functional technical and production organisation to a completely project oriented organisation was not considered practicable.

The start of Oberon class submarine refitting at Codock in 1971 had prompted the introduction of new project management techniques in the Dockyard. In 1975, Codock improved its management structure to better suit its more commercial method of operation, and began the development of the necessary systems to support this structure. This work included the specification and development of an integrated project management software package linking planning (based on multi-project resource scheduling), labour costing and material ordering and cost control. The central planning module of this system was the ICL 1900 Series PERT package with all other programs written specifically for the Dockyard. The system was designed to cope with the mixed demands of new ship construction, Naval surface ship and submarine refitting, commercial ship repair, and general engineering jobbing work.

The Dockyard adopted as standard a multilevel Work Breakdown Structure based on the US Ship Work Breakdown Structure (SWBS). For submarines, an existing, similar WBS was in use, already integrated into quality and data management systems, and this was not changed.

Overall, the system was designed for compliance with the US Department of Defense Instruction 7000.2 (Reference 8). Whilst

the system continues to evolve today, it was substantially operational by 1980.

The AOR contract required Codock to prepare a detailed Construction Plan which was to identify all major activities and events to enable the programme to be related to Payment Milestones and for the progress of construction to be satisfactorily monitored. The shipbuilder was required to provide monthly progress reports in a format specified by the Department of Defence.

For reasons outlined later, actual progress began to diverge substantially from the Approved Construction Plan. Accordingly the Plan, which was of necessity linked directly to the Contract Acceptance Date, became more and more irrelevant and ineffective as a progress monitoring tool. It was not until the contract was amended in late 1982 that progress monitoring became meaningful and relevant.

4.2.6 Contract Renegotiation.

The Production Package, with some exceptions, was delivered progressively by DTCN to the RAN and then Codock on time between December 1979 and July 1980. It soon became apparent to Codock that the Production Package did not conform in detail with the ship described in the Specification, and hence the contract.

Many of the identified differences were relatively minor and arose from the continuing development of the French design. Others related to areas where the Specification had been silent and the Codock tender had assumed a simpler method of construction than was evident from the construction drawings.

As an example of the latter type, Codock had assumed that the A brackets would be of cast steel, whereas the working drawings revealed high tensile steel fabrications.
As the Commonwealth had reserved the right to accept the tendered offer, a contract change was needed either to:

- Accept the French design at a price approximately five times the tendered offer, or

- Accept the tendered offer, at the expense of modifying the drawings and accepting a weight penalty of 17 tonnes.

This particular case was quickly resolved by a decision to accept the French design and was managed through the Change Control procedure: the resolution of most other differences was to take much longer.

By the end of 1980, a considerable number of differences had been identified, but little progress had been made with contract amendment. It became clear that had the Change Control procedure been adhered to for all differences as discovered, it would have taken some twelve years to amend the contract at the rate that was being achieved. Moreover, the costing detail required by the Commonwealth for each change in order to certify it as fair and reasonable was considerable and significant technical resources were being diverted away from supporting production.

Problems also arose with the quality of the documents received from France. Whilst some were of excellent quality, many were incomplete, inconsistent or simply illegible. These problems had their origin at DCAN Brest where the drawings had never been intended for use by others and changes made in production were not necessarily incorporated in the drawings.

The construction programme was clearly to be adversely affected by these issues, and in order to seek prompt resolution the Commonwealth requested a lump sum price from Codock to cover the consequences of all differences, whether identified or not, the production package deficiencies, and the resultant delay and dislocation. This price was submitted in December 1980. It was, however much higher than the Navy had expected, and there was a view that the shipbuilder was attempting to cover a basic underestimate in the process. Negotiations seeking to validate this price continued through 1981.

As a result of queries raised by Codock, an additional package of documents was received from France by the Commonwealth in August 1981. This was passed to Codock in February 1982 and whilst it answered many questions it added 120 differences to the list in contention.

Final resolution of the problem came with agreement that Codock would propose a new price and delivery following agreed redefinition of the ship.

A revised technical description of the ship was finally agreed in August 1982. By October 1982 some 600 line items of additional cost had been identified by Codock and as progress payments were linked to the contract price a considerable cash flow problem was developing.

The revised technical description was incorporated into the contract in December 1982. In essence, the change can be described as follows:

Definition	Ship to be Built
Original Contract	PR EXP 1, incorporating Design Changes and Local Variations, in accordance with the configuration detail of **Meuse** as applicable to PR EXP 1.
Revised Technical Description	**Meuse**, incorporating Design Changes and Local Variations and modified by PR EXP 1 configuration changes.

Modified contract conditions to incorporate a new price and delivery date were agreed in February 1983 although the contract was not amended until September 1983, two months after the original Contract Acceptance Date. The price basis was changed from Fixed Price to Fixed Price Incentive.

The resolution of the contractual differences enabled both the shipbuilder and the customer to concentrate on the building of the ship rather than on loss control and real progress was made with the project. HMAS **Success** was actually handed over some weeks ahead of the revised completion date, as amended for excusable delay, and the final cost of the ship was within 0.03% of the Target Price.

Changes to the configuration of HMAS **Success** continued after contract renegotiation, with 109 changes subsequently being incorporated. Improvements in the Commonwealth's procedures for handling the changes meant that the effect on programme was manageable. The impact of changes on the contract price can be seen in Figure 10.

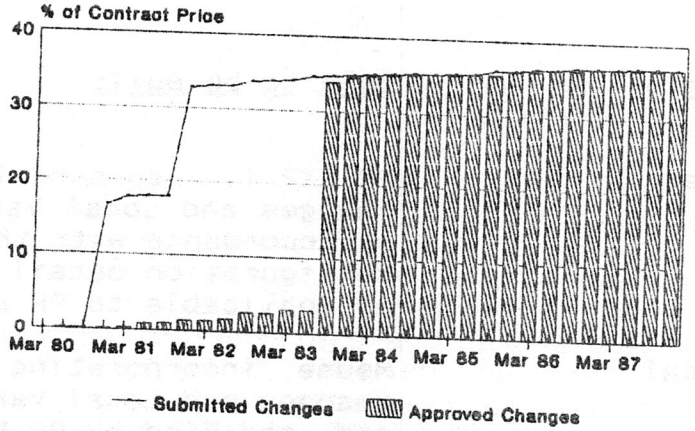


Figure 10 - The impact of Changes on the Contract Price

4.2.6 The Construction Programme.

4.2.6.1 Build Strategy.

With the prospect of building a ship of proven design, on a commercial contract basis, the original construction plan anticipated a high degree of early outfit. The hull structure unit breakdown was modified from the French arrangement to provide for block units of about 50 tonnes maximum weight, which would be suitable for fabrication by subcontractors throughout the Sydney region and transport by road and water to the Dockyard.

It had been intended that, as a minimum, all hot work, including hangers, seats, doors, hatches, ladders etc. should be completed prior to unit erection. As problems developed with the production drawings, this became a dream rather than a practical possibility and the only units to be erected in a substantially complete state were the Replenishment at Sea gantries.

The subcontract fabrication of hull units was assisted by the high degree of accuracy of cut parts achieved by the NC preparation at the Dockyard. With the exception of work undertaken by some fabricators unused to the standards required, work was usually of a high quality. Approximately 74% of the ships structure was constructed away from the island. This not only reduced the demand for labour in the shipyard, but was essential due to the space limitations on Cockatoo Island.

Fitting out was finally completed in a traditional manner. As experience of working to the French drawings grew, the difficulty of changing construction techniques after the

completion of the bulk of the detailed design became very evident.

Launching was delayed as long as possible, consistent with launching constraints and trials requirements. Success was about 65% complete when launched on 3rd March 1984.

The fitting out period included a long setting to work and trials period for some of the ship's more complex systems, including the ships extensive hydraulic system, believed to be the largest high pressure hydraulic system built in Australia.

4.2.6.2 Equipment Procurement.

Having the responsibility for the procurement of virtually all of the equipment and material for the ship, the shipbuilder engaged Ateliers et Chantiers de Bretagne (ACB) of Nantes, France, to assist with purchasing in Europe, and to act as the shipbuilders representative for communication with French authorities. ACB were also to work for both DTCN and the RAN during the project. The arrangement was to prove to be of considerable assistance in many ways.

Some difficulty was experienced with placing orders on French suppliers, particularly those who were aware that the Australian/French Memorandum of Understanding required the Australian shipbuilder to order their equipment. Difficulties were also experienced with passing on to equipment suppliers head contract conditions which in some instances were substantially more onerous than those normal in Europe for Naval construction.

Whilst delivery promises were not always met, no major delays resulted from equipment supply, and the benefits of having a minimal list of GFE were clearly evident. This is not to say that extraordinary measures were not occasionally necessary to achieve satisfactory deliveries, including at times, air freight.

In Europe, quality assurance assistance was provided by the French Service de la Surveillance Industrielle de l'Armament (SIAR), and extensive use was made of Classification Societies. Problems with quality nevertheless arose, at times with quite critical equipment. Experience soon made receipt inspection procedure strict and documentation was not necessarily taken at face value.

Major equipment suppliers were made contractually responsible to maximise the Australian content of their supplies. The single ship order naturally limited the extent to which Australian manufacture was possible. Nevertheless, this arrangement was outstandingly successful in some cases. For the

Replenishment at Sea equipment, for example, the supplier achieved a high level of Australian content, the equipment was delivered on time, the quality was high and technical support from the supplier was always readily available. When suppliers were prepared to make the effort, much could be achieved.

Many of the materials and equipments for Success, including steel, electric cables, switchboards, valves etc. were made in Australia. Major suppliers used to Navy requirements generally produced with reliable delivery and quality. This was sometimes not the case with minor suppliers and delivery was sometimes not achieved without continued pressure by the shipbuilder, and quality at times fell short of specification requirements. In limited instances (mainly with metal furniture) the standard of the finished product did not come up the shipbuilder's perception of "good shipbuilding practice" and the product was scrapped in favour of production by the Dockyard.

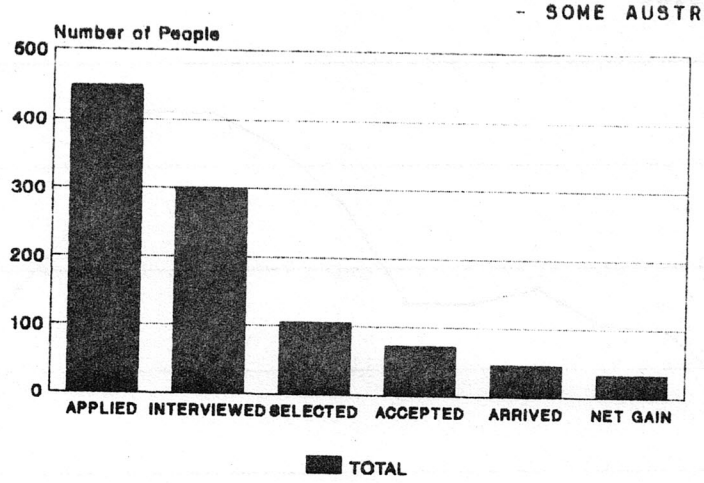
The contract required Codock to seek a 15% Australian content in major equipment supply, and this level was ultimately exceeded. Overall, some 82% of the total cost of Success was spent in Australia. Had it not been a single ship order, the figure could have been higher.

4.2.6.3 Labour.

Despite not having built a major ship for some years, a solid core of Naval shipbuilding experience existed at Codock and indications were that sufficient skilled trades labour would be available to supplement Dockyard resources. In the event, the build up for Success coincided with a generally high demand for labour throughout Australia. Moreover, people with shipbuilding skills had become rare following the general decline of the Australian shipbuilding industry during the 1970's.

Where labour was available, retraining by the Dockyard was often required. The technical college training of shipwrights, for example, had been tending towards the needs of a small craft industry rather than the construction of large steel ships.

With the high demand which rapidly developed for qualified and experienced technical people as the technical workload grew way beyond initial expectations, it became clear that adequate numbers of people could not be found within Australia. A recruitment programme was started in the United Kingdom in early 1980 to obtain 100 skilled technical and production people as quickly as possible. The response was excellent, however despite very good cooperation from Australian immigration authorities by the end of 1982 the net gain had been only 32. This experience is illustrated in Figure 11. These people did, however, make a major contribution to the project.



Net Gain indicated at end 1982.

Figure 11 - United Kingdom Recruitment.

By far the most successful means of obtaining additional resources was through the Dockyard's own apprentice training scheme. Codock has always trained large numbers of people, however the intake was increased dramatically as can be seen in Figure 12. This effort produced some fine tradesmen who comprised a high proportion of the workforce that completed the outfit of the ship. Technical and supervisory skills have a much longer lead time and no significant augmentation by this means was possible for the AOR project.

The employment trend in the Dockyard from 1960 to 1988 can be seen in Figure 13.

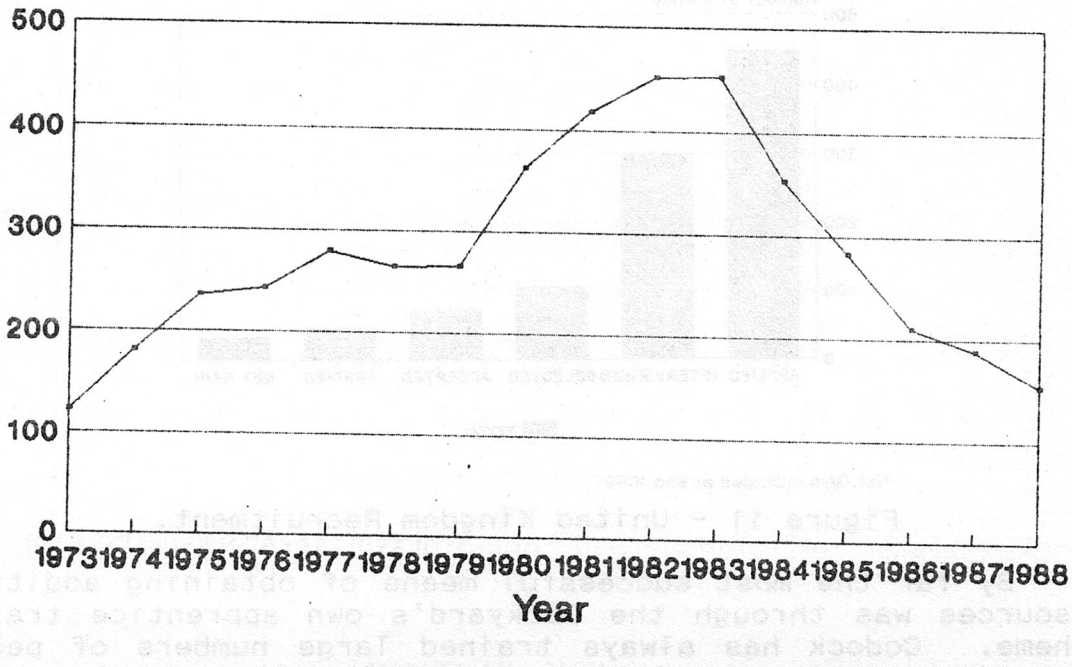


Figure 12 - Cockatoo Dockyard Apprentice Numbers
1973 - 1988

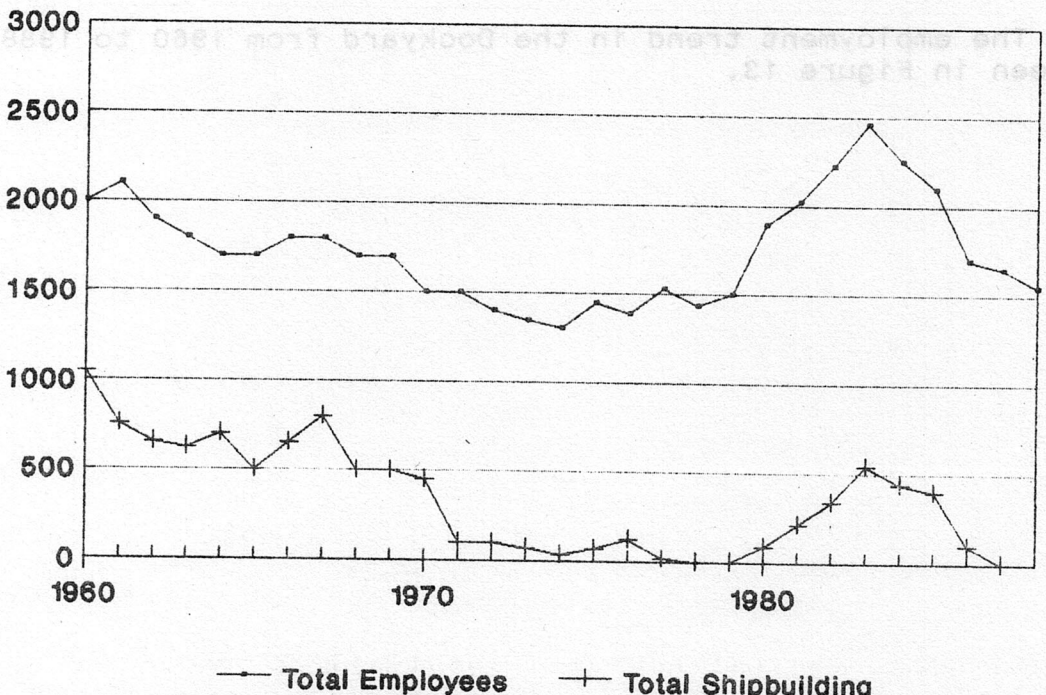


Figure 13 - Cockatoo Dockyard Employment History
1960 - 1988

4.2.6.4 Quality Control

Codock had been the first dockyard in Australia to introduce a formal quality control system, to satisfy the RAN requirements for refitting the Oberon Class submarines (References 6 and 9). The system complies with Australian Standard 1822.

The commercial nature of the contract for AOR-01 and the requirement for quality control to AS1822 presented some conceptual conflicts in the shipbuilder's organisation, where the need to minimise cost tended to constrain the development of rigorous quality procedures for the project. In practice, a quality control system can help contain costs by the prevention of problems which can be far more expensive to rectify if they are allowed to occur.

Approval of the Dockyard's quality system took some time, and was hampered by some contentious quality problems with welding and painting. These problems had their origin, to a large extent, in the general nature of the relevant specifications and the unfamiliarity with shipbuilding standards of some of the workforce.

The complex nature of the documentary definition of AOR 01 made the application of a rigorous quality system difficult. For example, Classification Society standards can be subject to subjective interpretation. The major problem of this nature, with welding, was resolved by engaging Bureau Veritas in an advisory role.

The introduction of different technical standards in the Baseline Variation/Design Specification resulted in non-compliance in areas where no changes were required from the Meuse configuration and work was completed exactly in accordance with the French drawings. This problem was overcome by amending the Specification to have these revised standards apply only in areas where there had been a design, equipment or material change, or to equipment manufactured in Australia to the French design.

Whilst this approach has resulted in different design standards applying to similar equipment throughout the ship (for example, switchboards), the variations were recorded through the Configuration Management System and in ILS documentation.

Whilst a quality system to AS1821 might have been more appropriate for the project, the contractual arrangements and proliferation of authorities would have continued to present problems. It is also unlikely that the shipbuilder's system could have been qualified to that level in a reasonable timescale.

4.2.6.5 Inspections, Tests, Trials and Acceptance.

With a Dockyard Test Organisation well established at Codock for the conduct of trials for submarines in refit, the same concept was adopted for Success. The operation of the DTO for submarines is described in Reference 6.

For Success, the Permanent Test Panel (AOR), the principal controlling body for all inspections, tests and trials was made up of the Dockyard's Quality Control Manager and Program Manager (AOR), and PARCBS (or their representatives). The PTP was responsible for the approval of test procedures, the analysis of results, approval of Defect and Deficiency lists and the acceptance of completed items.

The Production Package included copies of all test forms and procedures used by DCAN Brest for the construction of Meuse, and these were used as a basis for the preparation of approved test procedures. In many cases the French test forms required simply that equipment be given a "Good Working Test". These forms were rewritten to provide proper test and performance parameters, for items ranging from propulsion systems to the galley waste disposal unit.

With the priority having to be given to the preparation of production drawings, the writing of of Test forms did not start early enough and frequently there was very little time available for the their approval and preparation at the ship before a scheduled trial. A high degree of flexibility in the programme became essential at times.

Two hundred and fifteen tests and trials were completed including 47 at sea.

Unlike previous practice at Codock, the arrangements for the provision of the Navy crew for Sea Trials were formalised in an agreement which clearly set out the roles and responsibilities of the various parties. This was amplified by a detailed management plan. The arrangement worked very smoothly, and the 47 trials serials were completed in eleven days at sea (one more than planned) with excellent ship performance and very few defects arising. A further two days were spent at sea for Acceptance trials just before delivery.

All Contractor's Sea Trials were limited to those which could be completed without the necessary use of other Commonwealth assets. Sea Trials of replenishment at sea equipment and cargo pumping systems were carried out after Commissioning as part of the RAN Sea Acceptance Trials programme.

In late 1984 the RAN adopted a revised procedure for the conduct of inspections, tests and trials, and acceptance into service of new construction ships, which was applied for the first time for HMAS **Success** (Reference 10). The procedure was broadly similar to that used by the U.S. Navy.

This new procedure provided for the assessment of the performance of the ship by a Ship Acceptance Board(SAB), headed by a senior naval officer (for **Success**, a Rear Admiral), prior to acceptance of the ship for Fleet service.

After acceptance from the shipbuilder, a series of RAN Sea Acceptance Trials and Ship Qualification Trials were followed by a Post Delivery Availability (PDA) in the shipbuilder's yard. The PDA provided the opportunity for the shipbuilder to rectify any warranty defects, complete any work outstanding from Hand Over, and to incorporate any changes considered necessary by the SAB and approved for incorporation prior to Fleet Acceptance.

At Hand Over of **Success** some 180 desirable modifications had been identified for completion before Fleet Acceptance or by subsequent Alteration and Addition action. Some items had been identified during construction but too late for incorporation without long and costly delay. Many arose from experience with the operation of the ship during trials and some resulted from different RAN/French Navy operational practices. Others arose from what might be described as cultural differences - the need to provide greater grilling capacity in the galley was an example.

No detailed work had been possible on the preparation of work packages for these changes prior to the Hand Over of **Success** in April 1986. With the PDA planned to start in mid October 1986, and with funds necessarily limited, the priority list tended to change as individual estimates were prepared and material availability was determined.

Forty changes were completed during two assisted maintenance periods, and some 140 more were completed during the 4-1/2 month PDA which completed at the end of February 1987. The largest of these changes were the installation of an Omnipure sewage treatment plant and a re-arrangement of the ships boats, including the installation of Gravity davits for the ship's LCVP and slewing davits for rigid inflatable boats.

Of the total PDA workload, 93% related to configuration changes and 7% to maintenance and services. Warranty work was insignificant.

4.2.6.6 Integrated Logistic Support

In the French Navy, the Durance class replenishment ships were not initially provided with Logistic Support documentation to the same standard as combat ships, being regarded auxiliaries for which support to a commercial level was appropriate.

The original ILS Specification for AOR 01 required a more comprehensive range of ILS elements to be addressed by the shipbuilder. With little available source documentation, the task was committed on an estimated price basis. At that time Codock did not want to establish its own ILS Department, preferring to rely on subcontractors specialising in this field in Australia.

The lack of available experience in Naval ILS tasks and problems associated with matching the RAN's requirements to the available source material meant that little progress had been made by 1984. In the meantime, the French Navy had introduced a much more comprehensive system for their own ships. Accordingly, a revised specification for AOR 01 was prepared at the end of 1984 which enabled full advantage to be taken of the French developments. An ILS department was also established in Codock, and very close cooperation was maintained with the Navy's ILS Manager. Throughout the remainder of the project, the Navy's ILS Project team provided strong and professional leadership which enabled a great deal to be achieved.

In addition to technical documentation, a computer based Ships Logistic Information Management System (SLIMS) was developed to provide the ship and shore support authorities with access to a comprehensive logistic database based on the Master Equipment List.

Training programmes were also arranged for ship's staff for major equipment, and training films were prepared for some ships systems. The latter included an award winning set of training films produced by an Australian firm for the Replenishment at Sea system.

Despite the uncertain start, the Success ILS package became the most complete and comprehensive ever produced for a Naval ship built in Australia.

4.2.7 Project Outcome.

During all her builder's and later RAN sea trials, Success performed at least as well as, and in some respects, better than her French sisters. Whilst some adaptation of RAN operational

procedures has been necessary the ship has proved to be a very satisfactory Fleet unit.

Since the acceptance of Success the value of this type of ship has been clearly demonstrated. With the evolution of the RAN into a two ocean Navy, a second ship is clearly needed (HMAS Supply paid off into well earned retirement in 1985). Codock had been invited to submit a tender for AOR 02 in 1980, however this was deferred in view of the contractual difficulties with AOR 01. With the passage of time the second ship receded further into the distance and was later dropped from the Defence programme. Studies have continued into less expensive alternatives.

As Success was being built, project management of Defence acquisitions was subjected to intense political and public scrutiny and criticism. The approach taken for later projects, like the RAN New Construction Submarines and the Anzac Frigates, has been quite different, and they will hopefully benefit from the lessons learned.

5. AN ASSESSMENT OF EXPERIENCE.

5.1 SHIP DESIGN.

Both the projects examined in this paper involved the construction of ships designed for use by other Navies in different operational environments. In both cases, the designs were subject to extensive modification. The continuity experienced from 1945 to 1971 developed a significant capability with a broad depth of experience, which formed the basis for the confident approach to the AOE and DDL projects.

Much of this capability was lost during the 1970's, and some of the problems of detail which arose during the construction of Success stemmed from the lack of experience within the Navy and industry. Consequently, in the late 1980's, the RAN has no option but to rely on overseas design for its major ships, until the submarine and Anzac Frigate projects provide the workload and lead time necessary for the regrowth of an Australian design capability.

This regrowth will only occur if major Australian input is made to the design development and adaptation of these ships. The submarines are essentially a new design, but will be based on Swedish design philosophy. The frigates will be either of Dutch or German origin and will be based on existing designs. Design change for operational or cultural reasons will be needed, and to incorporate Australian materials and equipments.

The need for this basic level of design change, and the complications it introduces, will not diminish until Australia is in a position to design its own ships.

5.2 SHIP CONSTRUCTION CONTRACTS.

In the period since the start of the RAN Type 12 programme, 37 years ago, the approach to Naval ship construction contracts has changed completely. Reorganisation within the Australian Department of Defence has progressively removed the responsibility for ship construction from the Navy technical departments and placed it in the hands of a Central Capital Procurement Organisation. This change was occurring during the course of the replenishment ship project, and the untidy and divided responsibilities of that period have been eliminated.

Ship construction contracts have changed from cost reimbursement contracts where the emphasis was on technical aspects and not price, to total package fixed price contracts for multiple ships built to a performance specification. Progressively, risk, both technical and financial, has been passed from the customer to the contractor.

A balance must be maintained in this process. If these risks fall too heavily on the contractor, then the customer faces the greater risk that the contractor may prove unable to meet the challenge and fails to deliver.

The conditions which need to be met if future Australian Naval ship construction projects are to satisfy the expectations of the parties involved can be identified from the experience of the projects described.

- Ship Specification.

A clear and unambiguous specification of requirements is needed as a baseline for configuration management, change control, and quality control. Options should be eliminated at an early stage, as the more options the greater the uncertainty of the estimate and the higher the risk. This process demands adequate lead time, and in the past programmes have tended to be moulded to meet political or social objectives without due regard to the time and resources needed to ensure a sound basis of contract.

- Appropriate Contract.

It is essential that mechanisms exist within Navy shipbuilding contracts to enable the timely resolution of problems as they arise in order to avoid conflict. Whilst proven,

existing designs may be chosen, any ship in a yard that has not built to that design before, is a lead ship. The more that design is modified, the more important it is that this fact be recognised. The contracts must be readily capable of modification to incorporate change. The extent to which the need for change will be identified before contract will largely depend on the experience of the participants in this process.

- Clearly Defined Authority within the Customer's Organisation.

For the Type 12 programme, at least initially, the responsibilities in Defence were clearly defined and simple. The complexities of the AOR contract have since evolved into a centralised organisation with clear project management responsibility. There is now a recognition of the need for rapid and positive decision making.

- Clear targets for Project Management.

Project control requirements within Defence have developed with benefit from experience of other industries and major projects in the civil sphere. The cost and schedule control system developed for the new RAN submarine project - the Cost Monitoring and Control System (CMACS - Reference 11) is a complex and detailed system which enables the Defence Submarine Project office to have a clear picture of the progress of individual work packages throughout the project.

Whilst such a system is clearly needed for a project which will cost some twenty times as much as HMAS Success, it is important that it remains sufficiently flexible to adapt to changing circumstances in a project which is not planned to complete until the turn of the century. CMACS seems also to provide many opportunities for customer intervention, and in a major fixed price contract it is important that the contractor is able to fulfil his management responsibilities without undue constraint.

- Order Volume.

All the Type 12's and Success were virtually lead ships and little advantage was gained from series production. Success, in particular, showed how difficult it is to change shipbuilding methods once the detailed design of the baseline ship has been completed. Multiple orders can introduce many economies and present opportunities for production methods to be progressively improved.

In this regard, the submarine and Anzac frigate projects, with their commitment to multiple ship orders, present excellent opportunities to benefit from series production. Nevertheless, changes in programmes of this size must be expected, and it is

unlikely that the last Anzac frigate will be the same as the first.

- Continuity of Production.

A steady continuity of work is necessary for any industry to develop and maintain its special skills, particularly those with a long lead time. Inevitably, when work runs out, political and social pressures mount for orders to fill the vacuum. The customer then feels that his position is compromised and that he would benefit from greater competition, introducing inexperienced contenders and once again diluting the skill base. This syndrome has been as apparent in Australia as anywhere else in the World.

The competitive processes introduced for the latest RAN programmes have played their part in a major restructuring of the Australian Naval shipbuilding industry. This process has also resulted in available experienced resources being very thinly spread amongst the competing organisations.

From past experience it is clearly evident that people are the most critical resource in any major project. The submarine and Anzac frigate projects will represent the principal task of the Australian shipbuilding industry in the next ten years. They start at a time when employment in the Australian shipbuilding industry is at its lowest level since the Second World War, yet will demand the highest commitment of resources to Naval shipbuilding in Australia's history.

6. CONCLUSIONS – THE WAY AHEAD.

Traditional Naval shipbuilding depended on skilled tradesmen who could build ships with a minimum of technical information. The drawing office solution to a difficult problem - to mark the drawing "Arrange at Ship" - usually worked, as the skills existed in production to do just that.

The Second World War demonstrated the need for series production of ships with parts manufactured in locations unused to shipbuilding. The original plans for modular construction of the Type 12's in this manner were never achieved and proved to be some years ahead of their time.

The progressive reduction in the levels of experience in a declining shipbuilding industry, and the need to subcontract work for the most economical use of resources, has placed a greater responsibility on ship designers to design for production. The demand for specialised skills in ship production is also shifting to technical areas as modern shipbuilding techniques based on Group Technology are adopted. Modern, computer based management systems also place a high premium on skilled people.

Not only will many of the people who will build the new submarines and the Anzac frigates have had no prior shipbuilding experience, but Australia is also starting a major restructuring of its awards, trade training and skill structure with the emphasis on flexibility and multiskilling. These changes will occur during the course of the submarine and Anzac frigate projects, and have the potential to greatly improve the productivity of Australian Naval shipbuilding. The task of managing this process is considerable.

Throughout this task, it will be essential to remember that the product has to do a difficult job in a most demanding environment. Appropriate experienced and professional input to this most important aspect is essential, otherwise the product of the most closely managed and efficient project could fail in its primary mission. The main aim of the whole exercise is, after all, to build a ship.

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APPENDIX 1 — AUSTRALIAN TYPE 12 FRIGATES — PRINCIPAL CHANGES

HMA Ships Yarra and Parramatta

(compared to British Rothesay Class)

Hull

- Increased fuel and fresh water capacity.
- Full air-conditioning of all operational and accommodation spaces.
- Cafeteria Messing.
- Bunk accommodation for all senior and junior sailors to RAN standards.

Machinery

- Enclosed air-conditioned machinery control room, with pneumatic remote control of system valves.
- Cruising turbines deleted (removed before completion).

Weapons

- 12 21 inch Torpedo tubes deleted.

Weapons Electrical

- MRS 3 gun fire control in place of the Mk VI director.
- HSA LWO2 radar in place of Type 277.
- US electronic warfare equipment.
- Modified communications.

HMA Ships Stuart and Derwent.

Hull

- Extensive internal rearrangement to accommodate IKARA.

Weapons

- Ikara Guided missile system in place of one Mk 10 Mortar.
- Seacat guided missile system in place of 40 mm Mk 5 Bofors.

Weapons Electrical

- IKARA guidance system.
- AN/SQS 504 variable depth sonar.
- Modified electronic warfare installation.

HMA Ships Swan and Torrens

Hull

- Complete internal rearrangement.
- Modified forefoot to improve sonar performance.
- Trunk refuelling.
- Increased air conditioning plant capacity.

Machinery

- Y136 propulsion machinery configuration in place of Y130.
- Non retractable fin stabilisers
- Turbo alternator capacity increased from 2 x 400 kW to 2 x 500 kW.
- Diesel alternators relocated from 2 deck forward to 4 deck forward of boiler room and capacity increased from 3 x 200 kW to 2 x 500 kW.
- Extended hydraulic and pneumatic remote control of main and auxiliary machinery.
- Electric telegraphs in place of mechanical.
- Electric capstans in place of steam.
- Electric steering control in place of telemotor.

Electrical

- Improved electrical distribution system.
- Interphone system installed.
- Versatile Console System adopted for instrumentation.

Weapons

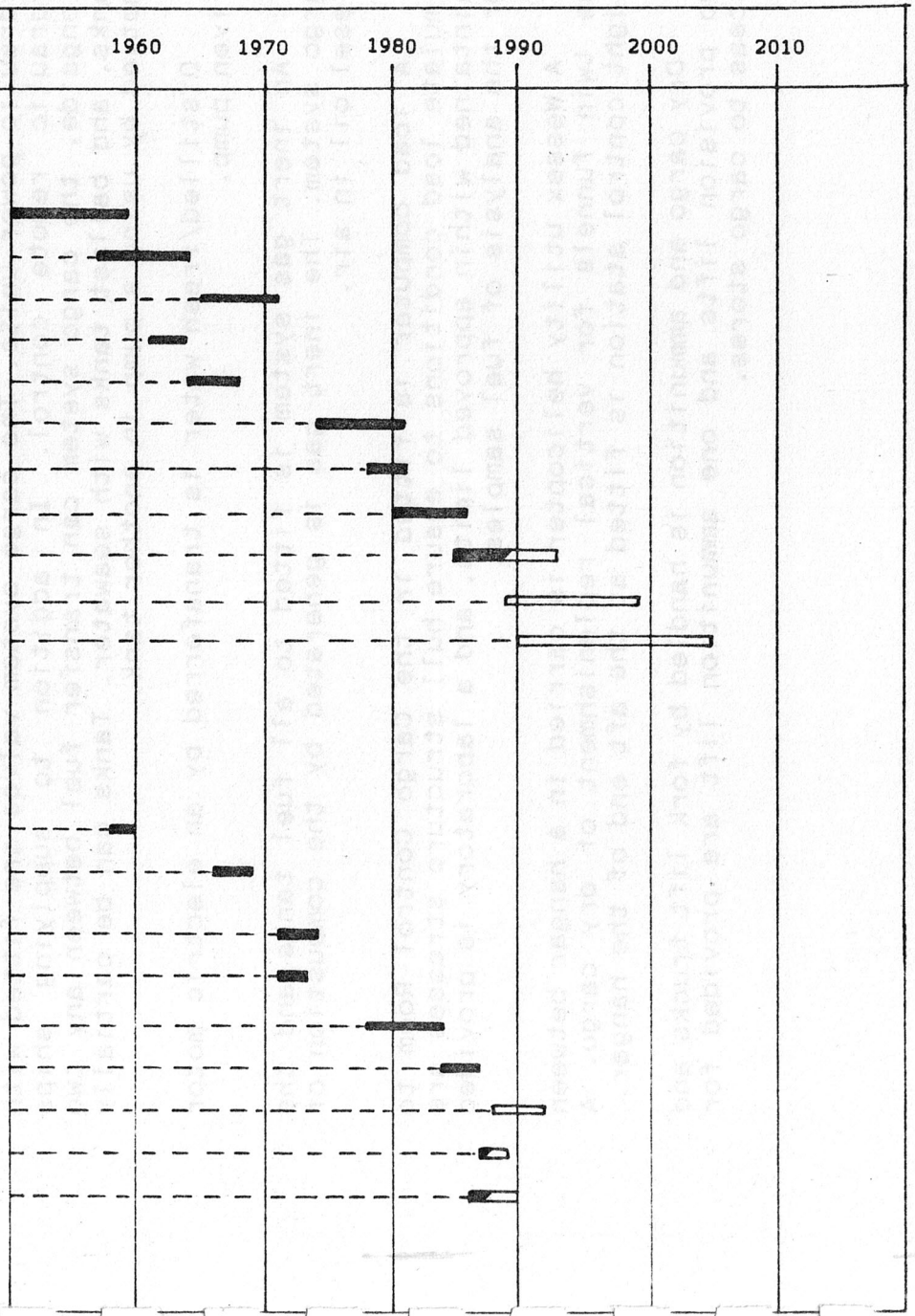
- 4.5" gun mounting upgraded from Mod 1 to Mod 3.
- A/S Mortar handling equipment modified.

Weapons Electrical

- M22 gun fire control in place of MRS 3.
- M44 Seacat fire control in place of GWS 20.
- Radar 293 deleted and navigation radar 8GR 301 fitted.
- Communications updated.
- Electronic warfare installation modified.

APPENDIX 2 - AUSTRALIAN NAVAL SHIPBUILDING SINCE 1950

SHIPS	NUMBER BUILT	DESIGN ORIGIN	BUILDER
OVER 1000 TONNES STD. DISPLACEMENT			
Daring Class Destroyers	3	UK	Codock (2) Wildock (1)
Type 12 Destroyer Escorts	4	UK	Codock (2) Wildock (2)
Type 12 Destroyer Escorts	2	UK	Codock (1) Wildock (1)
Survey Ship HMAS Moresby	1	Aust.	State Dockyard*
Destroyer Tender HMAS Stalwart	1	Aust.	Codock
Oceanographic Ship HMAS Cook	1	Aust.	Wildock
Amphibious Heavy Lift Ship HMAS Tobruk	1	UK	Carrington Slipways Pty Ltd
Fleet Underway Replenishment Ship HMAS Success	1	France	Codock
FFG 7 Class Frigates FFG 05 & 06	2	US	Wildock (Aust. Marine Eng Corp)
Submarines Type 471	6	Sweden	Australian Submarine Corp.
Anzac Frigates FFH 01 to 12	12	Germany/ Holland	AWS or AMEC Cons.
			* No longer in shipbuilding (1988)
UNDER 1000 TONNES STD. DISPLACEMENT			
General Purpose Vessels	2	Aust.	Walkers Ltd *
Attack Class Patrol Boats	20	Aust.	Walkers Ltd (10)* Evans Deakin Ind. Ltd (10)*
Landing Craft Heavy	8	Aust.	Walkers Ltd *
Hydrographic Ship HMAS Flinders	1	Aust.	Wildock
Fremantle Class Patrol Boats	14	UK	NQEA
Inshore Minehunters	2	Aust.	Carrington Slipways Pty Ltd
Inshore Minehunters	4	Aust.	Carrington Slipways Pty Ltd
Survey Motor Launches	4	Aust.	EGLO Engineering Pty Ltd
Pacific Patrol Boats	12 (export)	Aust.	Australian Shipbuilding Industries Pty Ltd



APPENDIX 3 — DESCRIPTION OF HMAS SUCCESS

HMAS Success is intended to supply ships of the RAN with diesel oil, avcat, fresh water, victualling stores (including refrigerated stores), ammunition (including missiles) and spares.

Success is fitted for simultaneous connected replenishment (CONREP) of two ships, one on each beam. The ship is fitted with four diesel oil fuelling stations (two port, two starboard), two avcat transfer stations (one each side), and four distilled/fresh water replenishment stations (two each side). Two heavy load and two light load cargo transfer points are provided (one each port and starboard).

All CONREP solid and liquid cargo operations are controlled from a centrally located Cargo Control Room sited between the two replenishment at sea gantries. Tank contents and the operation of all cargo transfer systems are monitored from this room.

The ship is fitted with a Hepburn automatic self tensioning replenishment at sea system.

Sixteen hydraulically driven submerged cargo pumps supply the diesel oil and avcat cargo distribution system. The pumps are fitted in the fuel tanks and are driven by four separate hydraulic power units. The cargo system valves are fitted with hydraulic remote control. In addition to supplying ships alongside, the cargo system can transfer fuel between any two tanks, and ballast tanks with seawater. Tanks can be partially emptied by using a pump in another tank.

Distilled/fresh water is transferred by an electric motor driven pump.

An inert gas system is fitted to all fuel tanks and the cargo system. The inert gas is generated by the combustion of diesel oil in air.

A load computer is fitted in the Cargo Control Room to simulate load conditions to ensure hull structure stresses are maintained within approved limits, and a laboratory is provided for the analysis of fuel samples.

A Wessex utility helicopter is carried in a hangar between the twin funnels for vertical replenishment of dry cargo. A flight control station is fitted at the aft end of the hangar.

Dry cargo and ammunition is handled by fork lift trucks and two provision lifts and one ammunition lift are provided for access to cargo stores.

HMAS Success is propelled by two controllable pitch propellers driven by Pielstick 16 PC 2.5V non reversing medium speed diesels through 2.97 to 1 single reduction gearboxes. A 2 Mw shaft driven alternator is driven from each gearbox to provide power for CONREP operations.

The propulsion machinery is controlled from a Machinery Control Room, by single levers for each shaft, on orders telegraphed from the Bridge.

The ship is provided with two independent power supply systems, each providing a 440 volt 60 Hz 3 phase 3 wire unearthed supply. The ship services system is supplied by three 480 Kw diesel alternators, capable of continuous parallel operation, but each connected to a separate section of the main switchboard. Shore supply facilities are provided as part of this system.

The two shaft driven alternators supply the replenishment at sea system through a separate switchboard. This system is also capable of supplying ship services.